The Economic Impact of Agency 229

An examination of industry and community impacts

Prepared by the Virginia Tech Office of Economic Development

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The Economic Impact of Agency 229 on the Commonwealth of Virginia

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INTRODUCTION

The social and economic impacts of Agency 229 on the Commonwealth of Virginia are vast and diverse. As a state-funded entity, legislative bodies often ask Agency 229 to illustrate those impacts. Currently, 229 faculty assess research and extension programming using quantitative metrics such as head-counts at trainings and research dollars awarded. Outcomes of activities are communicated qualitatively through impact statements that provide summary information on trainings and anecdotal evidence of benefits to attendees and those who benefit from direct technical assistance. Occasionally, researchers will team up with the Department of Agricultural and Applied Economics to assess the potential economic impact of an innovation. Others who focus on agricultural products sold through nationwide and commodity markets will compare yield gains over time and attribute a portion of gains to research and extension efforts. The numerous media headlines and narratives describing the localized impacts of research and technical assistance initiatives have been another powerful approach to telling Agency 229's story.

As the agency looks ahead, however, the growing trend for more data-driven funding justifications challenge Agency 229 to illustrate its economic impacts in different, more comprehensive ways that connect its activities to industry and community development in the commonwealth. This type of evaluation can further help prioritize resources and improve programming. Recently, Virginia's state legislature released a mandate, directing Agency 229 to develop a strategy for leveraging state investment with industry partnerships that "result in technological and scientific advancements needed to grow the state's agricultural and natural resource economy." Moreover, Agency 229 has to consider its role in university-led initiatives such as the Virginia Agriculture and Natural Resources Initiative: Growing our future with public-private partnership and the Global Systems Science Complex and Destination Area. These initiatives offer opportunities to leverage resources and increase the agency's overall economic impact.

This study assesses the current impacts of Agency 229 as they relate to the economy of Commonwealth of Virginia and provides recommendations on how to leverage activities and funding to increase those impacts in the future. We begin by providing an overview of Agency 229 and different approaches to studying the economic impact of university entities. Many approaches exist; however, because impacts of such a large entity can be difficult to quantify or even qualify, not many institutions have endeavored to conduct a large comprehensive study of this type. We approach the assessment of the economic impact of Agency 229 using an industry and community case study lens. By looking at the influence of 229 extension and research innovations have on individual sectors of the economy and specific communities, we can uncover many of the causal mechanisms through which 229 activities affect change and in turn facilitate economic growth and development. We first review five industries that contribute significantly to Virginia's agricultural economy and assess Agency 229 research and extension efforts as they relate to those sectors. We then take four communities located across the commonwealth as examples to identify social and economic impacts that VCE and Agency 229 research have at the county level.

BACKGROUND OF AGENCY 229 AND UNIVERSITY ECONOMIC IMPACTS

Agency 229 provides funding to Virginia Cooperative Extension (VCE) and the Virginia Agricultural Experiment Station (VAES). The Virginia General Assembly established VAES in 1886, anticipating the 1887 Federal Hatch Act. With the Smith-Lever Act of 1914, the federal government broadened land-grant universities' mission by creating the cooperative extension system.[1] Since then, Virginia's General Assembly has tasked Agency 229, under the leadership of Virginia Tech and in concert with Virginia State University, with developing and disseminating research that benefits all Virginians. Experts and educators funded under Agency 229 provide information, education, and tools that improve the lives of Virginians in many key areas.

The Virginia Extension system operates under a county-based model, with 107 local offices and four district offices. Those local offices are supported by 11 Agricultural Research and Extension Centers (ARECs) spread out across the state. The mission of VAES is to "perform basic and applied research on agricultural, environmental, natural, and community resources issues related to the future needs of Virginia, the region, the nation, and the world."[2]

The three colleges that each receive funding from Agency 229 are the College of Agriculture and Life Sciences, College of Natural Resources and Environment, and the Virginia-Maryland Regional College of Veterinary Medicine. Faculty from each of these three colleges have full or partial funding from Agency 229 through VAES or VCE appointments. During the 2015-2016 fiscal year, Agency 229 supported 170 full-time equivalent positions in VAES, both on the Blacksburg campus, and at the ARECs. When splitting amongst the three supporting colleges, 80 percent of those positions are in the College of Agriculture and life sciences, 7 percent are in the College of Veterinary Medicine, and 13 percent are in Natural Resources and Environment.

Although 229 is most commonly thought of as supporting the agriculture sector, research and extension activities directly impact the physical and financial health and well-being of many Virginians, not just those who work in agriculture. This, directly and indirectly, contributes to a healthy and vibrant workforce – a vital component of every industry in Virginia. VCE program areas include agriculture, community and leadership, natural resources, family, food & health, lawn & garden, and 4-H/Youth. Agency 229 supports 343 full-time equivalent VCE positions across the three colleges, central administration, four district offices, ARECs, and the 107 local offices. Local offices have agents in four key areas:

- Agricultural and Natural Resources (ANR)
- Family and Consumer Sciences (FCS): FCS extension workers take a holistic approach to the development of communities in Virginia. The majority of their work is educational. Special areas of service include nutrition/wellness, family financial education, and family and human development. Specific programs include:
    - Financial education and housing support
    - First-time home-buying and foreclosure avoidance
    - Home and family education, including parenting and communication

[1] Fornash, L (2011). Analysis of the Virginia Cooperative Extension Service (VCE) Structure, Funding Trends, and Research. Retrieved from: https://ext.vt.edu/content/dam/ext_vt_edu/about/sec-ed-report/vsoe-report-complete.pdf.
[2] Virginia Tech (2017). Virginia Agricultural Experiment Station. Retrieved from: https://vaes.vt.edu/index.html.

    - Health and nutrition, including SNAP education
- 4H Youth Development (4H): This program encourages youth to participate in a variety of activities emphasizing "learning by doing" so that youth develop as leaders and are ready for future endeavors. Some examples of 4-H Youth development programming include:
    - Community and project clubs
    - School enrichment and in-school programming (Reality Store, for example)
    - Camps
- Community Viability: Although there are no community viability specialists at the local level, each extension agent is responsible for connecting with partners, communities, and individuals in the areas of leadership and planning, community enterprise and resiliency, community food systems, planning. Examples of community viability activities undertaken by ANR, FCS, and 4H agents include:
    - Training county officials
    - Educating entrepreneurs
    - Growing the food system
    - Research into community needs.

Because VCE is a needs-based organization, programming in each locality is based on the needs of that community, as identified by a systematic or ad-hoc situation analysis, combining feedback from local and regional stakeholders. As seen in the community case study examples in the latter half of this report, some programs are more prominent in certain communities than others. For example, extension offices located in more urban areas focus on issues such as housing and financial management, while extension offices located in more rural agricultural counties might focus more on technical assistance to producers and programming related to job and college readiness. While 4H programs in the Northern Virginia region exist outside of school-time, with some SOL-related youth educational programming occurring during school time, Southwest Virginia 4H programming all takes place during school time. Each extension office has access to high quality, evidence-based programs that have been developed by specialists in Virginia, other states, or at the national 4-H level. Agents can correspond with extension specialists at the AREC or district level to develop or adapt more context specific programming to meet the needs of their specific community.

The work of the extension agents would not be possible without the assistance of volunteers. Indeed, volunteer management and training is a critical VCE function. VCE engages approximately 30,000 volunteers annually, equivalent to almost 1 million volunteer hours. There are volunteer opportunities in each of the four areas, including Master Gardeners, Naturalists, Food Volunteers, Family Nutrition, Financial Education, and 4H. Each extension office has an extension leadership council (ELC) that helps to keep programming relevant to local needs.

Measuring the Impacts of Agency 229

State Agricultural Experiment Stations have been a fundamental bedrock of innovation for the agricultural industry despite waning support. One reason for waning financial support may be that the delay between the beginning of the agricultural research and the first societal impacts are rather long, being estimated at nearly 15-20 years.[3] While these impacts may be significant, the lag between research, adoption, and economic indicators makes impact difficult to causally link to activities and is

[3] Joly, P. B., Colinet, L., Gaunand, A., Lemarí e, S., & Matt, M. (2016) Agricultural research impact assessment: issues, methods and challenges. [Research Report] auto-saisine. 51. Retrieved from: https://hal-sde.archives-ouvertes.fr/hal-01431457/document.

difficult to explain, especially in political climates focused up short-term impacts. As a result, "in the coming decades, the rate of U.S. agricultural productivity growth will reflect the diminished research investments made in the period 1980–2002 and thereafter".[4] Reductions in investment suggest a need to prepare for reduced agricultural productivity growth rates for the U.S. and global food security in years to come. This recognition should raise concerns about productivity growth in coming decades, which is required to insure an adequate supply of food to meet increasing demand.[5]

A review of 51 land-grant universities (LGU) for economic impact has found that, as a collective group, these institutions are interested in how to measure economic impact, possibly in reaction to declining investment and the need to illustrate their value to state economies. Only twelve state LGUs have conducted some form of economic impact analysis. Of those twelve, only University of Tennessee had done an economic impact analysis of all program areas. Texas A&M has emphasized conducting an economic impact analysis of significant Cooperative Extension educational programs, although their emphasis has remained on agricultural topics. The remaining land-grant universities have either conducted system-wide economic impact studies of the university on the state, with very cursory mentions of Cooperative Extension, or commissioned an Extension employee to do an economic analysis of specific programs. All of the program analyses utilized IMPLAN.

When reviewing economic impacts of higher education institutions more broadly, studies tend to use very narrow definitions of economic development practices to assess impact. Most metrics for measuring economic impact stem directly from policies of the eighties and nineties that emphasized technology transfer, patents, start-ups, direct capital inputs and revenues generated from research. Many universities have historically taken a 'first generation' approach to measuring economic impact, focusing on resource inputs such as capital, labor and time, and outputs, such as returns on investment.[6] These metrics reflect the industrial era more so than they do the current knowledge economy. Innovation is much more than technology, and it comprises much more than can be measured by a single metric.[7] However, after a review of higher education and other institutional impact studies, third and fourth generation indicators still seem more aspirational than reality.

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[4] Andersen, M. A. (2015). Public investment in US agricultural R&D and the economic benefits. *Food Policy*, *51*, 38-43: p. 42. Retrieved from: https://doi.org/10.1016/j.foodpol.2014.12.005

[5] Andersen, M. A. (2015) and Joly, P. B., Colinet, L., Gaunand, A., Lemarĭe, S., & Matt, M. (2016).

[6] Milbergs, E. & Vonortas, N. (n.d.). "Innovation metrics: Measurement to insight". White Paper prepared for the National Innovation Initiative 21st Century Innovation Working Group. Retrieved from: http://innovationmanagement.se/wp-content/uploads/pdf/Innovation-Metrics-NII.pdf

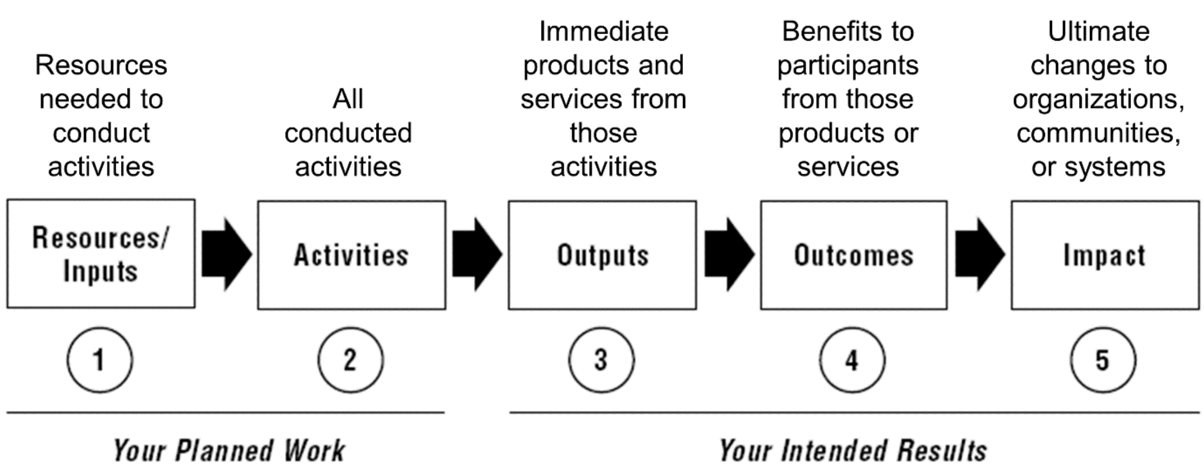
[7] Ibid.

Table 1: Metrics to measure economic development from 1950-Present [8]

1st Generation Input Indicators (1950s-60s)	2nd Generation Output indicators (1970s-80s)	3rd Generation Innovation Indicators (1990s)	4th Generation Process Indicators (2000 + emerging focus)
R&D expenditures S&T Personnel Capital Tech intensity	Patents Publications Products Quality Change	Innovation surveys Indexing Benchmarking innovation and capacity	Knowledge Intangibles Networks Demand Clusters Management techniques Risk/Return System Dynamics

Many organizations advocating for stronger evaluation and modeling of organizational impacts, such as higher education institutions, turn to logic models to visualize the relationship between organizational activity and ultimately social and economic impacts.

Figure 1: Sample Logic Model Framework[9]



The academic literature on the economic impacts of agriculture R&D and Extension work reveals attempts to not only illustrate the economic impact but also grapple with the qualitative, human, and social implications and benefits of Agricultural Experiment Stations and Cooperative Extension. To assess the economic impact of agricultural research R&D, many economists have tried to quantify the value. Traditionally, agricultural research and development assessment can be sorted into *ex-ante* and *ex-post* evaluations. One approach has been to calculate the rate of return on investment (RRI) through ex-ante

[8] Milsbergs & Vonortas, n.d., p. 4

[9] The Pell Institute for the Study of Opportunity in Higher Education (2017). Evaluation Toolkit. Retrieved from: http://toolkit.pellinstitute.org/evaluation-guide/plan-budget/using-a-logic-model/.

or ex-post evaluations.[10] While as many as 2,186 published RRIs may have over exaggerated the impacts of agriculture R&D, Hurley et al. (2014) identified a modified internal rate of return (MIRR) of 12 percent per year. This rate of return would mean $1.2 trillion annually as a result of U.S. Agriculture R&D. This figure would be 4.2 percent of the U.S.'s projected GDP in 2050.[11] Anderson (2015) confirmed that the real rate of return to public investments in agricultural R&D in the United States is estimated to be 10.5 percent annually, using a similar MIRR calculation.[12]

Recognizing the investment figure is important, Jin and Huffman (2016) also stressed the complexity of measuring AES and Cooperative Extension activities in this way. They warned that impact evaluators should guard against aggregating public agricultural research and extension dollars together if they want to have an accurate RRI calculation. Cooperative Extension is involved in a wide variety of educational activities, such as home economics, community development, and 4-H. Jin and Huffman (2016) relayed that from 1977 to 1992, only 55 percent of the gross activities of Cooperative Extension were for agricultural and natural resource education.[13]

Since its conception in the late 1950s, there has been a growing recognition of the complexity of impact assessments. Joly et al. (2016), for instance, explored how to measure the broader themes of agricultural impact research and development (R&D) than merely economic impact. They found that improving agricultural productivity had impacts on a multitude of current issues, including: "Dealing with environmental issues; Improving health: safety and healthy food provision, safety working conditions; Enhancing the social value of agriculture: poverty alleviation, maintenance of viable rural areas and quality of life in rural areas; and, Reducing food waste".[14] Joli et al. (2016) advocate for a Research Impact Assessment approach that combines the traditional economic impact assessment approach with a case study methodology, which provides narrative descriptions illustrating the complex relationships of activities and impacts. Moreover, because these activities and their impacts are so complex—societal impacts from research being inextricably linked to several networks of actors and activities—they recommended that the measure of economic impact analysis should not be attribution analysis, but contribution analysis. While attribution identifies causal relationships between activities and impacts (A+B=C where C would not exist without A), contribution studies illustrate how agriculture R&D may add to certain impacts without negating the presence of other contributing factors, thus acknowledging the complex system of economies and communities.[15] Meanwhile, Maru, Sparrow, Stirzaker, & Davies (2016) developed a holistic approach to agriculture R&D impact assessments that

[10] Norton, G., & Davis, J. (1981). Evaluating Returns to Agricultural Research: A Review. American Journal of Agricultural Economics, 63(4), 685-699. Retrieved from: http://www.jstor.org/stable/1241211
[11] Hurley, T. et al. (2014). "Re-examining the reported rates of return to food and agricultural research and development". American Journal of Agricultural Economics 96(5): 1492-1504. Retrieved from: https://academic.oup.com/ajae/article/96/5/1492/2738767/Re-examining-the-Reported-Rates-of-Return-to-Food.
[12] Andersen, M. A. (2015).
[13] Jin, Y., & Huffman, W. E. (2016) "Measuring Public Agricultural Research and Extension and Estimating their Impacts on Agricultural Productivity: New Insights from US Evidence." Agricultural Policy Review (1). Retrieved from: http://lib.dr.iastate.edu/agpolicyreview/vol2016/iss1/3.
[14] Joly, P. B., Colinet, L., Gaunand, A., Lemarı̆e, S., & Matt, M. (2016) Agricultural research impact assessment: issues, methods and challenges. [Research Report] auto-saisine. 51: pp. 8. Retrieved from: https://hal-sde.archives-ouvertes.fr/hal-01431457/document
[15] Ibid.

take into account the effects on 1) market linkage, (2) human and social capital, (3) institutional change or (4) innovation capacity.[16]

Traditionally, Agency 229 has communicated its impacts through narratives. These narratives include measures such as a number of people that attended, short-term measures of intended behavior change, and often spotlights on a person who received a personal impact. This has been the default approach to communicate for most Cooperative Extension and the Research Stations nationally. A movement across Cooperative Extension has shifted towards the use of *impact statements* or *public value statements*. Impact statements are concise but meaningful overviews of program results that communicate the difference that Extension educators make in people's lives as a result of educational programs. Public value statements are concise, meaningful overviews that convey how Extensions' programs induce participants to act in ways that benefit others in the community, which is the public value. Particularly if they illustrate Extension agent follow-up post-program and highlight broader behavioral change amongst program participants, impact statements, and public value statements can be effective tools to illustrate impact.

Combined with higher education economic impact measures and a logic model framework to encourage analytical rigor, Agency 229 could provide a more holistic vision of its impact. The Association of Public and Land-Grant Universities (APLU), for instance, has created a model with measures that illustrate impacts of higher education due to relationships with industry, talent and workforce development, knowledge incubation, and acceleration programming, and community economic development activities.[17]

[16] Maru, Y., Sparrow, A., Stirzaker, R., & Davies, J. (2016). "Integrated agricultural research for development (IAR4D) from a theory of change perspective." Agricultural Systems. Retrieved from: http://www.sciencedirect.com/science/article/pii/S0308521X16305443

[17] Association of Public and Land-Grant Universities (2017) Economic Development & Community Engagement. Retrieved from: http://www.aplu.org/projects-and-initiatives/economic-development-and-community-engagement/

METHODOLOGY

To assess the economic impact of Agency 229 on the Commonwealth of Virginia, we took a holistic approach combining both qualitative and quantitative data. When assessing the economic impact of a particular event or entity on a population, it becomes important to measure the counterfactual, that is, what would have happened without that event or entity. Because the work of 229 has impacted nearly every facet of Virginia's economy over the last 100+ years, and because every state has a cooperative extension system, it becomes impossible to accurately measure the state of Virginia's economy if the Hatch Act were never signed, and 229 did not exist. Questions like "would the agricultural industry exist without 229? Would our institutions in rural and urban areas be as strong without 229? Would the population of rural areas be as high without 229?" cannot be answered. For this reason, we approached the assessment of the economic impact of Agency 229 by collecting the first four elements of the logic model (inputs, activities, outputs, and outcomes) and tracing those elements to impacts on the five industries and four communities.

By looking at the influence of 229 extension and research innovations on individual sectors of the economy, and on specific communities, we can uncover many of the causal mechanisms through which 229 activities affect change and in turn facilitate economic growth and development. Note that quantitative data on the majority of these causal mechanisms is difficult to collect and in some cases impossible at this time given the current activities and research reporting frameworks in place.

In consultation with Agency 229 leadership, OED selected five industries to study based on both economic importance to Virginia and depth of research and extension activities at 229. They are:

1. Cattle (beef and dairy)
2. Vertically integrated meat production (poultry and swine)
3. Timber/Forestry/Wood products
4. Food and Beverage Manufacturing
5. Row crops (corn, soy, wheat, sorghum, tobacco)

Four communities representing each of VCE's four districts were also chosen. VCE central administration selected three communities per district. From that list of 12, OED selected four communities based on diversity of programming, industry, and demographics.

After deciding on the five industries and four communities potentially impacted by Agency 229, we then collected information about the activities taking place with associated inputs, outputs, and outcomes (Table 2).

Table 2: Sources of information and corresponding logic model area for Agency 229 Impacts

Data Source	Input	Activity	Output	Outcome	Impact
Faculty allocation reports	✓				
Faculty research areas	✓				
Impact summaries		✓			✓
OSP database		✓			
VTIP database		✓		✓	✓
Interviews with VCE agents		✓	✓	✓	
Interviews with VCE specialists from program teams				✓	✓
Interviews with VAES researchers		✓	✓	✓	
Interviews/surveys of local stakeholders				✓	✓

Interviews with industry		✓		✓	✓

Regarding research activities, VAES engages in local, state, federal, and corporate-sponsored research. This can range from a four-figure short-term field trial for an agrochemical company at a single AREC to a multi-year, multi-million dollar federally-sponsored programming effort that affects the entire commonwealth. No single repository or database is containing all VAES research efforts. However, there are several databases, that, when analyzed, provide information about the breadth and depth of VAES research (Table 2). First, the Virginia Tech Office of Sponsored Programs (OSP) administers federal grants, some corporate sponsored research, and has a record of transfers between the Foundation and VAES. This database is useful when looking at the amount of out-of-state investment into Virginia-based research as well as the types of research that is federally funded. Virginia Tech Intellectual Properties (VTIP), has several databases of information that contain patents and licenses of VAES researchers that provide a good metric for innovation happening within the three colleges, as well as the royalties received from patent licenses.

For VCE, much of the information about extension activities taking place at the local level is contained within individual faculty annual reviews which are difficult to analyze because of confidentiality concerns. Some activity information is contained within the OSP database (for example, large-scale federally-funded initiatives such as AgrAbility, funded by USDA). Agents and specialists also produce "impact statements" annually which highlight several initiatives that agents and specialists believe are important for the community and economic health.

These three databases (OSP, impact summaries, and VTIP) all contain different types of information about the activities, outputs, outcomes, and sometimes impacts of 229 research and extension programming. To analyze this information, each of the 5,000 unique projects contained in these databases was tagged by industry and location of impact.

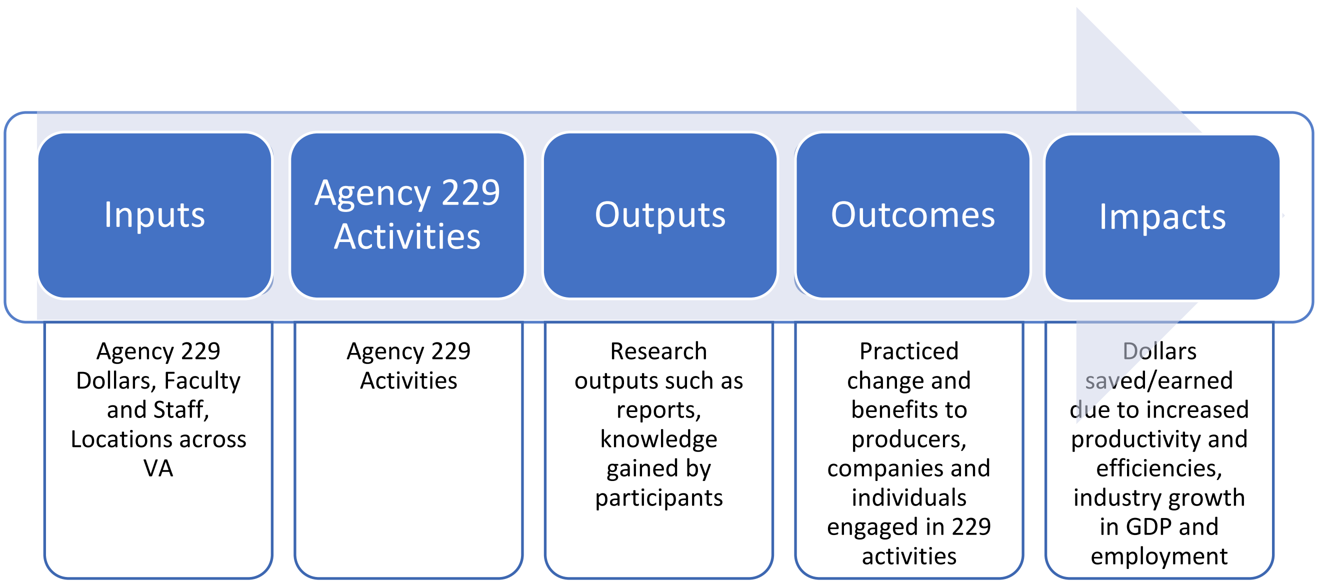
Table 3: Number of 229- related Projects by Data Source

Data Source	**Number of Unique Records (2013-2017)**
Impact Statements	3455
Sponsored Research (OSP)	1163
Virginia Tech Intellectual Properties – Licenses	1112
Total	4742

The next source of information was interviews with 229 research and extension faculty, as well as key industry representatives from each industry. We conducted ten interviews with external stakeholders from our industry and commodity agriculture groups, each representing one of the five target industries, and 25 interviews with 229 faculties at the senior administrative and program level for each of the five industries. For the community case study component, we conducted four group interviews with each of the four extension offices and received 67 detailed survey responses from stakeholders who have interacted with extension in each of the four communities. The following industry impact summaries and community case studies are therefore representatives of feedback from approximately 125 individuals, and data from 4742 project records.

INDUSTRY IMPACTS OF AGENCY 229

This section explores how Agency 229 research, technical assistance, and other activities affect five key industry groups: Cattle (beef and dairy), Vertically integrated meat production (poultry and swine), Timber/Forestry/Wood products, Food and Beverage Manufacturing, Row crops (corn, soy, wheat, sorghum, tobacco). We begin with a description of the industry in Virginia—its sales, exports, growth trends, national rankings, and employment in the Commonwealth of Virginia. Within that broader context, we describe the activities of Agency 229 that contribute to each industry, the impacts of those activities on the industry group, and the ways that Agency 229 may enhance those activities in the future. The logic of this structure is in line with the logic model framework.



Cattle (beef and dairy)

Virginia farmers received $3.4 billion dollars from sales (cash receipts) in 2015, more than two-thirds of which are from the sale of livestock and livestock products, including beef, poultry, eggs, dairy and pork.[18] Among livestock producers, beef and dairy cattle operations have provided around 40 percent of livestock sales since 2008 (Figure 2). Dairy farmers' shares of cash receipts (the cash farmers received from the sale of a crop) has fallen since 2008, partly due to the growth of cash receipts with beef operations (Figure 3). Since 2008, cash receipts for beef producers have increased 54 percent from $398 million to $614 million, with a 9 percent average annual increase (Figure 3). Alternatively, dairy producers' cash receipts fell 17 percent, from $374 to $311 million, in 2015 and had an annual decline of less than 1 percent (Figure 3).

Figure 2: 2008 and 2015 Cash Receipts from All Livestock Production and Shares from Beef, Dairy, and other Animal Product (in real 2009 dollars) [19]

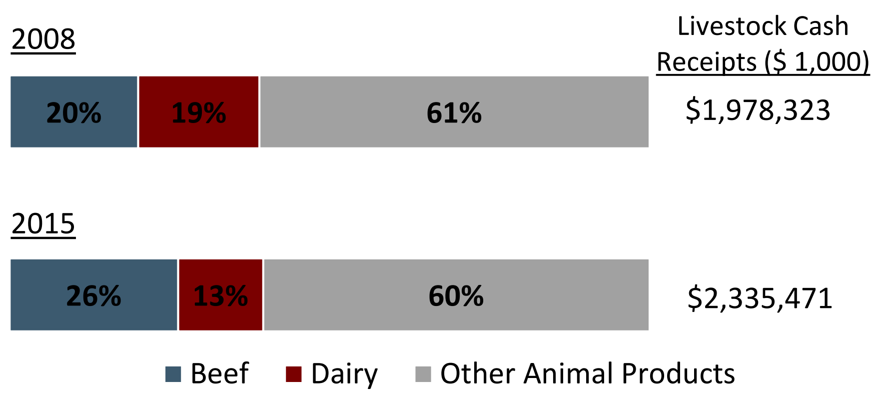
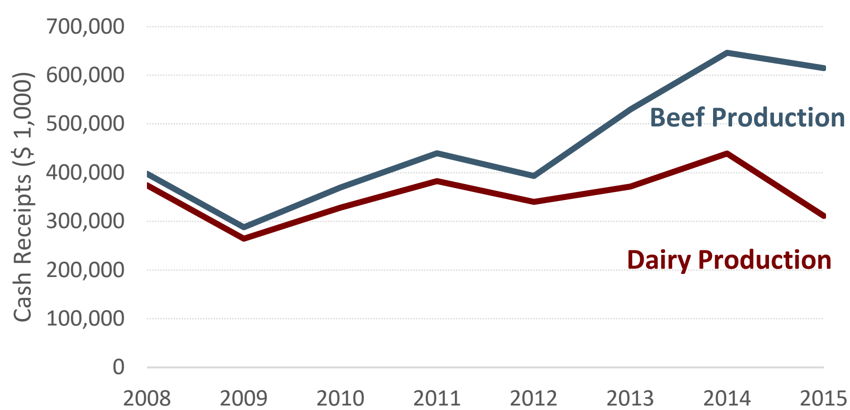


Figure 3 Total Cash Receipts for Beef and Dairy Operations from 2008 – 2015 (in real 2009 dollars)



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[18] Source: United States Department of Agriculture – Economic Research Service (USDA-ERS; 2017). USDA/ERS Farm Income and Wealth Statistics. Retrieved from data.ers.usda.gov (cash receipts by commodity).

[19] Source USDA-ERS (2017). USDA/ERS Farm Income and Wealth Statistics. Retrieved from data.ers.usda.gov (cash receipts by commodity).

In addition to sales directly from dairy and beef operations, these dairy and beef producers bolster the production of crops used in livestock feed. Feed crops include barley, corn, hay, and oats, and sales of these crops brought Virginia farmers $252.5 million in cash receipts in 2015.[20] Corn and hay are the most commonly grown feed crops and were harvested on more than 1.68 million acres of farmland in 2016.[21] Furthermore, in 2012, there were 3,290 operations with sales in corn. In addition to these feed suppliers, dairy and beef producers provide inputs for countless other food manufacturing and processing businesses, including other dairy products (cheese, yogurt, and ice cream), restaurants, frozen food processing, etc.

Both dairy and beef production are important export commodities for the state and rank in the top ten in terms of export value (Table 3). Beef production ranks 6th in export value, with $54.5 million in 2015 (Table 3). Since 2005, beef exports grew by roughly 20 percent annually and 377 percent cumulatively (Figure 4). Dairy exports experienced similar increases in exports; from 2005-2015 the export value of the dairy products increased from $17.9 million to $50.2 million (180 percent; Figure 4). Feed grain ranked 7th in export value in 2015 and grew by 188 percent in export value from 2005-2015. In Table 3, other livestock products exports are relevant for the beef industry as it includes live animals. Virginia beef production is characterized as calf-cow operations, with most calves exported as feeder cattle to other regions (mostly the Midwest) to be fed to appropriate weight for processing.[22]

Indicators of Economic Strength

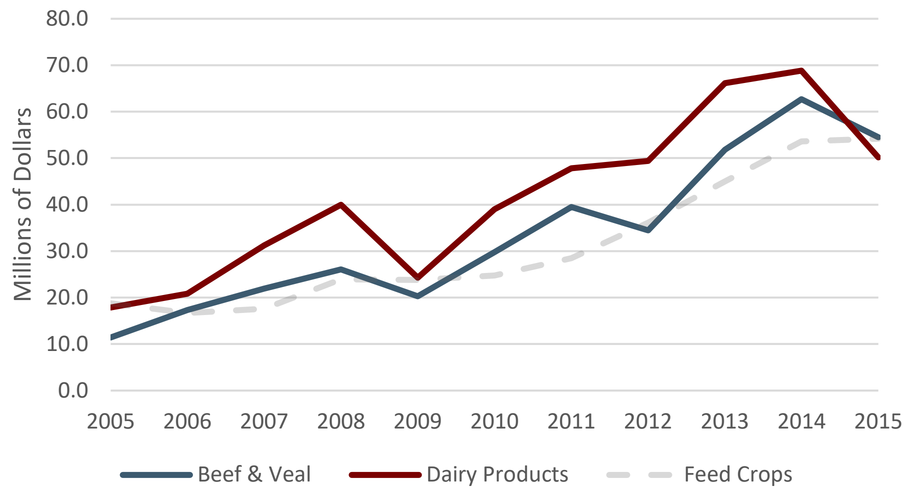
- Both beef and dairy rank in the Top 10 of agricultural exports
- Beef exports have grown by 377% over the last 10 years
- Dairy exports increased by 180% from 2005-2015

Table 4: 2015 Top Ten Export Commodities (in millions of dollars)[23]

Commodity	Export Value ($ millions)	Rank
Other Plant Products	$184.5	1
Soybeans	$110.1	2
Other Livestock Products	$93.2	3
Broiler Meat	$82.7	4
Tobacco	$79.0	5
Beef & Veal	$54.5	6
Feed & Other Feed Grains	$54.2	7
Cotton	$51.9	8
Dairy Products	$50.2	9
Other Poultry Products	$49.5	10

[20] Note: Unable to distinguish between feed for livestock operations, and includes feed used in poultry, hog, and other livestock production. Source USDA-ERS (2017). USDA/ERS Farm Income and Wealth Statistics. Retrieved from data.ers.usda.gov (cash receipts by commodity).
[21] Source: USDA, National Agricultural Statistics Service (NASS; 2017). Quick States Database. Retrieved from https://quickstats.nass.usda.gov/
[22] Source: Virginia Cooperative Extension (VCE; 2017). Beef Cattle Webpage. Website: https://ext.vt.edu/agriculture/beef-cattle.html
[23] USDA-ERS (2017). USDA/ERS State Export Data. Retrieved from ww.ers.usda.gov/data=products/state-export-data/ (U.S. Agricultural Exports, Commodity detail by State [New series]: Calendar years 2000-2015)

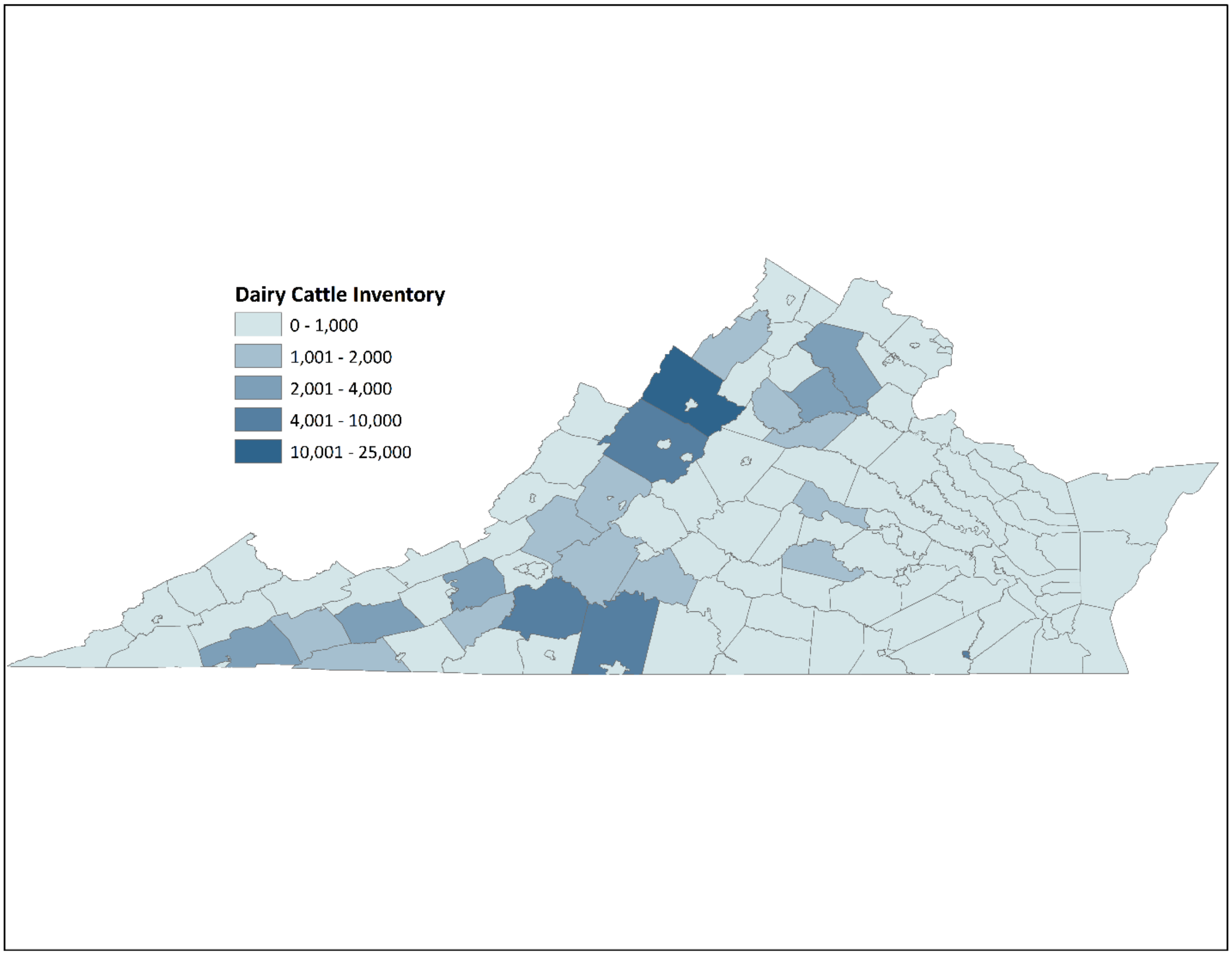
Figure 4: Export Value of Beef & Veal, Dairy Products, and Feed Crops from 2005 -2015[24]



Dairy production is found across all regions of Virginia, with particular concentrations in the Shanendoah Valley, Central and Southerwestern Virginia (Figure 5). Rockingham, Franklin, Augusta, and Pittsylvania, counties all had over 5,000 dairy cattle in inventory in 2012 and together had 55 percent of the dairy cattle in Virginia. Rockingham County had more than 25,000 dairy cattle in 2012.[25] Dairy cattle were kept on 1,168 dairy operations throughout the state. About 72 percent of dairy operations had fewer than 100 cows in their herd in 2010, and only 18 operations had larger than 500 dairy cattle in their inventory. A 2017 economic impact analysis by the Weldon Cooper Center of University of Virginia, found that in 2015, the dairy industry employed more than 16,000 individuals throughout the state and had an economic impact of $4.28 billion in 2015.[26]

[24] USDA-ERS (2017). USDA/ERS State Export Data. Retrieved from ww.ers.usda.gov/data=products/state-export-data/ (U.S. Agricultural Exports, Commodity detail by State [New series]: Calendar years 2000-2015)
[25] Source: USDA -NASS (2017). 2012 Virginia Agriculture Census. Retrieved from https://quickstats.nass.usda.gov/
[26] Rephann, T.J. (2017). The Economic Impact of Agriculture and Forest Industries in Virginia. Charlottesville, VA: Weldon Cooper Center for Public Service, University of Virginia

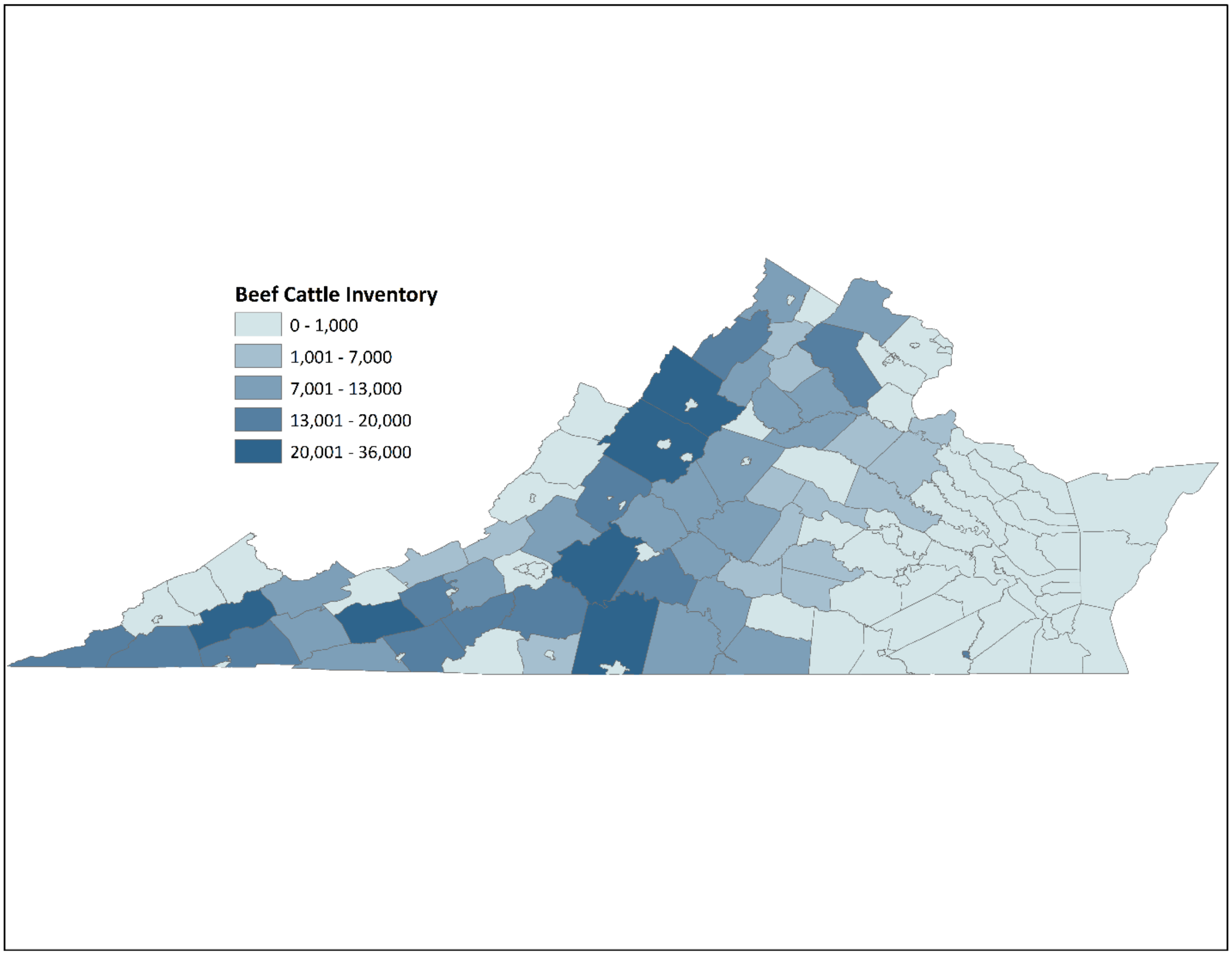
Figure 5: 2012 Dairy County Inventory by County



In terms of agriculture industries, beef operations are the biggest employers in Virginia, with a total employment of 37,450 individuals in 2015.[27] Geographically, beef cattle is found throughout the state (Figure 6) and in the 2012, there were 591,840 beef cattle in Virginia. Counties with more than 19,000 in beef cattle inventory include: Augusta, Bedford, Pittsylvania, Rockingham, Russell, Washington, and Wythe. Of the 19,596 beef operations in 2012, 93 percent had a beef herd of fewer than 100 cattle, and 41 operations had more than 500 cattle. In total, the economic impact of Virginia's beef industry was estimated at $6.1 billion in 2015.[28]

[27] Rephann, T.J. (2017). The Economic Impact of Agriculture and Forest Industries in Virginia. Charlottesville, VA: Weldon Cooper Center for Public Service, University of Virginia
[28] Ibid

Figure 6: 2012 Beef Inventory by County



Agency 229's Beef and Dairy Activities

Since beef and dairy related products are among the top agricultural commodity exports in Virginia, Agency 229 has extensive research and extension programming focused on both industries. This is partly illustrated by the reach of extension programing, which covers 60 counties throughout the Commonwealth. In addition, cattle-related research took place in the departments of Dairy Science, Animal and Poultry Sciences, Crop & Environmental Science, Biological Systems Engineering and Plant Pathology, Physiology, and Weed Science and in the College of Veterinary Medicine.

Funding for cattle-related programming included private companies, the Virginia Agricultural Council, United States Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA), the Virginia Small Grains Board, and the Virginia Tech Foundation. Research, funded both privately and federally, included studies on enhancing disease resistance, improving feed efficiency in dairy cattle, the genomic evaluation of beef cattle, and the epigenetic impacts of calf nutrition on mammary development. The success of 229's cattle programming is, in part, a result of the roughly $6 million leveraged funds from outside of the Virginia's state government (both private and federal funds).

Agency 229's beef and dairy programming mentioned above encompass all components of the beef and dairy value chain, including animal health, quality control, breeding, and food safety. In terms of facilities, many VCE agents and staff work out of the Shenandoah Valley AREC, which specializes in livestock production research. VAES recently opened a dairy facility at Kentland Farms near Blacksburg. Moreover, Virginia Tech provides several postsecondary education opportunities focused on dairy and beef cattle in the department of Animal and Poultry Science, Dairy Science and at Virginia-Maryland College of Veterinary Medicine; all of which benefit from 229 experiential learning and research opportunities.

<u>Beef and Dairy Activities (2012-2016)</u>

- $6 million in leveraged private and federal funding to conduct cattle-related research
- VCE dairy programs cover dairy financial management, forage quality and management, forage testing, mastitis, and replacements.
- VCE beef cattle programs include Retained Ownership, Premium Assured Heifer, Virginia Beef Quality Assurance (BQA), Virginia Beef Cattle Improvement Association, Virginia Master Cattleman, and the Virginia Quality Assured Feeder Cattle programs (VQA).

While much of the research conducted through VAES and Virginia Tech faculty have few immediate impacts, except for the impact of private and federal dollars spent in the state, these research activities have inevitable impacts on the educational and managerial programs overseen by Cooperation Extension. Findings from this research will ultimately result in new knowledge learned from these programs concerning nutritional advice, approaches to genetic improvements, and ways of promoting disease-resistance in dairy and feeder cattle, some of which may result in industry dollars saved on production costs and added revenue through increased product quality. In the meantime, much of the basic research conducted in the past by Agricultural Experiment Stations in Virginia and elsewhere have been translated into the many VCE activities described below, resulting in significant impacts on both the dairy and beef cattle industries.

Dairy Cattle

Dairy production happens throughout the Commonwealth and in 2015 totaled $4.28 billion.[29] VCE outreach has been imperative for dairy producers who have faced changing market dynamics recently, including a decline in the domestic consumption for fluid milk. VCE dairy extension programs cover an array of areas related to the dairy industry including dairy financial management, forage quality and management, forage testing, mastitis, and replacements. Through interviews, dairy producers highlighted the importance of the information that extension provides through on-site meetings, workshops, and other educational programs hosted by VCE.

One significant example of Cooperative Extension programming for the dairy cattle industry is VCE's focus on mastitis. An infection of the udder tissue, mastitis is one of the largest concerns for dairy producers. To combat the disease, farmers have to develop a holistic management strategy including proper sterilization of milking equipment, proper forage and feed, and maintain clean bedding for the herd. Strategies differ for each farmer, since each herds has a unique bacteria profile, and one of the services provided by Agency 229 in the sampling of a herd's bacteria at the Virginia Tech Mastitis and

[29] Rephann, T.J. (2017). The Economic Impact of Agriculture and Forest Industries in Virginia. Charlottesville, VA: Weldon Cooper Center for Public Service, University of Virginia

Immunology Laboratory. [30] After VCE faculty analyzes a farmer's herd sample, a mastitis control program can be developed and customized for each farm.

Several internal and external stakeholders cited the Agency's Mastitis Control, Management, and Information Program as particularly important to Virginia dairy farmers. The associated costs from clinical mastitis include milk production losses, product quality, veterinary services (including diagnostics and drugs), added labor and materials, vulnerability to other diseases, and possible culling. A 2007 review of peer-reviewed journal articles estimating the economic effects of bovine mastitis and mastitis management showed that, in the U.S. (specifically the states of California, Michigan and Ohio); the costs of clinical mastitis were $28-$40 per cow. Compared to prevention costs that were approximately $5 per cow.[31]

Beef Cattle

Beef operations are some of the largest employers in the agricultural industry in Virginia, therefore VCE has engaged in various activities to support Virginia's cattlemen.[32] Similar to dairy, VCE disseminates information through on-site visits and offers several educational programs. VCE agents also offer courses using applied education materials that distill the most recent research conducted by Virginia Tech faculty and others. Programs related to the beef industry include the Retained Ownership, Premium Assured Heifer, Virginia Beef Quality Assurance (BQA), Virginia Beef Cattle Improvement Association, Virginia Master Cattleman, and the Virginia Quality Assured Feeder Cattle programs (VQA).

The Premium Assured Heifer, BQA, Virginia Master Cattleman Programs, are similar management education programs and provide information on forage, reproduction, genetics, herd health, and other information to improve participants' production practices. The Virginia Beef Cattle Improvement Association, for instance, works with extension to improve the genetics of Virginia's cattle herd. Members of the association work closely with producers and beef industry representatives to understand better the challenges faced in the production including the quality of beef cattle. Another management program, the Retained Ownership Program, allows farmers with calf-feeder operations to assess the probability of finishing their cattle (i.e. growing them in Virginia until they are ready for processing), learn about the national cattle industry, and cosign their cattle to a cooperative in southwest Iowa where the cattle are finished. Once the cosigned cattle are marketed, Virginia producers receive information on estimated feed conversion, cost of gain analysis, and other probability indicators for farmers to better understand the beef market.

Virginia BQA is one, if not, the most widely known and effective program that VCE conducts in the beef industry. The program has been operating since 1987, providing management education and support for cattlemen as well as guaranteeing that producers within the program meet production standards. BQA ensures farmers in the program have adequately fed their herd, adopted proper disease prevention techniques, and trained other workers on the handling of cattle, among other standards. BQA then allows farmers to enter the Virginia Quality Assured Feeder Cattle programs, which provides further assistance to producers through marketing from the Virginia Cattlemen's Association and added technical assistance from VCE agents and faculty. Farmers receive resources and education on vaccine

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[30] Source: Virginia Tech (2017). The Dairy Extension Program; Mastitis. Retrieved from https://www.vtdairy.dasc.vt.edu/ms-program/mastitis.html.

[31] Halasa, T. et al. (2007). "Economic effects of bovine mastitis and mastitis management: A review." Veterinary Quarterly 29(1): 18-31. Retrieved from: http://www.tandfonline.com/doi/pdf/10.1080/01652176.2007.9695224?needAccess=true.

[32] Rephann, T.J. (2017). The Economic Impact of Agriculture and Forest Industries in Virginia. Charlottesville, VA: Weldon Cooper Center for Public Service, University of Virginia

and drug practices, record keeping, market information, livestock feed, transportation of cattle, cattle care, and more. Producers also have access to the Beef Industry Council, BQA-certified veterinarians and extension agents.

These services provided jointly by BQA and VQA, increase the efficiency and quality of producers' operations. VQA certified cattle signal to buyers the quality of the product, and farmers receive a premium compared to cattle outside the program. In 2015, on average, cattle in VQA received $82 premium per a head. In 2015, there were 18,394 feeder cattle (over a 12 month period) under BQA certification, which on average, would have brought Virginia cattle producers in the program more than $1.5 million compared to producers not BQA certified. As mentioned, Virginia feeder-cattle are mostly purchased by out-of-state processors, and thus sales represent new money for Virginia's economy. Importantly, the economic impact has plenty of room to grow as the BQA feeder cattle were only 5 percent of the estimated 350,000 calves at the beginning of 2015. In addition, as the demand to higher quality products increases, VQA cattle premiums will increase.

There is some crossover of these cattle education and management programs, but more importantly, these programs create a network for students, faculty, industry representatives, and producers that collaboratively improve the beef industry. For instance, the Virginia Cattlemen Association has a Virginia Tech student as an intern every year, it supports the Virginia Tech Beef Leadership Council (student organization), and receives support from VCE to coordinate the VQA program. This type of partnership highlights some of the intangible benefits inherent in extension activities; industry relationship with faculty and extension agents, applied education and experience for students, and dissemination of research through these described channels. Additionally, many of these partnerships bring substantial economic benefits to the Commonwealth.

Beef and Dairy Impacts (2012-2016)

- Industry knowledge gains, and thus industry dollars saved on production costs and added revenue through increased product quality.
- The Mastitis Control, Management, and Information Program can save producers $23-$35 per cow annually.
- VQA participants received premium prices on their quality feeder in 2015, they received an average of $82 per head. With over 18 thousand cattle in the program that year, VQA producers received $1.5 million more than non-VQA participants.

Enhancing Impacts

The success of BQA and VQA programs illustrate a coordinated effort between multiple stakeholders across private and public institutions that is largely facilitated by Agency 229 faculty and staff. The success of these programs could serve as a lesson for the engagement and outreach for future VCE programming. A single, albeit complex goal, of raising the quality of cattle have clear economic impacts on Virginia producers (current estimates suggest cattle in the BQA and VQA program receive between $90 -100 per a head). Such programming may not be applicable across the agriculture sector, but the BQA and VQA provide a framework to achieve economic growth in agriculture, and provide a model that could be scaled up in the Commonwealth.

Additionally, all the stakeholders interviewed for this report recommended the expansion of the BQA and VQA programs. Industry representatives, producers, Agency 229 research faculty, and extension agents mentioned that current supply for VQA cattle does not meet current demand. Participation has risen slightly over the last couple of years, and since 2012 there has been an 8 percent growth in the calves under BQA. VCE could expand resources for BQA; however, this is only part of the activities needed to increase the program. Midwest buyers of VQA cattle generally only buy large amounts of cattle at any given time. This requires close collaboration of cattle producers, which is particularly difficult in extremely remote areas such as many parts of Southern and Southwestern Virginia. Agency 229 will need to boost demand for the program and facilitate the cooperation of cattle producers for this effort to succeed.

Stakeholders interviewed for this study lauded Agency 229's mastitis programming, especially how the programming has aided dairy producers with reducing costs of operations. This programming has a large reach and supports many individual diary producers. However, stakeholders stressed the need for dairy programming to go beyond helping diary producers manage current costs. This includes investing in technology to boost productivity and helping farmers stay competitive in the national and global markets. In addition, investment in value-added technologies and resources as necessary investment to help producers take advantage of changing domestic consumption in fluid milk. Stakeholders mentioned several peer land grant universities (i.e. Wisconsin) as examples of the types of investments Agency 229 can make to bolster the dairy industry.

Vertically integrated meat production (VIMP)

Virginia's pork and poultry industries are a large contributor to the livestock sector, which is the largest sector in the Commonwealth's agriculture economy. These industries are increasingly characterized as vertically integrated, meaning large meat processors own the feed, animals, and meat processing facilities, and farmers produce under contracts with the meat processors. Integration has led to lower costs in production, causing lower prices for consumers, and has partly reduced risks for poultry and hog farmers who produce chickens under contracts with large meat processing companies.

Table 5: The Total Number of Operations and Number under Contract for the Virginia Poultry and Hog Industry in 2012[33]

	Number of Operations		Percent Under
	Total	Contract	Contract
Broiler	966	481	50%
Layers	5,656	96	2%
Turkey	663	221	33%
Hogs	919	28	3%

Vertically Integrated Meat Production (VIMP) is led by large international meat brands located in Virginia, including Purdue, Tyson, and Smithfield. In addition, eight poultry processing companies are located in Virginia: Cargill, George's Foods, Tyson Foods, VPGS, LLC, Pilgrim's Pride, Purdue Farms, New Market Poultry, and Shenandoah Valley Organics. The poultry industry has steadily adopted VIMP as a model of production, and recently has experienced substantial increases in output and economic value as demand for poultry has increased (Table 4).

In 2012, approximately 7,126 operations either had chickens (broilers, layers) and/or turkeys. Broiler (chicken meat) operations tended to have large production operations, with 58 percent of broiler

[33] Source: USDA –NASS (2017). 2012 Virginia Agriculture Census. Retrieved from https://quickstats.nass.usda.gov/

operations selling more than 100,000 birds in 2012.[34] Alternatively, less than 0.1 percent of egg producers had more than 100,000 layers in inventory while 87 percent of the 5,656 egg operations had fewer than 49 layers in inventory.[35] In 2012, there were 663 turkey operations in Virginia. Out of the 429 operations with sales, 14 percent sold more than 100,000 turkeys.[36] Hog operations in Virginia tended to have a smaller inventory and sales, with 81 percent of the 1,265 hog farms having fewer than 24 hogs in inventory in December 2012.[37] Furthermore, there were only 24 operations with more than 5,000 hogs sold in Virginia in 2012.[38]

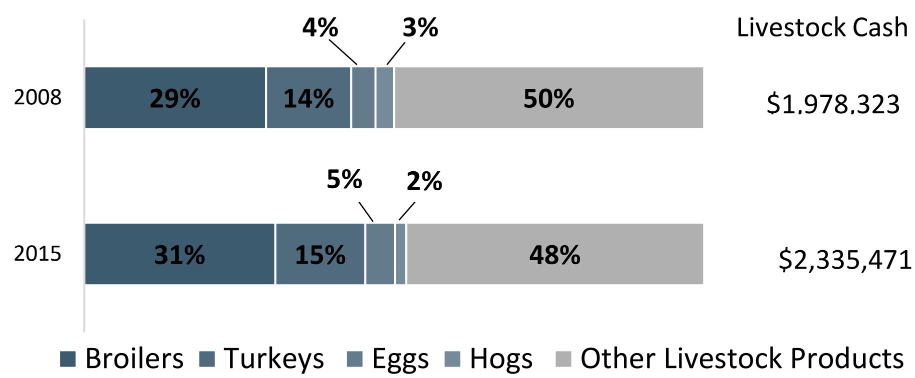
In 2015, the pork and poultry industry comprised 36 percent ($1.2 billion) of the $3.4 billion that Virginia farmers received (cash receipts) from the sale of agricultural products. In terms of livestock production, the poultry and pork industries represent 52.1 percent of the $2.33 billion cash receipts for livestock products (Figure 7). Since 2008, both industries represented, on average, 33 percent of annual farm cash receipts, largely due to the size and success of Virginia's poultry industry.

<u>Annual Poultry and Pork Sales (2015)</u>

- Broiler sales were $719 million
- Turkey sales were $339 million
- Hogs sales were $43 million
- The poultry industry grew by 26% from 2008-2015

The poultry industry includes the production of broilers (chicken meat), chicken eggs, farm chickens, and turkeys. Table 4 outlines the cash receipts and changes in cash receipts from the poultry industry. Broilers are the largest product of the industry, followed by turkeys, chicken eggs, and farm chickens. The poultry industry grew by 26 percent from 2008-2015, with an annual average increase of 3.8 percent (Figure 7). Though hog producers received more than $43 million in cash receipts in 2015, this was a 26.3 percent decrease from 2008. Furthermore, from 2008 – 2015 hog farmers had an annual average reduction in cash receipts of 3.4 percent (Table 5).

Figure 7: 2008 and 2015 Livestock Cash Receipts and Share of Poultry and Pork[39]



[34] Source: USDA – National Agricultural Statistics Service (NASS; 2017). 2012 Virginia Agriculture Census. Retrieved from https://quickstats.nass.usda.gov/
[35] *Ibid*
[36] *Ibid*
[37] *Ibid*
[38] *Ibid*
[39] Source: United States Department of Agriculture – Economic Research Service (USDA-ERS; 2017). USDA/ERS Farm and Income and Wealth Statics. Retrieved from data.ers.usda.gov (Cash Receipts by Commodity)

Table 6: Total Amount (in $1,000) and Cumulative and Average Annual Change in Cash Receipts for the Poultry and Hog Industry[40]

	Cash Receipts (in $ 1,000) 2008	2015	Cumulative Change (2008-2015)	Ave. Annual Percent Change
Total Poultry Industry	$931,676	$1,173,133	25.9%	3.8%
Broilers	$580,227	$719,802	24.1%	3.8%
Turkeys	$272,273	$339,665	24.8%	4.7%
Chicken Eggs	$77,711	$111,325	43.3%	5.7%
Farm Chickens	$1,464	$2,342	60.0%	7.4%
Hogs	$58,372	$43,048	-26.3%	-3.4%

Vertical integration has allowed companies like Perdue and Smithfield to increase their employment, thus becoming large regional employers. In 2015, livestock processing plants employed more than 13,300 individuals, which makes Virginia the 16th ranked state in terms of livestock industry employment.[41] Moreover, the counties where these facilities reside have the highest concentration of employment in livestock processing. Rockingham County where Cargill, Perdue, and Tyson have processing facilities had 2,975 employees in poultry (chicken and turkey) processing in 2015.[42] Hanover County, where Tyson has a processing facility, had 750 employees in poultry (chicken) processing in 2015.[43] Isle of Wight County, where Smithfield Foods' headquarters is located, had 3,750 in employees in swine processing in 2015.[44] These three counties account for about 58 percent of the jobs in livestock processing in Virginia. A majority of the growers under contracts also reside in the surrounding counties. For example, Rockingham, Page, Augusta and Shenandoah counties accounted for roughly 69 percent of broiler production in 2012, and are located near the Cargill, Perdue, and Tyson facilities who rely on contract growers.

Both the poultry and hog industry are important export commodities for Virginia. In 2014, broilers were ranked the most valuable export commodity, with turkeys, eggs, and hogs, ranked at 4th, 11th, and 14th respectively.[45] On a national scale, Virginia ranked 12th and 13th in the United States in terms of the export value of broiler and other poultry products (eggs and turkeys) in 2015. The state exported more than $82 million in broilers and $49.5 million in other poultry products in 2015, which was 43 percent and 20 percent growth in the export value since 2005 respectively (Figure 8). Meanwhile, Virginia's pork

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[40] *Ibid*

[41] Source: Harvard Business School, Institute for Strategy Competitiveness (2014). US Cluster Mapping. Retrieved from http://www.clustermapping.us/region/state/virginia/cluster-portfolio. Note: this figure includes beef processing plant, as well as poultry and hog processors.

[42] *Ibid*

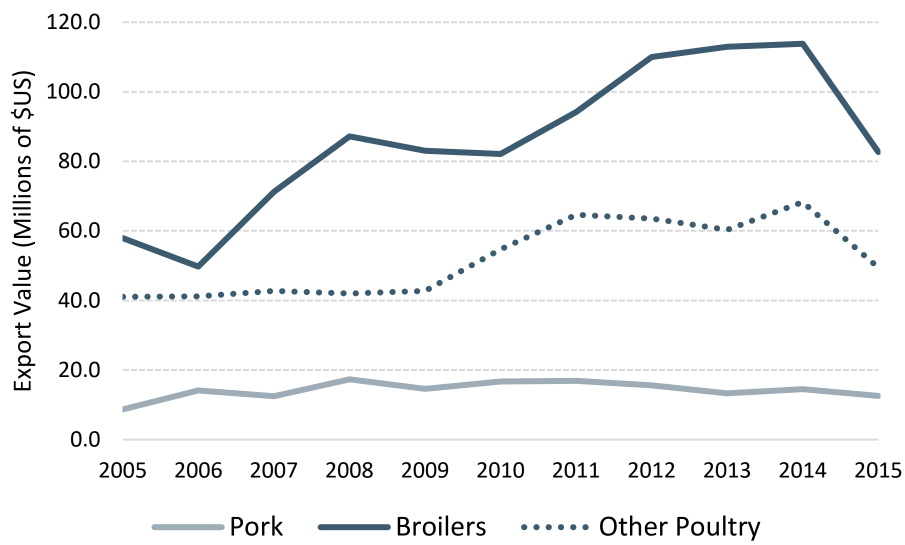
[43] *Ibid*

[44] *Ibid*

[45] Virginia Department of Agriculture and Consumer Services (2017). Virginia's Top 20 Farm Commodities. Accessed on http://www.vdacs.virginia.gov/agriculture-top20.shtml.

industry exported $12.5 million of pork in 2015, representing a 44 percent increase in export value since 2005.

Figure 8 Export Value of Broilers, Other Poultry Products, and Pork from 2005 – 2015[46]



The total economic contribution of Virginia's poultry industry is not captured in the above figures. Along with job creation in chicken, turkey, and egg processing and manufacturing and on farm employment, the poultry industry contributes to supply chain jobs, including feed production and manufacturing, poultry research and education, wholesale jobs, and more. The Weldon Cooper Center conducted an impact analysis on the entire agriculture industry, which included the economic impact of the poultry industry. The Weldon Cooper Center study mirrored a study produced by the chicken and egg industry and estimated that poultry production provided around 31,490 jobs, with an economic impact of $9.1 billion (75 percent from output and 25 percent from value-added) in 2015.[47] A similar report funded by the chicken and egg industry estimated that the chicken industry provided an economic impact to Virginia of over $10.2 billion in 2016.[48] The study found that in addition to jobs in direct chicken production and processing in 2016, the industry provided an additional 25,377 jobs in indirect businesses (i.e. input suppliers). In total, these jobs paid out more than $2 billion in wages and the average wage supported by chicken production was $54,186 in 2016.

Part of the economic impact of both the pork and poultry industry is supports farmers of feed crops. In 2015, poultry and pork feed crop (corn and soybean) farmers received more than in $328.9 million cash receipts.[49] Moreover, the crops were planted on more than 1 million acres of Virginia farmland.[50]

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[46] Source: United States Department of Agriculture – Economic Research Service (USDA-ERS; 2017). USDA/ERS Farm and Income and Wealth Statics. Retrieved from data.ers.usda.gov (Cash Receipts by Commodity)
[47] Source: Rephann, T.J. (2017). The Economic Impact of Agriculture and Forest Industries in Virginia. Charlottesville, VA: Weldon Cooper Center for Public Service, University of Virginia
[48] Source: John Dunham & Associates (2016). 2016 Economic Impact Study of the Poultry Industry. Retrieved from http://www.chickenfeedsamerica.org/
[49] Source: USDA - ERS (2017). USDA/ERS Farm and Income and Wealth Statics. Retrieved from data.ers.usda.gov (Cash Receipts by Commodity). Note: Not all of corn and soybean production went to pork and poultry feed.
[50] Source: USDA –NASS (2017). Quick Stats database. Retrieved from https://quickstats.nass.usda.gov/

Though Virginia produces a large volume of grain for feed, the state is a net importer of grain.[51] On the state level, the Virginia livestock sector (the poultry industry is the largest consumer of grains in Virginia) required an estimated 1.21 million additional tons of grain for feed annually, from 2009 -2014.[52] The Shenandoah Valley, which is the most productive region of the state in terms of feed production, also houses a majority of poultry production and has a significant grain deficit. The counties of Rockingham, Augusta, Page, and Shenandoah also have grain deficits of 724, 257, 243, and 147 thousand tons, respectively.[53] Virginia's grain deficit has been declining due to an increase in grain production and increases in feed efficiency across the various livestock industries.[54]

Agency 229 VIMP Activities

Animal health and food safety are key to the success of both the poultry and hog industries in Virginia. Therefore, Agency 229 has a myriad of activities focused on the health of hogs, chickens, and turkeys on Virginia farms. Animal health research is conducted at both the departments of Animal and Poultry Sciences at Virginia Tech, and the Virginia-Maryland Regional College of Veterinary Medicine. In addition to improving animal health, Agency 229 is actively working on public health concerns; for example, preventing disease outbreaks like avian flu. Outside of the Agency's health related activities, researchers are conducting research to improve feed efficiency and livestock genetics, and extension is disseminating information to poultry and swine farmers throughout the Commonwealth.

Sponsored research projects were conducted from public and private sources, at the departments of Food Science Technology, Biological Systems Engineering, Crop & Soil Science, and Animal & Poultry Sciences. Funders for those research programs include private companies, USDA, NIFE, VDACS, the Virginia Tech Foundation Pratt Fund, The Virginia Pork Industry Association, National Science Foundation, American Egg Board, and the National Fish & Wildlife Foundation. Over the past five years, research expenditures related to VIMP have exceeded $7 million with several large research programs funded by both the federal government and private corporations.

These research activities are conducted across the Commonwealth, and include the Swine Center and five poultry houses (for both chicken and turkeys) located at Virginia Tech. Virginia Cooperative Extension (VCE) has research and extension activities in swine production at the Tidewater AREC located in Suffolk, Virginia. The swine extension office hosts a pork conference every year, providing resources for small scale and niche producers on development in markets and pork production. In addition to activities in the pork industry, VCE provides information on poultry management, food safety guidelines and

Poultry and Hog Activities (2012-2016)

- $7 million in leveraged private and federal funding to conduct VIMP-related research.
- Agency 229 research is largely concerned with animal health and disease, food safety, and environmental impacts (e.g. effluent).
- As most VIMP activities are overseen by the larger companies, VCE's niche in helping individual farmers is often through assisting in disease management/food security, litter management, and non-nutrient based poultry management information such as lighting and water.

[51] Source: Caffarelli, P., G. Ferriera, G. Groover, and K. Boys. (2016). Grain Consumption and Production in Virginia: A Trend and Spatial Examination. Retreived from

[52] *Ibid*

[53] *Ibid*

[54] *Ibid*

regulations, and manure management for both poultry and hog operations. In terms of food safety and meat processing, Virginia Tech houses the Meat Science Center, a fully equipped meat processing plant.

Because the production of poultry and swine is vertically integrated, the way that VIMP industries interact with 229 is different from the way the cattle or small ruminant industries might. First, many VIMP companies have their own research centers that innovate in terms of bird and swine production management systems. Given their national and international reach, they also rely heavily on schools outside of Virginia that have more extensive poultry or swine science programs closer to their headquarters (University of Alabama, for example). VIMP companies then use this research to set specifications and management practices in terms of nutrition standards, medication, etc. that contract growers are required to follow. For this reason, large poultry and swine growers under contract in Virginia do not rely *heavily* on extension agents for many of the production questions that cattle or small ruminant growers might.

There are, however several important ways that 229 research and extension benefits the VIMP industry. For example, in poultry 229 has activities in disease management/food security, litter management, and non-nutrient based poultry management information such as lighting and water. These three areas are the responsibility of the growers, rather than the VIMP companies themselves. For example, in the Shenandoah Valley, extension agents regularly work with contract poultry growers to develop litter management plans. This is a direct result of legislation in the late 1990s stemming from the negative effects of poultry litter runoff in the Chesapeake Bay.

Agency 229 litter management activities have contributed to state policy, which has enabled the growth of VIMP industries. Such was the case with the poultry industry when news broke that poultry litter was contaminating the Chesapeake Bay. To protect the Chesapeake Bay, there were proposals limiting the application of phosphorous on all cropland, thereby severely reducing the application of poultry litter and requiring companies to spend millions to haul away and dispose of poultry litter. This prospect would have cost growers millions in commercial fertilizers. In response, VAES faculty conducted research on how phosphorous reacts in soils, leading to a phosphorous site index. By advocating for the use of this index, rather than a blanket restriction on phosphorous application, poultry litter in Virginia has retained its value while protecting the Chesapeake Bay, which minimizes the economic impact of this regulation. States such as Maryland, which have blanket restrictions, have experienced a negative economic impact from this policy. In those states, the industry spends millions of dollars to move the litter for alternate uses. Through research and advocacy, Virginia was able to approach the legislation in a cost effective way, achieving the environmental objectives while allowing the industry to be economically viable and grow.

Now, VCE agents work with growers to spread poultry litter according to this phosphorous site index, leading to healthier crops, healthier waterways, and the continued growth of the poultry industry. While the economic impact of that legislative effort and the phosphorous site index is hard to quantify, it is reasonable to assume that the growth in the past 20 years may not have happened without it, leading to a loss of jobs and profits. Moreover, because the VIMP-related research includes litter and effluent control, this research could also significantly impact other industries dealing in biofuel and water management.

In addition to litter management extension, there are several other extension efforts geared towards poultry growers and representatives of the poultry industry responsible for training and management of those contract growers. Every year VCE holds a Poultry Health and Management Seminar, which contains a full day of programming. Topics include the management of poultry flocks, lighting in the poultry house, water quality for birds, and ventilation of poultry houses.

Activities on health management is paramount for the VIMP industry and has large economic impact on Virginia. The economic impact of a serious disease outbreak can be catastrophic. In 2002, for example, there was a major outbreak of avian influenza. $130 million was lost due to that outbreak in terms of production, and the cost to the federal government was more than $100 million paid out in indemnity to owners of poultry operations. Since 2002, the research and extension activities related to disease and outbreak management have evolved significantly. For example, now there are research and extension efforts on how to deal with carcass disposal in the case of an outbreak and biosecurity standards for VIMP management. In addition to research in the Department of Animal and Poultry sciences, the College of Veterinary Medicine is involved in the Poultry Disease Task Force. A faculty member from the College of Veterinary Medicine helped develop a GPS database of poultry farms in Virginia, so in the case of another avian influenza outbreak, we can create maps of projected outbreaks and implement biosecurity to manage those incidents. In addition to avoiding hundreds of millions in lost revenue to the poultry industry, having robust disease management and biosecurity protocols in Virginia make it an attractive investment for VIMP companies in terms of risk management.

Finally, Agency 229 facilities and programming that align with VIMP industries also provide students and farmers with education on current production practices. While funding for teaching those students does not come from Agency 229, students benefit from the experiential learning and research opportunities led by 229 faculty. The Tidewater AREC, for example, teaches students about the proper processing of meat and conducts research to improve food safety. Industry representatives cited this type of learning as critical to the growth and success of vertically integrated meat processing (VIMP) industries, as it contributes to workforce preparation and expertise.

VIMP Impacts (2012-2016)

- VIMP facilities are highly vulnerable to disease. Agency 229's disease prevention programming is like an insurance policy so the industry and government do not lose hundreds of millions of revenue as they did during the 2002 Avian Flu Outbreak.
- Through research and the development of phosphorous site indexing that has contributed to more moderate regulations on Virginia's poultry industry compared to many states, Agency 229 has helped the industry to grow and utilize poultry litter as fertilizer in the Commonwealth.
- Agency 229 expertise and research facilities indirectly help prepare students for work in VIMP industries.

Enhancing impacts

Partly due to the production systems associated with VIMP, and scale and resources of companies in the industry, Agency 229's engagement with companies is limited to producer support. VIMP companies generally provide technical assistance and often, inputs directly to contract growers. VIMP production, particularly poultry, has become one of the Commonwealth's most valuable agriculture industry, and Agency 229's role in this industry differ from other agriculture commodities and traditional extension programming. For instance, stakeholders noted the value of extensions staff providing concise regulatory information to producers as integral to the industry's value chain. Thus, this is the case where the Agency could reorient services to be complimentary to industry services, rather as directly competing. Regardless, these companies view Agency 229 current outreach to producer as an asset illustrated by the expansion of production.

When stakeholders were asked about the ways in which 229 could enhance their impacts on the poultry industry in the next 10 years, two areas arose. The first was investments in funding targeted research in areas such as biosecurity, disease management, and bird health. Investing in expertise in these concentrated areas could allow Virginia Tech to find a larger niche within poultry research, and could attract external investment from VIMP companies. The second key area of growth for greater economic impact is expanding extension outreach in litter management. Helping growers become more cost efficient in the areas that they have control over could save them money and time, leading to higher profits. Finally, investments in youth outreach could also be beneficial, fostering a new generation of poultry growers to keep poultry as the top agricultural product in the Commonwealth.

Both poultry and swine stakeholders stressed that investments in AREC facilities and on campus, were needed in order to reach industry needs and standards.

Food and Beverage Manufacturing

Food manufacturing includes processors of raw agriculture products (i.e. milk, beef, and rice milling), processed food manufacturing (i.e. frozen food, cookies, and pasta manufacturing) and companion animal food manufacturing (pet food). The beverage manufacturing industry is broadly defined as wineries, breweries, distilleries, and other non-alcoholic beverage products. In addition, both industries purchase inputs from Virginia farmers, including apples, grapes, barley, and other agricultural crops for production. Both industries have experienced growth in Virginia since 2006. Real Gross Domestic Product (GDP; dollar measure of the economic output) from Food, Beverage, and Tobacco manufacturing grew from $12.6 billion to $14.5 billion from 2006-2015[55] (this estimate does not include the value of crops used as inputs in the industry, i.e. grape, barley, or other commodity production). This growth in economic output in Virginia occurs even as Food, Beverage, and Tobacco manufacturing at the national level has experienced a 6 percent decline in real GDP over the same period, which indicates Virginia has a niche in the food and beverage manufacturing sector. The growth in economic output from the beverage industry is partly explained by the rise of craft breweries and wineries throughout the state. Food processing is Virginia's second largest manufacturing sector, occupying 15 percent of total manufacturing employment, with 580 establishments.

Figure 10 outlines the growth in both direct employment and number of establishments for breweries and wineries. The number of wineries increased from 191 establishments in 2009 to 331 establishments in 2016. This influx of wineries led to a 156 percent growth in employment from 2009-2016. Beer manufacturing has had a similar trend with a 72 percent growth in employment from 2009-2015. However, unlike the wine industry, beer manufacturing experienced a decline in employment during the recession. The growth in employment since 2010, is due to the substantial increase in craft breweries over the last decade, as the number of breweries increased from 42 to 175 establishments (2009-2016; Figure 10). Together wineries and breweries paid more than that $146 million in wages in 2015, 75 percent from breweries.[56] Average hourly wages for each industry varied greatly, with breweries on average paying about $26 an hour and about $9 an hour at wineries in 2015.[57] The difference is due to the nature of each industry as wineries are more likely to have hosts and waiters on staff that typically make less.

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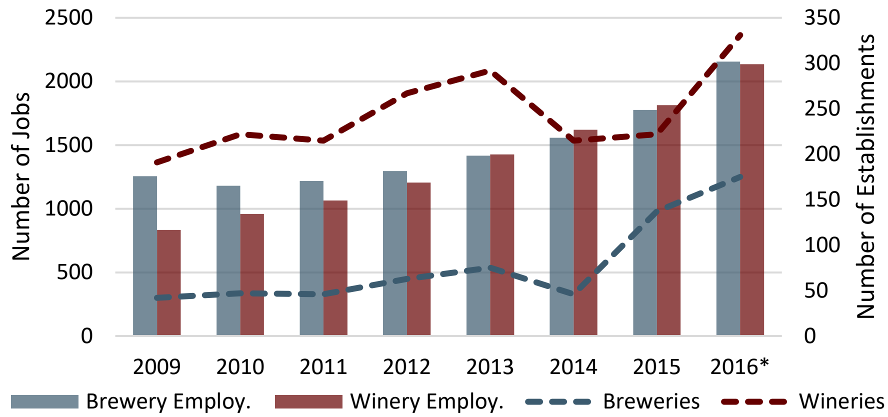
[55] In 2009 chained dollars. Source U.S. Bureau of Economic Analysis (2017). GDP by State. Retrieved from https://www.bea.gov/regional/index.htm

[56] Source: U.S. Census Bureau (2017). State and County Employment and Wage, Quarterly Census of Employment and Wages (QCEW). Retrieved from https://www.bls.gov/data/. Note a 40 hour work week was assumed when constructing average hourly wage

[57] Not: Wineries wages are substantially lower as wineries tend to have a wider variety of jobs and many are jobs related to the hotel and food service industries.

Figure 9: Number of Employees and Establishments at Virginian Breweries and Wineries[58]



*2016 Employment Data is Preliminary

Similar trends in employment, the number of establishments, and total wages to employees occurred in the food manufacturing industry. There were 519 establishments with more than 30,000 employees in the food manufacturing industry in 2016 (Table 6). Moreover, the industry paid more than $1.26 billion in wages in 2016, and saw a growth in the average hourly wage from about $16 to $20 from 2009 to 2016 (26 percent growth; Table 6). Within the industry, animal slaughtering and processing is by far the largest employer, with 13,488 employees in 2016 (roughly 45 percent; Table 7). The next two largest sub-industries are bakeries and other food manufacturing, which provided 4,568 and 4,927 jobs in 2016 (15 percent and 16 percent; Table 7).

Table 7: Food Manufacturing Establishment, Employment, Total Wages, and Average Hourly Wages[59]

	2009	**2016***	**Growth (2009 - 2016)**
Number of Establishments	430	519	21%
Number of Employees	29,539	30,230	2%
Total Wages ($1,000s)	1,078,821	1,257,925	17%
Average Hourly Wage	$15.93	$20.00	26%

*2016 data is preliminary

Table 8: Total Number and Share of Employees by Food Manufacturing Industry Sub-Groups[60]

NAICS (4-Digit) Industry Code	Number of Employees	Share

[58] Source for Establishments: Virginia Department of Alcoholic Beverage Control (ABC; 2017). 2009 -2016 Fiscal Year Annual Reports. Retrieved from https://www.abc.virginia.gov/about/agency-overview/sales-and-revenue. Source for Employment: U.S. Census Bureau (2017). State and County Employment and Wage, QCEW. Retrieved from https://www.bls.gov/data/.
[59] Source: U.S. Census Bureau (2017). State and County Employment and Wage, QCEW. Retrieved from https://www.bls.gov/data/.
[60] Source: U.S. Census Bureau (2017). State and County Employment and Wage, QCEW. Retrieved from https://www.bls.gov/data/.

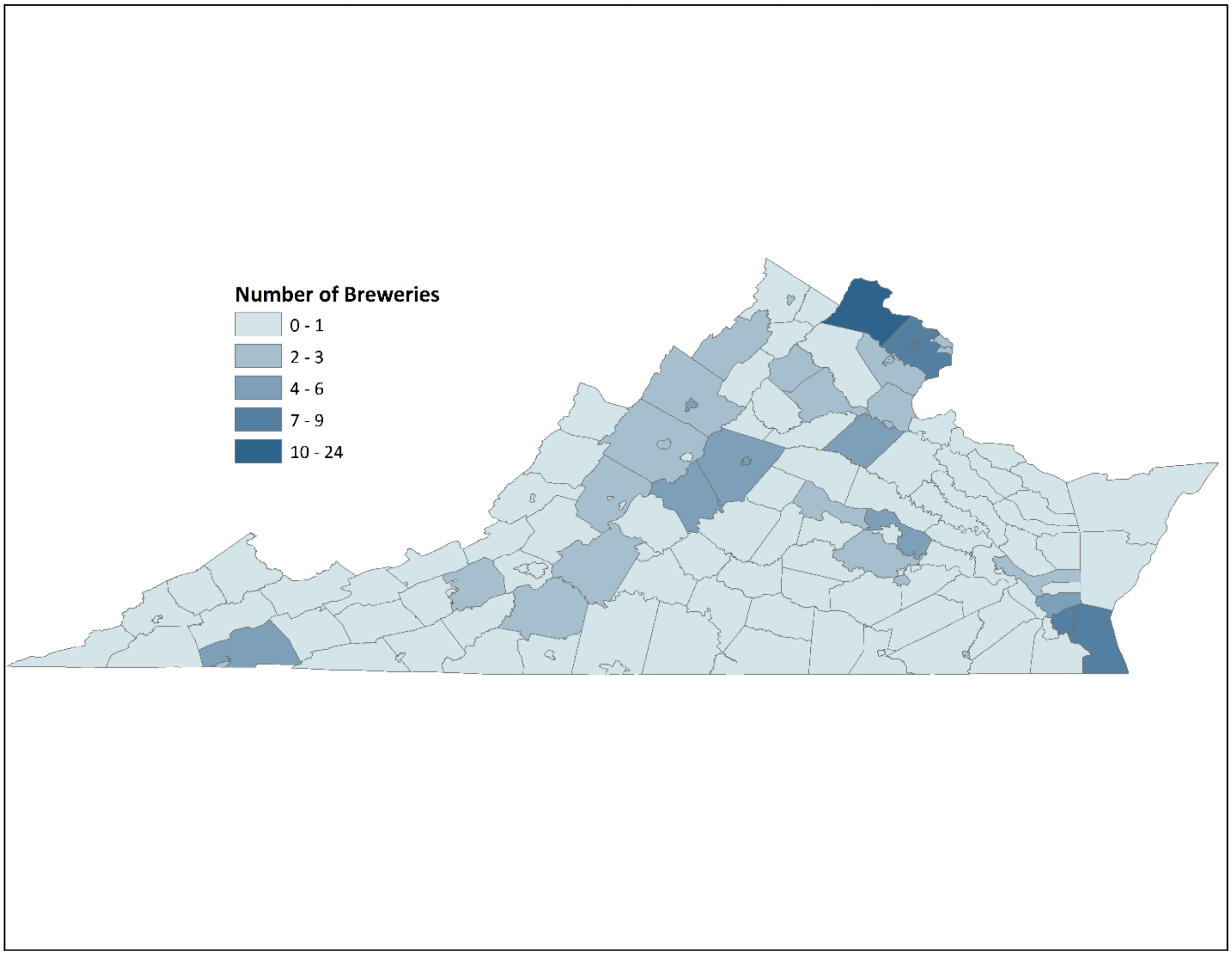
Sugar and Confectionery Products	1,300	4.3%
Animal Food	1,002	3.3%
Grain and Oilseed Milling	301	1.0%
Fruit and Vegetable Preserving and Specialty	1,220	4.0%
Dairy Products	1,975	6.5%
Animal Slaughtering and Processing	13,488	44.6%
Seafood Products	1,448	4.8%
Bakeries and Tortilla	4,568	15.1%
Other Food	4,927	16.3%
Total	**30,230**	**100.0%**

*Data is preliminary

The increase of breweries throughout the state has taken place in counties surrounding population centers and in cities (Figure 9). Loudon and Fairfax counties have 33 establishments registered as breweries, while the cities of Richmond (11 breweries), Charlottesville (6 breweries), Norfolk (7 breweries) and Virginia Beach (8 breweries) have 32 breweries among them. The economic impact and market for craft beer in Virginia is expanding, and several large west coast craft breweries are opening east coast production facilities that are expected to add an additional 600 new jobs to the state.[61] These west coast breweries include Deschutes Brewery (Oregon) and Ballast Point Brewing Company (California) in Roanoke, Green Flash Brewing Company (California) in Virginia Beach, and Stone Brewing (California) in Richmond. In addition to the rise of craft breweries, Virginia is the site of several large beer manufacturers, including Anheuser-Busch in Williamsburg and MillerCoors in Elkton. These two breweries alone employed around 1,125 individuals in 2015 (375 at MillerCoors and 750 at Anheuser-Busch).[62] Wineries are found throughout the state, though there are strong concentrations around urban areas, including Northern Virginia, Richmond, and Charlottesville. Loudon and Fauquier counties have 85 wineries, and Nelson and Fauquier counties have 46 establishments.

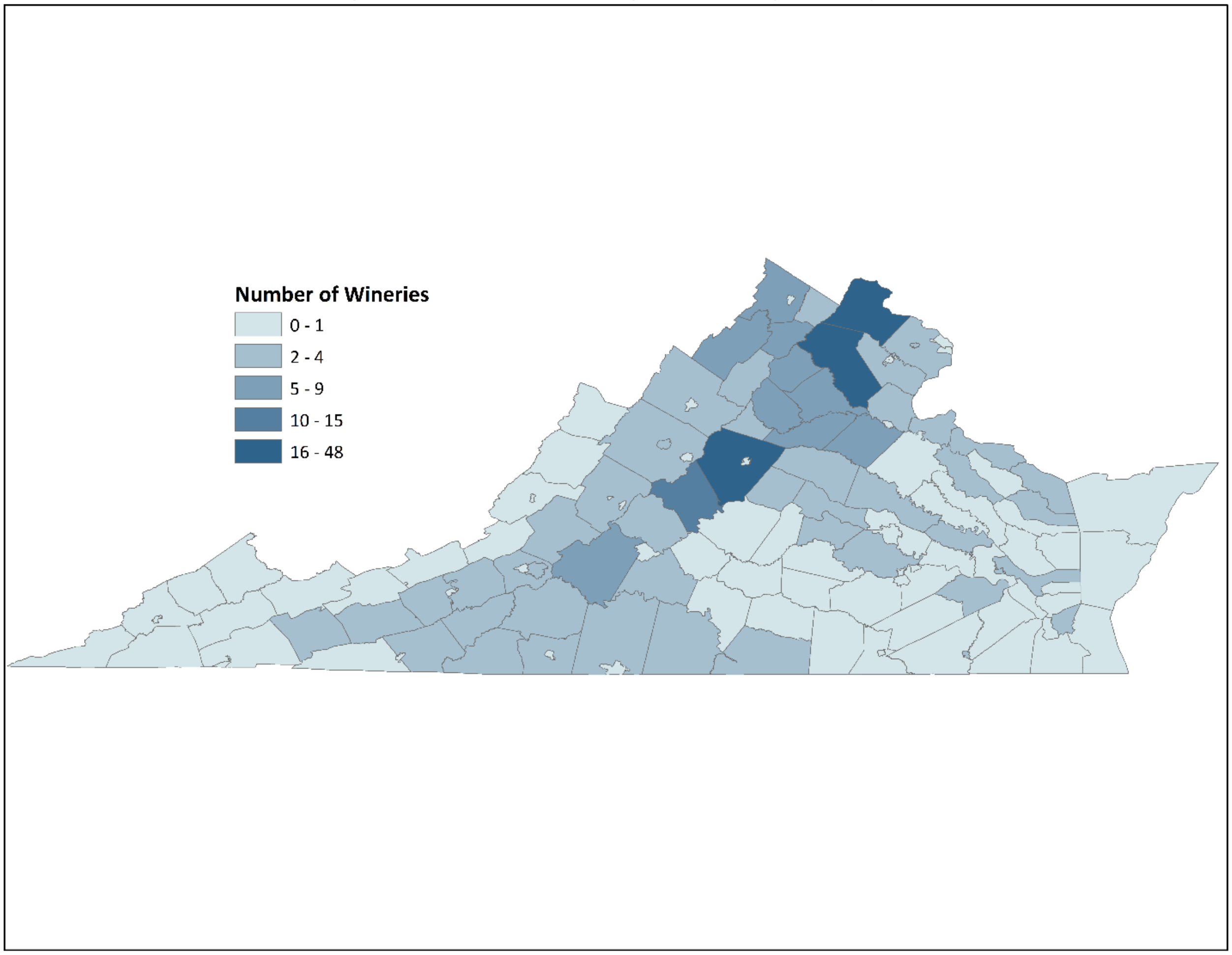
[61] Rephann, T.J. (2017). The Economic Impact of Agriculture and Forest Industries in Virginia. Charlottesville, VA: Weldon Cooper Center for Public Service, University of Virginia.
[62] Source: Harvard Business School, Institute for Strategy Competitiveness (2014). US Cluster Mapping. Retrieved from http://www.clustermapping.us/region/state/virginia/cluster-portfolio

Figure 10: 2016 Number of Breweries by Locality[63]



[63] Source: Virginia ABC (2017). 2009 -2016 Fiscal Year Annual Reports. Retrieved from https://www.abc.virginia.gov/about/agency-overview/sales-and-revenue.

Figure 11: 2016 Number of Wineries by Locality[64]



These previous figures on both the wine and beer industries grossly undervalue the total economic impact from each industry. For instance an economic impact report prepared by Beer Institute,[65] estimates that Virginia's beer industry employed over 3,691 individuals in wholesale and an additional 23,164 individuals in retail in 2016.[66] The Beer Institute found that the industry provided an economic impact of over $9.3 billion to Virginia in 2016.[67] A similar report conduct by A Frank, Rimerman + Co. LLP on the wine industry found that, in addition to employment at wineries, the industry employs individuals at vineyards, distributors, and in tourism; total employment in the industry was estimated at

[64] Source: Virginia ABC (2017). 2009 -2016 Fiscal Year Annual Reports. Retrieved from https://www.abc.virginia.gov/about/agency-overview/sales-and-revenue.

[65] Is a national trade association for the American Brewing Industry, more information at http://www.beerinstitute.org/

[66] Source: Beer Institute (2016). Beer Serves America, Economic Impact of the Beer Industry Virginia Report. Retrieved from http://beerservesamerica.org/

[67] Source: Beer Institute (2016). Beer Serves America, Economic Impact of the Beer Industry Virginia Report. Retrieved from http://beerservesamerica.org/

8,218 individuals in 2015.[68] The report concluded that the total economic impact from Virginia's wine industry was $1.37 billion in 2015.[69]

Included in these economic impact analyses are the valuation of employment and sales of Virginia farmers supplying inputs for both industries. Virginia farmers growing grapes, primary inputs for wineries, received more than $16.2 million in cash receipts (cash receipts farmers received from the sale of a crop) in 2015.[70] Grape farmers have seen an 8 percent average annual growth rate in cash receipts from 2008-2015 and cumulatively experienced a 56 percent growth in cash receipts during this period (Table 8). Wine grape production increased over the same period by 24 percent. This growth in production is partly due to the 27 percent expansion in the wine grape bearing area and it has led to an increase in grape production from 7,000 tons in 2008 to 8,682 tons in 2015. Despite this growth, Virginia wineries are still in need of Virginia grapes, in order to be considered Virginia wines. Currently many are importing significant portions of their wine grapes from elsewhere.

Table 10: Grape Cash Receipts (in $1,000), Wine Grape Production, and Wine Grape Cultivated Area[71]

	2008	2011	2015	Cumulative Change
Wine Grape Production (Tons)	7,000	7,728	8,682	24%
Wipe Grape Bearing Acres	2,500	2,774	3,172	27%
Cash Receipts ($1,000)	10,486	9,987	16,309	56%

The historical importance of the wine industry and the economic growth potential for beer manufacturing, has spurred support of the industry from Agency 229 activities.

[68] Source: A Frank, Rimerman + Co, LLP Report (2017). Retrieved from http://governor.virginia.gov/media/8546/virginia-2015-ei-update-final.pdf. Note this report was commissioned by the Virginia Wine Board.
[69] This result includes
[70] Source: United States Department of Agriculture – Economic Research Service (USDA-ERS; 2017). USDA/ERS Farm and Income and Wealth Statics. Retrieved from data.ers.usda.gov (cash receipts by commodity)
[71] Cash Receipts Source: USDA-ERS (2017). USDA/ERS Farm Income and Wealth Stastics. Retrieved from data.ers.usda.gov (cash receipts by commodity). Wine Grape Production and Cultivated Area Source: Virginia Wine Board (2017). 2009 -2015 Commercial Grape Report. Retrieved from https://www.virginiawine.org/grape-reports.

Agency 229 Food and Beverage Manufacturing Activities

Agency 229 has various activities on all levels of the value chain for the beverage and food manufacturing industries. These activities include research on crops used as inputs (including grapes, apples, barley, meat, and hops) for the food and beverage industries, quality control for the hops and grapes used at Virginia breweries and wineries, and a brewing facility at Virginia Tech available for research, testing, and extension education. In addition, manufacturing of livestock products also falls under the Agency's food manufacturing activities. The pilot plant – located in the Human and Agriculture Biosciences Building 1 (HABB1) on the Blacksburg campus – is a major point of collaboration between 229 researchers and extension agents and the food and beverage industry. Activities at the facility include product safety testing, packaging, sensory and flavor analysis, production systems, refrigeration, etc. In addition to fermented beverages and foods, products tested at the plant range from high pressure packaged items (like hummus and guacamole), milk, jerky, and more.

Food and Beverage Activities (2012-2016)

- $3.6 million in leveraged private and federal funding to conduct food and beverage manufacturing-related research.
- Agency 229 research topics include product safety testing, packaging, sensory and flavor, analysis, and production systems.
- VCE has educational programming for beer manufacturing, meat processing, food safety, viniculture, packaging, and more.

Wine grape production and agritourism are two focal areas undertaken by Agency 229's wine industry activities. The Alson H Smith Jr. Agricultural Research and Extension Center, located outside Winchester, VA, has a specific focus on wine grape production. Moreover, Virginia Tech's Wine/Enology Grape Chemistry Groups conducts quality analysis on grapes sent to the lab for farmers.

With rising interests in craft beer making, Agency 229 has supported several beer manufacturing programs and facilities at Virginia Tech, and expanded resources available to farmers growing hops. In 2017, the Enology Lab at Virginia Tech added hops quality assessments to their operations. In addition to hops testing, the extension services performs soil testing to improve hops production. Recently 229 built a state-of-the-art brewing facility, available to both students and brewers looking to conduct research and improve the quality of their beer making. Moreover, Virginia Tech is one of a handful of universities that offers a degree focused on beer making. The Bachelors of Science in Fermentation Science, in the Department of Food Science & Technology, prepares students for careers in food processing and is recognized by the Master Brewers Association of the Americas. While 229 dollars are not used for teaching, students benefit from the expertise of 229 faculty, and hands-on research experiences afforded by the state-of-the-art brewing and malting facilities.

The Food Innovations Program provides guidelines for food processing and safety regulations, resources on starting food businesses, and information on the specific labels used on various food products. The program has produced a large amount of extension publications, available online for food entrepreneurs in Virginia and elsewhere. If more specific technical assistance is needed, individuals and companies can contact their local extension office, where agents are trained in basic food entrepreneurship and food safety practices. There are also regional food innovations counselors located at district offices throughout the Commonwealth. For questions that cannot be answered through that channel, businesses also have the option of receiving direct technical assistance from the Food Innovations director. This organizational structure allows the program to reach more people in the Commonwealth. In addition to educational and technical assistance, the program provides food-testing services for new food products in the market.

VCE offers an accredited course on the food safety called ServSafe® Training for food workers, along with organizing a Master Food Volunteer Program. The Master Food Volunteer organizes and trains individuals interested in educating communities on cooking, nutrition, and physical fitness. Along with food safety programs throughout the food processing industry, VCE has an extension center focused solely on the processing and handling of seafood located in Hampton, VA. Several research and testing facilities also exist on Virginia Tech's Blacksburg campus for food businesses. Facilities include a food safety pilot plant, food processing pilot plant, and a high pressure processing plant.

Faculty from the Food Science Technology (FST) Department meets twice a year with an industry advisory board. The board includes representatives from ConAgra, Smithfield, Dupont, Cargill, Sabra, Ecolab, Deschutes, and Tyson. This advisory board allows research and programming to be tailored to current and future needs of this growing industry group. Industry affiliates benefit from board membership because it gives them an opportunity to provide input on areas where the industry is growing, and allows companies to better understand developments in research. It also allows companies to interact with one another, fostering potential points of collaboration between them.

Many companies represented on the board, along with other Virginia and non-Virginia companies, engage in sponsored research programs and testing conducted through FST at the pilot facility. In addition to money for research and scholarships, companies donate equipment to the facility, for testing, learning, and demonstration. The facilities at the pilot plant are a major point of industry collaboration. Before the plant was built, there was minimal interaction. Now, the plant collaborates with numerous companies annually across the food and beverage industry.

Several examples of fruitful industry collaboration include a study that looks at how food is affected by regulations requiring LED lights in refrigerated cases. Through an extensive sensory study, researchers found that LED lights change the flavor of certain food products. This finding caused researchers to explore new avenues of research including new packaging that limits the effect of LED lights, and consumer acceptability of the new packaging. Another packaging company has invested in research regarding the acceptability of certain frozen food packaging in different stages of preparation. The plant therefore becomes an important point of collaboration between frozen food companies and packaging companies – collaboration that likely would not have happened in Virginia if it were not for this facility.

Research between industry and FST can lead companies to expand their product lines, leading to higher profits, greater investment, and more Virginia jobs. One example of collaboration is a case, where a holding meat processing company needed to validate a process developed by a subsidiary company that had been recently acquired. 229 researchers found that the process did not lead to a safe product. This finding led researchers to work with the company to develop a new process that produced a similar product in a way that was safe for consumers. The 8-month validation process culminated in approval by USDA, and decision to locate a manufacturing facility in Virginia, adding 200 new jobs. Other beverage related industry-sponsored research includes the development of natural food flavorings and dyes and natural antimicrobials. This research can impact existing companies looking to expand their product lines, in addition to food entrepreneurs seeking a niche in the market.

Another way that industry collaboration can lead to economic impact, in regards to food safety is in investments avoided. For example, a food manufacturing company with a significant Virginia presence, sponsored research examining their current manufacturing process to evaluate whether or not an investment in new equipment and a new process would lead to safer food in a more cost-effective way. The 229 researchers found that the new equipment would not, in fact, lead to a safer or more cost efficient product, and the company was saved several millions in investments that it was able to put to more productive uses.

In addition to testing for food and beverage companies by 229 researchers, companies sometimes send their own researchers to learn alongside 229 faculty. There are several examples of West Coast beverage companies interested in opening an East Coast location who have first sent their researchers to work with 229 faculty to evaluate their processes and look at the water availability and suitability for their products. This type of relationship building has and can lead to business attraction, and subsequent jobs and investments in this growing and often high-paying Virginia sector.

In terms of workforce development, Virginia Tech offers undergraduate and graduate degrees in food science, within the Food Science and Technology Department. Outside of the Food Science and Technology Department, the university recently added (2012 was the first graduating class) an undergraduate degree in the packaging, with an emphasis of designing packaged used in the food industry. Though teaching is not a 229-funded activity, industry representatives frequently cite the value of experiential hands-on learning that students engage in at these world-class facilities.

Members of the Food and Beverage industry continue to see graduates as a significantly impactful contribution to their growth and success. They value the experiential education provided at Virginia Tech, and see the ability to continue to connect to 229 research through hiring graduates as extremely beneficial. Overall, while difficult to quantify, the economic impact of 229 research and extension for the food and beverage processing industry include safer, tastier products that are more readily purchased and enjoyed by consumers. Collaborations between researchers and industry have led several companies to locate to Virginia, creating jobs.

Enhancing Impacts

Industry representatives highlighted the level of engagement through the FST program. The HABB1 facility was cited as an innovative facility, where industry representatives and Agency 229 staff and faculty collaborate on research and product development. The facility can serve as a model for investments in other AREC facilities as industry input was used in the development of the facility. These investments have helped attract large fermented beverage manufacturers to the region and Commonwealth of Virginia. Stakeholders suggested that increasing capacity at HABB1 and in spaces similar to the pilot plant, would allow Agency 229 to have an impact on a wider range of industries, in addition to beer and other fermented beverage manufacturers.

Outside of investing in infrastructure to promote industry relationships, stakeholders suggested improving outreach to industry including a more streamlined means of collaborating. This could take the form of a consortium with other East Coast universities with complementary skills, allowing Virginia food and beverage manufacturers to come to Virginia Tech to access expertise from other institutions.

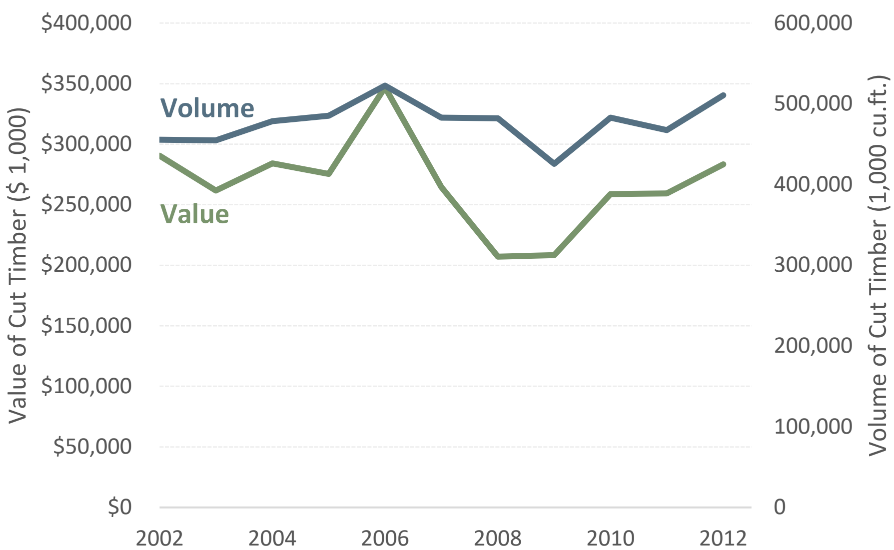
FST’s food innovation programming is a successful avenue to support food entrepreneurs and grow the economy. The services and equipment provided to start-up food and beverage companies, was often the last step before participating companies entered the market. Stakeholders noted that increases in resources to food innovation programming could increase the outreach to food and beverage entrepreneurs.

Forestry/wood products/timber

Virginia's forests provide economic value through the sale of cut timber, downstream forest product manufacturing (pulp, paper, furniture, etc.), tourism, environmental services (i.e. improving water and air quality) and other activities related to forestry. Part of the importance of forest-related industries is due to the size of Virginia's forest, which cover 62% of the land area or more than 16 million acres.[72] In 2014, about 82 percent of forested land was privately owned, with the federal government owning about 14 percent, and state and local government owning the remaining 4 percent.[73] In terms of forest types, Virginia is known as a predominately hardwood producing state, with roughly 79 percent of the forests under hardwood types and the remaining 21 percent softwood tree types such as pine.[74]

Sales from cut timber brought forest owners more than $238 million in 2012 (Figure 12). Figure 12 outlines the sales and volume of cut timber in Virginia from 2002- 2012, and shows the value of cut timber has fallen by 18 percent from the peak value in 2006. However, there has been a recovery in sales post-recession, with a 37 percent growth in sales from the industry's low of $207 million in 2008. Another indicator of the post-recession recovery of the timber industry is that annual production level of 510.5 million cubic feet is near the 2006 peak of 522.5 million cubic ft. Virginia's timber operations are found throughout the state (Figure 13), though there is a larger concentration of timber operations in rural counties. Timber is mainly harvested in the Piedmont region of Southern Virginia (Figure 13). Brunswick, Charlotte, Buckingham, Pittsylvania and Sussex counties each harvested more than $10 million in timber, with a combined total of about $66.9 million of timber sales in 2012.

Figure 9: Value and Volume of Cut Timber in Virginia, 2002-2012[75]



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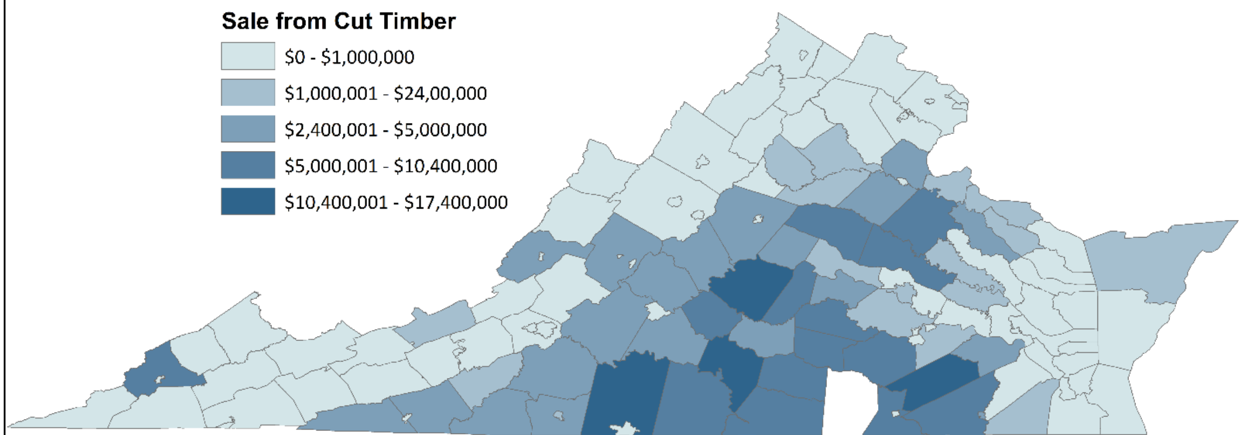
[72] Source: Virginia Department of Forestry (VDOF; 2016). 2016 State of the Forest. Retrieved from http://www.dof.virginia.gov/infopubs/_sof/SOF-2016_pub.pdf.

[73] Source: *Ibid*

[74] Source: *Ibid*

[75] Source: VDOF (2014). Timber Production and Supply. Retrieved from http://dof.virginia.gov/harvest/data/index.htm.

Figure 10: 2012 Sales Reported from Cut Timber by County[76]



Forest management and cutting of timber represent a fraction of the jobs supported by Virginia forests. Logging, forestry, and forestry support services provided approximately 2,484 jobs in 2016, and these jobs paid more than $101 million in wages (Table 10). Industries that use timber as a main input, including wood product and paper manufacturing, employed more than 21,000 individuals and paid out more than $1 billion in wages in 2016 (Table 10). However, since 2006, there has been a 14 percent fall in wages and a 28 percent fall in employment (Figure 14). There has been a recovery since the economic downturn during the recession and the fall out from the housing crisis, as wages and employment have grown by 22 percent and 9 percent since 2011, respectively (Figure 14).

Table 41: 2006 and 2016 Employment and Wages Paid from Selected Virginia Forest Industries[77]

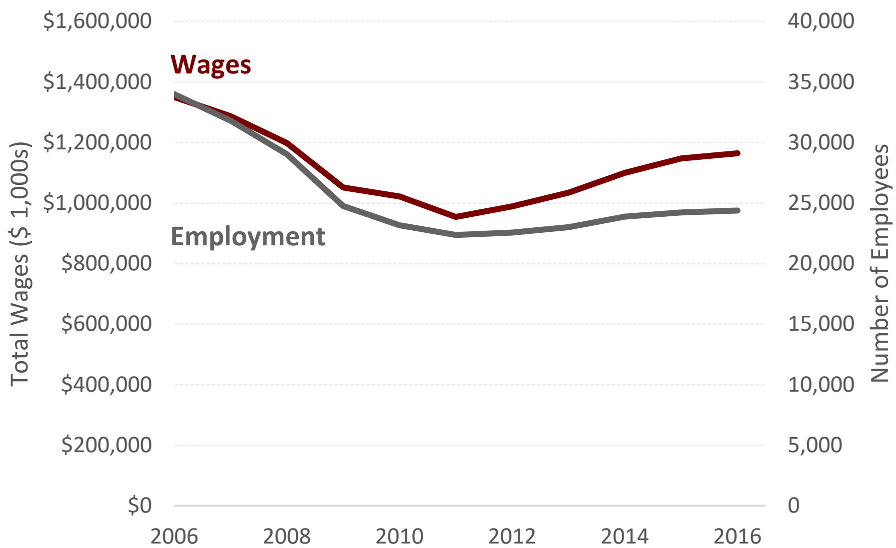
	Employment		**Wage ($1,000s)**	
	2006	2016	2006	2016
Forestry & Logging	2,103	2,223	$62,338	$90,117

[76] *Ibid*

[77] Source: U.S. Census Bureau (2017). State and County Employment and Wage, Quarterly Census of Employment and Wages (QCEW). Retrieved from https://www.bls.gov/data/.

Forestry Support Activities	274	261	$9,518	$11,795
Wood Product Manufacturing	20,082	14,038	$647,987	$545,505
Paper Manufacturing	11,529	7,870	$630,094	$516,567
Total	33,988	24,392	$1,349,937	$1,163,984

Figure 11: 2006 – 2016 Wages and Employment from Select Virginia Forest-Related Industries [78]



Virginia has experienced substantial growth in the export of wood and wood related products. Figure 14 illustrates the total value of select wood related commodities including: Wood and Articles of Wood (Harmonized System code (HS) 44), Cork and Articles of Cork (HS code 45), Wood Pulp Etc. (HS code 47), and Paper & Paperboard 7 articles (HS code 48). In 2016, Virginia exported more than $1.3 billion in wood related products, which was a 59 percent increase from 2006 (Figure 15). Paper and paper related products have historically comprised the largest share of export value; however, this share has fallen in recent years as the value of exported wood pulp has risen (Figure 15). In 2016, wood pulp and paper products comprised about 19 percent and 52 percent of the total export value, respectively. In 2006, these shares in total export value were 6 percent for wood pulp and 65 percent for paper products. Over the last decade, wood pulp has seen a 444 percent growth in export value, while paper has experienced a 27 percent increase and wood (timber) has seen a 57 percent increase (Figure 15).

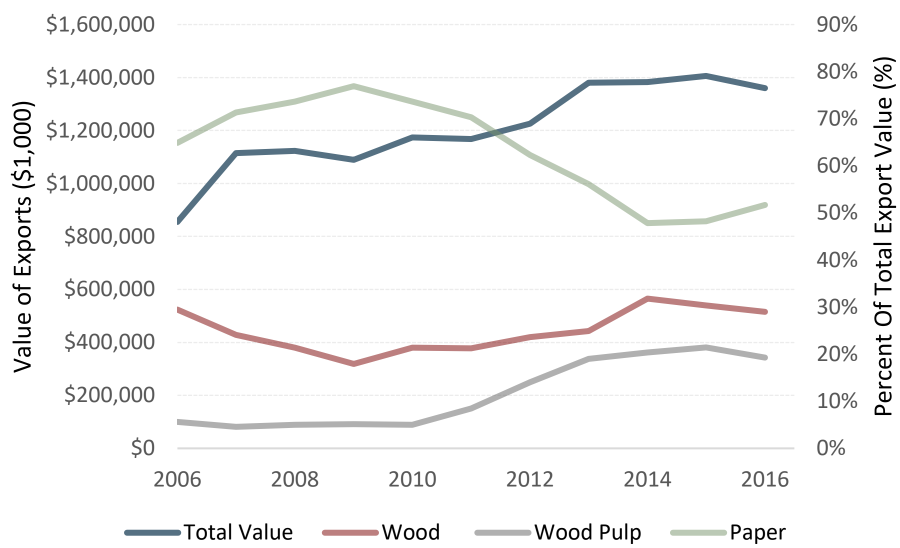
Wages, sale of cut timbers, and the exports of value-added, wood-related products grossly underestimate the true economic value of Virginia Forests. On top of the value provided from the direct sale of wood and other wood related products, forests provide many ecosystem services. An economic impact study of Virginia's forest conduct by the Weldon Cooper Center of the University of Virginia, assessed an economic value of the air and water quality services provided by forests. The study estimates that these services provide more than $6.6 billion in economic value to the state, with water quality service comprising about 80 percent of the estimate.[79] Moreover, forests are a popular destination for tourism and many Virginia businesses are based on tourism related to Virginia's forests.

[78] *Ibid*

[79] Rephann, T.J. (2017). The Economic Impact of Agriculture and Forest Industries in Virginia. Charlottesville, VA: Weldon Cooper Center for Public Service, University of Virginia

In total, forests are estimated to have an economic impact of over $30.3 billion in 2015, with $21 billion coming from industry output and an additional $9.3 billion in value-added.[80] Part of this estimated impact is due to the 107,900 jobs supported by Virginia forests.[81]

Figure 12 Export Value (in $1,000s) and Share of Value of Select Wood Products from 2006 to 2016[82]



229 Forestry, Wood Products, and Timber Activities

Agency 229 has programs to support forest owners through the Virginia Cooperative Extension (VCE), VAES faculty conducting research, education programs at both Virginia Tech and Virginia State University, and through the management of an extensive network of volunteers.

Primary research conducted by Agency 229 faculty and staff includes tree pest management, sustainable harvesting practices, and sustainable forestry management. Forestry related projects were conducted by faculty and staff from the departments of Forest Resources and Environmental Conservation, Entomology, Agricultural and Applied Economic, Horticulture, and Crop and Science. Over the past 5 years, funded research expenditures related to forestry and forested-related products topped $3.6 million. Funders include private companies, United States Department of Agriculture Forest Service, Virginia Department of Forestry, Appalachian Sustainable Development, Virginia Tech Foundation Inc., and Virginia Department of Agriculture and Consumer Services. In addition, VCE had 155 activities where forestry were the primary focus area, but had additional impacts on community development, education of the public and influences on agriculture.

Agency 229 research and technical assistance activities for forestry and wood products industries take place across Virginia. The Reynolds Homestead, located in Critz, Virginia, is home to research on forest biology and conducts projects on improving forest-harvesting techniques. The Shenandoah Valley AREC, in Raphine, Virginia, conducts research and projects on small-scale forestry and wood lot management.

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[80] *Ibid*
[81] *Ibid*
[82] Source: U.S. Census Bureau (2017). Economic Indicators Division USA Trade Online; U.S. Import and Export Merchandise Trade Statistics. Origin of Movement Exports, Origin state-based. HS Codes 44, 45, 47, & 48. Note: HS Code 45, Cork and Articles of Cork were used to construct total value but the share of value was omitted due to size (less than 1%). Retrieved from https://usatrade.census.gov/

The Fishburn School Forest is a 1,353 acre demonstration forest that Virginia Tech's department of Forest Resources and Environmental Conservation uses to give students applied education in forest management. Moreover, Virginia Tech has a harvesting research laboratory, providing students with hands-on experience in researching sustainable forest processing and harvesting techniques. The Center for Forest Products and Business (hosted in the department of Sustainable Biomaterials) provides the industry with resources on forest product marketing, sales, lean manufacturing and business planning. The center has a focused research agenda on trends that impact forest products firms and understanding forest product markets.

Agency 229 has an extensive outreach program to teach the public of the benefits associated environmental conservation. For instance, VCE supports the Virginia Master Naturalists Program, which educates volunteers on Virginia forests and wildlife, along with the Virginia's link to Education about Forestry (LEAF). More than 450 Virginians participate in the Virginia Master Naturalist Program, which requires completion of a 40-hour education course. In 2016, the program had approximately 2,980 members who collectively volunteered more than 152 thousand hours in the areas of education, citizen science, stewardship, and administration (including travel time). This amount of volunteer service was assessed at valuing a total of $3.97 million towards the conservation of Virginia's lands and forests. Volunteerism is a public engagement that introduces the challenges faced by landowners, the services provided from forests, and the efforts in properly harvesting trees and sustaining currents forests to public stakeholders.

VCE provides outreach and technical assistance in forest harvesting, farming (agriculture production in forest lands), urban forestry, and landowner management. VCE helps manages the Virginia Forest Landowner Education Program (VFLEP). VFLEP provides short courses (both in-person and online) on best forest management practices, resources available to forest owners, and devising a forest management plan. In addition, VFLEP supports several workshops and conferences including Preparing for Generation NEXT, a conference highlighting techniques in stewardship and conservancy of forests to support the longevity of Virginia's forests. Part of the Generation Next conference is a short-course on the transferring of land between family generations. VCE also hosts weekend retreats and field days to various proprieties throughout the Commonwealth. Retreat and field day participants are introduced to the prevailing forest practices on example Virginian properties. VFLEP, Generation NEXT and these retreat/field day programs are tied together with an extensive outreach program that includes a newsletter to past participants and other relevant stakeholders (there are around 12,000 recipients of the various newsletters extension maintains). The activities directly support a thriving

Forestry and Wood Products Activities (2012-2016)

- $3.6 million in leveraged private and federal funding to conduct forestry and forest-related research
- Agency 229 research topics include tree pest management, sustainable harvesting practices, and sustainable forestry management.
- VCE has educational programming that promotes the benefits of environmental conservation and sustainable forestry management. It also provides technical assistance in forest harvesting, farming forested lands, urban forestry, and forestry landowner management.

forestry industry that engages directly with Agency 229 faculty and staff. The information transmission activities conducted by VCE has placed the Commonwealth's forest landowners ahead of their state peers. A Virginia Tech researcher reported that on average 50 percent of the forest landowners in Virginia who attended a forestry landowner program, devised management strategies. Land management strategies are seldom used around the United States, with only an average of 3 percent of landowners adopting the practice. In the same survey of landowners who completed the landowner management training program, 57 percent of program participants reported attending more than one VCE program. Using the lessons learned from these VCE programs, 63 percent of participants reported to have improved wildlife habitats, and 50 percent successfully identified and reduced the amount of invasive species. Over the long term, what the sustainable forestry management practices program participants learn and apply to their property can increase the return on investment property owners see from their forests through timber sales. Management plans are a key part of a successful timber harvesting operation.

<u>Forestry and Wood Products Impacts (2012-2016)</u>

- Practiced change among program participants has resulted in improved wildlife habitats, reduced numbers of invasive species, higher ROI for property owners, and better timber product for the industry.
- Over 4,000 individuals have been certified through the SHARP Logger program. Training through this program can help owners and loggers halve the time it would normally take to harvest timber, thereby doubling their ROI.
- Agency 229 expertise and research facilities indirectly impact the preparation of students for work in forestry and wood production.

For instance, the SHARP Logger Program provides training on logging safety, sustainable forestry, and harvest planning and best management practices, and requires loggers to continue education to maintain a SHARP logger certificate after the initial course. The program is supported by the timber industry in conjunction with the Sustainable Forestry Initiative (SFI). SFI is a national initiative that supports the sustainable harvesting of timber. A result from SHARP programming is forest owners and loggers can effectively harvest softwood every 25 years and hardwood every 50 years. For reference, an industry expert stated that poorly managed hardwood forest can be harvested every 75 – 100 years. Therefore, Virginia hardwood forests would be able to double their returns over a 100-year period if every forester, logger, and forest owner participated and completed SHARP certification. More than 4,000 individuals have already been certified by the program since 1996. In fact, the success of the program has led to all significant logging operations to have at least one employee completing SHARP certification at some point.

While Agency 229 does not directly support teaching, it has indirect impacts on students and their preparation for the workforce. 229 faculty often engage students in 229 research, and the expertise they bring to the classroom when they teach (as part of their other faculty appointment) ensures an adept and industry-ready workforce for the forestry and wood-products industries. Virginia Tech offers an extensive undergraduate and graduate program in forest and forest related industries through the College of Natural Resources and Environment, which benefits from the technical knowledge and experiences of 229 faculty. Within the college of Natural Resources and Environment are the departments of Fish and Wildlife Conservation, Forest Resources and Environmental Conservation, Geography, Sustainable Biomaterials, and the Center for Leadership in Global Sustainability. Students gain hands-on experience through the various facilities throughout the University and Virginia, which are supported and maintained by Agency 229.

Enhancing Impacts

Internal and external interviews revealed that the extension operations in forestry were extremely impactful, however currently there are only five specialists working on forest management and harvesting. Extension specialists are stretched thin across the state and additional extension agents can pay dividends on the impact on the forestry industry. In turn, this would increase the resources available to successful VCE programs similar to SHARP Logger. The success of the SHARP Logger program in engaging private industry is clear, as internal stakeholders stated that all forest harvesting operations in the state have at least one employee that has completed the program. The program represents a successful extension program, where private industry is actively engaged in the preservation of a natural resource abundant in the Commonwealth, with resources and education provided by public institutions.

Importantly, much of the economic benefits resulting from 229 forestry activities are delivered through the environmental services provided by conserving and properly managing forestlands. These services were highlighted by external and internal stakeholders, however are hard to quantify in terms of economic value. 229 could better illustrate the agency's economic value by building capacity in valuing these services. Investments towards establishing economic valuation of environmental services can help the organization tell its stories and identify areas for programmatic improvement.

Row crops

For the purposes of this report, row crops include corn, soy, wheat, barley, peanuts, and tobacco and comprise roughly a third of annual cash receipts from agriculture production in Virginia between 2008 and 2015.[83] Row crop production is concentrated on four key commodities (see Table 11), including corn, soybean, wheat, and tobacco that collectively account for 47 percent of farm field crop cash recipients (Table 1) and a third of Virginia's agricultural exports ($260.6 million) in 2015. [84] From the 2012 Census of Agriculture, there were 19,601 operations (farms) in Virginia that reported crop sales, with corn and soybeans accounting for 3,390 (17 percent) and 2,492 (13 percent) of these operations. Tobacco and wheat combined accounted for 11 percent of total operations with 577 and 1,589 operations for each crop, respectively. These crops are planted on large farm operations, with 37 percent of corn, 43 percent of soybeans, 32 percent of tobacco, and 53 percent of wheat operations being planted on farms larger than 500 acres.

Table 12: Top Row Crops Planted in Virginia in 2015 85

Crop	Cash Receipt ($1,000)
Soybean	175,277
Corn	152,627
Tobacco	105,168
Wheat	68,630

[83] Source: United States Department of Agriculture – Economic Research Service (USDA-ERS; 2017). USDA/ERS Farm Income and Wealth Statistics. Retrieved from data.ers.usda.gov (Cash receipts by commodity).
[84] Source: USDA-ERS (2017). USDA/ERS Farm Income and Wealth Statistics. Retrieved from data.ers.usda.gov (Cash receipts by commodity). Source: USDA-ERS (2017). USDA/ERS State Export Data. Retrieved from www.ers.usda.gov/data-products/state-export-data/ (U.S. Agricultural Exports, Commodity detail by State [New series]: Calendar years 2000 – 2015)
[85] Source: USDA-ERS (2017). USDA/ERS Farm Income and Wealth Statistics. Retrieved from data.ers.usda.gov (Cash receipts by commodity).

Peanuts	15,813
Barley	3,360
Other Field Crops	557,977
Total Row Crop	**520,875**

Though the share of row crops' cash receipts from the four key commodities have remained relatively constant since 2010, (Figure 16) acres harvested for each of the four crops has shifted dramatically (Table 11). Tobacco, corn, and wheat all experienced a reduction in acres harvested from 1997 – 2016, while soybeans saw a significant expansion of acres harvested over the same period (Table 11). Other important crops planted in Virginia, include hay, potatoes, peanuts, and tomatoes, which made up 10, 1, 1, and 3 percent of farm cash receipts, respectively, in 2015.[86]

Figure 13: 2010 and 2015 Share of Field Crop Cash Receipts for Virginia [87]

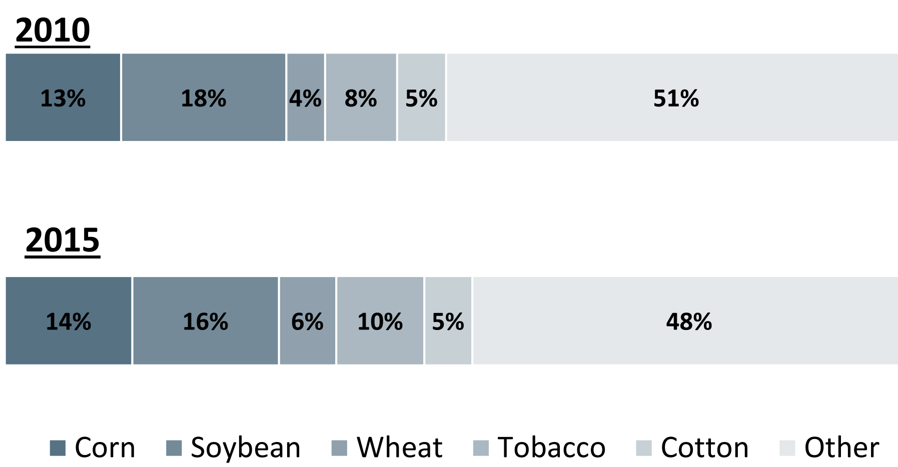


Table 53: Area Harvested (in 1,000s of acres) and Percent Change in Area Harvested in Virginia

	Area Harvested (1,000 of acres)			Percent Change		
Crop	1997	2007	2016	1997 - 2007	2007 - 2016	1997 - 2016
Corn	485.0	535.0	470.0	10.3%	-12.1%	-3.1%
Soybean	490.0	500.0	600.0	2.0%	20.0%	22.4%
Tobacco	53.1	20.6	23.5	-61.2%	13.9%	-55.8%
Wheat	260.0	205.0	175.0	-21.2%	-14.6%	-32.7%

[86] Source: USDA-ERS (2017). USDA/ERS Farm Income and Wealth Statistics. Retrieved from data.ers.usda.gov (Cash receipts by commodity).

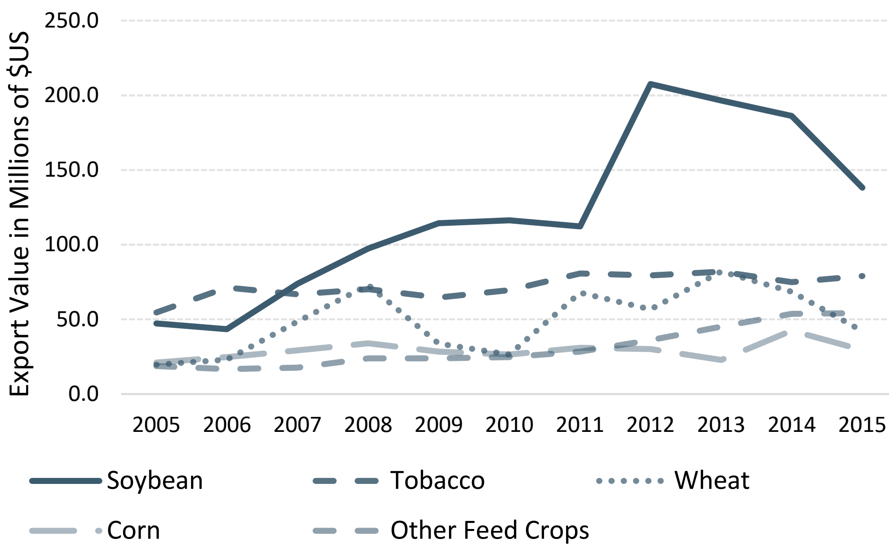
[87] Source: USDA-ERS (2017). USDA/ERS Farm Income and Wealth Statistics. Retrieved from data.ers.usda.gov (Cash receipts by commodity).

Crop production is spread throughout Virginia; however, several regions have higher intensification of production for specific crops that is influenced by the end market for each commodity. For example, a high concentration of corn production occurs in the Shenandoah Valley, which primarily serves as feed for livestock production in the region (poultry and cattle).[88] Figure 25 and 26 maps (in Appendix X) the corn grain and silage production for 2012 by counties. The two dark blue counties in the North West portion of the state are Augusta and Rockingham counties, both producing more than 1.3 million bushels of corn for grain and over 75,000 tons of corn for silage. In Eastern Virginia, there is a high concentration of wheat, corn, and soybean that is either exported or used in the local swine and poultry industries (Figure 25 – 28; Appendix X).[89] The Eastern Shore, consisting of Accomack and Northampton counties (the two eastern most counties on the map, is one of the most productive regions of the states, with high levels of production in corn, soybean, and wheat. Tobacco grows in Southern Virginia on the counties bordering North Carolina, including Brunswick, Lunenburg, Mecklenburg, Halifax, and Pittsylvania (Figure 29).[90]

A 2017 economic impact study of the agriculture and forestry sector by the Weldon Cooper Center for Public Service at the University of Virginia, highlighted the drivers in the change of row crop commodity production in Virginia. Feed crop production particularly soybean and corn, has seen expansion due to increases in biofuel production and international demand for livestock products.[91] Figure 17 captures these shifts in international demand for Virginia's agricultural exports. Notably soybean and other feed crops have experienced a 192 and 188 percent growth in the value exported between 2005 -2015, respectively. Tobacco on the other hand, has experienced a contraction in both, production area (Table 1 & 2) and the number of farms selling tobacco, which fell from 6,062 in 1997 to 557 by 2012.[92] This exodus of farmers and loss of area harvested is partly due to shifts in consumer behavior, increases in government regulations, and reduction in government support to farmers.[93] However though domestic demand is decreasing, international demand for the state's tobacco has remained relatively unchanged in terms of export value (Figure 17).

[88] Virginia Cooperative Extension (VCE). (2015). Grain and Soybean production and Storage in Virginia: A Summary and Spatial Examination. Publication AAEC – 60P. Blacksburg, VA: Virginia Tech.
[89] VCE. 2015. Grain and Soybean production and Storage in Virginia: A Summary and Spatial Examination. Publication AAEC – 60P. Blacksburg, VA: Virginia Tech.
[90] Source: USDA-NASS (2017). Retrieved from agcensus.usda.gov (2012, Census of Agriculture).
[91] Rephann, T. J. (2017). The Economic Impact of Agriculture and Forest Industries in Virginia. Charlottesville, VA: Weldon Cooper Center for Public Service, University of Virginia.
[92] Source: United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS; 2017). Retrieved from quickstats.nass.usda.gov (2012 Census of Agriculture).
[93] Rephann, T. J. (2013). The Economic Impact of Virginia's Agriculture and Forest Industries. Charlottesville, VA: Weldon Cooper Center for Public Service, University of Virginia.

Figure 14: Export Value of Key Virginian Commodities from 2005 - 2015[94]



229 Row Crops Research and Extension Activities

Agency 229 plays a significant role in the development of the row crops sector, both in Virginia, and nationally, with an increased focus on small grains (including wheat, barley), followed by corn, soybeans, peanuts, and tobacco. Main research and extension activities for each crop are conducted in the department of Crop, Soil and Environmental Sciences (CSES), through AREC research and extension activities, and through specialty programs such as the Small Grains program. Research and outreach activities in CSES are focused in three areas, including agronomy, crop improvement, breeding and genomics (discussed in the next paragraph), and environmental science. Agronomy CSES faculty are engaged in activities related to forage, row crop, and turf grass management. Environmental science activities include research in the soil and nutrient management, soil processes, waste management, water quality, and land reclamation (which has particular importance to the Virginia coal production region). This research is connected to many of the other Departments within the College of Agriculture, such as Horticulture, Entomology, Animal and Poultry Sciences, Dairy Sciences (animal feed), Agricultural and Applied Economics, Food Science Technology, and others.

Most activity is related to variety or efficiency improvements. Variety improvement research, mainly in small grains, leads to new patented varieties, licensed by growers throughout the United States. The small grains program develops, tests, and licenses varieties of wheat, soybeans, barley and peanuts. The royalties from those licenses return to the College of Agriculture and are subsequently used for research. Over the past five years, the small grains program has generated $3.7 million in royalties. This is in addition to the economic benefits farmers receive from adopting these improved varieties.

Table 64: Royalties for New Varieties developed through 229 Activities, FY 2013-17

	FY2013		FY2014		FY2015		FY2016		FY2017
Wheat	834,081.88		856,118.88		633,648.76		431,738.13		310,381.91

[94] Source: USDA-ERS (2017). USDA/ERS State Export Data. Retrieved from www.ers.usda.gov/data-products/state-export-data/ (U.S. Agricultural Exports, Commodity detail by State [New series]: Calendar years 2000 – 2015)

Soybean	33,888.25		20,832.91		4,202.15		11,698.73		43,384.13
Barley	75,311.76		95,095.87		68,280.24		36,155.94		60,159.22
Peanut	82,423.64		49,847.20		51,080.84		5,050.19		1,375.12
Total	1,025,705.53		1,021,894.86		757,211.99		484,642.99		415,300.38

Efficiency improvements in the management of each of the other row crops saves Virginia farmers millions of dollars annually.

In addition to lab-based research on the Blacksburg campus, much of the research on disease resistance, pesticide use, and variety trials is conducted using on-farm trials and at the ARECs throughout Virginia. This research is often funded by seed companies, chemical companies, and fertilizer manufacturers or wholesalers. It is critical to conduct research in each row-crop producing region in Virginia because of geographic differences in climate and pest species; the location of the AREC or farm often influences the primary crop under investigation. ARECs with a high emphasis on row crops include Eastern Virginia (small grains and soybean), Southern piedmont (Tobacco), Southwest Virginia (Tobacco), and Tidewater (cotton, soybean, and peanut). While field trials (the research side), and field days (the extension side) often occur on AREC property, much of this field research is conducted on property owned by farmers themselves. These row crop farmers see tremendous benefits in being part of field trial experiments. In exchange for a small plot of their land, producers are able to work closely with extension agents and specialists to better understand growing conditions and best management practices. They are the first to see the benefit of adopting a new variety, and also benefit from learning about the scientific research process. Fellow farmers are able to see the new variety or technique on land more similar to their own. These on-farm trials are a critical part of encouraging farmers to adopt improved varieties and more efficient, environmentally friendly management techniques, leading to large-scale economic benefits.

<u>Row Crops Activities (2012-2016)</u>

- $13.7 million in leveraged private and federal funding to conduct row crop-related research
- Agency 229 research includes agronomy, crop improvement, breeding and genomics, and environmental science
- VCE has education programs on proper management of pests, application of fertilizers, and cost reducing techniques. A big part of the research conducted is in crop breeding, and VCE has an extensive outreach on the introduction of new crop varieties in farms.

Seed companies, chemical companies, and fertilizer manufacturers or wholesalers also benefit from their sponsorship of field trials. Scientists are able to compare their varietals to those of their competitors using scientific methods, providing unbiased objective information to farmers about the use and benefits of certain products. This information also assists the companies in better understanding which areas of Virginia their product may or may not work, and in what conditions. Many attendees of these field trials are seed consultants and realtors. Being able to advocate for a product that farmers are satisfied with ultimately leads to higher sales and profits for that company.

Another area of research is in market development for their crops. For a commodity with high capital investment and low margins, finding additional local, export, and value added markets for these agricultural commodities contribute to a large and distributed economic impact. Some examples of that are in biofuels and the development of specialty grains for breads, brewing, and livestock feed. Examples of the impact of that research is not always linear, as highlighted in the following examples.

Fourteen years ago, a VCE program together with a barley breeder made a hull-less barley for the purpose of bioenergy and livestock feed. While the original intent of the biofuel research did not come to fruition, the research did have one unintended, but significantly positive economic consequence – more money in the pockets of corn producers. By having an ethanol facility built in Virginia, there are now two markets for Virginia corn - ethanol and the grain market. This has led the basis on the corn crop (money Virginia growers receive over the national average) to be improved by 20-30 cents a bushel. Corn producers therefore receive more per bushel than they would have if the facility was not located in Virginia. While at the time, the livestock feed market did not adopt the use of hull-less barley for that purpose, there has been a recent renewed interest in the crop, which could have potential economic impact in the next several years.

Another unintended but beneficial result of research into barley varietals is in the high growth area of the malting and brewing industry. As the number of craft breweries in the state tops 140, there is a need and desire to garner a greater portion of the industry with Virginia grown products. While the industry is still in its fledgling stages in terms of using Virginia raw commodities, there have been strides in developing varieties for the brewing industry, and also marketing Virginia grains to Virginia brewers. Although grains grown for brewing will likely never surpass the current grain market supply, growing malt barley could be a big opportunity for growers who are able to supply a niche market. Researchers in the Crops and Soil Sciences department are conducting applied research to generate varieties that can be grown and used in the beer industry. Currently they have assessed how much beer can be made with a given amount of grain (to better understand demand from brewers), and are partnering with the Food Science & Technology department to do flavor profiles on varieties. After the flavor profile is better understood, faculty members will meet with brewers and distillers in the state to provide them this information. Initial meetings with industry have generated a great deal of interest in the use of this raw agricultural commodity in the brewing industry.

Producing an input for this growing market could have large economic implications for the grain and brewing industry. Currently, feed barley is sold for $2 a bushel. Malting barley that has been delivered and tested (for malt beverages), sells for between $9 and $11 a bushel. Although the costs of production and processing are higher, the profits margins are also greater for producers who want to expand into that market. The same kind of potential for greater economic benefits by transitioning to different varietals exists in the bread industry. Currently, Virginia grows soft winter wheat that is suitable for products that are not leavened. Expanding into hard wheat varietals in Virginia could lead to increased benefits to farmers. There are several varietals of hard wheats developed by Virginia Tech researchers, and the rights are owned by a group of farmers who formed an LLC in Virginia. Disrupting the bread value chain with Virginia-grown wheat could lead to greater benefits for producers, and also for bread makers and millers as the demand and thus premium for a locally identifiable product increases.

Areas of significant economic impact include a reduction in the impacts of disease on crop yields through wheat and barley research. One particular research program reduced the cost of production for wheat and barley farms by $2.4 million dollars annually. Research on generating improved wheat varieties generated more than $8 million in royalties and garnered $3.3 million dollars in additional funding to support research since 2011. A program on improving energy efficiency on tobacco farms resulted in 11 farms in Virginia receiving a $220,225 fund to adopt more energy efficient equipment. Two peanut varieties developed through the Peanut Variety and Quality Evaluation Program added more than $16 million in value to the crop since introduction. Researchers have also contributed significantly to yield improvements in corn and soybeans through improved management strategies. According to experts, a common rule of thumb when assessing the impact of research and extension on yield improvements is that over time, 50 percent of gains are due to management, and 50 percent are due to production/genetics. For corn, the majority of genetic research is conducted by seed companies. However, 2/3 of management improvements are due to extension. Looking at corn, yields in Virginia have increased 4.2 bushels per acre per year, or $18.90 annually. If half of that is due to genetics, and half is due to management – and 2/3 of increases in management are directly attributable to VCE, then on average, VCE contributes about $6.23 per bushel of value to corn producers. With 350,000 acres of corn produced in Virginia in 2016, VCE contributes an estimated additional $2.2 million dollars annually to corn producers.

<u>Row Crops Impacts (2012-2016)</u>

- Wheat and barley research reduced the cost of production in Virginia by $2.4 million annually.
- Wheat varieties developed by Agency faculty have generated more than $8 million in royalties and garnered $3.3 million dollars in additional funding
- 11 Farmers who participated in an energy efficient program received $220,225 in additional funding
- Two peanut varieties developed due to Agency efforts brought farmers more than $16 million since their introduction
- VCE contributes an additional $2.2 million dollars to corn producers from VCE efforts to improve corn management.
- Soybean producers gain an additional $1.3 million in income due to management improvement from VCE

Using the same calculation for soybeans, VCE's estimated contribution is an additional $1.3 million in additional income from this one crop each year. The same calculation could be made for the other commodity crops.

Enhancing Impacts

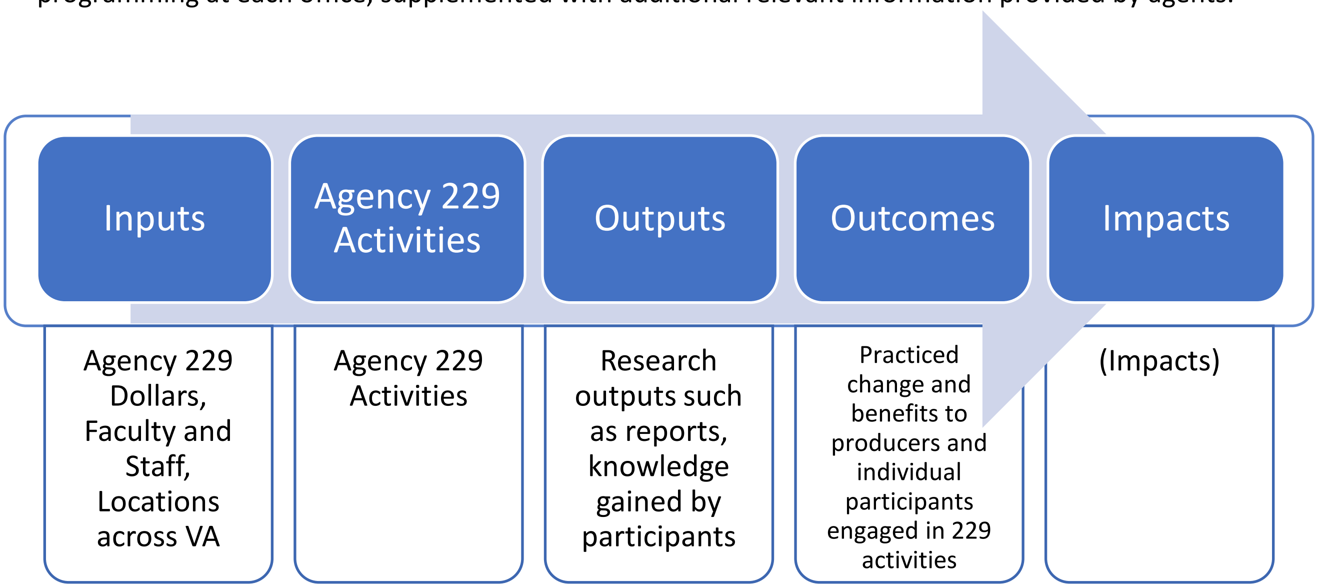
Currently, the majority of research and extension efforts are focused in the regions of Virginia that are the most productive (east of 95 and on the Coastal Plain). However, other regions of Virginia that are heavier in livestock could also benefit from additional research and extension efforts that bolster row crop production. An example of this would be if CSES focuses on small grain production in the Southern Virginia counties. In looking at the dairy and livestock sectors, it makes sense to expand the opportunity for them to increase small grain production in those counties for animal feed. There are plans to look at the use of hull-less barley in dairy rations, and also see the benefits of hull-less barley for finishing beef cattle. Because the majority of Virginia cattle is sold as feeder cattle to the grain producing states in the mid-west, there might be an opportunity through an increase in hull-less barley production, to make finishing cattle in Southern Virginia more economically viable. Already, there are producers in the Midwest who are finishing Virginia cattle on hull-less barley – if 229 could help farmers increase production of hull-less barley in Southern Virginia, that could open up the finished cattle market and garner large economic returns.

Both internal and external stakeholders noted that AREC facilities needed additional resources to expand capacity to conducts variety improvement and disease management for row crop production. For instance, field trials and field days provide farmers with trusted unbiased information that leads to adoption of more productive varieties and techniques. Investment at AREC can expand Agency's 229 capabilities of hosting such events and conducting the research. Part of enhancing the capacity of ARECs and therefore, the economic impact of research is additional funding to expand the outreach efforts. This outreach effort is an important part of the relationship with industry, as extension often relies on the needs of farmers throughout the Commonwealth.

Another area of increasing capacity at Agency 229 mentioned by stakeholders was increasing resources for research on new markets for existing crops. In addition to additional markets for barley, and wheat, there is interest in growing sorghum in Virginia for the vertically integrated hog market.

COMMUNITY IMPACTS OF AGENCY 229

To better understand how Agency 229 impacts the economy of Virginia outside of the five major industries listed above, researchers conducted four locality-based case studies. The three counties and one independent city are geographically dispersed, and vary in size, demographics, and top economic industries: Pittsylvania County, Washington County, Virginia Beach City, and Prince William County. The case study approach included phone interviews with extension agents in each county, online surveys of key stakeholders, and an analysis of the 229 impacts database (*Note: quotes in the following section are pulled from surveys or interviews conducted for the study)*. The triangulation of these three sources provide a deeper understanding about how Agency 229 impacts the economy at a community-level. We received 67 complete responses to the online survey, a response rate of over 90percent: 15 respondents from Pittsylvania County, 25 respondents from Washington County, 16 respondents from Virginia Beach City, and eight respondents in Prince William County. The database helped determine the type of programming at each office, supplemented with additional relevant information provided by agents.



Pittsylvania County

Pittsylvania County is the largest county in Virginia with about 983 square miles of rolling hills located at the foothills of Appalachia. The county is adjacent to the border of North Carolina and located in the central-southern Piedmont region of Virginia.[95] As of 2017, the county has a population of about 61,500 people.[96] Agriculture is the largest industry in terms of employment, with the highest amount of job occupations in the county listed as farmers and/or ranchers.[97] In 2017, the agricultural output in the county was over $122 million.[98] The top five agricultural outputs (sales of the product) of Pittsylvania County include dairy cattle and milk production, tobacco farming, beef cattle farming, crop farming, and animal production (Table 15).[99] The Pittsylvania extension office consists of three extension agents; a marketing coordinator, an administrative assistant, and a program assistant. The extension office noted that their strongest stakeholders are agricultural producers.

Table 75: Top five agricultural industries in Pittsylvania County

Description	Income	Output
Dairy cattle and milk production	$ 7,791,583.42	$ 37,709,163.67
Tobacco farming	$ 11,547,243.12	$ 28,364,912.03
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	$ 5,845,083.92	$ 22,762,189.87
All other crop farming	$ 8,679,793.36	$ 18,927,537.92
Animal production, except cattle and poultry and eggs	$ 3,026,192.11	$ 3,760,152.82

The importance of agriculture is mirrored the extension office extensive programming on Agriculture and Natural Resources, and 4-H Youth Development. Agriculture and Natural Resources programming focuses primarily on livestock and tobacco production, whereas 4-H programming promotes healthy lifestyles, and develops public speaking, and financial and agricultural literacy. However, the office's has robust programming in Family and Consumer Science, which focuses on increasing access to healthy foods for impoverished household, obesity prevention, and bed bug eradication. In addition, the office's Community Viability programming led to collaborative community talks on community engagement, facilitation, and resiliency. Figure 18 Succinctly summarizes the community's perspective on the impact of the local extension office's programming.

[95] About the County. Retrieved from: https://www.pittsylvaniacountyva.gov/327/About-the-Community
[96] EMSI data based primarily on the Quarterly Census of Employment and Wages (QCEW) from the Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA).
[97] Ibid.
[98] IMPLAN.
[99] Ibid.

Figure 18: Qualitative Impact of Virginia Cooperative Extension in Pittsylvania, according to survey respondents

Pittsylvania County VCE

Family and Consumer Science
"Any assistance to better prepare teens for adulthood financial challenges is important. The one day program in the county schools may be the only financial training some teens ever get."

Agriculture and Natural Resources
"The extension office is vital to the local farming community. Whether they are having an issue with livestock or their crops, the extension agents are a lifeline in helping the farmers get their issues resolved."

4-H Youth Development
"I believe that the programs 4-H offers is a positive for the younger generation as it gets them involved in something that will benefit them the rest of their lives."

Summary of Pittsylvania County's Extension Activities

The four extension focus areas are well represented in the county's activities from the last five years of programming. Following is a brief overview activities; a more detailed look at the county's activity can be found in Appendix Y (pg.)

Agriculture and Natural Resources:

Pittsylvania County extension agents dedicated a large portion of their time working with tobacco farmers. Extension agents work with tobacco producers helping with fertilizer best practices plans and diagnosing the health of tobacco crops. Tobacco companies require Good Agricultural Practices (GAP) training, therefore the county's extension office provides GAP courses for farmers. Without this support from extension, tobacco producers would have had to pay for training elsewhere, representing a significant cost for producers.

Virginia law requires all commercial pesticide applicators to be certified; therefore, the county's extension office organizes several pesticide application certification programs.

One tobacco farmer explained that since attending the pesticide recertification classes offered by VCE, his profits have increased.

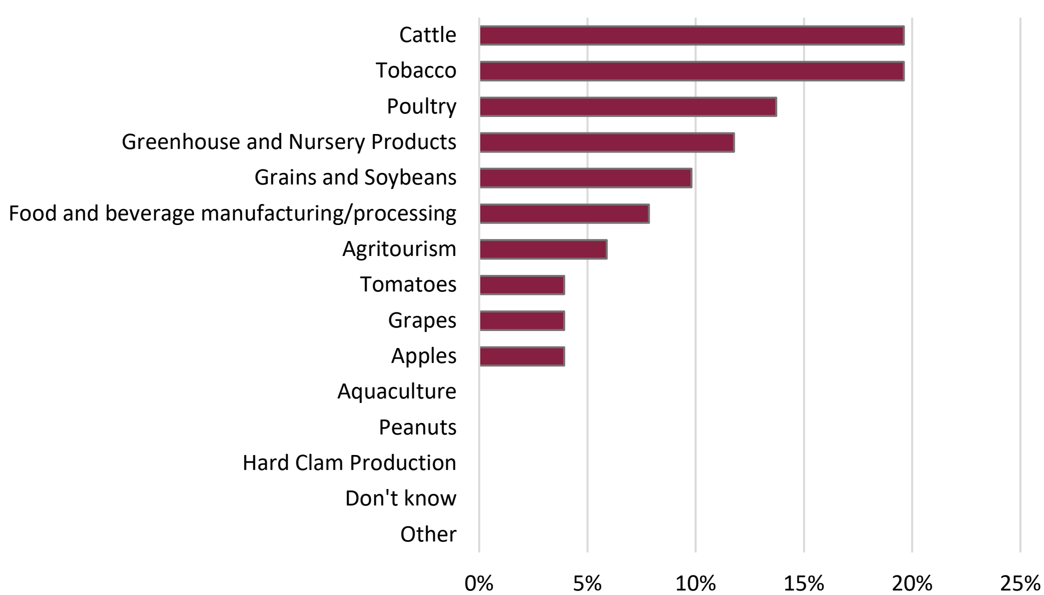
Additionally, the Pittsylvania extension office collaborated with the Tobacco Commission on a program to help tobacco-dependent producers find ways to diversify production. Through Tobacco Commission grants, the producers were able to increase livestock and grain production, or alternatively produce other locally grown food. The extension office also collaborated with the Tobacco Commission to initiate an Agriculture Energy Efficiency program to assess current energy usage and provide implementation strategies to save energy and reduce costs for farmers.

For cattle farming (dairy and beef cattle) agents help promote better business management and connect producers with insurance opportunities. Extension agents also help educate cattle farmers about the importance of higher quality genetic stock to improve the quality of their products.

To help mitigate the impacts of a decline in the price of fluid milk on producers, the extension office hosted a workshop about how to maintain milk revenues and protect dairy assets. In addition to protecting diary producers from volatility in the milk market, extension provided training on properly storing cattle feed. The Central Virginia Commodity Storage program, is designed to teach livestock producers on how to properly store hay for livestock feed. According the impact statement from the extension office, "In 2015, producers collectively stored 5,232, round bales of hay, 1,197 square bales of hay, and 23,000 bushel of grain. Producers saved $58,800 worth of feed resources through proper storage."[5]

Figure 19 highlights the agriculture industries community members stated as being most affected by extension programming. Both tobacco and cattle farming are the county's top agriculture commodities, and the survey results illustrate the responsiveness of extension's programming.

Figure 19: Impact of Virginia Cooperative Extension in Pittsylvania County, according to survey respondents



4-H Youth Development

The primary motive of 4-H programming is to help youth with thinking about the future and helping develop skills to obtain jobs. Most of the county's 4-H Youth Development programs emphasize and enhance building life skills such as critical-thinking and decision-making skills.

Part of the program developing life skills, included after-school sessions for elementary-aged children to practice public speaking. These classes were followed by several public speaking competition at the elementary school. "The Reality Store" teaches high school age children, about how to be fiscally responsible. In addition, "The Reality Store" enabled the students to think about career opportunities in the area. The extension office started a nutrition program called "Teen Cuisine" to teach children how to prepare nutritious food.

A participant's parent noted, "They learn how to execute a business plan that includes hard work, perseverance and sometimes failure. They learn from the failures and circumstances they can't control."

The 4-H program organized a livestock show and a workshop focused solely on horses, titled "Not Just Horsing Around". The two programs focused on agricultural literacy among youth; by teach participants of all the responsibilities associated with rearing livestock. For instance, participants learned about animal health, routine animal care, maintaining financial records, and marketing. In the equine workshops, participants learned about "barn safety, coloring and markings of horses, the science of biting, buying your first horse, horse packing and more."[100] Survey participants note that children who participated in 4-H livestock programs show leadership skills, become more responsible, and learn how to persevere when faced with challenging situations.

Family and Consumer Science

Family Consumer Science programming focused on food security, promoting healthy lifestyles, and prevention of bed bugs. Food insecurity is a pervasive issue in Pittsylvania County, and the county has a higher food insecurity rate (12.9%) compared to the statewide rate (11.8%*).*[101] Extension agents tackled food security by both improving and supporting local production, and increasing access of healthy food option for lower income populations within the county. Also, due to the county's high adult obesity rate (33%), the extension office organized an "Eat Smart, Move More" class for lower income household that are affected by obesity.

As previously mentioned the office has hosted a training on how to protect individuals and their businesses from bed bugs. These classes are part of a larger statewide initiative to eradicate bed bugs in Virginia. The event was located in Danville and drew expert faculty from Virginia Tech's Department of Entomology.

Community Viability

Community Viability programming in Pittsylvania County includes extension agents attending workshops on community engagement, leadership, facilitation skills, and resiliency. As a result of one of these

[100] Impact statement from the database of VCE programs.
[101] Impact statement, cited Feeding America.

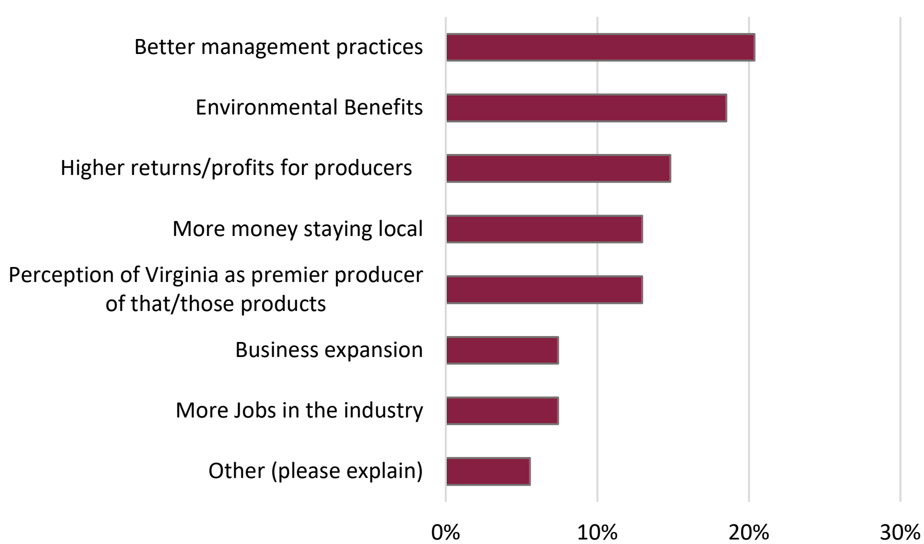
workshops, the Pittsylvania County Board of Supervisors reviewed and expanded their work plan and created specific growth strategies for 2017.

Community Recommendations to Enhance Extension's Impact

Figure 20 demonstrates how the extension office in Pittsylvania positively impacts the community —the top three areas include better management practices, environmental benefits, and higher returns/profits for producers. The farming community improved their management practices due to the extension office's assistance. The extension office explained their cost share programs as being most beneficial to farmers, citing these programs immediately improve a farmer's profits. An extension agent explained, "At least in the agriculture world, our clients really do appreciate the things that we do, and I do think that what we do is valuable to them."

In order to improve the economic impact of extension in Pittsylvania County, community members recommended adding more staff, more educational programs, and access to more programs. Increasing funding would also improve the efficacy of the county's extension office. Inconsistent staffing causes a deterioration of their relationships with community members and partners, thus negatively impacting their overall effectiveness. The extension agents also noted opportunities for new types of programming such as tapping into the large population of horse owners living throughout Pittsylvania County. Survey respondents explained that VCE does great work with the resources they are afforded from Agency 229 but would like to see continued information about crops and livestock, more youth agricultural programs, and more research on pesticides.

Figure 20: Impact of Virginia Cooperative Extension in Pittsylvania County, according to survey respondents



Washington County

Washington County is located in Southwest Virginia with the Appalachian Mountain range passing through it. Washington County's economy historically has been primarily agricultural-based. Once a county with strong tobacco production, in recent decades cattle farming and beef production have become the predominant agriculture industry in Washington County.[102] The population has remained relatively constant the last ten years, at 54,100 people. Washington County is one of the most prosperous counties in Southwest Virginia, in terms of agriculture production, but county extension agents note that the county has difficulty attracting new businesses.[103] While there has been a substantial decrease in the number of agricultural jobs in the last ten years, agriculture has the highest number of jobs in Washington County, followed by cashiers.[104] Washington County's agricultural outputs is over $81 million, in 2017.[105] Washington County's top five agricultural outputs include beef cattle farming, crop farming, poultry and egg production, dairy cattle production, and veterinary services as seen below in Table 14.[106]

The county's extension office is comprised of two extension agents, an associate extension agent, one program assistant, two administrative assistants, a small farms technician and a staff member focused on community nutrition. Over the past five years in Washington County, Agency 229 has funded programs related to cattle production, education, youth development, community development and forestry.

Table 86: Top five agricultural products in Washington County

Description	Income	Output
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	$2,187,019.14	$28,612,276.08
All other crop farming	$3,782,523.04	$16,824,462.89
Poultry and egg production	$1,137,359.25	$14,390,963.55
Dairy cattle and milk production	$ 833,307.98	$10,450,743.68
Veterinary services	$4,158,344.57	$ 9,327,895.16

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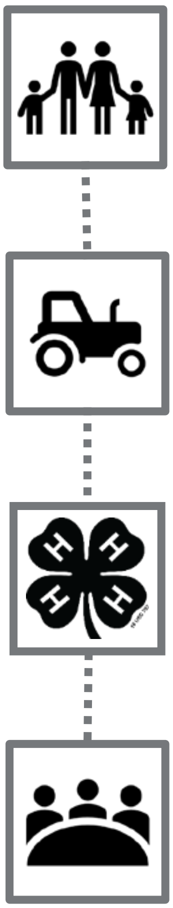
102 (2017). "A Brief History of Washington County, Virginia." Retrieved from: https://www.washcova.com/visitors/history/
103 Interview with extension agent.
104 EMSI data based primarily on the Quarterly Census of Employment and Wages (QCEW) from the Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA).
105 IMPLAN
106 Ibid.

Figure 23: Qualitative Impact of Virginia Cooperative Extension in Washington County, according to survey respondents

Washington County VCE



Family and Consumer Science

"This programming promotes family budgeting which is becoming much more important as the economy continues to tighten. It also promotes healthy eating through a community garden which means a healthier community."

Agriculture and Natural Resources

"It is good to know that there is a place that you can go to get answers to questions that arise from time to time. Nowhere else can you go to get researched based answers that are provided quickly and for free."

4-H Youth Development

"If it was not for 4H, I would not be in the position I am in today, as a leader in my community and industry."

"Our county has been blessed with a pool of great leaders who are current or former 4H members. In my own life, 4H helped me to become a better leader."

Community Viability

"It is very encouraging to have someone to come along side of you and help you understand how best to use the resources you have on your farm. We learned a great deal from the classes we participated in."

Agriculture and Natural Resources

Almost two-thirds of the programs, based on the database of impact statements complied by OED, offered in Washington County are related to the Agriculture and Natural Resources sector. Since cattle livestock operations are the largest part of the county's agricultural economy, the extension office offers substantial programming to support and bolster cattle producers. Survey respondents stated that extension agents provide the most assistance to cattle producers, followed by other agricultural industries like tobacco. Programs, specifically catered to the cattle industry, include a cattleman's course and the Beef Quality Assurance program. Both of these courses cover topics such as meat science, food safety, and learning about quality cuts of meat (see previous cattle section above for more information about the monetary impacts of the BQA feeder cattle program).

Since certified Virginia Premium Assured Heifers are valued at a price higher than non-certified cattle, extension agents have worked to increase the overall participation in the region. This program brings higher premiums, translating to higher incomes among livestock producers, and economic growth. In

2013, 2014, and 2016, extension agents worked with beef cattle producers to increase certification of cattle through this marketing program. In addition, Washington County extension provided educational programs, on-farm consultations, and vaccination verification. Specifically, extension agents worked with beef producers in identifying animals that could participate in the Virginia Premium Assured Heifers program and made recommendations based on production. The extension agents remarked that the premium for bred heifers varied from about $330 to $1,366 per head value-added. In 2016, the extension agents noted that the two programs they hosted on branding heifers created approximately $114,300- $119,700 for beef cattle producers. In addition, the calving process is paramount to producer success and the county extension office collaborated with local veterinarians to assist in this process

One of the livestock producers who attended a workshop about how to cope with hay shortages implemented the early weaning strategy, which helped a herd of about 700 to 800 cattle.

Due to hay shortages from adverse weather events in the county, the extension office organized meetings to help livestock producers cope with these adverse environmental and business conditions. The extension agents taught over 169 people, mostly livestock producers, about strategies to mitigate the effects of hay shortages "including early weaning, stockpiling fescue, replacing hay with grain, and suggesting other alternative feed options."[107] The extension agent noted that one of the livestock producers who attended the workshop implemented an early weaning strategy, which helped a herd of about 700 to 800 cattle manage hay shortages during that year. Moreover, the extension agents have also incorporated risk management sessions in order to educate producers on insurance and to help protect them from price fluctuations.[108]

Outside of livestock production, extension agents have robust programming in supporting both grain and tobacco producers. Producers learn technical skills from the extension programming like how to safely raise crops with pesticides, conduct soil testing, increase production, and grow quality forage. The extension office also has a cost share grant funded by the Tobacco Commission for $5 million, which has helped to improve facilities and variety genetics in tobacco. One survey respondent explained that extension agents have "helped me find markets for my products and increased my profitability." Survey respondents explained how extension agents have helped improve crops, expanded agricultural opportunity, and provide an excellent return on their investment. Farmers express they have become more efficient producers and better marketers due to extension programming.

To demonstrate the importance of extension's role in rural economies, the Washington County extension office, in collaboration with the Washington County Agriculture Advisory Committee and the Washington County Chamber of Commerce Agriculture Committee, conducted farm tours for about 30 legislators. The tour included a visit to a farm machinery plant and a food distribution center, provided decision makers an opportunity to learn more about the agricultural industry and the industry's importance to rural communities. Notably, the United States Senators representing Virginia, Mark Warner and Tim Kaine, attended the tour one year. These events were always well attended and highly regarded, as illustrated by a follow-up survey conducted by extension on participants.[109]

[107] Impact statement from database of VCE programs.
[108] Ibid.
[109] Impact statement from the database of VCE programs.

The office has robust programming outside of agriculture, including to support the timber industry and forest landowners. One such program focused on sustainable forest management with K-12 students. Not only did this program enhance the students' learning, it has expanded the local teachers' knowledge of the subject and given them confidence to teach about sustainable forest practices including how to "produce forest products, enhance wildlife habitat, and regenerate new forests for the next generation."[110] Additionally, the extension office developed a program to respond to trespassing on timber harvesting operations, and provided educational workshops on securing property boundaries to protect their natural resources; these workshops reached about 154 landowners.[111]

4-H Youth Development
4-H Youth Development is one of the extension office's most popular programs. Like many counties in Virginia, Washington County extension agents explained that one major challenge to economic growth is drug addiction. Addiction can threaten the reliability of labor and therefore negatively affect the county industries. The extension office believes that participation in 4-H reduces drug use through youth empowerment. Survey respondents believe that 4-H programs have a positive impact on youth through increased leadership skills, increased agricultural knowledge, greater sense of community and belonging, increased confidence, and better conversation skills. One survey respondent emphasized the importance of 4-H programming: "I would say put as much as you can into this program; the progress the youth develop is indescribable." Another survey respondent explained how youth who have participated in 4-H clubs have developed valuable interview and job skills and are more likely to be employed.

"I would say put as much as you can into this program (4-H); the progress the youth develop is *indescribable*."

The Washington County Extension Leadership Council conducted a needs analysis and determined youth leadership development as one of its most salient. In response 4-H Youth Development extension agents organized a program called "Strong Teen Programming" which specifically focused on teaching teenage-aged youth life skills and gave them a place to develop leadership skills. In 2015, about 210 Washington County youth attended a 4-H camp that focused on building skills like communication, teamwork, and responsibility.[112] About 89% of youth who attended the camp noted that they had learned how to take responsibility for their actions and improved their decision-making skills.[113] One camper explained that "camp has made me a better person overall," and another camper mentioned, "I learned to be patient with others."[114]

"I have never known another youth organization that prepares children so well with public speaking, leadership, and decision making skills."

County 4-H programming also focused on education; for example, the extension agents worked with fourth and fifth graders to sharpen writing and oral communication skills through a program titled "4-

110 Ibid.
111 Ibid.
112 Impact statement from database of VCE programs.
113 Ibid.
114 Ibid.

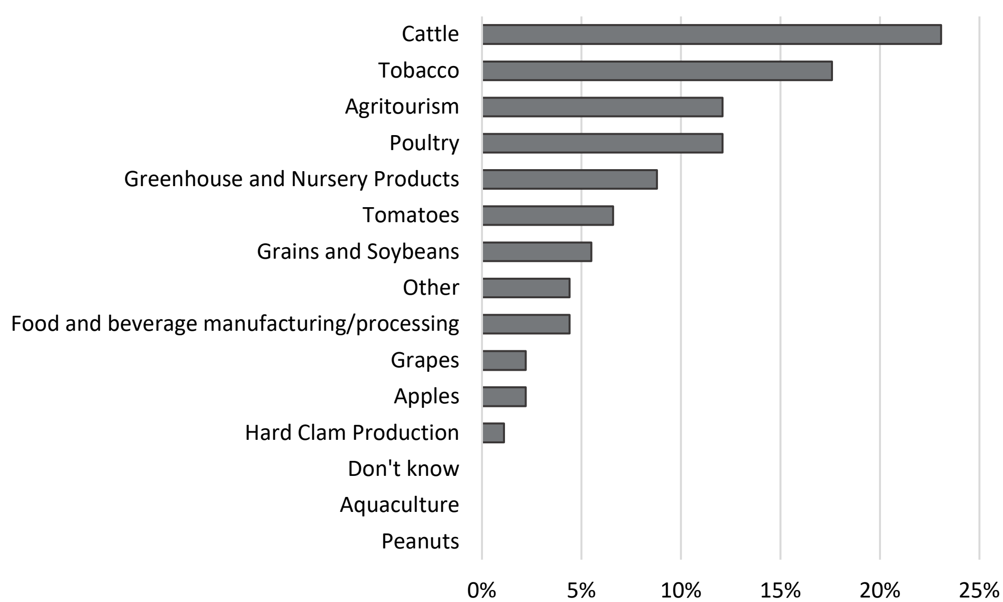
H’ers Become Great Speakers.” The instructors taught students about the 5-paragraph writing model in preparation, for a presentation contest hosted by 4-H, that had over 200 students participating. One parent articulated her satisfaction for the program stating, “I have never known another youth organization that prepares children so well with public speaking, leadership, and decision making skills.” The extension agents also hosted a History Bowl for fourth graders to improve their knowledge of history and Standards of Learning (SOL) scores; consequently, the Washington County School System administration credited higher SOL scores to the History Quiz Bowl.

Family and Consumer Science

In regards to Family and Consumer Science, the extension office offers courses on health, nutrition, and financial management. About half of the survey respondents – from the OED survey – were familiar with programming for Family and Consumer Science. The course taught participants how to prepare healthy meals, gardening and canning their produce, and developed nutritional education to promote a more vibrant and healthier community.

The extension office identified a need for food safety certification courses, so that residents could obtain jobs in the food industry. Therefore, the office held multiple courses reaching approximately 200 individuals in Washington County and surrounding counties.[115] The extension agent noted that 100% of those who participated, adopted at least one new food safety behavior from class. Extension agents explained that, based on the Center for Disease Control and Prevention (CDC), the average cost per foodborne illness cases in 2013, ranges from $1,068 to $1,626 and therefore, estimated the total projected economic impact for the courses was between $265,932 and $404,874.[116]

The office also participated in an initiative called “Stronger Economies Together,” where Washington County worked with surrounding counties to create a regional economic development plan based on regional assets.



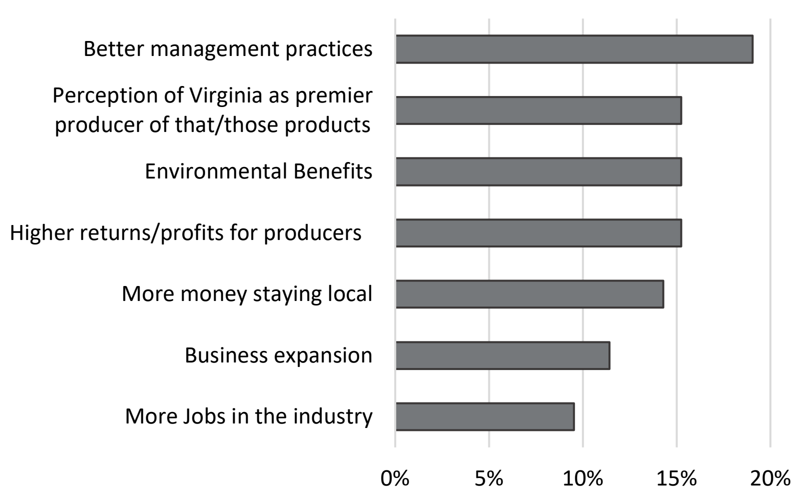
[115] Impact statement from database of VCE programs.
[116] Ibid.

Figure 21: Industries Most Impacted by Virginia Cooperative Extension work in Washington County, according to survey respondents

Figure 21 demonstrates the cattle and tobacco industries are the most impacted by the Washington County Extension Office's activities as reported by the survey respondents. These industries are the most important to the county – in terms of output –, illustrating a commitment to helping the area's producers and local economy. In addition to the industries listed in the survey, respondents cited hay production, sheep, Christmas trees and goats as important crops impacted by extension. Many respondents also wrote in "the entire community" when asked in which areas extension has the most impact.

Stakeholders claim the extension office has significantly improved the management practices for agriculture producers in the county. In addition to providing technical assistance to product, extension has also helped promote Virginia as a premier producer of agricultural products, provided environmental benefits through programming, and has helped increased profits for producers. Survey respondents believe that if the extension office received more funding, they could increase production and diversify their products into niche markets. Additionally, survey respondents, stated more funding towards extension could increase the reach 4-H Youth development programming, better adapt activities to community needs, and allow for better publicized events which would lead to larger impacts. The community expressed high praise for the work the extension agents have already accomplished through educational programs, and stressed that the office is the main contact for a variety of community needs. An area extension agent mentioned, "We are called on for almost everything. We get questions about everything." The Washington County extension office is not only an essential resource for agricultural producers, but for all the county's residents.

Figure 22: Impact of Virginia Cooperative Extension in Washington County, according to survey respondents



Virginia Beach City

Virginia Beach was colonized in the early 1600s and is now the most populated city in the Commonwealth. It has a population of about 455,000 people and covers about 307 square miles of land, water, and beaches.[117] Virginia Beach is located in Southeast Virginia on the waterfront; and is popular destination for family vacations. Virginia Beach is known for its oceanfront resort area, wildlife preserves and parks, cultural museums and a strong presence of military personnel and US national defense facilities.[118] The population of Virginia Beach has increased by about 5 percent (20,140 people) over the past ten years.[119] Population increases are mainly among the Millennial and Baby Boomer generations, while other all age groups have been declining (similar to national trends).[120] As the population increased in Virginia Beach City, there was also a 3% increase in the number of jobs in the last ten years. However, over this time period, there was a 14 percent decrease in the number of military jobs, which is still Virginia Beach's largest employer.[121]

Virginia Beach is racially diverse, and has experienced increases in the Asian and Hispanic populations over the past ten years.[122] The city is comprised of both urban and rural landscapes, with a mix of both high and low-income areas. Virginia Beach's primary industries include tourism, military bases, waterways, and agriculture. The output from the agriculture industry in Virginia Beach is over $18 million (2017).[123] Virginia Beach's top five agricultural outputs are commercial fishing, animal production except (cattle, poultry, and eggs), grain farming, fruit farming, and greenhouse, nursery, and floriculture production.[124] Based on reports from the Virginia Beach extension office, the total economic impact of agricultural products in Virginia Beach is estimated at $124,621,855 and the total value (sales) of agricultural products is $40,857,744.[125]

Table 97: Top five agricultural industries in Virginia Beach City

Description	Income	Output
Commercial fishing	$ 1,048,290.70	$ 11,669,638.63
Grain farming	$ (150,152.86)	$ 6,120,214.46
Animal production, except cattle and poultry and eggs	$ (158,126.53)	$ 4,135,844.71
Fruit farming	$ 359,777.97	$ 1,039,828.78
Greenhouse, nursery, and floriculture production	$ 535,001.29	$ 1,384,015.68

117 (2017). "About the City." https://www.vbgov.com/about/Pages/default.aspx
118 Ibid.
119 EMSI data based primarily on the Quarterly Census of Employment and Wages (QCEW) from the Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA).
120 Ibid.
121 Ibid.
122 Ibid.
123 IMPLAN
124 Ibid.
125 Virginia Beach VCE Reports

Virginia Beach's extension office is comprised of five extension agents, representing the following programs: Family and Consumer Sciences, 4-H Youth Development Animal Science, Horticulture, Agriculture and Natural Resources, and SNAP Education. There are three program assistants, an administrative assistant and a horticulture/agriculture/natural resources help desk volunteer. The Virginia Beach extension office works with both agricultural producers in rural parts of the city and with urban residents.

Agriculture and Natural Resources

Due to the importance of Virginia Beach's agriculture industry, the extension office has many programs geared toward supporting the agricultural community. The extension office provides technical assistance to farmers and teaches new methods to help farmers improve their practices. Extension has also conducted informative sessions on ham-curing, rain harvesting (with rain barrels), pest management, and both waste and water management. Also, through home gardening courses, extension agents have increased local youth's awareness and interest in learning the origins of food. In addition, the office has held several programs in financial literacy for both farmers, and urban high-school aged children. One survey respondent noted, "They are always professional, quick to respond, and knowledgeable."

"They [the extension officers] are always professional, quick to respond, and knowledgeable."

Virginia Beach's Master Gardener Volunteer program is very active in the region, and the Master Gardeners help the extension agents to host educational sessions on environmental stewardship. Included in these sessions are education on urban forestry, water quality, and sustainable landscape management. The Master Gardeners have also helped at local food banks by providing fresh fruits and vegetables from their own gardens. The volunteers also maintain demonstration gardens to teach Virginia Beach residents how to grow their own food. The Master Gardeners collaborated with the extension office to host a series of programs called "Ready, Set, Grow" which teaches first and second graders the importance of plants. A program called The Junior Master Gardener Camp provides an opportunity for underserved local youth to learn more about the environment and agriculture.

Due to its geographic location and proximity to the Chesapeake Bay, Virginia Beach extension work to promote environmentally friendly gardening practices to protect the bay. This includes a program called "Green Thumb Gardening Series," designed to encourage residents to be better stewards of the earth. Residents learn gardening techniques that promote safe environmental practices and protect the local water system. Attendees expressed satisfaction in the program with about 90% of attendees stating they would highly recommend the series to others and would attend the series in following year. Since the greenhouse and nursery industry is one of Virginia's top industries, the extension office offered a hydrangea producer workshop, with the aim of teaching growers strategies to maximize the efficiency in hydrangea production. In a different program to support the industry, the extension office collaborated with a private company to offer a workshop based on business management and marketing techniques for greenhouse and nursery producers.

Research conducted at the Hampton Roads ARECs, is focused on regional agricultural production and responsive to the regional agricultural community's needs. For example, strawberry producers identified the need to using proper fumigants on strawberry production in order to remain profitable. When a popular strawberry fumigant was recently banned, it negatively affected regional strawberry production and increased manual labor costs in order to control weeds. In response, AREC researchers are examining a better alternative fumigants to apply on strawberries. The research team working on this project intend to share their findings with regional strawberry producers, by hosting field days for the producers. In addition, the Virginia Beach extension office assisted in forming a Virginia Strawberry Association to "encourage, develop, and promote all phases of the strawberry industry in Virginia," as stated by a Virginia Beach extension agent.

In addition to specialty crops like strawberries, the Hampton Roads AREC studies wheat. Researchers at the Hampton Roads AREC discovered improved wheat varieties which could increase farmers' income by about $52.20 per acre (assuming wheat is valued at $6.00 a bushel). This finding and similar research is shared with wheat producers in the region, is published in local newsletters and a VCE publication. The extension office also helps agricultural producers by offering pesticide recertification programs, allowing producers to maintain their certification and continue to apply pesticides. Another way the extension office aids agricultural producers is by conducting Agriculture Damage Assessment impacts; these assessments evaluate the extent of damage caused by natural disasters. The assessments allow agricultural producers to apply for federal and state assistance following natural disasters.

4-H Youth Development

For 4-H Youth Development programming, the extension office organizes clubs and camps to teach youth about leadership and citizenship. The 4-H camp has a wide reach, in the 2015-2016 4-H year, 244 youth participated in 4-H community clubs, 269 youth participated in 4-H clubs on the military bases, and 5,205 youth participated in 4-H sponsored school enrichment activities.[126] The Virginia Beach extension office also, offers 4-H camp for ages 9 to 13, which that emphasized the development of attendees communication skills and confidence. The extension office reported that 96% of youth felt they could now talk to other teenagers and adults, as a result of the program.[127] This particular 4-H camp is consistently at capacity, which is an indication that the camp is well received by the community. The Virginia Beach extension office also hosted "Camp Millionaire," that provided children with an introduction to financial literacy and taught them how to become financially independent. Moreover, local teenagers ranging from 14 to 18 participated in the State 4-H Congress, where they learned skills such as networking, leadership, teambuilding and becoming more culturally aware citizens. Since much of the Virginia Beach student population is not aware of where their food originates, the extension office hosts annual farm day events to teach students about crops, livestock, poultry, beekeeping, horticulture, forestry, conservation, water quality, food and nutrition.

4-H Programming from 2015-2016

- **244 youth participants in community clubs**
- **269 youth participants in military clubs**
- **5,205 youth participated in school enrichment activities**

[126] Impact statement from database of VCE programs.
[127] Ibid.

Family and Consumer Science

Virginia Beach's Family and Consumer Science programming offers an array of educational sessions covering topics like financial literacy, household cleaning, promoting healthy lifestyles, and integrated pest management strategies for bed bugs to the Virginia Beach community. In a course about building financial capacity with adults, the participants learned how to establish financial goals, write a spending and saving plan, create a plan to pay down debt, and review their credit report annually. This is part of the larger VCE financial courses offered across Virginia that reaches about 6,507 residents annually.[128] Before these statewide courses, only 31% of participants had a plan to pay down debts whereas after the course about 85% had written a plan.[129] In addition, the Extension Leadership Council, the City of Virginia Department of Human Services Family Center Unit and Child Protective Services were concerned with the cleanliness of family households in certain parts of Virginia Beach. In response to this concern, the extension office organized monthly workshops to help families create housekeeping plans and learn how to properly clean their homes. As part of Family and Consumer Science programming, the extension office also participated in a statewide Department of Agriculture and Consumer Services (VDACS) project on the Pesticide Control Act; their objective was to create a team of urban pest consultants to help create and implement integrated pest management plans for facilities in their respective localities.

Figure 24: Industries most impacted by Virginia Beach Extension, according to survey respondents.

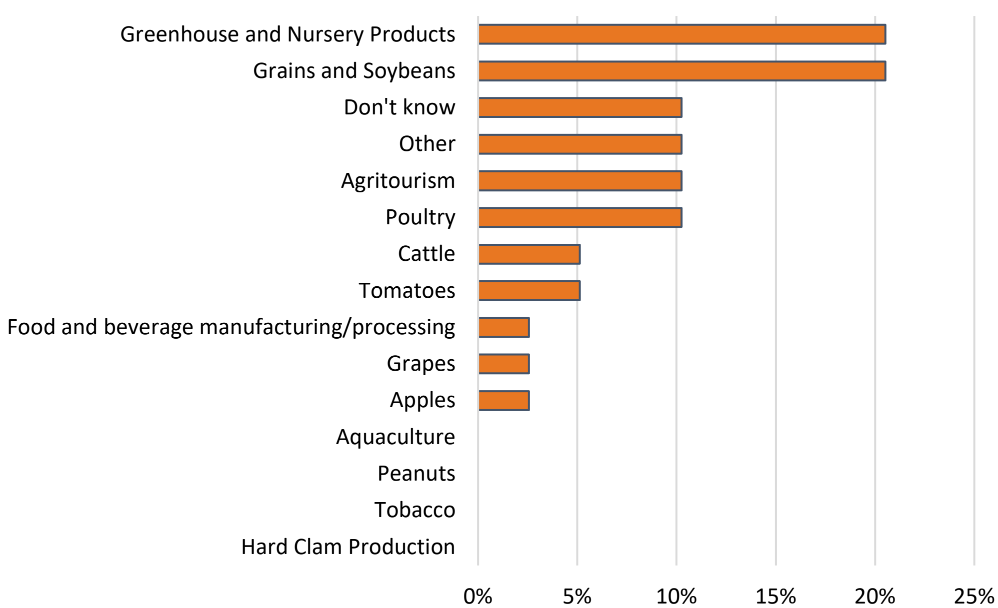
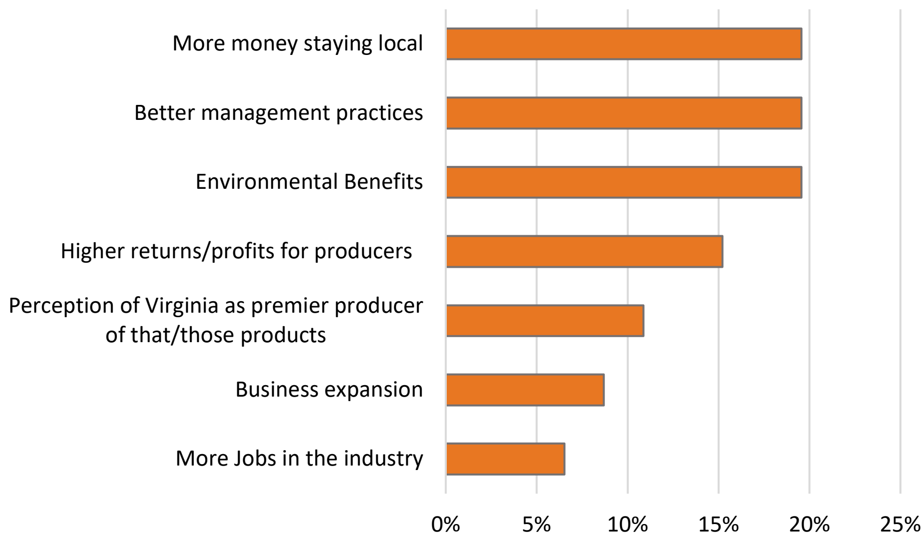


Figure 24 represents the industries most impacted by Virginia Beach Extension according to the survey respondents. The industries most impacted by Virginia Beach VCE, according to survey respondents,

[128] Impact statement from database of VCE programs.
[129] Ibid.

were greenhouse and nursery products, and grains and soybeans. Other important industries cited by respondents include strawberries, pumpkins, hops, and the equine industry.

Figure 25: Impact of Virginia Cooperative Extension on Virginia Beach, according to survey respondents



According to the survey, community members believe that the extension agency has helped to keep money local, improve agriculture management practices, and provide environmental benefits. The extension agency could increase their economic impact with more funding since they primarily rely on volunteers. When asked how they would utilize an increase in funding, extension agents explained they would invest in research to improve facility technology to improve communication with local producers. For instance, agents explained that they spend a large part of their days coordinating e-mails and text messages to communicate with producers. Community members expressed that they would like to see the office increase their outreach to better serve the whole community. They hope that funding continues for current programs and that additional funding is allocated to fill current vacancies at the extension office. An agent also explained that much of the programming occurs due to the large number of local volunteers. However, agents believe they could be more effective in reaching residents if they had at least two extension agents in each area rather than one or at a minimum have an additional agent dedicated to coordinating volunteers. Another community member mentioned improving relations among nonprofits and municipalities, but noted the agency is doing great work on behalf of the community despite their funding and staffing constraints.

Figure 26: Qualitative Impact of Virginia Cooperative Extension on Virginia Beach, according to survey respondents

Virginia Beach VCE

Family and Consumer Science
"Any time we can reach children and adults who may face challenges, I think the community benefits. I believe the positive effects are most immediately seen from the evaluations and feedback forms given during the events where people share what they learned and how it will change how they think about money."

Agriculture and Natural Resources
"In an area that is determined to develop on every single parcel of land it can find, programs such as these are vital to maintaining our agricultural roots."

4-H Youth Development
"The 4-H program has a positive effect on youth by providing them an atmosphere of team building, individualism, caring for their natural resources, and providing them with insight into agriculture and the connection of where their food comes from."

Community Viability
"Extension in Virginia Beach is the place to go for answers. Team support and collaboration with the public and private sector continues to be a key role in the City."

Prince William County

Prince William is situated in Northeast Virginia, extends to the Potomac River, and houses the large Quantico military base. The county has experienced increases in population, jobs, and minority groups during the past decade.[130] The population in Prince William County is comprised of about 463,900 people, which is a 26 percent increase over the past 10 years[131] All age categories have seen an increase during this time. In terms of race and ethnicity, the Hispanic population in Prince William County has increased by about 43 percent and the number of African-American residents increased by 39% percent over this time. These population increases have been met with similar job increases, with about a 27% increase in the number of jobs in the county (about 41,021 jobs). [132] The military base is the largest employer in the county with approximately 8,200 jobs as of 2017.[133] Agriculture does not play as large of a role in Prince William County, as it does in other counties and this is reflected in the programming conducted by VCE in the county. Agricultural economic output is over $17 million, the lowest of the counties compared in this study.[134]

Prince William's extension office has 23 permanent staff positions, although most of these positions are part-time. The office manages about 1,400 volunteers, allowing for extensive community programming. Since their population demographics have become more diverse in the last ten years, the extension agency has adapted to respond to these demographic changes. For example, due to the substantial increase in the Hispanic population, the extension office started providing educational sessions in both Spanish and English.

Prince William County's extension programming primarily revolves around community education courses in areas such as financial education, familial communication, 4-H clubs, children safety courses, nutritional education, and some local gardening instruction sessions. According to the impact statement database compiled by OED, the majority extension programming is in health, pest management, vegetable gardening, lawns, water quality, and youth development.

Agriculture and Natural Resources

The county extension's Agriculture and Natural Resources programing primarily focused on school gardens, pesticide application, the Master Gardener program, and lawn management. With over 200 people participating in the Master Gardener Volunteer program, the Master Gardeners are active in helping with extension programming throughout the county. The Master Gardeners have helped with water quality education sessions, a lawn class on soil testing and fertilizers, and assisted local farmers at farmers markets. The extension office hosted educational programs with help from the Master Gardeners about protecting water quality since the county is located inside the Chesapeake Bay watershed. The Master Gardeners also, connect producers at farmers markets with food pantries, in order to donate excess produce that was not sold. The Master Gardeners developed a program called "Plant A Row," were the volunteers donate fresh fruits and vegetables to a local foodbank.

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[130] Prince William County Government. "About Us." http://www.pwcecondev.org/about-us
[131] EMSI data based primarily on the Quarterly Census of Employment and Wages (QCEW) from the Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA).
[132] Ibid.
[133] Ibid.
[134] IMPLAN.

In 2016, the Prince William extension office assisted with over 300 lawn management plans for their residents.

Since about half of Prince William County is urban and many residents have lawns, extension staff obtained certification to do nutrient management plans. Last year the office wrote about 300 lawn management plans for Prince William County residents.[135] [136] The Prince William extension office believes that residents have the right to well-researched, unbiased information, so local residents can make informed decisions. For instance, a lawn care supplier might persuade residents to use a certain brand to care for their lawn, however it might not be the most environmentally safe brand.[137] The office offers a commercial landscaping workshop, and over the course of six weeks, the workshops informs participants on best practices. Topics include: plant disease, pests, pruning, care of trees, weeds, pesticides fertilizer, and turf. About 93% of the attendees thought the course material offered in the workshop would be useful to them in their jobs and had plans to implement these best practices.[138]

4-H Youth Development

"We are pleased that our 4-Hers are being forced to use critical thinking, analysis and other higher-level thinking skills. We are so thrilled that 4-H has been provided this grant and we know the youth will greatly benefit."

4-H programs in Prince William County promote healthy eating, exercise and programming about home safety. Since most parents work full-time in Prince William County, extension developed programming on educating families on youth safety when they are home alone. One program called the 'Safe at Home, Safe Alone' classes, help fourth graders feel more confident about being home alone. About 7,000 county youth demonstrated they had learned something new as a result of these courses, through the administration of pre- and post- tests.[139] Moreover, there is a high presence of gang related activities in Prince William County and therefore, the extensions office's 4-H programming has emphasized keeping children out of dangerous situations by providing community service activities and teen mentor programs. The county's 4-H programming includes after-school clubs to provide additional learning experiences including opportunities for youth to learn more about Science, Technology, Engineering, and Math (STEM)-related activities like robotics, broadcasting, and radio technology. The leaders of the 4-H STEM programming in robotics expressed satisfaction when stating, "We are pleased that our 4-Hers are being forced to use critical thinking, analysis and other higher-level thinking skills. We are so thrilled that 4-H has been provided this grant and we know the youth will greatly benefit."[140] 4-H programing in Prince William County also promotes healthy lifestyles among children with the "Get Fit, That's It" program. This program educates students from pre-school to high-school age about how to lead healthy lives. Some of the topics included drinking more water, incorporating fresh fruits and vegetables into their diet, and spending at least an hour a day

[135] Dalton, C. (2016). Rural Preservation in Prince William County. Retrieved from: "http://eservice.pwcgov.org/planning/documents/CPU/Rural_Preservation.pdf"
[136] Impact statement from database of VCE programs.
[137] VCE Extension agent phone interview.
[138] Impact statement from database of VCE programs.
[139] Prince William County Programming Statistics from 2017
[140] Impact statement from database of VCE programs.

being physically active. In addition, 4-H programming includes environmental and natural resources projects that have also helped youth learn about how to be responsible, environmental stewards through community service activities.

Family and Consumer Science

Prince William County extension office has extensive programming in the area of Family and Consumer Science. For instance, the Master Food Volunteer Program promotes healthy lifestyles in both adult and youth residents of the county. The Chef Clubs, offered in middle schools, assist with childhood obesity prevention by teaching children how to cook healthy food options. Much of the programming conducted through this program included topics like nutrition education on meal planning, food safety, and physical activity. In addition, the extension office collaborated with the Risk Management Department of Prince William County to create a wellness program for its employees. Another program developed by extension office taught people how to live with diabetes. Diabetes is prevalent in the county, with a reported 10% of the population living with diabetes, which is the sixth leading cause of death in Virginia.[141] The classes taught people how to create lifestyle changes in terms of nutrition, physical activity, medication compliance, and stress management. In addition, the county's health programming has focused on Supplemental Nutrition Assistance Program (SNAP) education. Extension worked to promote SNAP vouchers at farmers markets and teaching residents about how to stretch their SNAP dollars to receive the most value.

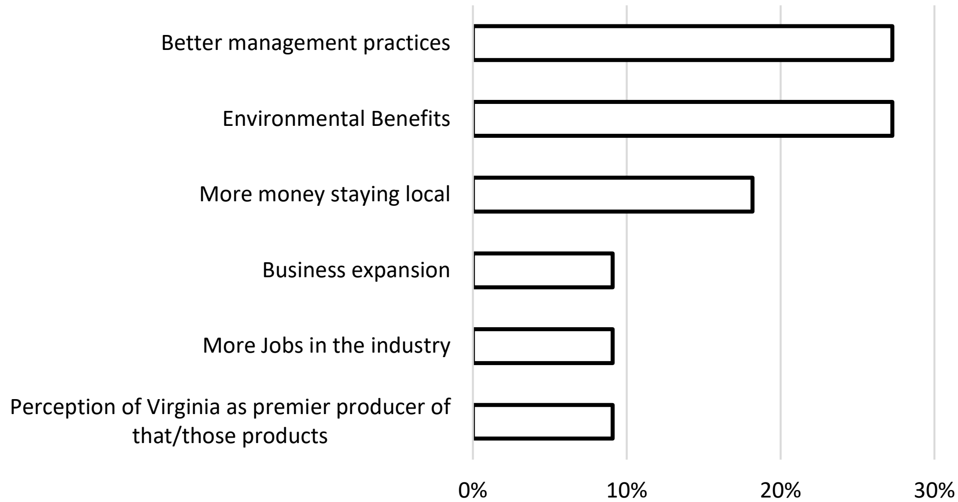
Housing and financial management is also part of Family and Consumer Science programming. Notably, the extension staff includes a Department of Housing and Urban Development (HUD) Housing Counselor. In the last year, Prince William County saved about 130 families from losing their homes to foreclosure, and 97% of the office's mortgage default clients did not lose their homes to foreclosure.[142] Much of the programming is based on helping residents with their finances through 57 financial educators, the majority of whom are volunteers. About 96% of residents who attended financial education courses improved their knowledge in the subject. As a result of one-on-one counseling, about 94% of clients improved their financial situation over time through increased savings, reduced debt, and/or an improved credit score.[143]

In 2016, Prince William County saved about 130 families from losing their homes to foreclosure through financial counseling.

Finally, the extension office has provided programming targeted at inmates transitioning back into community life by conducting educational sessions about intra-familial communication skills and how to be self-sufficient members of society. The office have provided a variety of family support programs including courses in family communication and parenting. According to survey respondents, the family programming has helped families with their finances, has decreased recidivism in the county jail, has increased mothers' abilities to cope with parenting challenges, and has created more educated and resilient citizens, thus promoting a safer community.

[141] Impact statement from database of VCE programs.
[142] Prince William County Programming Statistics from 2017.
[143] Prince William County Programming Statistics from 2017.

Figure 27: Impact of Virginia Cooperative Extension in Prince William County, according to survey respondents



As Figure 27 denotes, survey respondents explain that Prince William County's extension office has improved their management practices, provided environmental benefits, and helped money stay local. In order to improve Prince William County's economic impact, if more of the staff were permanent full-time positions rather than part-time, the extension office would be able to assist more community members. Another challenge the extension office has faced includes a lack of funding for marketing, especially through social media. The office could increase their outreach if they were able to increase their social media presence. The extension office explained that without their extension office, foreclosure rates in Prince William County would rise steeply, bankruptcy filings would be greater, and nonprofits would have to spend more money to fill other roles that extension provides to Prince William County residents. The extension office provides un-biased information and improves the economic value in the community through education in both classroom and one-on-one advising sessions. Prince William County extension office has demonstrated their far-reaching impact through educational programming in an urban context.

Figure 28: Impact of Virginia Cooperative Extension in Prince William County, according to survey respondents

Prince William County VCE

Family and Consumer Science

"They help several inmates to maintain their financial awareness so they can control their budgeting. The program has and will continue decrease the recidivism rate in our jail."

Agriculture and Natural Resources

"Better environmental stewardship as far as care and maintenance of homeowners' turf and landscape. More judicious use and application of chemicals to yards."

4-H Youth Development

"Young people gained an added sense of responsibility and a better understanding of the environment."

Community Viability

"Our community is a better place to live, work and play."

Key Takeaways of Community Case Studies

Each Virginia Cooperative Extension office in these case studies adjusted their programming to best fit the needs of their communities. For example, the two rural case studies, Pittsylvania County and Washington County both spend a majority of their programming on agriculture by assisting producers through technical assistance and educational programming. In Pittsylvania County tobacco is the primary agricultural product followed by cattle. Thus in a phone interview, the county's extension agents explained that the office spends a large amount of their effort diagnosing tobacco plants and helping improve farm management practices. The cattle industry is the top agricultural industry in Washington County, with survey respondents noting that the county extension agents provide the most assistance with area cattle farmers. However, because illegal drug use has also been an issue in Washington County, the VCE office responded by increasing their 4-H programming to promote youth development to deter children from drug use. This was considered the most popular program according to survey respondents in Washington County.

Virginia Beach's extension agency works in both a rural and urban context and with low and high income residents. In addition to working with agricultural producers, extension agents spends much of their time working in urban topics like financial planning, food security, youth development, and urban forestry. Prince William County's extension office is an example of an extension agency adapting to provide programming to the changing needs of the community. In recent years, the Hispanic population has increased, thus the extension office began to offer educational sessions in both Spanish and English. The Prince William County extension office also, focuses heavily on community development efforts, specifically financial management, home ownership, family communication, and youth development. Each of these case studies provides insight into how extension agencies, that vary both geographically and demographically, respond to the challenges of their communities.

Their resulting impacts are positive and vary upon the activity type. Interviews with VCE agents and survey responses from those who participate in Extension activities cited various impacts as a result of VCE programming. For example, technical agricultural assistance resulted in improved environmental practices, more efficient producers, increased profits, and overall better farm management practices. One producer mentioned that they have a sense of security knowing the extension agent is an available resource. Positive impacts from 4-H programming included youth developing leadership skills, improved work ethic, public speaking skills, presentation skills, and communication skills and overall improved their self-confidence. Those who participated in family and consumer science programming mentioned improved personal financial management, healthier livelihoods, food safety courses provided workforce development for businesses, self-sufficiency through food preservation and home gardening.

Table 108: Positive impacts based on VCE programming activity type

Family and Consumer Sciences Programs	**4-H Youth Programs**	**Community Viability Programs**	**Agriculture and Natural Resources Programs**
- Improved personal and familial financial management - Healthier livelihoods through improved nutrition -Workforce development - More self-sufficient citizens - Fills educational gaps within the community - Improved quality of life for those who take advantage of the programming - Decreased habitual offender rates - More resilient citizens	- Increased leadership skills - Improved work ethic - Gained public speaking and presentation skills - Increased self-confidence - Animal husbandry skills - Financial records and budgeting knowledge - Future leaders in society - Healthier lifestyle choices	- Increased farm profitability - Expanded agricultural opportunity - Excellent return on investment - Improved community food systems - More informed community members - Increased self-sufficiency	- Improved environmental practices - Better environmental stewards - More efficient producers - Increased agricultural profits - Better farm practices and production - Improved marketing skills - Good relationships with extension agents - Improved land value - Increased environmental awareness - "Better community to live, work, and play"

To enhance these impacts, VCE should continue to be responsive to the needs of its changing communities. Particularly as urban areas grow in Virginia and economies in rural regions are revealed to have more systemic challenges (e.g. opioid addiction), programming offered through 4-H as well as Family and Consumer Sciences may prove to have greater social and economic impacts than what Agency 229 is traditionally known for—direct industry assistance. As illustrated in the case studies, this type of programming can contribute to better personal and professional financial management as well as can prepare participants for healthy, self-sufficient lifestyles in which they contribute to communities and economies through the workforce and volunteering. Funding for this type of programming is lower compared to other Agency 229 funding, which may indicate a need to create more flexible funding.

RECOMMENDATIONS AND CONCLUSION

Faculty and industry stakeholders agree that the intersection of research and extension is where 229 has the greatest impact for the greatest number of Virginians. In order to increase the impacts described in the five industry and four community cases, there are several areas of focus.

1. Increase applied research in Blacksburg that is directly responsive to Virginia needs as identified by local agents. There is concern among stakeholders that much of the Blacksburg-based research is motivated by federal grants, rather than local needs. Blacksburg-based researchers contend that funding and the tenure-track incentive structure limits the amount of research conducted that benefits only specific communities. Economic returns to basic research can extremely high, and impacts of this broader research have the potential to affect many Virginia

communities, however the return on investment from that research often takes many years (experts estimate that it takes 15-20 years for basic agricultural research to produce significant returns). Balancing this ratio of research, incentivizing site-specific applied research, and connecting specialists to agents more effectively may lead to greater economic impacts at the local level.

2. Upgrade AREC facilities to allow producers to see latest technology and methods first hand in order to adopt them and increase their incomes, also attract new industries. The pilot plant in the HAABI building is the greatest example of industry and research collaboration leading to industry attraction and growth. Many ARECs across the Commonwealth do not have these types of upgraded facilities, which hinder both industry engagement, and the ability of current producers to expand their operations and become more profitable. Upgrading these facilities to keep them current with the latest technology could reap large economic rewards in other key Virginia industries.
3. Industry representatives recommend that the work of the program teams be expanded and deepened. There needs to be a more streamlined and organized way for companies or producers within the key industries to pose problems and easily access the facilities and expertise needed to grow their businesses.
4. Connect the social science departments (especially AAEC and ALCE) with the other CALS, ANR, and Vet Med departments to conduct adoption studies and ROI analysis to estimate past and future impacts of technologies and process improvements that encourage private investment. Throughout our research, we found numerous examples of areas of great economic impact. However much of this impact has not been quantified. For some industries, for example the cattle industry and the row crops industry, it is easy to see the level of adoption and rate of return of agricultural innovations and management practices. However this calculation is more difficult for the non-commodity agriculture industries, and in the case of non-agriculture extension programming. Connecting this research with one or both of the social science departments within the College of Agriculture could help researchers and agents measure the adoption of recommended practices and varieties, assess the productivity increases, and subsequently measure the monetary economic impact of extension and research activities.
5. Increase reach and dissemination of applied research in Blacksburg and at ARECs. It is a consensus among internal and external stakeholders that the reach of VCE needs to expand. There are several suggested ways of doing this. One way often cited in interviews is through personnel development of extension agents. Increased funding that encourage quality agents to be hired, and stay could greatly increase the impacts of 229 research funding. Another area is in the development and promotion of up-to-date publications, placed on the website, and search engine optimization strategies to ensure that search queries return VCE information first.
6. For extension, see which programs could adopt the framework of the beef and timber VCE programming. These programs have collaborative education programs with a single economic goal (for beef to improve the quality of beef and for timber to reduce forest regrowth time). Education material and curriculum is adapted from faculty research, and presented in a clear and applied manner that improves the production techniques for each industry. Moreover, these industries incorporate private industries and associations to help develop and market the products for each industry. Expanding the BQA program and the SHARP logger program could lead to very large economic returns.

Our analysis shows that Agency 229 has an extremely high impact on Virginia's economy. VCE extension and research is critical to the health of each of the five top agricultural industries in Virginia. Indeed, without 229 funding, it is not clear if these industries would exist in Virginia, resulting in the loss of billions dollars of economic benefit. 229 also impacts each community in the Commonwealth. Beyond technical assistance to agricultural producers, extension helps individuals lead healthier lives, plan for their futures, and have stronger families. Ultimately, it is people who make up an economy, and the more productive these people are, the stronger an economy is. While tax incentives can play a role in the decision of a company to relocate or expand, workforce is most commonly cited as a major factor in a company's decision making process. VCE provides tremendous benefits to communities, and hence the workforce. This shows that VCE doesn't just impact agricultural industries, but nearly every other industry in Virginia. Upgrading facilities and extending the ability of extension to play a greater role in people's lives can have large positive economic consequences. The magnitude of those benefits might be impossible to quantify, but stakeholders agree that they are critical to the continued growth of the agricultural sector, and the health of the residents of the Commonwealth.