CENTER FOR ECONOMIC AND COMMUNITY ENGAGEMENT
VIRGINIA TECH

Virginia Cooperative Extension

Economic Valuation Assessment of Natural Resources Programming

Virginia Tech Center for Economic and Community Engagement

Updated: August 2026

Executive Summary

Virginia Cooperative Extension (VCE) plays a vital role in delivering research-based education and Extension programs that enhance the well-being of individuals, communities, and natural systems across the Commonwealth of Virginia and beyond. To better understand how these Extension programs impact local economies, representatives from the VCE natural resource management program team partnered with the Virginia Tech Center for Economic and Community Engagement (VT CECE) for an economic valuation assessment of programming.

The assessment included a comprehensive literature review, semi-structured interviews with key VCE natural resources faculty, and a workshop designed to engage VCE natural resource management personnel in finding common themes among their program impact areas that may translate into economic benefit for Virginians. Five specialists and two agents from VCE's natural resource management team represented a diverse set of programmatic areas, allowing for identification of cross-program alignments under the Natural Resources, Forestry and Environment initiative of Virginia Cooperative Extension.

From this process, VT CECE developed a shared logic model to organize some of VCE's natural resource programming into several overarching focus areas. Among these, **forest products, ecosystem services, and human health and safety** emerged as critical domains with clear opportunities for economic impact evaluation. This report highlights the human health and safety domain by presenting an economic impact statement that integrates metrics currently collected by select VCE natural resource faculty with values derived from existing literature. The economic impact statement demonstrates how natural resource programming has provided Virginians with cost savings through the prevention of acute gastrointestinal illness and lead exposure, access to low-cost water testing, avoided workplace injuries through improved logger safety, and outdoor health benefits associated with increased time in nature. The total human health and safety-related economic impact of select programs under the VCE Natural Resources, Forestry and Environment Initiative in 2025 was estimated at $6.74 million.

By aligning VCE's natural resource programmatic data with evidence-based economic valuation, this analysis provides a defensible and transparent estimate of the economic contributions associated with human health and safety outcomes. The resulting framework both strengthens the team's ability to communicate its impact to stakeholders and establishes a replicable model for evaluating additional program areas in the future.

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Process Overview

Virginia Cooperative Extension (VCE) programs provide meaningful outcomes for participants and natural ecosystems. However, translating these outcomes into measurable economic value and documenting collective impact requires structured evaluation. An overview of the processes and methods used to document collective impact is outlined here, with detailed information on the appropriate sections provided throughout this report. This summary is intended to provide guidance for future evaluation efforts of other identified impact areas.

Phase 1: Scoping and Literature Review

Upon initial program launch, VT CECE staff met with key VCE natural resource management faculty interested in economic evaluation. Five VCE specialists and two VCE agents sent in various annual reports and programmatic data to the VT CECE team to guide the project's focus. These initial reports laid groundwork for a robust literature review, capturing information on current evaluation tools used by VCE natural resource management personnel and promising practices from other Extension programs.

VT CECE evaluated existing academic studies, policy reports, and Extension evaluation frameworks in a literature review documenting best practices in impact evaluation and extension evaluation. The literature review ensured that evaluation methods were grounded in defensible, peer-reviewed methods.

Phase 2: Stakeholder Engagement and Data Collection

VT CECE then developed an interview protocol and conducted semi-structured interviews with VCE natural resources personnel across multiple program areas (see Appendix A.). The diversity of programmatic experience (ranging from water quality services to logging programs to natural resource volunteer efforts) was essential for capturing a holistic view of VCE natural resources programming conducted as part of the natural resources, forestry and environment initiative.

Based on key themes identified from interviews and the initial program reports and data shared, VT CECE coordinated a one-day workshop with collaborating VCE personnel to identify shared impact areas. This workshop featured a presentation of initial literature review findings, along with activities to identify program outcomes and outputs, which fed

into larger thematic areas. VT CECE also presented a draft unified logic model developed through analysis of interview responses.

From this workshop, the VCE natural resources faculty and VT CECE staff identified three core areas that all programs represented in the workshop contributed to: **human health and safety, forest products, and ecosystem services.**

Phase 3: Synthesis and Economic Valuation Assessment

Following the workshop, VT CECE distributed worksheets (see Appendix A.) to all participating members present designed to further capture their outputs and outcomes in the lens of the three identified thematic areas. VCE natural resources management representatives captured their respective program's activities, outputs, and outcomes as related to the three core areas.

After analyzing worksheet responses, VT CECE developed an economic impact statement and refined unified logic model based upon VCE faculty reactions and insights. The impact statement was derived from integrating the VCE team's existing metrics with valuation estimates provided from existing literature. This involved:

- Translating program outputs into measurable outcomes
- Identifying appropriate economic proxies or valuation factors
- Ensuring methodological transparency and defensibility

Together, this evaluation process requires significant time investment from VCE faculty to ensure that the evaluation team has appropriate materials, insights, and understanding of shared processes. VCE faculty may invest time in gathering appropriate program data, participating in interviews and workshops, and discussing areas of shared impact. Evaluators also invest significant time and resources through developing stakeholder engagement materials, analyzing VCE reports and external literature, and compiling impact statements, logic models, and reports documenting these efforts.

The evaluation process is time and resource intensive, and underscores that Extension and evaluation staff alike must devote ample time to adequately document and understand areas of shared economic impact.

Review of Literature

Cooperative Extension serves as a foundational component to the United States' approach to public education and community engagement. The Smith-Lever Act of 1914 created a formal partnership among land-grant universities, federal agencies like the United States Department of Agriculture, state, and local governments to provide community education. Initially, Extension programming focused on agricultural productivity, though has now expanded nationwide to include programming on youth development, public health, environmental sustainability, and community engagement. This model allows Extension services to address regional needs while maintaining a shared national mission.

Within the national Cooperative Extension system, Virginia Cooperative Extension (VCE) first developed from Virginia's long-standing agricultural tradition. During the 1800s, agricultural knowledge was primarily shared through fairs and informal exchanges, with limited access to formal education. Following the passage of the Morrill Land-Grant Act of 1862, agricultural education was more widely accessible and standardized at Virginia Tech. Land-grant universities particularly emphasized practical education in agricultural and mechanical arts. The Smith-Lever Act of 1914 formally established the Cooperative Extension System, creating a structured partnership between universities and local communities to share research-based knowledge.

Early Extension work in Virginia typically involved Extension specialists and agents providing hands-on education directly to those in the agriculture industry. Over time, Extension programs diversified to offer home-based education on nutrition, household management, natural resources, and positive youth development. Today, Virginia Cooperative Extension operates through a cooperative partnership among federal, state, and local governments, with support from the U.S. Department of Agriculture and Virginia's land grant institutions: Virginia Tech and Virginia State University. VCE provides services through regional and local Extension offices and statewide initiatives, improving community and agricultural education throughout the state. Agents serve these regional and local Extension offices, serving as local educators who work directly with counties or districts to deliver programming and services. Specialists support Extension work directly through universities and Agricultural Research and Extension Centers and may conduct research or teach in a particular field of expertise.

Given the importance of these Extension services, measuring the overall impact of services on these areas is crucial to understanding Extension's role in supporting quality of life and economic vitality in the state. This literature review details the current state of natural resources in Virginia, along with trends and methodologies of measuring impact in Extension services throughout the country. This analysis clarifies the broader role of

Extension in addressing contemporary challenges facing natural resources in the state and the prevailing methods of evaluating Extension impact.

State of Natural Resources in Virginia

Virginia's natural resources, particularly forests and water, are central to both the state's economy and public wellbeing. Forests cover approximately 16 million acres or about 62% of Virginia's land area[1] and support a forest products industry that contributes over $23.6 billion annually in direct output and an additional $11.3 billion including value-added industries[2]. Beyond market value, forests provide essential ecosystem services, including water filtration, watershed protection, and carbon sequestration, which together provide well over $1 billion annually in avoided costs and carbon sequestration services[3]. As noted by Goerlich: forests also "benefit the public and general societal welfare by providing ecosystem services. These include scenery, carbon sequestration, filtered air and water, biodiversity, enhanced national security, and family values, among others".[4] However, these benefits face increasing threats from land fragmentation, parcelization, and development pressures, which complicate long-term management and increase the risk of forest conversion.

Water quality is a closely linked concern, particularly for the approximately 1.6 million Virginians who rely on private wells for drinking water.[5] These systems are not regulated under the Safe Drinking Water Act, placing responsibility for testing and maintenance on homeowners.[6] Research indicates that contamination is a persistent issue, as a Southwest Virginia study found that 44% of sampled wells contained coliform bacteria, some with *E.*

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[1] Paul, A. (2011). The Economic Benefits of Natural Goods and Services A Report for the Piedmont Environmental Council. https://www.pecva.org/wp-content/uploads/library/documents/Resources-Publications/Reports/Land-Conservation/2011-the-economic-benefit-of-natural-services-report.pdf

[2] Rephann, T. (2022). The Economic Impact of the Agriculture and Forest Industries in Virginia. University of Virginia. https://www.coopercenter.org/research/economic-impact-agriculture-forest-industries-virginia

[3] (Paul, A. (2011). The Economic Benefits of Natural Goods and Services A Report for the Piedmont Environmental Council. https://www.pecva.org/wp-content/uploads/library/documents/Resources-Publications/Reports/Land-Conservation/2011-the-economic-benefit-of-natural-services-report.pdf

[4] Goerlich, D. L., Munsell, J. F., Boyd, H. H., & Moeltner, K. (2021). Demonstrating the Public Value of Extension Forestry Programming Through Benefit Transfer Analysis. Journal of Extension, 57(6), Article 6. https://doi.org/10.34068/joe.57.06.06

[5] Virginia Cooperative Extension. (n.d.). Well Informed Virginia. https://www.wellwater.bse.vt.edu/well-informed-virginia.php

[6] EPA. (2024, February 14). Overview of the Safe Drinking Water Act. US EPA. https://www.epa.gov/sdwa/overview-safe-drinking-water-act

coli, [7] while in a statewide study, 20% of wells exceeded EPA action levels for lead.[8] Together, these forestry and water challenges highlight the need for coordinated, research-based management and outreach efforts.

Representatives from the VCE natural resource management team address these challenges through integrated natural resource education programs. The Virginia Forest Landowner Education Program (VFLEP) supports approximately 375,000 Virginia private forest landowners with guidance on sustainable forest management, timber sales, and conservation planning.[9] Within VFLEP, the Real Forestry for Real Estate (RFRE) targets real estate professionals to reduce forest fragmentation by promoting conservation-minded land transactions at the point of sale. The SHARP Logger Program provides training in water quality protection, safety compliance, and best management practices (BMPs),[10] contributing to Virginia's 95% BMP implementation rates.[11] Best management practices for loggers are science-based, operational guidelines designed to protect water quality, minimize soil erosion, and maintain sustainable forests during timber harvesting.[12] Key practices include installing water bars, creating stream-side management zones (SMZs), constructing proper road drainage, and stabilizing landing areas.

Complementing these forestry efforts, the Virginia Household Water Quality Program (VAHWQP) provides low-cost water testing and education to private well users, having tested over 35,000 water supplies serving over 50,000 Virginians in all counties since 2009.[13] The Virginia Master Naturalist program further strengthens natural resource stewardship through volunteer engagement, supporting activities such as water quality

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[7] Cohen, A., Rasheduzzaman, M., Darling, A., Krometis, L.-A., Edwards, M., Brown, T., Ahmed, T., Wettstone, E., Pholwat, S., Taniuchi, M., & Rogawski McQuade, E. T. (2022). Bottled and Well Water Quality in a Small Central Appalachian Community: Household-Level Analysis of Enteric Pathogens, Inorganic Chemicals, and Health Outcomes in Rural Southwest Virginia. International Journal of Environmental Research and Public Health, 19(14), 8610. https://doi.org/10.3390/ijerph19148610

[8] Pieper, K. J., Krometis, L.-A. H., Gallagher, D. L., Benham, B. L., & Edwards, M. (2015). Incidence of waterborne lead in private drinking water systems in Virginia. Journal of Water and Health, 13(3), 897–908. https://doi.org/10.2166/wh.2015.275

[9] Virginia Tech. (2026). Landowner Programs. Vt.edu. https://forestupdate.frec.vt.edu/landownerprograms.html

[10] Virginia Tech. (2025). SHARP Logger. https://sharplogger.vt.edu/

[11] Virginia Department of Forestry. (n.d.). Forestry Best Management Practices (BMPs) for Water Quality [Review of Forestry Best Management Practices (BMPs) for Water Quality]. Dof.virginia.gov. https://dof.virginia.gov/forest-utilization-sustainability/logger-assistance/forestry-best-management-practices-bmps-for-water-quality/

[12] Shaffer, R. M. (2009). A logger's guide to forest planning. Virginia Polytechnic Institute and State University, College of Agriculture and Life Sciences. https://vtechworks.lib.vt.edu/server/api/core/bitstreams/239e45fa-aac2-4b4f-8434-b1deeb852c5b/content

[13] Virginia Cooperative Extension. (2025). Virginia Household Water Quality Program. https://www.wellwater.bse.vt.edu/vahwqp.php

monitoring, habitat restoration, and environmental education.[14] Together, these programs form a comprehensive, research-based approach that protects Virginia's forests and water resources while enhancing public awareness and long-term sustainability.

Application of Logic Models and Impact Statements

A variety of methodologies may be used to evaluate the impact of Extension services, though logic models are the most widely used. Logic models document how specific Extension activities and services lead to outcomes and long-term impacts. They may be particularly useful for documenting program changes and maintaining alignment between expected outcomes and measurable results over time. When applied systematically, they strengthen linkages between planning, implementation, and assessment.

Impact statements extend the work of logic models by communicating outcomes within the broader narrative of program value to the public. Connecting evidence through economic, environmental, and social lenses connects individual programs to larger community priorities. While many extension programs are by their very nature holistic and social-impact driven, using logic models and impact statements to communicate program success [15] facilitates a wider understanding of Extension work, which can in turn justify the credibility and validity of programs to both external stakeholders and funders.

Logic models and impact statements are also valuable tools that program faculty and staff use for reflection, evaluation, and continuous program improvement. Logic models provide a structured method to examine how activities are influencing long-term impacts, and can also reveal areas of disconnect. Impact statements communicate the broader narrative of these evaluations, and program administrators can similarly analyze these statements to identify areas to strengthen, expand, or modify program services to better serve communities.

Advocating for Funding

Effective impact statements and structured logic models are both important tools for demonstrating impact and accountability and sustaining public investment in extension programming. Specifically, logic models operationalize accountability by directly linking program activities to targeted outputs as specified by grant objectives or requirements. Structured logic model pathways demonstrate intentional design and how financial resources are expected to fund activities and generate specific outputs. In competitive

[14] Virginia Cooperative Extension. (2025, August 11). Virginia Master Naturalists. https://www.virginiamasternaturalist.org/

[15] Israel, G. D., Benge, M., & Beattie, P. N. (2010, October). Logic model basics. *IFAS Extension at University of Florida*. https://ask.ifas.ufl.edu/publication/WC106/pdf

funding environments, logic models that demonstrate a clear and thorough understanding of program activities and impacts are better positioned to demonstrate alignment with funding priorities.[16]

From a funding perspective, logic models are both a planning tool and justification framework.[17] When proposals include a clearly articulated logic model, reviewers understand how inputs including personnel time, partnerships, and financial resources are converted into outputs and outcomes. This transparency allows programs to clearly communicate how their programs align with specific priority areas identified by agencies or governmental partners. When program activities are mapped directly to measurable outcomes, logic models demonstrate that requested funds are not allocated to isolated activities but are instead a component of a results-oriented framework.

Logic models also inherently support scalability and sustainability- both key considerations in funding decisions.[18] When outcomes are clearly defined and connected to activities, it is then easier to demonstrate progress over time and to expand successful components. A logic model can also be used to illustrate how additional funding can impact the full scope of activities offered in a particular programming area and how these may change or expand program outcomes and impacts. Some logic models may specify the particular grants or funding resources used as program inputs. Thus, a change in these inputs can impact the particular services offered and the number of service beneficiaries, changing the magnitude of impact.[19]

Holistic Understanding of Impacts

Logic models and broader theories of change contribute to a holistic understanding of extension program impacts by framing individual activities within a systems-level perspective. Individual programs are not isolated; instead, logic models situate these programs within structured pathways that link together resources, strategies, outcomes, and long-term impacts.

A holistic approach is particularly important in extension work as programs often address interconnected challenges relating to natural resources, community development, public

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[16] National Institute of Food and Agriculture. (n.d.). Logic model planning process. *United States Department of Agriculture*. https://www.nifa.usda.gov/grants/grant-training/logic-model-planning-process

[17] Kingsley, S. (2025, April). Understanding and building logic models for grants. *Oklahoma State University Extension*. https://extension.okstate.edu/fact-sheets/understanding-and-building-logic-models-for-grants.html

[18] University of Wisconsin-Madison. (n.d.). Introduction/Overview. *Enhancing Program Performance with Logic Models*. https://logicmodel.extension.wisc.edu/

[19] Kingsley, S. (2025, April). Understanding and building logic models for grants. *Oklahoma State University Extension*. https://extension.okstate.edu/fact-sheets/understanding-and-building-logic-models-for-grants

health, agriculture, and youth development. When multiple logic models are used across programs, they can further contribute to shared institutional understanding. While each model may represent a distinct subject area, they together can reflect common outcome categories, strategic priorities, and evaluation standards.[20] This alignment allows stakeholders to understand how initiatives collectively advance organizational or regional goals.

Multiple logic models across several different programs may be further strengthened by utilizing common and consistent outcome frameworks across programs to more effectively compare results and report cumulative progress.[21] This may include structuring outcomes surrounding a common metric (broadly, people assisted; homes assisted; forest area assisted, etc.), documenting related activities across logic models, or denoting shared outputs/impacts that are interrelated across models. Multiple logic models may also be nested within each other to document their relations: for instance, a broad program overview logic model may contain logic models for each individual activity or program within the broader model.[22]

[20] Briscoe Advisory Ltd. (2025). Using theory of change and logic models to demonstrate real-world impact. https://www.briscoe-advisory.com/_files/ugd/662b57_a24a7c9e5f1e489097ce7fbd8cbec186.pdf?index=true

[21] University of Wisconsin-Madison. (n.d.). 4.4 Multiple Logic Models. *Enhancing Program Performance with Logic Models*. https://logicmodel.extension.wisc.edu/introduction-overview/section-4-what-does-a-logic-model-look-like/4-5-multiple-logic-models/

[22] University of Wisconsin-Madison. (n.d.). 4.4 Multiple Logic Models. Enhancing Program Performance with Logic Models. https://logicmodel.extension.wisc.edu/introduction-overview/section-4-what-does-a-logic-model-look-like/4-5-multiple-logic-models/

This consistency strengthens overall understanding of program models and emphasizes the comparable outcome categories and evaluation standards across various programs. Thus, logic models can guide both individual program processes and can be linked to each other to identify shared features across programs.

Review of Methodologies

Evaluating the full economic impact of the representatives from the VCE natural resource management team's work presents a significant challenge, and one without a straightforward solution. Current evaluation efforts capture meaningful outputs, such as the number of participants or trainees, acres managed by forestry and logger participants, and volunteer hours contributed. But these metrics reflect only part of the picture. Acres enrolled and volunteer hours, for instance, represent sustained, long-term commitments that require considerable effort to cultivate and maintain, and cannot be reduced to simple short-term indicators. What is largely missing across the VCE natural resources management team's work is a robust economic evaluation framework that translates these outputs into measurable monetary outcomes, i.e. the value generated through improved stewardship of natural resources. Developing such a framework is precisely why economic impact assessment methods are worth exploring. This section reviews the most common methodologies used to evaluate cooperative extension programs, with the goal of identifying approaches that the VCE natural resource management team may want to adopt or adapt in the future.

Cost Benefit Analysis of Extension Programs

Cost–benefit analysis (CBA) can be used for Extension programs to assess their economic value and determine if spending on one program is justified compared to another.[23] Two main metrics are used:

- benefit–cost ratio: total benefits divided by total costs
- return on investment (ROI): net benefits divided by total costs, expressed as a percentage.

Extension professionals can conduct a CBA by identifying program outcomes, especially those that can be converted into monetary values, and organizing them using an "impact hierarchy." The hierarchy includes participant satisfaction, learning, change of attitude and behavior, as well as long-term results such as social, economic, or environmental impacts.

[23] Jayaratne, K. S. U. (2021). Learn how to analyze cost-benefits of Extension programming (North Carolina Cooperative Extension). North Carolina State University. https://evaluation.ces.ncsu.edu/wp-content/uploads/2021/02/Learn_How_to_Analyze_Cost_Benefits.pdf?fwd=no

Extension professionals can estimate program costs using personnel time plus organizational overhead. Then impacts are converted into monetary terms, including cost savings, increased income, avoided costs, and reduced risks. CBA is feasible for Extension programming, particularly for programs with measurable economic outcomes, and can help demonstrate accountability and program effectiveness to stakeholders.

Any CBA carries its own price tag, and for the VCE natural resource management team, that tension is especially real. An average cost-benefit analysis will cost $24,000, but costs vary based on the size of the evaluation.[24] Programs that address water quality, forest health, and sustaining natural resources generate benefits that are difficult to measure and expensive to quantify, meaning a thorough BCA could be cost-prohibitive. It's important to consider proportionality: the depth of analysis should match the scale and stakes of the program.[25] A small local initiative needs only a light-touch analysis, while a major statewide program justifies greater investment in data and modeling. What this framing can miss, however, is that information produced by a CBA doesn't just serve one program, it has lasting value for future VCE evaluations and for Extension programs elsewhere. That broader utility means investing a bit more in data quality can be worth it when looking at VCE holistically. The goal is analysis that is lean enough to be feasible, but rigorous enough to be genuinely useful.

IMPLAN Modeling

IMPLAN input-output modeling is widely used in Extension to estimate the economic impacts of programs by translating spending into measures such as jobs, income, and total economic activity.[26] The model works by using detailed data on program expenditures, typically divided into payroll and non-payroll spending, and applying these to sector-specific economic relationships within a regional economy. These spending inputs are paired with built-in data on industry linkages, local purchasing patterns, and household income to estimate three types of effects. Direct effects capture the initial program spending and employment, indirect effects reflect business to business transactions in the supply chain, and induced effects represent additional economic activity generated when employees spend their earnings locally. Assumptions about how

[24] Moore, R. (2019, February 28). *When to conduct cost-benefit analysis: The costs and benefits of cost-benefit analysis*. Scioto Analysis. https://www.sciotoanalysis.com/news/2019/2/28/when-to-conduct-cost-benefit-analysis-the-costs-and-benefits-of-cost-benefit

[25] Actionable Intelligence for Social Policy. (2015). Benefit-cost analysis of integrated data systems. University of Pennsylvania. https://aisp.upenn.edu/wp-content/uploads/2015/09/0033_12_SP2_Benefit_Cost_000.pdf

[26] Kerna, A., Frisvold, G., Jacobs, L., Farrell, V. A., Houtkooper, L., & Misner, S. (2015). Application of IMPLAN to Extension programs: Economic impacts of the University of Arizona Cooperative Extension SNAP-Ed spending. Journal of Extension, 53(6), Article 6TOT4. https://doi.org/10.34068/joe.53.06.21

much spending occurs within the local economy are also required to produce accurate estimates.

While IMPLAN provides a practical way to quantify Extension's economic footprint, results must be interpreted carefully, particularly the distinction between gross and net effects. Programs funded with external sources can demonstrate net new economic activity, whereas locally funded programs may only reflect economic contributions that could have occurred through other public spending. Importantly, IMPLAN should not be used for avoided costs associated with a VCE activity, since that economic value is not new money being brought into the local economy. Overall, IMPLAN is a useful and accessible tool for demonstrating economic impacts, but its accuracy depends on the quality of expenditure data, the appropriateness of model assumptions, and a clear understanding of what type of economic effect is being measured.

Assessment During the Learning Phase

Logic modeling is commonly used by Extension faculty and staff to guide impact assessment. It organizes measurable outcomes into three stages: learning, action, and impact.[27] Sometimes logic models are required as part of a proposal for funding or justification for initiating a program, and subsequently are not used by extension professionals in an evaluation capacity.

Although impact can be measured at multiple stages, assessment most often occurs during the learning phase because it is simpler, less costly, and easier to implement. The learning phase refers to the end of the program or workshop.

Assessment at the learning stage provides an accessible entry point for program evaluation. It can be conducted by faculty/staff or through participant self-report surveys. While this approach does not typically produce direct economic impact data, it still generates useful evidence for reporting to stakeholders, communicating results to the public, and supporting funding requests.

Three common assessment methods are used during the learning phase. Observation involves directly recording participant behavior changes, often used with youth programs. Pre- and post-tests measure knowledge or attitude changes by comparing responses before and after a program. Retrospective post-tests, administered at the end of a program, ask participants to reflect on their knowledge before and after participation; this

[27] Tennessee Extension, University of Tennessee Institute of Agriculture. (2021). *Cooperative Extension's guide to measuring economic impact: A, B, C's of economic impact measurement*. https://eesd.tennessee.edu/wp-content/uploads/sites/242/2021/10/CooperativeExtensionsMeasuringEconomicImpactABC.pdf

approach is more time efficient and may improve accuracy because participants better understand the subject matter when evaluating their prior knowledge.

Evaluating Extension Programming – Traditional Economic Approach

Extension professionals focus on evaluating programming by answering the question: *Did the program meet its objectives*?[28] Typically, objectives are clarified by short-, medium-, and long-term goals. In the short term, participants' knowledge, attitudes, or awareness are influenced by the program. This leads to a behavior change in the medium-term, such as adopting a new technology or practice. Finally, the long-term outcomes capture changes to the participants' economic, social, and/ environmental condition. Measuring condition change directly is challenging and may need to be done by extrapolating from information cited in the literature.

Extension professionals may need to establish a counterfactual to evaluate the medium-term outcomes to ensure the impacts of the program are isolated. The counterfactual asks: *to what extent are participants adopting a new practice or technology compared to nonparticipants?* Without having a comparison group, extension professionals will often overestimate the impact of their programming. Similarly, defining a counterfactual for the long-term conditions helps control for confounding variables. The question becomes: *did the social, economic, or environmental conditions of participants improve over time relative to the conditions of nonparticipants?* This type of impact evaluation is used to validate the causal linkage between a program's activities and an outcome.

After defining the research objectives and questions, extension professionals should form a hypothesis about the causal link between their program and its intended impacts. [29] Forming hypotheses for short, medium, and long-term impacts helps the evaluator to identify outcomes that are linked to the program's objectives for evaluation. Often extension professionals do not fully engage in this step of the process and instead rely on logic models. Logic models are descriptive summaries of a program and do not fully account for causal pathways between resources, outputs, and outcomes. They are a useful starting point but more rigorous evaluation requires hypotheses that can be tested with data.

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[28] Wright, A., Wright, J., McCorkle, D., & Hyde, J. (2025). Are we measuring impact accurately? Identifying potential sources of bias in the evaluation of extension personnel and programs. Applied Economic Perspectives and Policy, 47(1), 49–64. https://doi.org/10.1002/aepp.13478

[29] Wright, A., Wright, J., McCorkle, D., & Hyde, J. (2025). Are we measuring impact accurately? Identifying potential sources of bias in the evaluation of extension personnel and programs. Applied Economic Perspectives and Policy, 47(1), 49–64. https://doi.org/10.1002/aepp.13478

When objectives are well-defined and linked to program outcomes, extension professionals should begin collecting data to measure progress towards outcomes. Generally, short-term goals are the easiest to measure with follow-up surveys to participants during or after program completion. Measuring medium and long-term goals is more complicated, especially if evaluators need to gather data about a comparison group of nonparticipants and changes to social, environmental and economic conditions. Sometimes publicly available data on the population at large is the only option for evaluation when participants and nonparticipants are difficult to reach in the medium and long term after the program's completion.

Next, extension professionals will analyze the data collected using statistical methods. Qualitative data can also be analyzed by summarizing open-ended responses on a survey, for example. For post-program surveys that measure short-term changes in attitudes, beliefs, or knowledge, simple descriptive statistics is usually sufficient to measure changes. For long-term impact, a common approach in the literature is difference-in-differences (DiD) method. Using this method, changes in a treatment group before and after the program are compared to a control group who does not participate in the program, both over the same period of time. Since many extension workers don't have a statistics background, professional development in statistical evaluation is one solution to empower evaluators to be able to more rigorously evaluate their programs. Partnerships with faculty researchers to analyze program data can also overcome this barrier.

Finally, from the above steps, evaluators can draw conclusions about the impact of the extension program with important caveats. Any limitations from the data collection process or evaluation methods should be acknowledged when making final conclusions about impact findings. Selection bias is unavoidable since participants usually opt into the treatment group to participate in an extension program, but including additional controls if using a regression framework can partially address this bias. If data is lacking to properly evaluate medium and long-term objectives, extension administrators should communicate why accurate and consistent data collection is essential for evaluation. Administrators may need to create buy-in from extension staff by emphasizing how evaluation results feed into program sustainability and funding. This approach illustrates a traditional, applied economics method, and may not be appropriate or feasible for all extension programs.

Since extension programs cover diverse topic areas and collect different metrics, aggregating data across programs is not always feasible, limiting evaluators' ability to tell a

cohesive story about the public value of extension.[30] Beyond the traditional counterfactual approach to quantify impacts, there are other methods to also cleanly identify how extension activities contributed to economic impacts. One method is to link self-reported behavior and knowledge change from participants to economic data. This process avoids statistical analysis or a control group. Instead, survey data is used to make conclusions about short, medium, and long-term outcomes. This involves asking questions about knowledge gain, intent to change behavior, and self-reported economic value dependent on the program purpose (e.g. dollars per acre saved, number of acres, etc).

Economic evaluation of the VCE natural resources management team, whether through a CBA, input-output modeling in IMPLAN, economic data extrapolation, or treatment-control group design, offer compelling evidence of program value, but come with significant resource demands that need to be balanced with personnel capacity constraints. The entire VCE system of more than 500 agents and specialists have access to one part-time formal evaluation specialist. Given that Extension professionals are already working at or beyond capacity to deliver programming, the additional burden of sophisticated economic analysis and/ data collection is difficult to absorb without dedicated support. More resources and support from trained evaluators would help programs and/ activities to measure their value more robustly and accurately. Regardless of the evaluation method chosen, making deliberate investments into program evaluation staff would be a small step forward to sustaining this work more permanently.

Theory-Based Evaluation

Theory-based evaluation approaches, such as contribution analysis, realist evaluation, and process tracing, can be used to understand how and why extension programs produce outcomes.[31] These approaches focus on identifying the causal mechanisms that link activities to results. They typically involve two stages. First, in the conceptual stage, Extension professionals work with local stakeholders to develop a theory of change, or impact pathway, that outlines how an intervention is expected to lead to desired outcomes, including key assumptions, risks, and contextual factors. Second, in the empirical stage, this theory is tested using qualitative and quantitative evidence to examine whether the proposed mechanisms explain observed outcomes and to assess alternative explanations.

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[30] Lamm, A. J., Rabinowitz, A., Lamm, K. W., & Faulk, K. (2020). Measuring the Aggregated Public Value of Extension. Journal of Extension, 58(6), Article 6. https://doi.org/10.34068/joe.58.06.06

[31] Mohammed, E. Y., & Bladon, A. J. (2017). Theory-based impact evaluation. International Institute for Environment and Development.

A major strength of theory-based evaluation is its flexibility and its ability to incorporate local knowledge, making it well suited for complex programs with multiple interacting factors. By combining different sources of evidence, it helps build a more complete picture of program impacts and can inform improvements, scaling, and replication. However, its findings depend heavily on the quality of the initial theory of change and the evidence used to test it. Because it often relies on stakeholder perspectives and lacks fully standardized methods for assessing evidence, results can be somewhat subjective. Rather than providing definitive proof of causality, theory-based evaluation strengthens confidence in explanations of how change occurs and highlights areas where further analysis is needed.

Cooperative Extension Economic Impact Trends & Examples

Measuring Economic Impact

In 2008, the University Leadership Council surveyed land grant universities to understand if they are measuring the economic impact of their extension programs, the results of those impact assessments, and how the assessment results are used.[32] Of the 30 respondents, 21 extension programs reported measuring some economic impact, though infrequently and related to specific program outcomes. Land grant universities mainly reported using survey data at the time of learning to assess impact and only included economic impact when programs offered clear economic changes like increased yields or reduced costs. Extension specialists noted the challenge of linking economic impact to youth education or community development programs that relate to public value or improved quality of life. Others noted that the high cost of comprehensive assessments prohibited such studies from being completed.

Researchers from the University of Georgia reported using survey instruments to measure self-reported knowledge gain, intent to change behavior, and self-reported economic value of extension programming.[33] Researchers then extrapolate the economic impact based on the reported impact on the participants. While this kind of extrapolation is typical for Extension economic assessments, the researchers do report several limitations with this approach. Self-reported data is biased by participant perceptions about the value of programming, which leads to over or under reporting their actual knowledge levels, behavioral intention, and the associated economic value. Survey instruments also only

[32] University Leadership Council. (2008). *Cooperative Extensions: Measuring Economic Impact*. https://eesd.tennessee.edu/wp-content/uploads/sites/242/2021/10/CooperativeExtensionsMeasuringEconomicImpactABC.pdf

[33] Lamm, A. J., Rabinowitz, A., Lamm, K. W., & Faulk, K. (2020). Measuring the Aggregated Public Value of Extension. Journal of Extension, 58(6), Article 6. https://doi.org/10.34068/joe.58.06.06

measure behavioral intent, not actual behavioral change or the long-term adoption of behavior.

Examples of Cooperative Extension Impact Reporting

Arizona, Illinois, and North Carolina: The Economic and Functional Impact of Cooperative Extensions

Three Cooperative Extension agencies, Arizona, Illinois, and North Carolina contracted Teconomy Partners LLC to assess the public value and economic impact of their programs between the years of 2019 to 2022.[34] To measure the economic impact of Extension expenditures, the researchers used an Implan model for the direct, indirect, and induced impacts of Extension employment. Inputs included employment (measured as full-time equivalent employment), labor income (total compensation, including salaries, wages, and the full cost of benefits), and output (measured as total expenditures).

For example, Teconomy estimated that N.C. Cooperative Extension adds $205 million in impact from operational expenditures, $1.5 billion in estimated impacts on the state forest and agriculture industries, and $365 million in potential impact through improved health and youth engagement. Overall, Teconomy Partners estimates that N.C. Cooperative Extension generates an estimated 33:1 economic impact return for State and County investments. Illinois Extension economic impacts were similar: $126 million in total output impact and $477.3 million estimated in functional impact on the Illinois economy. Each report tracks and estimates economic values for the functional impact of seven principal domains of focus including primary agriculture and forest production, natural resources and environmental stewardship, emergency preparedness and disaster response.

Generally, Teconomy Partners estimates economic value for functional impact by calculating one percent change in economic outcome. For example, given the AZ Extension's cross-sector work to conserve water, they estimated that a 0.1% increase in

[34] Arizona Cooperative Extension. (2022). The Economic and Functional Impact of Arizona Cooperative Extension. https://extension.arizona.edu/sites/default/files/data/The%20Economic%20and%20Functional%20Impact%20of%20Arizona%20Extension.pdf
Illinois Extension. (2020). The Economic and Functional Impact of Unitersity fo Illinois Extension. https://extension.illinois.edu/sites/default/files/illinois_extension_economic_and_functional_impacts_-_final_report.pdf
N.C. Cooperative Extension. (2019). The Economic and Functional Impact of North Carolina Cooperative Extension. https://eit-wagpress-prod.s3.amazonaws.com/media/documents/NC-Cooperative-Extension-Impact-Report-secure.pdf

groundwater conservation as a result of this work would equate to $150 million in equivalent GDP value per year.[35]

The consultants for the three Extension agencies standardized impact indicators into three categories: economic value (cost savings and revenue increases), environmental outcomes (resource conservation), and social improvements (health, education, and community capacity). When possible, researchers then converted these outcomes to monetized values by aggregating the estimated value across participants. Common examples include per-acre savings or cost-per-practice behavior change. Researchers noted that attributing impact to program influence was challenging. Claiming impact requires evidence of adopting practices or behavior change directly resulting from Extension educational programming. They recommend combining multiple data sources like participant surveys, follow-up interviews, environmental monitoring data, and economic modeling estimates.

For the Natural Resource and Environmental Stewardship domain, researchers identified common areas of functional impact: Environmental Sustainability, Natural Resource Management, Enhanced Quality of Life and Public Health, and Risk Management, Mitigation, and Reduction. They measured impact by tracking adoption of recommended practices through surveys and follow-ups and then calculating impacts using known scientific conversion factors. For example, functional impact could include avoided/reduced treatment costs, reduced infrastructure burden, or ecosystem service value. Researchers then aggregate those results to estimate statewide impact. In general, they recommend defining clear outcome indicators before any data collection, using conservative assumptions when attributing impacts, and combining behavior change data (assessed through follow-up interviews) with scientific conversion factors.

There is a well-established body of literature on conversion factors and hedonic price modelling in adjacent fields like environmental economics, public health, and labor economics. However, the Teconomy studies are rare examples of applying these concepts to extension activities. A literature review of economic conversion factors and their application to VCE programming would be a meaningful next step in enhancing VCE's ability to demonstrate the economic value of their efforts. The challenge that remains is the extent to which the counterfactual case can be made. Only then can the monetary estimate be placed into an input-output model to look at the effects on regional and state

[35] AZ Extension. (2022). The Economic and Functional Impact of Arizona Extension, p. 40. https://extension.arizona.edu/sites/default/files/data/The%20Economic%20and%20Functional%20Impact%20of%20Arizona%20Extension.pdf

economies. This is why carefully tracing the outcomes of efforts is critical to measuring true impact.

Extension Program Economic Impact Statements

In a review of 36 impact statements from the National Land-Grant Impacts Database, one researcher found that most of the impact statements reported knowledge change (66.7%), followed by change in the adoption of practices (44.4%), and economic benefits (25%).[36] Six of the nine studies reporting economic benefit based the results on participant self-reported economic benefit. The researcher noted that most of the economic benefits reported in Extension impact statements were not estimated using any form of rigorous economic analysis.

Example: Regional Soybean School Generates Over $1.25 million in Projected Economic Impact

As an example of a typical economic impact statement, N.C. Cooperative Extension described a program that delivered education on risk management, marketing, weed and disease control, and regulatory compliance. The program served 89 participants, representing nearly 36,000 soybean acres. Thirty-five growers representing 28,460 acres reported an anticipated average yield increase of four bushels per acre as a result of adopting practices presented during the training. At $11.00 per bushel, Extension agents estimated that the workshop created $1.25 million in projected farm-level economic impact. The team did not report any long-term surveys demonstrating behavioral change from the workshop.

Key Takeaways

Existing literature supports that Extension programs play a critical role in addressing natural resource challenges in Virginia. However, current evaluation methods do not fully capture the impact of these programs. Most programs rely on short-term or self-reported data that measures knowledge gain or intent to change behavior, rather than actual behavior change or long-term environmental and economic outcomes.

To design more effective impact evaluation protocols for VCE natural resource management programs, improvements in data collection and outcome measurement are needed to strengthen understanding of program impacts. Follow-up surveys should include standardized questions that consistently capture key outcomes, such as

[36] Wright, Andrew, Jeffrey Wright, Dean McCorkle, and Jeffrey Hyde. 2025. " Are we Measuring Impact Accurately? Identifying Potential Sources of Bias in the Evaluation of Extension Personnel and Programs." Applied Economic Perspectives and Policy 47(1): 49–64. https://doi.org/10.1002/aepp.13478

participants' adoption of recommended practices, changes in nutrient and pollutant levels where applicable, acres of land affected, and the incidence of injury, illness, or other health outcomes after an appropriate period following program participation. Collecting these data will improve the ability to quantify program outcomes and estimate economic impacts.

Equally important is identifying relevant metrics from the literature that can be combined with program data to produce accurate and defensible economic impact estimates. Additional examples of outcome measures are provided in the economic impact statement below. Developing a consistent logic model or theory of change across programs further strengthens impact evaluation by clearly linking program inputs and activities to outputs and long-term outcomes. Overall, addressing these gaps will improve the accuracy, consistency, and credibility of impact evaluations while better demonstrating the value of Extension's natural resource management programs to Virginia.

Interview Summary

In February and early March 2026, Graduate Assistants at the Center for Economic and Community Engagement (CECE) interviewed five specialists and two extension agents from across Virginia Tech's Natural Resources, Forestry, and Environment Extension programs. These conversations focused on what each program does, who it serves, and how it tracks results. Even though the programs differ in topic and audience, they share many of the same strengths and challenges.

1. Education as a Pathway to Impact

Across all programs, we identified a shared theory of change: educational programming leads to increased knowledge, which can influence behavioral changes and ultimately result in improved natural resource management and conservation outcomes. Programs target a wide range of audiences, such as landowners, youth, natural resource professionals, and the general public, but consistently emphasize knowledge transfer as the primary entry point for impact.

2. Varied Use of Logic Models

Not all programs are explicitly guided by formal logic models. While some initiatives have clearly defined inputs, outputs, and outcomes, others operate with more of a needs-based model. For example, the SHARP logger program is market-based, loggers enroll in the program as a selling requirement from SFI certified logging companies. This variation presents a challenge to fully understanding the logic of knowledge and behavior changes that lead to broader impact. Still, interviewees shared a range of program activities that we were able to incorporate into a shared, high-level logic model of VCE programming.

3. Strength in Measuring Short-Term Outcomes

Most programs demonstrate strong capacity to measure immediate outcomes, particularly knowledge gain. Post-program evaluations such as exit surveys are commonly used and provide consistent evidence of learning and participant satisfaction. These tools represent a key strength across the programs.

4. Challenges in Capturing Medium- and Long-Term Outcomes

Interviewees consistently noted difficulty in measuring behavioral change and long-term impacts. Several barriers contribute to this challenge:

- Extension programs have limited capacity and resources to conduct follow-up with participants. Most of the interviewees were juggling multiple roles across programs, including research, field work, advising, and keeping up with administrative tasks.

- When program leaders conducted follow-up surveys, participant engagement declined the more time that passed. Several interviewees also mentioned participants may not remember specific data points about their natural resource management, particularly in the long-term.
- Many external stakeholders and factors influence outcomes. For example, VMN activities often occur in partnership settings where other entities are also performing water quality monitoring. Having multiple organizations working on natural resource conservation in the same setting makes it difficult for VCE leaders to feel comfortable claiming impact.

As a result, programs often lack empirical data demonstrating sustained behavior change or environmental impact, even when such impacts are likely occurring. Given the complexity of measuring long-term outcomes, there is growing recognition of the need to position programs within a broader "system of change." Rather than attributing outcomes solely to a single program, many interviewees emphasized the importance of acknowledging their role as one contributor among many influencing natural resource management decisions.

5. Challenges in Cross-Program Impact Measurement

Comparing and aggregating impact across programs is complicated by several factors:

- Programs lack standardized metrics to capture cross-programmatic impact. For example, if each program leader wants to understand how their activities contribute to water quality, more specific data needs to be collected as a starting point to draw wider conclusions. Each program would need to understand how participants influence water quality and find ways to quantify and aggregate those outcomes.
- Program goals, audiences, and structure differ from one another, although we did find overlap in many areas. Since programming is siloed, some shared impacts may not be apparent. VCE uses many different delivery methods (e.g., online modules, in-person workshops, field tours, multi-day retreats) which further complicates the measurement of knowledge and behavior change. These differences make it difficult to apply a single evaluation framework without careful alignment.

6. Approaches to Economic Impact

Interviewees identified several ways programs currently demonstrate economic value:

- The value of volunteer time (e.g., through programs like Master Naturalists)
- Cost savings compared to equivalent services in the private marketplace
- The perceived value of services from the beneficiary perspective

These examples could be adopted by more VCE natural resource programs to produce shared economic value statements. Since these values don't rely on measuring the economic value of a particular resource, they could provide a more straightforward path to capturing shared economic value across activities.

Overall, the interviews allowed us to fully understand the scope of activities across the Natural Resources, Forestry, and Environment group. The varying approaches to impact across programs helped inform the agenda for the workshop on shared impacts that took place during phase II of the project.

Shared Logic Model

Please see the unified logic model presented on the next page.

INPUTS	ACTIVITIES	OUTPUTS	OUTCOMES	IMPACT
What we invest	*What we do*	*What we produce*	*What changes*	*Why it matters*
People & Partners: VCE specialist, agents, staff • Graduate & undergraduate researchers • Volunteer instructors & VMN chapter leaders • Legal, financial & forestry experts • Partnerships: VDOF, SFI, VFA, VLA, VSU, Black Family Land Trust, VAR, VDH, DCR, DWR, VMNH, VIMS, DEQ **Funding:** • State, university, grant, industry, and private funding **Materials, Tools, Resources:** • Educational publications, videos & digital platforms • Training content, facilities & demonstration sites • Online platforms & credential databases	**Education & Outreach:** • Landowner workshops, conferences & retreats • Field tours & demonstrations • Online modules, webinars & video series • VMN 40-hr basic training & continuing education • SHARP Logger core & CE training (classroom & field) • Water testing clinics in 60+ counties/year • Heirs' Property & minority landowner education • Attorney & realtor continuing education **Applied Research:** • Applied research for industry partners (agrivoltaics, stormwater, energy) **Technical Assistance:** • Industry consultation & supply chain training **Collaboration & Network Building:** • Building interdisciplinary teams for problem solving • Youth and adult networks • Connecting industry partners	**Education and Training Outputs:** • Number of educational workshops **Participation Metrics:** • Number of individuals reached in educational programs • Number of professionals and volunteers trained • Water clinics in 60+ counties/year • SHARP Logger completions, continuing education, & credential database **Research Outputs:** • Publications, guides, newsletters & online resources • Applied research publications & demonstrations	**SHORT-TERM** **Learning** • Forest Landowners learn about ecosystem services, managing and marketing forest products, and outdoor safety. • SHARP Logger participants learn safe working practices, regulatory requirements, and sustainable forestry practices (BMPs). • VMN volunteers build skills in outdoor education and awareness of natural resource stewardship and water quality. • VAHWQP participants learn about their homes' water quality and system maintenance **MEDIUM-TERM** **Behavior Change** • Landowners implement management practices that improve the health and productivity of their forests. • Loggers implement safe working practices and environmental Best Management Practices. • VMN volunteers lead educational programs and community participants spend more time outdoors. • VAHWQP participants take or intend to act related to improving household quality. **LONG-TERM** **Condition Change** • Landowners keep forests intact, stay safe from outdoor hazards, and improve ecosystem services on their land. • Healthier forests provide sustainable and profitable timber for forest product manufacturers. • Logger accident rates, work injuries, and insurance claims are reduced for training participants. • Water quality is protected due to logger BMPs and VAHWQP participants reducing contamination and protecting groundwater resources. • VMN volunteers increase public awareness of outdoor benefits. • Community participants of VMN programming are physically and mentally healthier.	**HUMAN HEALTH & SAFETY** Virginians are healthier through reduced exposure to water-borne illnesses and lead. Forest workers are safer and experience fewer workplace injuries. Virginians save money on healthcare costs. Virginians have improved mental and physical health from being outdoors in quality green spaces. **ECOSYSTEM SERVICES** Forests are healthier, intact, better managed, and provide sustained ecological benefits like water quality improvements. Carbon sequestration and air filtration are improved through maintaining healthy forests. **COMMERCIAL FOREST PRODUCTS** Virginia's logging industry and forest products industries are financially viable long-term.
PROGRAMS: Generation NEXT (Legacy Planning) | Virginia Forest Landowner Education Program | Real Forestry for Real Estate | SHARP Logger Program | Virginia Household Water Quality Program | Virginia Master Naturalists | Sustainable Forest Supply Chain Collaborative | Agricultural Byproduct Utilization & Renewable Energy | Natural Resources at the Interface				

Economic Impact Statement

Human Health & Safety – Economic Impacts

Overview:

Virginia Cooperative Extension's natural resource management team improves human health and safety across the Commonwealth through educational outreach, worker training, and community engagement. Health and human safety work spans four key areas: reducing waterborne disease risk through private well testing, improving occupational safety for Virginia's logging workforce, and supporting community health through nature access via the Virginia Master Naturalist Program.

In 2025, the combined economic impact of these programs is estimated at $6,743,000 ($7,231,929 when adjusted for inflation) in health-related cost savings for Virginians by preventing hospitalizations, reducing childhood lead exposure, averting logging injuries, and lowering long-term healthcare costs through nature-based volunteerism.

Functional Impacts on Human Health & Safety:

Waterborne Disease & Water Contamination Reduction:

Nearly 1.6 million Virginians, accounting for 19% of the state's population, rely on private water supplies for household water.[37] Homeowners are solely responsible for testing, maintenance, addressing contamination, and resolving other problems for these systems. Without regular testing, families risk exposure to harmful bacteria, heavy metals, and other contaminants that can affect human health, shorten system lifespan, and increase costs.

In 2025, the Virginia Household Water Quality Program (VAHWQP) tested 2,254 wells serving 5,676 Virginians in 41 counties.[38] The program delivered $721,280 in value at a cost of $157,780 (in part due to a grant from partner SERCAP), saving families 78% compared to commercial testing, and saving Virginians over $500,000.[39] Testing revealed 40.5% of wells exceeded healthy sodium levels, 32.6% tested positive for coliform bacteria, 9.5% for manganese, 7.6% for lead, 6.6% for copper, and 4.6% for *E. coli*.

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[37] Ling, E. (2025). Virginia Household Water Quality Program 2025 Annual Report [Infographic]. Virginia Cooperative Extension. https://www.canva.com/design/DAG_hsQRtvw/wwcXkXonkJ5FVgEcVjTGYw/view

[38] Ling, E. (2025). Virginia Household Water Quality Program 2025 Annual Report [Infographic]. Virginia Cooperative Extension. https://www.canva.com/design/DAG_hsQRtvw/wwcXkXonkJ5FVgEcVjTGYw/view

[39] Ling, E. (2025). Virginia Household Water Quality Program 2025 Annual Report [Infographic]. Virginia Cooperative Extension. https://www.canva.com/design/DAG_hsQRtvw/wwcXkXonkJ5FVgEcVjTGYw/view

By testing water for 5,676 Virginians, the VAHWQP is helping reduce the risk of severe illness from contaminants. Acute gastrointestinal illness (AGI) for example, is caused by microbial contamination in drinking water, primarily associated with private wells, with an average cost of $1,366 average per hospitalization.[40] Of the 5,676 Virginians who participated in well testing in 2025, 70% took action to improve their water quality after testing, totaling 3,973 participants. Of those 3,973 at risk for AGI through their well water, an estimated 6.6% likely had drinking water containing E. coli, which causes AGI[41] By these participants identifying this contamination and prompting corrective action, the VCE team may have prevented around **$357,892** in healthcare costs.

Lead exposure carries its own serious consequences, particularly for young children, whose developing brains are vulnerable even at very low levels. Children under six who are exposed to lead face lasting neurodevelopmental effects, including impaired cognition, lower graduation rates, and increased risk of involvement in the justice system.[42] Given that approximately 6% of Virginians are under the age of six,[43] an estimated 18 young children served by VAHWQP who took action to improve their water quality may have been exposed to unsafe lead levels. Based on research done by Columbia University, protecting children from lead exposure yields an estimated $50,000 in lifetime benefits per child.[44] If VAHWQP tests water for a new group of children each year, the VCE team's work in 2025 may represent **$900,000** in lifetime savings for those children.

In 2025 alone, the VCE Natural Resource Management team put just over **$1.25 million** back into the pockets of Virginians through the Health and Safety impacts of the VAHWQP program.

Worker / Occupational Safety:

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[40] DeFelice, N., Johnston, J., MacDonald Gibson, J. (2016). Reducing Emergency Department Visits for Acute Gastrointestinal Illnesses in North Carolina (USA) by Extending Community Water Service. Journal of Environmental Health Perspectives, 124(10):1583–1591. https://pmc.ncbi.nlm.nih.gov/articles/PMC5047767/

[41] Smith, A., Krometis, LA., Hagedorn, C., Lawrence, A., Benham, B., Ling, E., Ziegler, P., Marmagas, S. (2014). Associations between fecal indicator bacteria prevalence and demographic data in private water supplies in Virginia. Journal of Water Health, 12(4): 824-834. https://doi.org/10.2166/wh.2014.026

[42] Levallois, P., Barn, P., Valcke, M., Gauvin, D., & Kosatsky, T. (2018). Public Health Consequences of Lead in Drinking Water. Current Environmental Health Reports, 5(2), 255–262. https://doi.org/10.1007/s40572-018-0193-0

[43] QuickFacts: Virginia. (2025). Census Bureau QuickFacts; United States Census Bureau. https://www.census.gov/quickfacts/fact/table/VA/AGE135224

[44] Muennig, P. (2009). The Social Costs of Childhood Lead Exposure in the Post–Lead Regulation Era. Archives of Pediatrics & Adolescent Medicine, 163(9), 844. https://doi.org/10.1001/archpediatrics.2009.128

Logging is considered the most dangerous job in the United States, with the Bureau of Labor Statistics reporting a fatal injury rate of 110.4 per 100,000 workers in the logging industry (0.11%).[45] Research on the occupational safety and health of Virginia loggers indicates that approximately 14% of loggers experience an injury annually, and over half (51%) report being injured at some point in their careers.[46] Since 1996, the VCE natural resource team has worked to improve logger safety through the Sustainable Harvesting and Resource Professional (SHARP) Logger program, which has reached over 4,500 harvesting professionals from 2002 to 2025.[47]

Workplace injuries carry significant financial consequences. According to the National Safety Council (NSC), the average medically consulted injury costs approximately $48,000, including wage losses, medical expenses, administrative expenses, and employer costs.[48] The economic cost of a work-related fatality is around $1.5 million.[49]

The SHARP Logger program has demonstrated a measurable impact, with a recent comprehensive survey of 632 responses showing 90% of participants agreed the program helped to improve safety on logging operations.[50] Based on the 569 respondents reporting safety improvements, if 14% avoided injury due to the program, this would represent substantial cost savings. Using an estimate of $48,000 per injury, the program potentially saved loggers and employers almost **$3,840,000**. This figure does not factor in the potential economic or social benefits of lives saved through safer logging practices.

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[45] U.S. Bureau of Labor Statistics. (2024). Rate and number of fatal work injuries in selected occupations. U.S. Department of Labor. https://www.bls.gov/charts/census-of-fatal-occupational-injuries/rate-and-number-of-fatal-work-injuries-in-selected-occupations.htm

[46] [10] Kim, S., Nussbaum, M. A., Schoenfisch, A. L., Barrett, S. M., Bolding, M. C., & Dickerson, D. E. (2017). Occupational Safety and Health Concerns in Logging: A Cross-Sectional Assessment in Virginia. Forests, 8(11), 440. https://doi.org/10.3390/f8110440

[47] Barrett, S. (2025). SHARP Logger Program Impact Statement. https://virginiatech.sharepoint.com/:w:/r/sites/OfficeofEconomicDevelopment/_layouts/15/Doc.aspx?sourcedoc=%7B39FA16FE-E36C-48FF-8657-3AD0B58104EB%7D&file=2025%20SHARP%20Impact%20statement.docx&action=default&mobileredirect=true

[48] National Safety Council. (2024). Work injury costs. Injury Facts. https://injuryfacts.nsc.org/work/costs/work-injury-costs/

[49] National Safety Council. (2024). Work injury costs. Injury Facts. https://injuryfacts.nsc.org/work/costs/work-injury-costs/

[50] Barrett, S. (2025). SHARP Logger Program Impact Statement. https://virginiatech.sharepoint.com/:w:/r/sites/OfficeofEconomicDevelopment/_layouts/15/Doc.aspx?sourcedoc=%7B39FA16FE-E36C-48FF-8657-3AD0B58104EB%7D&file=2025%20SHARP%20Impact%20statement.docx&action=default&mobileredirect=true

General Health and Wellbeing Impacts from Nature Access:

Lastly, the Virginia Master Naturalist program supports community volunteering initiatives and provides opportunities for Virginians to spend time in nature supporting natural resource conservation. Spending time outdoors has measurable health and economic benefits. Time in nature is linked to a variety of health improvements, including improved cognition and reduced risks of cardiovascular disease and depression. Research by White et al. indicates that individuals who spend at least 120 minutes per week in natural environments are significantly more likely to report good health and a high level of [51] compared to those are not exposed to nature throughout the week.[52]

Furthermore, a study of Californians showed that individuals with the highest exposure to nature have annual healthcare costs approximately $374 lower than those with limited exposure.[53] A study of Australian parks tourism also found that regularly visiting green space is associated with overall healthcare savings of 2-5%.[54] In Virginia, annual personal healthcare expenditures averaged $10,625 per person in 2023.[55] A 2–5% reduction in healthcare spending translates to annual savings of approximately $213 to $531 per individual, mirroring the findings of the California study.

Through the Virginia Master Naturalist Program, 2,892 volunteers reported service hours in 2024.[56] Applying these estimated savings suggests total annual healthcare cost reductions of approximately **$1 million**. It should be noted that this is a conservative estimate, as it only accounts for the health benefits experienced by VMN volunteers themselves. The program's broader impact is likely much greater, as volunteers also engage thousands of

[52] White, M. P., Alcock, I., Grellier, J., Wheeler, B. W., Hartig, T., Warber, S. L., Bone, A., Depledge, M. H., & Fleming, L. E. (2019). Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Scientific Reports, 9*(1), 1–11. https://doi.org/10.1038/s41598-019-44097-3

[53] Van Den Eeden, S. K., Browning, M. H. E. M., Becker, D. A., Shan, J., Alexeeff, S. E., Thomas Ray, G. Quesenberry, C. P., Kuo, M. (2022, May). Association between residential green cover and direct healthcare costs in Northern California: An individual level analysis of 5 million persons. *Environment International, 163*. https://doi.org/10.1016/j.envint.2022.107174

[54] Loch, A., Sexton, S., Maclean, J., O'Connor, P., Adamson, D., Scholz, G. (2024, December). Increased monetary equity and health wellbeing benefits for marginal urban socioeconomic groups from access to green space. *Urban Forestry & Urban Greening, 102*. https://doi.org/10.1016/j.ufug.2024.128576

[55] OnPoint Health Data. (2025, January 16). Tracking Virginia's 2023 health care spending & employment trends. https://www.onpointhealthdata.org/docs/resources/tracking-virginias-2023-health-care-spending-and-employment-trends.pdf

[56] Virginia Master Naturalists. (2025, January 31). *Virginia Master Naturalist program 2024 year in review*. Virginia Cooperative Extension. https://www.virginiamasternaturalist.org/blog/virginia-master-naturalist-program-2024-year-in-review/

additional individuals in outdoor activities who may not otherwise have taken part in those opportunities.

Annual Human Health & Safety Economic Impact Calculations:

Impact	Number of Participants in 2025	Number of People Potentially Impacted	Cost Savings	Total Economic Savings
Acute Gastrointestinal Incidence	**5,676**	**70%*5676 = 3,973 participants taking action avoiding AGI** **3,973*0.066 E. coli presence = 262 potential AGI cases**	**$39.9 million cost of total AGI hospitalizations / 29,200 AGI emergency visits = $1,366 per AGI case**	**$357,892** ** $487,066 Adjusted for inflation to Dec. 2025*
DeFelice, N., Johnston, J., MacDonald Gibson, J. (2016). Reducing Emergency Department Visits for Acute Gastrointestinal Illnesses in North Carolina (USA) by Extending Community Water Service. Journal of Environmental Health Perspectives, 124(10):1583–1591. https://pmc.ncbi.nlm.nih.gov/articles/PMC5047767/ "Of these attributable (AGI) cases, … 29,200 were associated with private well contamination. The estimated statewide annual cost of emergency department visits attributable to microbiological contamination of drinking water (from private well contamination) is 39.9 million USD." Smith, A., Krometis, LA., Hagedorn, C., Lawrence, A., Benham, B., Ling, E., Ziegler, P., Marmagas, S. (2014). Associations between fecal indicator bacteria prevalence and demographic data in private water supplies in Virginia. Journal of Water Health, 12(4): 824-834. https://doi.org/10.2166/wh.2014.026 "in over 800 (Virginia) samples collected at the point-of-use from homes with private water supply systems… 6.6% tested positive for E. coli."				
Lead Exposure	**5,676**	**70% * 5676 = 3,973 participants taking action avoiding lead** **7.6% * 3,973 = 302 could be exposed to lead** **6% of VA population is under the age of 6 = 0.06 * 302 = 18**	**$50,000 in lifetime savings from preventing childhood lead exposure**	**$900,000** **Inflation calculation not feasible due to lifetime savings rather than annual*
Muennig, P. (2009). The Social Costs of Childhood Lead Exposure in the Post–Lead Regulation Era. Archives of Pediatrics & Adolescent Medicine, 163(9), 844. https://doi.org/10.1001/archpediatrics.2009.128 "Reducing blood lead levels to less than 1 μg/dL among all US children between birth and age 6 years would reduce crime and increase on-time high school graduation rates later in life. The net				

societal benefits arising from these improvements… would amount to $50 000 in savings during the average person's lifetime at a 3% discount rate"				
Water Testing	**5,676**	**5,676**	**$99.28 per household**	**$563,500**
Ling, E. (2025). Virginia Household Water Quality Program 2025 Annual Report [Infographic]. Virginia Cooperative Extension. https://www.canva.com/design/DAG_hsQRtvw/wwcXkXonkJ5FVgEcVjTGYw/view "Serving 5,676 Virginians … VAHWQP delivered testing services at a cost of $157,780 compared to an estimated $721,280, saving families 78% compared to commercial testing." [$721,280 - $157,780 / 5,676 = $99.28 per family"				
Improved Logger Safety	**740**	**90% of 632 survey respondents reported improved safety attributed to the SHARP Logger trainings = 569 * 14% annual injury rate = 80 loggers avoided injury**	**$48,000 per medically consulted work injury (2024)**	**$3,840,000** **$4,034,691 adjusted for inflation to Dec. 2025*
Kim, S., Nussbaum, M. A., Schoenfisch, A. L., Barrett, S. M., Bolding, M. C., & Dickerson, D. E. (2017). Occupational Safety and Health Concerns in Logging: A Cross-Sectional Assessment in Virginia. Forests, 8(11), 440. https://doi.org/10.3390/f8110440 "Respondents were at a high risk of workplace injuries, with reported career and 12-month injury prevalences of 51% and 14%, respectively." *National Safety Council. (2024). Work injury costs. Injury Facts. https://injuryfacts.nsc.org/work/costs/work-injury-costs/* "Cost per medically consulted injury in 2024 was $48,000, while the cost per death was $1,540,000."				
Outdoor Health Benefits	**2,892 (Active volunteers in 2024)**	**2,892**	**$374 average healthcare cost savings per person**	**$1,081,608** **$1,246,672 adjusted for inflation to Dec. 2025*
Van Den Eeden, S. K., Browning, M. H. E. M., Becker, D. A., Shan, J., Alexeeff, S. E., Thomas Ray, G. Quesenberry, C. P., Kuo, M. (2022, May). Association between residential green cover and direct healthcare costs in Northern California: An individual level analysis of 5 million persons. Environment International, 163. https://doi.org/10.1016/j.envint.2022.107174 "Individuals in the top decile of residential green cover had adjusted healthcare costs of $374.04 per person per year less than individuals living in the bottom decile"				
Total				**$6,743,000**

				**7,231,929 adjusted for inflation to Dec. 2025*

*Inflation adjusted by the United States Department of Labor Consumer Price Index Calculator

Limitations:

Several limitations should be considered when interpreting these estimates.

The 2025 SHARP Logger calculation assumes that participants in the SHARP Logger training who reported improved safety in their logging operations fully avoided the 14% annual logger injury rate. In reality, safety improvements are likely reduced but are not guaranteed to entirely eliminate injury risk. Future longitudinal data collection that tracks participant injury prevalence over time would produce a more robust estimate of the cost savings the program generates through avoided injuries.

More broadly, many of the economic impact estimates rely on assumptions about risk exposure and behavior change. For example, calculations related to waterborne illness and lead exposure assume that identified contamination leads to corrective action and that such action fully prevents adverse health outcomes. Estimates of avoided healthcare costs from nature exposure assume that participation in the Virginia Master Naturalist program directly increases time spent outdoors and associated health benefits that volunteers would have otherwise not experienced, which may not be true for all participants. Additionally, some benefits such as improved quality of life, reduced pain and suffering, and avoided fatalities that provide societal benefits are not fully captured in monetary terms.

Lastly, this economic impact statement only captures data from a subset of VCE natural resource programs in 2025. Measuring the cumulative impact across program lifetimes would require additional data collection.

Opportunities for Future Research:

The estimates presented in this report rely on existing literature to quantify economic value, but the strength of future impact statements depends on the VCE natural resource team's ability to pair those literature findings with program-specific behavioral data. Across all program areas, a shared priority for future research is the collection of follow-up data from participants — tracking whether educational interventions translated into meaningful behavior change, such as whether well owners acted on contamination findings, whether loggers sustained safety practices over time, or whether Master Naturalist volunteers reported increased time outdoors. Gathering this information

requires maintaining contact with participants after the point of service, which presents a practical challenge for programs that interact with large, dispersed audiences. Future work should explore low-burden engagement strategies, such as brief follow-up surveys distributed digitally, or opt-in contact lists established at point of participation, to improve response rates and reduce attrition over time. As longitudinal data accumulates, it will become possible to replace assumed behavioral outcomes with measured ones, producing more defensible and precise economic estimates.

In addition to strengthening existing program metrics, two thematic areas emerged from workshop findings as promising directions for future economic impact analysis: ecosystem services and forest products. Incorporating these lenses into future reporting will allow VCE's natural resource team to capture economic value beyond human health and safety, including the impacts their work has on healthy forests and natural systems in supporting water quality, carbon sequestration, biodiversity, and rural livelihoods. Applying consistent economic frameworks across these thematic areas would provide a more comprehensive account of the total value VCE natural resource management programs generate for Virginians and the Commonwealth's natural resources.

Conclusion

The VCE natural resource management team (working under the VCE Natural Resource, Forestry and Environment Initiative) delivers measurable and meaningful benefits to human health and safety across the Commonwealth. Through a combination of preventative education, workforce training, and community-based programming, these efforts reduce exposure to environmental health risks, improve occupational safety outcomes, and promote long-term wellbeing.

The estimated $7 million in annual cost savings shows the economic value of some of these programs but might underestimate their full societal impact. Interventions such as private well testing and lead exposure prevention generate lifelong benefits that extend beyond immediate healthcare savings, while safety improvements in the logging industry reduce both financial burdens and the human costs associated with injury and fatality. Similarly, investments in nature access and outdoor education contribute to broader public health outcomes, including reduced chronic disease risk and improved mental health.

Taken together, these programs demonstrate that relatively low-cost, education-based interventions can produce substantial economic returns while improving quality of life for Virginians. Continued investment in these initiatives is likely to yield increasing benefits over time, particularly as environmental health risks like vector-borne illness rise with climate change effects. Future research to fully understand the economic impact of Extension programming may include strengthening assessment of behavior change following VCE natural resource program efforts and assessment of the economic impacts of forest products and ecosystem services.

Appendix

Interview Protocol

The purpose of this interview is to better understand your program's mission, core activities, logic model, and approaches to measuring and communicating impact. We are particularly interested in learning how your program conceptualizes impact, how your current logic models guide your work, and any areas to improve or strengthen impact assessments. Your responses will help inform the development of impact statements and refined logic models that encompass the variety of VCE natural resource management programs.

We will create interview summaries to inform the team's logic model workshop, and your responses may be shared with the group. Can we record this interview?

Main Theme	**Probing Questions**	**Notes**
Program Content How do you explain your program's mission?	How do your program's activities relate to VCE's mission? What are your key defining program activities?	
Logic Models How did you develop your current logic model?	How does the logic model help you understand or explain your work? How often do you revisit your logic model? Does your logic model shape any adjustments to program activities? Are there any areas of your logic model that do not accurately represent the current state of your program?	
Programs without logic models	What are the key outcomes of your program activities? (quantifiable)	

	How do those outcomes feed into impact? (high-level, societal level)	
Impacts How would you explain your program's impact to a colleague?	How do you currently quantify the economic impact of your program? What economic impact research do you find relevant to your work? Could you share examples? In what ways would you like to measure impact but aren't currently? (What are your constraints?) Who are the beneficiaries of your program? Is there overlap with other Extension programs? Where are program metrics collected? Are we able to view the data?	

Worksheet for Tracing Your Program's Impact

During our March 20th workshop, we identified three common areas of impact shared across the VCE Natural Resource Group programs: **Health & Safety, Ecosystem Services, and Forest Production**.

Purpose: Use this worksheet to map how your program contributes to each of these three impact areas across Virginia.

Instructions:

- **Think aspirationally.** When considering your program's influence, set aside external or confounding factors.
- **Focus on the big picture.** Our goal is to build a cohesive, big-picture narrative that shows how all programs collectively contribute to these impact areas (regardless of whether you currently track metrics for these outcomes).
- **Apply an economic lens.** What are the economic dimensions of your program's work? This will help inform the economic impact statements.

Impact Area Definitions:

Health & Safety Impacts: Program outcomes that improve human health, prevent disease, and reduce injuries.

Ecosystem Services: Program outcomes that create direct and indirect benefits from ecosystems to humans. This includes:

- ***Provisioning services:*** the material or energy outputs from an ecosystem, including food, forage, fiber, fresh water, and other resources
- ***Regulating services:*** benefits obtained through moderation or control of ecosystem processes, including regulation of local climate, air, or soil quality; carbon sequestration; flood, erosion, or disease control; and pollination
- ***Supporting services:*** services that maintain fundamental ecosystem processes, such as habitat for plants and wildlife, or the maintenance of genetic and biological diversity
- ***Cultural services:*** the non-material benefits that ecosystems provide to human societies and culture, including opportunities for recreation, tourism, aesthetic or artistic appreciation, and spirituality

(Source: USDA)

Forest Production: Program outcomes that strengthen the forest economy, including forest management, employment generation, and manufacturing.

Worksheet Example: SHARP Logger Program Long-Term Outcomes

Health & Safety

- Knowledge Change:
    - Logger trainings increase awareness of OSHA requirements and safety practices.
- Behavior Change:
    - Loggers change their safety practices in the field.
- Long-term Outcome:
    - The SHARP Logger program reduces logger injuries.

Ecosystem Services:

- Knowledge Change:
    - Logger trainings increase awareness of sustainable best management practices (BMPs).
- Behavior Change:
    - Loggers implement BMPs in the field.
- Long-term Outcome:
    - The implementation of BMPs improves environmental quality in [xyz] ways.

1. *How does your program impact "Health and Safety"?*

a. Short-term: What knowledge change(s) occurs? How do people become more aware or gain access to information regarding their health and safety?

b. How do you currently measure knowledge change?

c. Medium-term: What behavioral changes occur? How do people take action to become more healthy or safe?

d. How do you currently measure behavior change?

e. Long-term: What are the long-term program outcomes related to health and safety?

2. *How does your program impact "Ecosystem Services"?*

a. Short-term: What knowledge change(s) occurs? How do people become more aware or gain access to information regarding ecosystem services?

b. How do you currently measure knowledge change?

c. Medium-term: What behavioral changes occur? How do people take action to protect or enhance Virginia's ecosystem services?

d. How do you currently measure behavior change?

e. Long-term: What are the long-term program outcomes related to ecosystem services?

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3. How does your program impact "Forest products"?

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a. Short-term: What knowledge change(s) occurs? How do people become more aware or gain access to information regarding forest products?

b. How do you currently measure knowledge change?

c. Medium-term: What behavioral changes occur? How do people take action to protect, enhance, or promote Virginia's forest products?

d. How do you currently measure behavior change?

e. Long-term: What are the long-term program outcomes related to forest products?