Agricultural Conservation Practices:

Clean Water and Climate-Smart Investments

CHESAPEAKE BAY FOUNDATION

Saving a National Treasure

WILL PARSON/CHESAPEAKE BAY PROGRAM

Agricultural Conservation Practices:

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The Blueprint

The Chesapeake Clean Water Blueprint is the historic federal/state plan established in 2010 to restore the Bay's water quality and, in doing so, also improve the many streams and rivers that feed it. It outlines pollution limits; plans to meet those limits developed by each of the six Bay states and the District of Columbia (known as Watershed Implementation Plans, or WIPs); and accountability measures by which the U.S. Environmental Protection Agency must ensure states implement their plans. The Blueprint calls for all Bay states and the District of Columbia to have in place, by 2025, the practices and policies necessary to meet the Bay›s pollution limits.

Methods

The economic analysis looked at 17 agricultural conservation practices that states are implementing as part of their plans to achieve pollution reductions. The Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST) and data from the U.S. Department of Agriculture were used to estimate the cost of implementing each practice and the remaining amount of implementation work left to complete by 2025, based on the most recent WIP progress data (end of 2020). Using these numbers, economic impacts were then calculated using the Regional Input-Output Modeling System from the U.S. Bureau of Economic Analysis. To ensure the estimates are conservative, the analysis included only counties with more than 30 percent of their land area in the Chesapeake Bay watershed.

Executive Summary of Economic Impacts of Implementing the Chesapeake Clean Water Blueprint: Agriculture

The six states and the District of Columbia that share the 64,000-square-mile Chesapeake Bay watershed are currently carrying out plans—called Watershed Implementation Plans (WIPs)—to achieve the pollution reductions called for in the Chesapeake Clean Water Blueprint, the science-based plan designed to restore the health of the Bay. The 2025 deadline for implementation is fast approaching and more than 90 percent of the remaining reductions must come from agriculture. Though progress has been made, it is still far short of what is needed. Increased funding for conservation practices, as outlined in the state plans, is therefore critical to success.

The Chesapeake Bay Foundation (CBF) worked with natural resource economists to estimate the economic impact of implementing the remaining agricultural conservation practices in the state plans. The analysis shows that investing in these conservation practices is truly that—an investment with positive economic effects above and beyond the cost. For every dollar spent implementing additional agricultural conservation practices under the Blueprint, the Chesapeake Bay region can expect $1.75 in economic returns to local businesses and workers through additional sales of goods and services and greater earnings, totaling $655.2 million annually through 2025. This investment will also support an estimated 6,673 jobs a year between 2020 and 2025.

Key Findings

An economic assessment (*see sidebar for methods*) of the state WIPs found that implementing the remaining agricultural conservation practices called for in the plans would provide an additional $655.2 million annually in total output (sales of goods and services) for local businesses and workers—including $268.9 million in earnings—and support 6,673 jobs each year in the Chesapeake Bay watershed (Table 1). It also found:

- Every dollar spent on further conservation practices in the watershed would, on average, return an estimated $1.75, including increased sales of goods and services and increased earnings for businesses and workers. Depending on the practice, location, and level of investment, the return ranges from $1.39 to $1.82.
- Implementing agricultural conservation practices in Pennsylvania, which is relying on farms to achieve more than 90 percent of its remaining pollution reductions, would result in an estimated $352.5 million in economic impacts (Figure 1). That includes the benefit of $145.1 million in annual earnings for businesses and workers and the support of 3,457 jobs each year.
- In Virginia, investment in agricultural conservation practices would result in an estimated $191.2 million in economic impacts, including the benefit of $78.6 million in annual earnings for businesses and workers and the support of 2,067 jobs each year.

- Implementing the agricultural conservation practices in Maryland's plan would result in $41.2 million in economic impacts, including the benefit of $16.5 million in annual earnings for businesses and workers and the support of 423 jobs each year.
- Delaware, New York, and West Virginia would also see significant economic effects from investing in the agricultural conservation practices outlined in their plans, with additional economic impacts estimated at $44.6 million, $18.2 million, and $7.5 million annually, respectively.
- Of the 17 conservation practices assessed, eight collectively account for just over half of the estimated economic impacts in the watershed. These practices include: managing applications of nitrogen and phosphorus fertilizer; managing tillage; planting cover crops; providing alternative water sources to livestock away from streams; improving the quality of pastures through prescribed grazing; managing horse pastures; and planting forest buffers and grass buffers along streams. Together, investing in these practices as called for in the state plans would result in estimated economic impacts to businesses and workers of $332 million each year until 2025.

Economic impacts—The additional sales and earnings businesses and workers receive due to increased purchases of their goods and services, as well as the effects of having that money flow to other businesses in the area. For example, the economic effect of planting forest buffers would include the money paid directly to businesses and workers who plant the trees; the money those businesses pay to their suppliers who grow the trees; and the money their workers spend at restaurants, grocery stores, and other businesses.

Table 1. Annual Expenditures and Economic Impacts of Implementing Agriculture Conservation Practices in the Chesapeake Bay Watershed (millions of $ 2021)

Expenditures (millions of $ 2021)	Conservation Practice	Economic Impacts (millions of $ 2021)		Jobs Supported	Economic Impacts per $1 Spent ($)
		Total	Earnings*		
77.3	Nutrient Application Management	131.8	60.2	1,833	1.70
16.1	Tillage Management	27.0	12.3	382	1.67
77.9	Cover Crops	137.2	62.3	1,842	1.76
0.04	Pasture Alternative Watering	0.1	0.01	<1	1.62
5.6	Prescribed Grazing	9.8	1.8	56	1.74
0.4	Horse Pasture Management	0.5	0.1	3	1.39
10.1	Forest Buffers	17.2	7.9	223	1.70
4.9	Grass Buffers	8.4	3.8	113	1.72
1.8	Wetland Restoration	3.1	1.1	15	1.76
26.7	Soil and Water Conservation Plans	44.2	20.2	601	1.66
0.1	Agricultural Drainage Management	0.1	0.0	1	1.58
49.2	Non-Urban Stream Restoration	86.1	30.7	485	1.75
86.8	Waste Management Systems	157.6	57.6	916	1.82
6.8	Barnyard Runoff Control and Loafing Lot Management	12.1	4.4	70	1.78
9.5	Manure Transport	17.0	5.0	89	1.78
1.8	Land Retirement	3.0	1.3	44	1.68
$375.1	**Total**	**$655.2**	**$268.9**	**6,673**	**$1.75**

*Earnings are included in the total economic impacts.

Discussion and Recommendations

The analysis clearly shows that investments in the agricultural conservation practices that are necessary for Chesapeake Bay restoration will also benefit businesses and workers in the region above and beyond their cost. These economic dividends are in addition to the estimated $130 billion annually in natural benefits[1]—including cleaner water, better aquatic and terrestrial habitat, and enhanced recreational experiences—that will result from a restored Chesapeake Bay.

The overall economic effect of various practices is influenced by the amount that states expect to invest and where. For example, the practice with the largest total economic return is animal waste management systems, which is also the practice with the greatest financial investment across the watershed. This is a reflection of the relatively high cost of these systems. On a dollar-invested for dollar-return basis, however, the economic return is not much higher for animal waste management systems than for practices like wetland restoration and forested buffers (Table 1, Figure 2). And it is worth noting that conservation practices vary in their cost-effectiveness for reducing pollution and providing additional benefits to communities and the environment. For example, it takes a $7.62 investment in forest buffers to reduce a pound of nitrogen, whereas reducing a pound of nitrogen takes

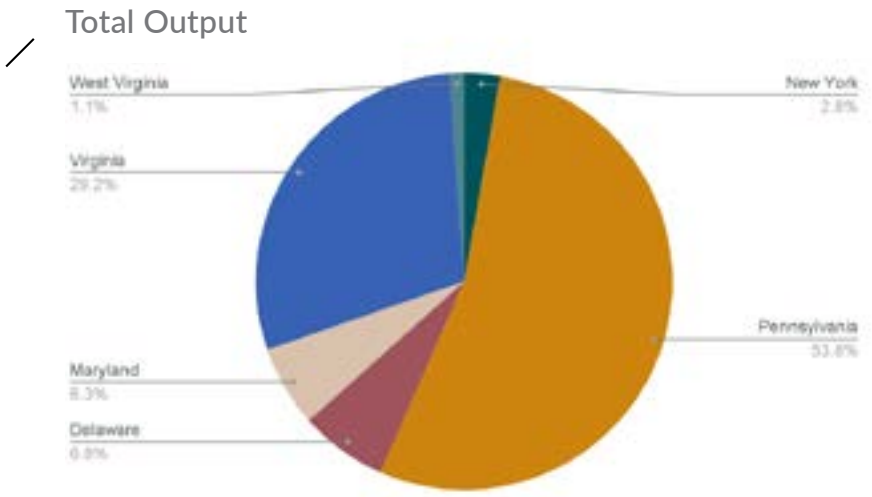

Figure 1. *Total Economic Impacts of Agriculture BMP Implementation in the Chesapeake Bay Watershed, per Year and by State ($655.2 million total, $ 2021)*

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.

There are no WIP III agriculture BMP goals in the District of Columbia's portion of the watershed.

1 *Spencer Phillips and Beth McGee (2016). Ecosystem Service Benefits of a Cleaner Chesapeake Bay. Coastal Management, 44:3, 241-258.*

a $2,350 investment for animal waste management systems[2]. Moreover, forest buffers provide shade and habitat for wildlife, store carbon, mitigate flooding, and can provide additional revenue for farmers through the production of nuts, fruit, livestock forage, and even honey. Targeting funding to practices that are cost-effective and provide a holistic range of benefits can, and should, help ensure the greatest outcomes for the region's water quality and community wellbeing.

In sum, funding the full implementation of agricultural conservation practices in the Chesapeake Bay watershed is an investment that will pay both economic and environmental dividends. Along with improved water quality, agricultural conservation practices provide a significant opportunity to benefit farmers and communities, particularly as climate change places more stress on our nation's food system. These benefits include healthier and more productive soil, increased resilience to costly weather extremes like floods and drought, the capture and storage of greenhouse gases that contribute to climate change, and habitat for game and wildlife. In addition to consideration of the economic effects, investments in agricultural conservation practices should prioritize those that provide multiple benefits to water quality, climate resilience, and communities to achieve the most effective use of funding.

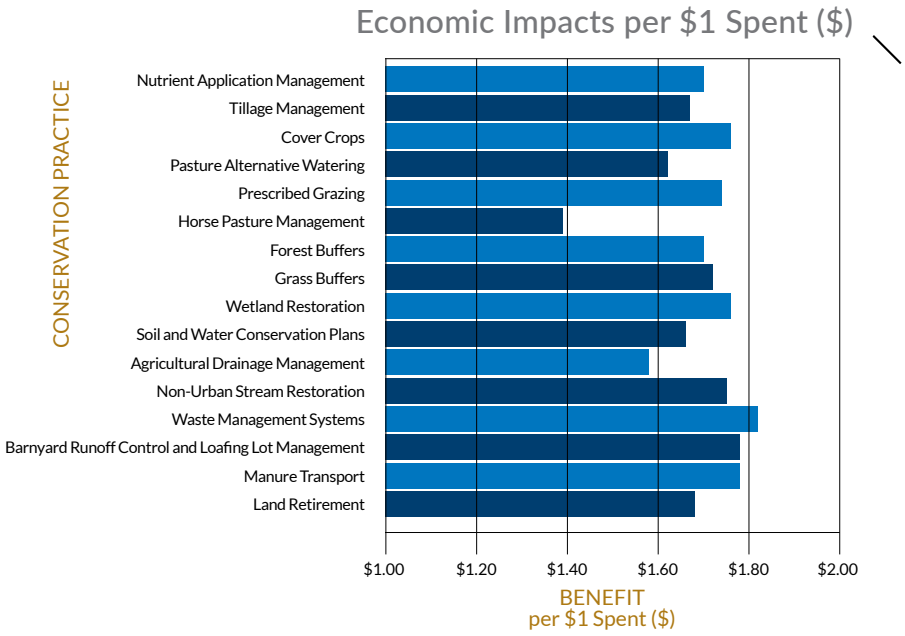

Figure 2. *Total Economic Impacts Per Dollar Spent on Agricultural Conservation Practices in the Chesapeake Bay Watershed, By Conservation Practice ($ 2021)*

2 *Based on cost data from the Chesapeake Assessment Scenario Tool.*

Economic Impacts of Implementing the Phase III Watershed Implementation Plans:

Agriculture BMPs

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About

Key-Log Economics is an independent ecological economic research and consulting firm that works with clients to develop the facts and arguments that make for a competent understanding of today's conservation, environmental, and sustainability challenges.

Overview

Funding for continued implementation of Best Management Practices (BMPs) throughout the Chesapeake Bay watershed provides a means to promote economic recovery while advancing Bay restoration to achieve the goals outlined in state Watershed Implementation Plans (WIPs). To that end, we quantify the regional-level economic stimulus and job creation that is expected to result from continued implementation of select BMPs.[1]

In coordination with CBF staff, we identify the 17 agricultural BMPs included in the analysis. For each BMP, we obtain Phase III WIP implementation levels from the Chesapeake Assessment Scenario Tool (CAST; Chesapeake Bay Program, 2020). CAST also provides estimates of the cost of implementing these practices. These costs serve as the inputs for calculations of the total economic impact of BMP implementation. Those impacts are expressed in terms of additional output (sales), wage income, and jobs in the study region; calculations are completed using the U.S. Bureau of Economic Analysis' (BEA) Regional Input-Output Modeling System (RIMS II). Results suggest that achieving the FInal Phase III WIPs in the Chesapeake Bay watershed with the selected BMPs provides an additional $655.2 million in total output (sales of goods and services; 2021 dollars), including $268.9 million in earnings, and supports 6,673 jobs a year between 2020 and 2025. We estimate that the economic return, in terms of total output, associated with BMP implementation is $1.75 per dollar spent in the Chesapeake Bay watershed, with 18 jobs supported per million dollars spent.

Methods

Study Region

The Chesapeake Bay watershed is composed of 7 basins identified by 6-digit hydrologic unit codes (HU6s). These are the Upper, Lower, and West Branch Susquehanna, the Potomac, the Upper and Lower Chesapeake, and the James basins. Our objective was to estimate the economic impact of spending on BMP implementation in those 7 basins and for 14 of the 15 combinations[2] of state and basin in the Chesapeake Bay watershed shown in Figure 1. Thus we need to define impact assessment zones comprising groups of entire counties.

[1] This analysis updates and expands an earlier analysis conducted by the UVA Weldon Cooper Center (Rephann, 2010). That report focused only on agricultural practices in Virginia.

[2] We excluded the West Virginia portion of the James River basin from the analysis due to its extremely small land area.

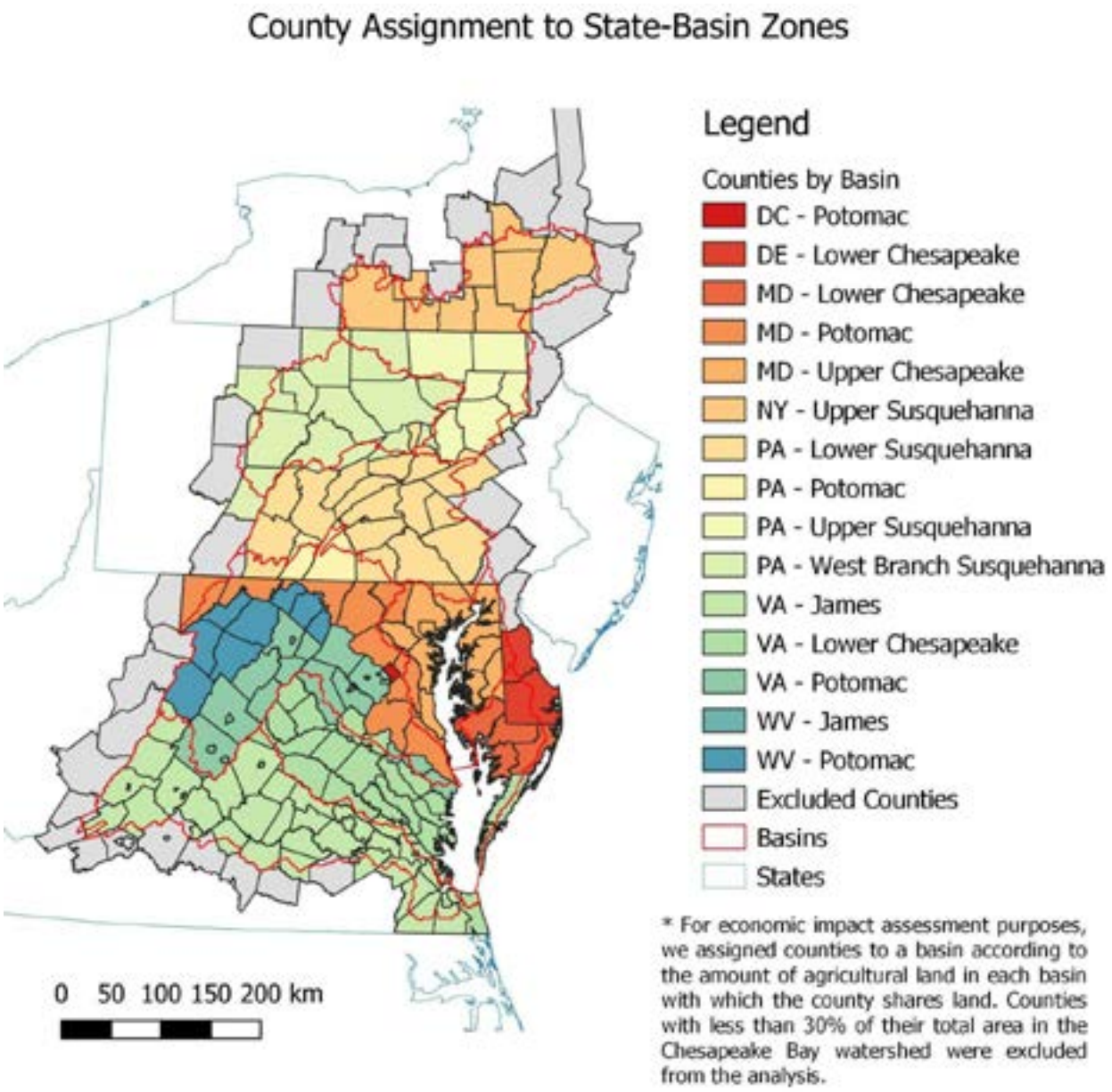

Figure 1. Assignment of Counties to Basins According to Agricultural Land

To define these groups, we first identified the 206 counties (including 31 independent cities in Virginia[3]) in or adjacent to counties that touch the Chesapeake Bay watershed. We then exclude 37 counties (and three Virginia independent cities within them) that have less than 30 percent of their land in the

[3] The independent cities are shown with their separate outlines on the map, but for the economic impact analysis, some are combined with adjacent counties. So, for example, Charlottesville City is combined with Albemarle County for the economic analysis.

watershed[4]. Finally, we assign each remaining county to the basin that drains the majority of the county's agricultural land. We identified agricultural land using satellite imagery compiled as the National Land Cover Database (Dewitz, 2021). One could have done the same using the percentage of urban or built-up land, but we reason that the bulk of the Phase III implementation will be through agricultural, not urban BMPs. For most of the counties, an urban-land-based assignment would be the same as the agricultural-land-based assignment.

Best Management Practices

Best Management Practices, or BMPs, are management actions to reduce nitrogen, phosphorus and sediment loads to local waters. Seventeen agriculture BMPs were selected for analysis by the Chesapeake Bay Foundation (descriptions are provided in Appendix A):

- Nutrient application management (nitrogen and phosphorus)
- Tillage management (low residue, continuous high residue, and conservation)
- Cover crops (traditional and commodity)
- Pasture alternative watering
- Prescribed grazing
- Horse pasture management
- Forest buffers
- Grass buffers
- Wetland restoration
- Soil and water conservation plans
- Agricultural drainage management
- Non-urban stream restoration
- Waste management systems (livestock and poultry)
- Barnyard runoff control and loafing lot management
- Manure transport
- Land retirement (cropland to pasture and cropland to agricultural open space)

The unit cost (e.g., dollars per acre) of implementing most of the BMPs was obtained by state from CAST (Chesapeake Bay Program, 2020). Average costs for tillage and agricultural drainage management were not available in CAST and we used figures from the U.S. Department of Agriculture's Natural Resources Conservation Service (U.S. Department of Agriculture, 2021) (costs are provided in Appendix A).

Remaining BMP implementation by 2025 is the level of implementation stated in the 2025 Final Phase III WIP goals minus the progress achieved by the end of 2020 (latest data available) for each county (or independent city) and BMP. Some BMPs are implemented annually (e.g., acres of crop cover per year). For others, a cumulative goal by 2025 is stated (e.g., acres of forest buffer). To estimate an average annual implementation rate for BMPs for which a 2025 goal is stated, we divided the progress remaining by 5, the number of years between 2020 and 2025.

[4] The 30% threshold was a natural break in the distribution of the percentage of county land in the watershed. Including counties with less land than this in the watershed would have, in our opinion, led to overestimation of the economic impact of BMP implementation.

The annual cost of implementing each BMP from 2021 to 2025 is the average annual implementation level times the annualized cost per unit of implementing each BMP (from CAST), or times the average annual cost (from the U.S. Department of Agriculture, 2021). The total annualized cost is equal to capital and opportunity costs, amortized over the BMP's lifespan, and added to annual operations and maintenance costs (Chesapeake Bay Program, 2020). Tillage and agricultural drainage management are implemented annually, and their annual costs include the current costs for material and labor within each state, and the fair marketplace compensation for opportunity costs that may arise (e.g., conversion of productive land) (U.S. Department of Agriculture, 2021).

Economic Impacts

Regional Input-Output Modeling System

We estimate the economic impacts of achieving the Final Phase III WIPs using the annual cost of implementing BMPs between 2021 and 2025 and economic multipliers obtained from the BEA Regional Input-Output Modeling System (RIMS II; U.S. Bureau of Economic Analysis, 2022). RIMS II is a regional economic model used to estimate the potential economic impact of projects.[5] The model provides multipliers estimating the impact of changes in final demand (changes in the purchases of goods or services by final users) on one or more regional industries in terms of output, employment, and labor earnings. That is, the total change that occurs in all industries for each additional dollar delivered to final demand by a specific industry. Multipliers are available for all industries in a region (any state, county, or combination of states or counties defined by the user) and for specific industries.

RIMS II was developed and is maintained by the U.S. Bureau of Economic Analysis. The most recent RIMS II multipliers (2022) are based on 2012 national benchmark input-output data and 2020 regional data. The model provides both Type I and Type II multipliers: Type I multipliers account for both the direct and indirect (interindustry) impacts of a final-demand change; Type II multipliers also account for induced impacts (household spending). For example, the direct employment impact of an increase in investment in forest buffers would be more jobs for people planting trees. An indirect impact would be more jobs for tree nursery workers, because the tree planters would buy the seedlings from the nursery. And an induced impact would be more jobs in the grocery stores where tree planters and nursery workers buy their food.

Calculating Economic Impacts

To obtain multipliers applicable to BMP implementation, we defined 7 regions consisting of counties (and independent cities) within each of the 7 Chesapeake Bay basins, as described above.

We aligned the BMPs with the appropriate RIMS II industry based on descriptions provided in the Chesapeake Bay Program's CAST (Chesapeake Bay Program, 2020) and *Quick Reference Guide* (Chesapeake Bay Program, 2018), North American Industry Classification System Manual (Office of Management and Budget, 2017), or the industry it was assigned in Rephann (2010).

[5] Available at https://apps.bea.gov/regional/rims/rimsii/

Then, for each basin, we multiply average annual costs for each BMP by the corresponding multipliers for total output, earnings, and employment to calculate the economic impacts of implementing the BMPs. This assumes all BMP expenditures are made within the basin. To estimate the aggregate impacts for all of the basins in each state (i.e., the entire Chesapeake Bay watershed in each state), we sum the impacts for the portions of the state in each basin (see Table B2). For example, the Virginia state total is the sum of the impacts in the Virginia portions of the Lower Chesapeake and Potomac basins plus the entire James basin.

Results

The RIMS II modeling results suggest that achieving the FInal Phase III WIPs in the Chesapeake Bay watershed with the 17 selected agriculture BMPs provides an additional $655.2 million in total output (sales of goods and services), including $268.9 million in earnings (in 2021 dollars), and supports 6,673 jobs a year. These are estimates of the total impact across all industries in the region (U.S. Bureau of Economic Analysis, 2013). Total output is the value of all industry production, including the sale of intermediate inputs for use in production, as well as sales of products to final consumers. Earnings consists of wages and salaries, proprietors' income, and employer contributions for health insurance. The employment estimate represents the average number of jobs supported each year; these jobs are "created" only in the first year of BMP implementation. Note that "jobs" include full-time, part-time, and seasonal jobs, and are not full-time equivalents.

Impacts by BMP

Implementation of the waste management systems, cover crops, and nutrient application management BMPs account for approximately two-thirds of the economic impacts, in terms of total output and jobs (Table 1, Figure 2). This is primarily because the majority of total direct expenditures are for these BMPs. Overall, every dollar spent is estimated to result in an additional $1.75 in industry output to the Chesapeake Bay watershed (See "Comparison of Impacts per Dollar Spent"). Approximately 18 jobs would be supported annually for each million dollars spent for BMP implementation.

Table 1. Annual Expenditures and Economic Impact of Agriculture BMP Implementation in the Chesapeake Bay Watershed (millions of $2021)

Direct Expenditures	BMP	Economic Impacts: Output	Earnings	Jobs
$77.3	Nutrient Application Management	$131.8	$60.2	1,833
16.1	Tillage Management	27.0	12.3	382
77.9	Cover Crops	137.2	62.3	1,842
0.04	Pasture Alternative Watering	0.1	0.01	<1
5.6	Prescribed Grazing	9.8	1.8	56
0.4	Horse Pasture Management	0.5	0.1	3
10.1	Forest Buffers	17.2	7.9	223
4.9	Grass Buffers	8.4	3.8	113
1.8	Wetland Restoration	3.1	1.1	15
26.7	Soil and Water Conservation Plans	44.2	20.2	601
0.1	Agricultural Drainage Management	0.1	0.0	1
49.2	Non-Urban Stream Restoration	86.1	30.7	485
86.8	Waste Management Systems	157.6	57.6	916
6.8	Barnyard Runoff Control and Loafing Lot Management	12.1	4.4	70
9.5	Manure Transport	17.0	5.0	89
1.8	Land Retirement	3.0	1.3	44
$375.1	**Total**	**$655.2**	**$268.9**	**6,673**

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.

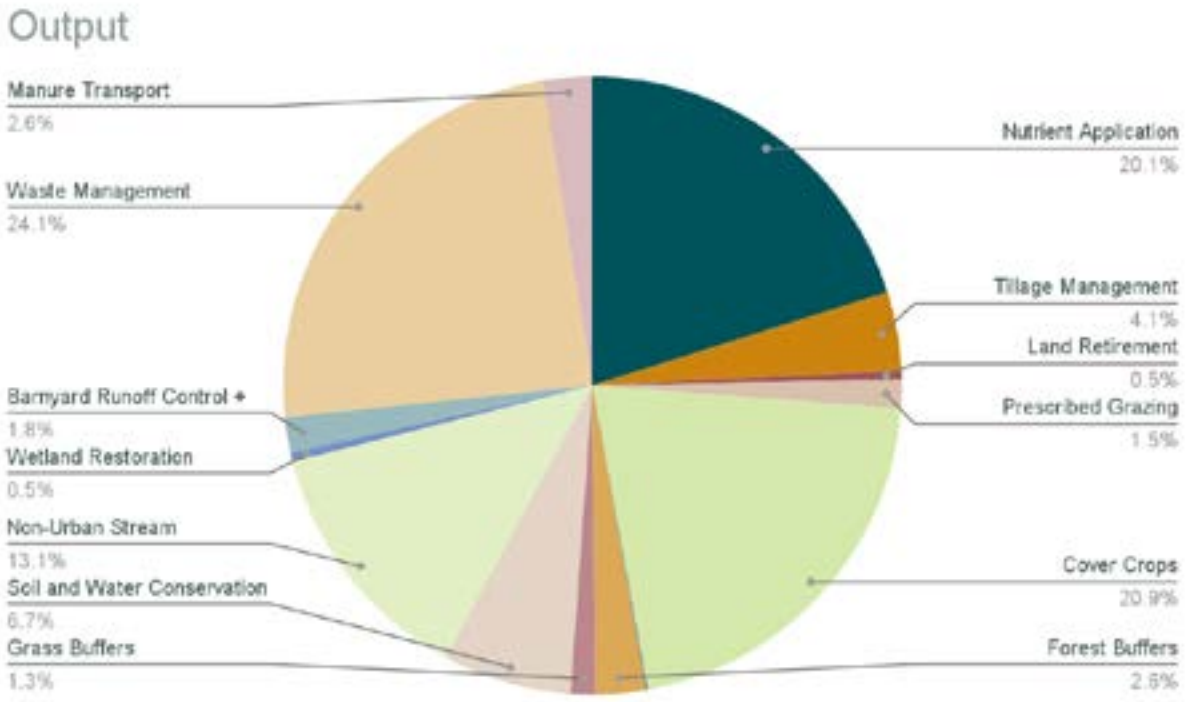

Figure 2. Total Output Impact of BMP Implementation in the Chesapeake Bay Watershed for Agriculture BMPs per Year ($655.2 million total, $2021)
Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Notes: "Barnyard Runoff Control +" refers to Barnyard Runoff Control and Loafing Lot Management. Pasture Alternative Watering, Agricultural Drainage Management, and Horse pasture management each represent less than 0.1% of the total output impact and are not shown.

The relative importance of earnings and employment impacts are similar to those for total output. Cover crops and nutrient application management practices provide the majority of jobs associated with BMP implementation in the watershed (Figure 3).

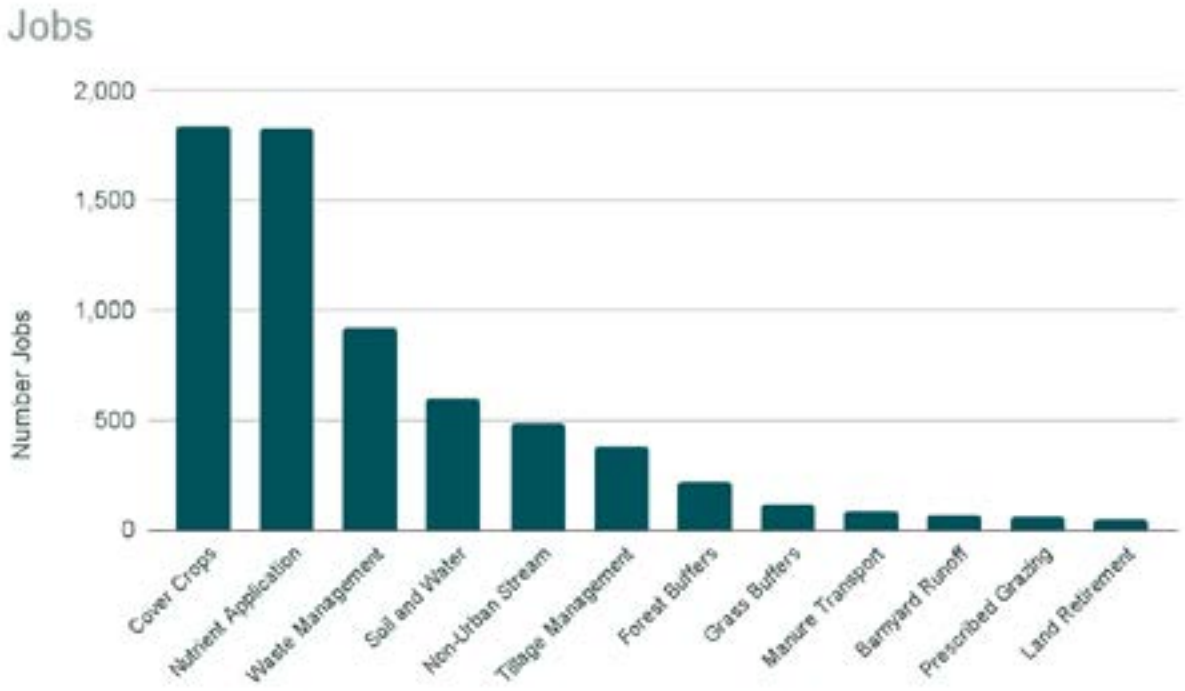

Figure 3. Annual Employment Impact of BMP Implementation in the Chesapeake Bay Watershed for Agriculture, by BMP (6,673 jobs total)
Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Notes: "Soil and Water" refers to Soil and Water Conservation Plans, "Non-Urban Stream" refers to Non-Urban Stream Restoration, and "Barnyard Runoff" refers to Barnyard Runoff Control and Loafing Lot Management. Wetland restoration, horse pasture management, agricultural drainage management, and pasture alternative watering BMP implementation each support 15 jobs or fewer (19 total).

Comparison of Impacts per Dollar Spent

Results of the RIMS II modeling suggest that the economic return in terms of total output associated with BMP implementation ranges from $1.82 per dollar spent (for the waste management systems practice) to $1.39 per dollar spent (for horse pasture management) (Table 2). Overall, the economic return is $1.75 per dollar spent) and each million dollars spent for BMP implementation supports 18 jobs a year in the Chesapeake Bay watershed, based on model results (U.S. Bureau of Economic Analysis, 2022).

Expenditures on nutrient application management, tillage management, cover crops, and land retirement practices support the most jobs (24 to 25) per million dollars spent, while horse pasture management, wetland restoration, and manure transport practices support the fewest jobs (8 to 9) per million dollars spent).

Table 2. Total Output and Jobs Supported by BMP Implementation per Dollar Spent in the Chesapeake Bay Watershed per year, by BMP ($2021)

BMP	Output per $1 Spent	Jobs per $1 Million Spent
Nutrient Application Management	1.70	24
Tillage Management	1.67	24
Cover Crops	1.76	24
Pasture Alternative Watering	1.62	<1
Prescribed Grazing	1.74	10
Horse Pasture Management	1.39	8
Forest Buffers	1.70	22
Grass Buffers	1.72	23
Wetland Restoration	1.76	8
Soil and Water Conservation Plans	1.66	23
Agricultural Drainage Management	1.58	17
Non-Urban Stream Restoration	1.75	10
Waste Management Systems	1.82	11
Barnyard Runoff Control and Loafing Lot Management	1.78	10
Manure Transport	1.78	9
Land Retirement	1.68	25
Total	**$1.75**	**18**

Note: Calculated by dividing total output and employment impacts by direct expenditures (Table 1).

Impacts by State

The majority of the economic impacts of implementation of agriculture BMPs in the Chesapeake Bay watershed are associated with expenditures in the portions of the watershed in Pennsylvania and Virginia[6] (Table 3, Figures 4 and 5). These states account for 83% of total direct expenditures. BMP expenditures in the Delaware and Maryland portions of the watershed provide just over 10% of the total impacts. The New York and West Virginia portions represent about 4% of the total. (See also Appendix B).

[6] For states that contain portions of more than one basin (such as Virginia; see Table B2), the state total is the sum of the impacts of the portions of the basins in that state (e.g., the Virginia portions of the Lower Chesapeake and Potomac basins plus the entire James basin).

Table 3. Annual Expenditures and Economic Impact of Agriculture BMP Implementation in the Chesapeake Bay Watershed, by State (millions of $2021)

Direct Expenditures		Economic Impacts: Output	Earnings	Jobs
$10.8	New York	$18.2	$7.8	187
195.7	Pennsylvania	352.5	145.1	3,457
23.1	Maryland	41.2	16.5	423
25.1	Delaware	44.6	18.0	486
0	District of Columbia	0	0	0
116.1	Virginia	191.2	78.6	2,067
4.4	West Virginia	7.5	2.9	53
$375.1	**Total**	**$655.2**	**$268.9**	**6,673**

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Notes: For states that contain more than one basin (see Table B2), the state total is the sum of the impacts of the portion of each basin in that state.
There are no WIP III agriculture BMP goals in the District of Columbia's portion of the watershed.
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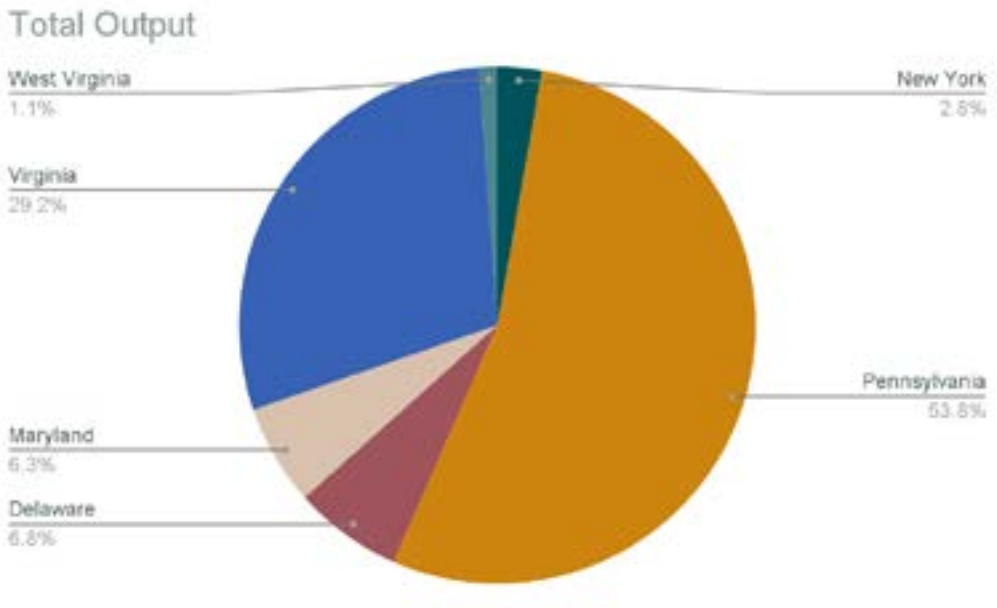

Figure 4. Total Output Impact of Agriculture BMP Implementation in the Chesapeake Bay Watershed, per Year and by State ($655.2 million total, $2021)
Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
There are no WIP III agriculture BMP goals in the District of Columbia's portion of the watershed.

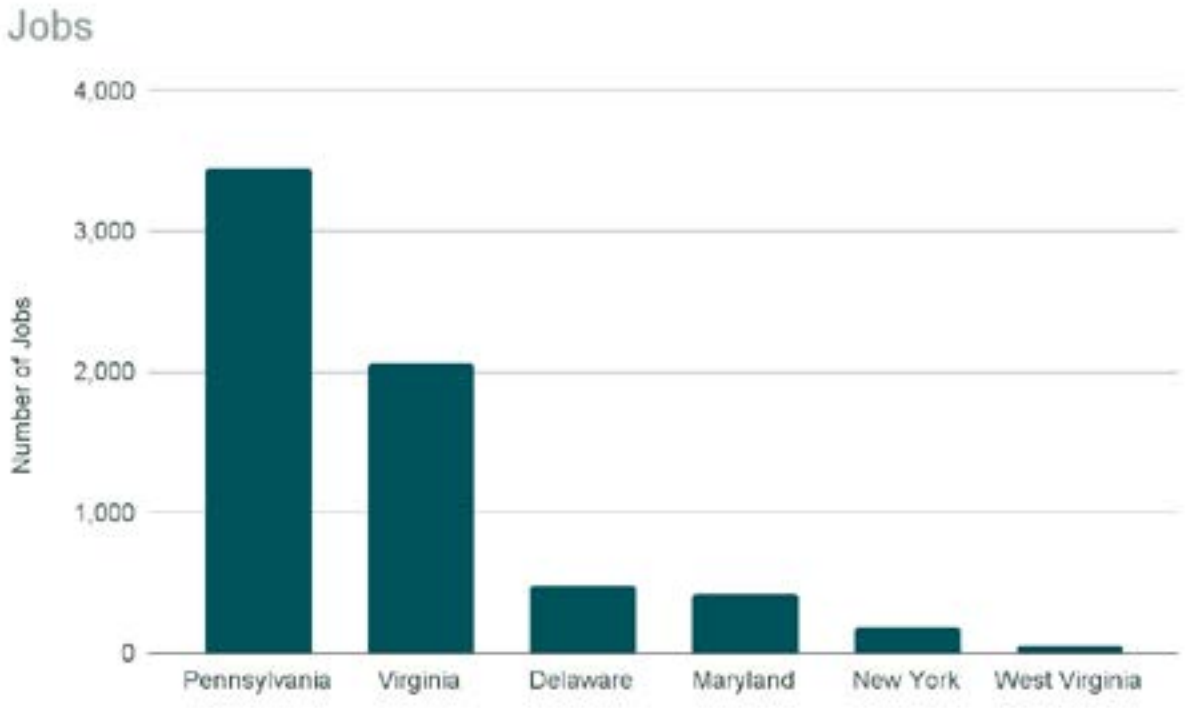

Figure 5. Employment Impact of Agriculture BMP Implementation in the Chesapeake Bay Watershed, per Year and by State (6,673 total)
Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Note: There are no WIP III agriculture BMP goals in the District of Columbia' portion of the watershed.

Limitations

One limitation of using RIMS II and similar I-O models is that they may overestimate the potential impacts of large and/or multi-year projects. Economic impacts happen due to sudden, unexpected changes in demand, such as new demand for tree planting services. If and only if you can hire all the new forestry technicians, etc., to do the work in the short term will you get the full multiplier effect. Over time, economic sectors change to accommodate the increased investment and therefore impacts may be less than originally estimated. For example, tree planting companies may anticipate business growth in upcoming years and invest in new technologies or practices that save labor. Workers may anticipate potential job opportunities and switch occupations, increasing the labor pool and thus driving down wages and reducing the multiplier effect. Any number of things can happen in the medium- to long-run that will change the way that the investment will pan out in the economy. Hence, the greater the number of years over which large project investments span, the greater the potential for economic impacts to be overstated.

Notwithstanding this caveat, it is clear that investment in agricultural BMPs will pay economic dividends over and above the cost of implementing the BMPs. These dividends will, of course, be in addition to the value of ecosystem services, such as cleaner water, better aquatic and terrestrial habitat,

and enhanced recreational experience that the BMPs will produce. (See Phillips and McGee (2016) for estimates of the economic value of cleaner water in the Chesapeake Bay watershed.)

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Appendix A. Best Management Practices

Table A1. Agriculture Best Management Practices

Best Management Practice	Description
Nutrient Application Management Nitrogen and Phosphorus	Promoting the efficient use of fertilizer and reduction of nutrient loss by managing rate, timing, and placement
Tillage Management: Low Residue Continuous High Residue Conservation	Retention of a portion of crop residue coverage at time of planting with minimum soil disturbance
Cover Crops: Traditional Commodity	Short-term crops grown after the main cropping season that reduces nutrient losses to ground and surface water by sequestering nutrients
Pasture Alternative Watering	Use of alternative drinking water sources such as permanent or portable livestock water troughs placed away from the stream corridor (off-stream watering without fencing)
Prescribed Grazing	Range of techniques to improve the quality and quantity of forages grown on pastures and reduce the impact of animal travel lanes, animal concentration areas, or other degraded areas. Pastures under PG systems are defined as having a vegetative cover of 60% or greater
Horse Pasture Management	Maintenance of a 50% pasture cover with managed species (desirable, inherent) and managing high traffic areas
Forest Buffers	Converts streamside pasture to forest and prevents livestock from entering the stream
Grass Buffers	Converts streamside pasture to open space and prevents livestock from entering the stream. Linear strips of grass or other non-woody vegetation maintained to help filter nutrients, sediment, and other pollutants from runoff
Wetland Restoration	Re-establish wetlands by manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning the natural/historic functions to a former wetland
Soil and Water Conservation Plans	A combination of agronomic, management, and engineered practices that protect and improve soil productivity and water quality, and to prevent deterioration of natural resources on all or part of a farm.
Agricultural Drainage Management	Process of managing water discharges from surface and/or subsurface agricultural drainage systems, to raise and lower the water level within the soil profile throughout the year following an operation and maintenance plan

Best Management Practice	Description
Non Urban Stream Restoration	A change to the stream corridor that improves the stream ecosystem by restoring the natural hydrology and landscape of a stream, and helps improve habitat and water quality conditions in degraded streams
Waste Management Systems Livestock and Poultry	Any structure designed for the collection, transfer, and storage of manures and associated wastes generated from the confined portion of animal operations
Barnyard Runoff Control	Installation of practices to control runoff from barnyard areas
Loafing Lot Management	Stabilization of areas frequently and intensively used by people, animals, or vehicles by establishing vegetative cover, surfacing with suitable materials, and/or installing structures
Manure Transport	Transport of excess manure into or out of a county
Land Retirement Cropland to Pasture	Conversion of land area to pasture. Agricultural land retirement takes marginal and highly erosive cropland out of production by planting permanent vegetative cover such as shrubs, grasses, and/or trees
Cropland to Agricultural Open Space	Converts land area to hay without nutrients.

Source: Chesapeake Bay Program, 2020.

Table A2. Agriculture Best Management Practice Costs by State, Annualized ($2021/acre unless other unit provided)

BMP	Virginia	West Virginia	Maryland	Delaware	Pennsylvania	New York
Nutrient Management: Core N	$6.45	$6.92	$6.59	$6.54	$6.64	$6.10
N Rate	9.91	10.28	10.08	10.08	9.97	9.51
N Placement	9.91	10.28	10.08	10.08	9.97	9.51
N Timing	9.91	10.28	10.08	10.08	9.97	9.51
Core P	7.10	7.56	7.24	7.19	7.29	6.74
P Rate	9.91	10.28	10.08	10.08	9.97	9.51
P Placement	9.91	10.28	10.08	10.08	9.97	9.51
P Timing	9.91	10.28	10.08	10.08	9.97	9.51
Tillage Management: Conservation	22.34	22.02	21.83	26.04	24.49	24.46
Continuous High Residue	23.08	22.76	22.56	26.91	25.31	25.28
Low Residue	23.08	22.76	22.56	26.91	25.31	25.28
Cover Crop	82.13	81.66	81.35	87.95	85.53	85.47
Off Stream Watering Without Fencing	1.87	1.92	1.10	0.55	0.54	0.55
Precision Intensive Rotational/ Prescribed Grazing	17.44	20.90	69.38	31.82	92.07	73.50
Horse Pasture Management	76.80	73.53	76.06	78.29	93.56	77.46
Forest Buffer	163.25	136.21	363.29	425.47	438.62	411.00
Forest Buffer - Narrow	163.25	136.21	363.29	425.47	438.62	411.00
Wetland Restoration: Floodplain	165.19	195.72	217.24	215.33	208.34	175.96
Headwater	235.64	446.71	532.26	511.73	489.23	468.17
Average	200.42	321.21	374.75	363.53	348.79	322.07

BMP	Virginia	West Virginia	Maryland	Delaware	Pennsylvania	New York
Land Retirement: to Pasture	$69.70	$126.02	$96.06	$98.76	$73.03	$60.45
to Ag Open Space	184.22	155.45	185.32	184.54	199.10	145.02
Average	126.96	140.73	140.69	141.65	136.06	102.73
Grass Buffer	124.05	97.85	219.23	248.01	259.96	224.36
Grass Buffer - Narrow	124.09	97.90	219.23	248.01	259.96	224.36
Average						
Soil Conservation and Water Quality Plans	28.65	26.83	27.45	28.42	28.23	32.32
Drainage Water Management	1.46	1.41	3.00	3.16	3.42	3.55
Non Urban Stream Restoration ($/foot)	113.66	113.66	113.66	113.66	113.66	113.66
Animal Waste Management System ($/animal)	93.29	132.50	139.50	126.97	122.51	135.65
Barnyard Runoff Control	491.36	566.28	713.23	649.82	625.74	707.87
Loafing Lot Management	21,681.31	21,681.31	21,681.31	21,681.31	21,681.31	21,681.31
Average	11,086.33	11,123.79	11,197.27	11,165.56	11,153.53	11,194.59
Manure Transport ($/dry ton)	22.13	22.13	22.13	22.13	22.13	22.13

Sources: Chesapeake Bay Program, 2020; U.S. Department of Agriculture, 2021.
Note: 2018 dollars adjusted to 2021 dollars using the Consumer Price Index.

Appendix B. Economic Impact Analysis

Table B1. Assignment of Agriculture Best Management Practices to Industry Codes for Economic Impact Analysis

BMP	NAICS Industry Code	Industry Title	RIMS Industry Code	Industry Title
Nutrient Application Management	11511	Support activities for crop production	115000	Support activities for agriculture and forestry
Tillage Management	11511	Support activities for crop production	115000	Support activities for agriculture and forestry
Cover Crops	11511	Support activities for crop production	115000	Support activities for agriculture and forestry
Pasture Alternative Watering (a)	112XX	Animal production and aquaculture	112120	Dairy cattle and milk production
			1121A0	Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming
Prescribed Grazing (a)	112XX	Animal production and aquaculture	112120	Dairy cattle and milk production
			1121A0	Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming
Horse Pasture Management	112920	Horses and other equine production	112A00	Animal production (except cattle and poultry and eggs)
Forest Buffers	115310	Support activities for forestry	115000	Support activities for agriculture and forestry
Grass Buffers	115310	Support activities for forestry	115000	Support activities for agriculture and forestry
Wetland Restoration	2379	Other heavy and civil engineering construction	2332E0	Nonresidential structures
Soil and Water Conservation Plans	11511	Support activities for crop production	115000	Support activities for agriculture and forestry
Agricultural Drainage Management	11511	Other heavy and civil engineering construction	115000	Support activities for agriculture and forestry
Non-Urban Stream Restoration	2379	Other heavy and civil engineering construction	2332E0	Nonresidential structures
Waste Management Systems	23622	Commercial and institutional building construction	2332E0	Nonresidential structures

BMP	NAICS Industry Code	Industry Title	RIMS Industry Code	Industry Title
Barnyard Runoff Control and Loafing Lot Management	2379	Other heavy and civil engineering construction	2332E0	Nonresidential structures
Manure Transport	4842	Specialized freight trucking	48400	Truck transportation
Land Retirement (cropland to pasture)	11511	Support activities for crop production	115000	Support activities for agriculture and forestry

Sources: Rephann, 2010; U.S. Office of Management and Budget, 2017; Chesapeake Bay Program, 2018 & 2020.

(a) The RIMS II industry code depends on the type of animal, which is not specified in the BMP. Therefore, the RIMS industry with the smaller multiplier is used to calculate economic impacts to provide a conservative estimate.

Economic Impacts by State and Basin

In this table, as is the case throughout the report, "state" means the portion of the state that is in the Chesapeake Bay watershed, not the entire state.

Table B2. Annual Expenditures and Economic Impacts of Agriculture BMP Implementation in the Chesapeake Bay Watershed, by State and Basin (millions of $2021)

Direct Expenditures		Economic Impacts: Output	Earnings	Jobs
$375.1	**Total**	**$655.2**	**$268.9**	**6,673**
10.8	**New York**	**18.2**	**7.8**	**187**
10.8	Upper Susquehanna	18.2	7.8	187
$195.7	**Pennsylvania**	**$352.5**	**$145.1**	**3,457**
19.2	Upper Susquehanna	32.2	14.3	365
63.8	West Branch Susquehanna	103.1	40.2	922
103.0	Lower Susquehanna	201.1	83.2	1,954
9.6	Potomac	16.2	7.4	216
$23.1	**Maryland**	**$41.2**	**$16.5**	**423**
10.3	Upper Chesapeake	19.2	7.4	196
5.9	Lower Chesapeake	10.4	3.9	86
6.9	Potomac	11.7	5.2	141
$25.1	**Delaware**	**$44.6**	**$18.0**	**486**
25.1	Lower Chesapeake	44.6	18.0	486
$0	**District of Columbia**	**$0**	**$0**	**0**
0.0	Potomac	0.0	0.0	0
$116.1	**Virginia**	**$191.2**	**$78.6**	**2,067**
56.2	Potomac	95.4	40.0	926
30.4	Lower Chesapeake	41.0	17.9	572
29.4	James	54.7	20.7	569
$4.4	**West Virginia**	**$7.5**	**$2.9**	**53**
4.4	Potomac	7.5	2.9	53

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Notes: There are no WIP III agriculture BMP goals in the District of Columbia. "State" means the portion of the Chesapeake Bay watershed in the listed state, not the entire state.

Economic Impacts by State

In these tables, as is the case throughout the report, "state" means the portion of the state that is in the Chesapeake Bay watershed, not the entire state.

Table B3. Annual Expenditures and Economic Impacts of Agriculture BMP Implementation in New York's Basin of the Chesapeake Bay Watershed (millions of $2021)

Direct Expenditures	BMP	Economic Impacts: Output	Earnings	Jobs
$4.9	Nutrient Application Management	$8.1	$3.8	105
0.2	Tillage Management	0.4	0.2	5
1.1	Cover Crops	1.7	0.8	22
0	Pasture Alternative Watering	0	0	0
0.4	Prescribed Grazing	0.7	0.1	3
0.01	Horse Pasture Management	0.01	0.003	<1
0.1	Forest Buffers	0.2	0.1	2
0.02	Grass Buffers	0.03	0.02	<1
0.04	Wetland Restoration	0.1	0.03	<1
0.9	Soil and Water Conservation Plans	1.4	0.7	18
0	Agricultural Drainage Management	0	0	0
2.5	Non-Urban Stream Restoration	4.6	1.7	26
0.3	Waste Management Systems	0.6	0.2	4
0.1	Barnyard Runoff Control and Loafing Lot Management	0.2	0.1	1
0	Manure Transport	0	0	0
0.02	Land Retirement	0.04	0.02	1
$10.8	**Total**	**$18.2**	**$7.8**	**187**

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Note: New York contains a portion of the Upper Susquehanna basin.

Table B4. Annual Expenditures and Economic Impacts of Agriculture BMP Implementation in Pennsylvania's Basins of the Chesapeake Bay Watershed (millions of $2021)

Direct Expenditures	BMP	Economic Impacts: Output	Earnings	Jobs
$33.0	Nutrient Application Management	$58.9	$26.7	742
7.0	Tillage Management	12.7	5.7	159
49.7	Cover Crops	90.0	40.7	1,128
0.01	Pasture Alternative Watering	0.01	0.003	<1
4.4	Prescribed Grazing	7.9	1.5	46
0	Horse Pasture Management	0	0	0
9.2	Forest Buffers	15.6	7.1	199
3.17	Grass Buffers	5.36	2.45	68
0.6	Wetland Restoration	1.0	0.4	4
17.6	Soil and Water Conservation Plans	29.7	13.6	382
0.0	Agricultural Drainage Management	0.0	0.0	<1
22.8	Non-Urban Stream Restoration	40.4	14.2	216
38.8	Waste Management Systems	73.8	27.0	415
3.0	Barnyard Runoff Control and Loafing Lot Management	5.6	2.0	32
6.0	Manure Transport	10.8	3.2	56
0.4	Land Retirement	0.8	0.3	10
$195.7	**Total**	**$352.5**	**$145.1**	**3,457**

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Notes: Pennsylvania contains portions of the Upper Susquehanna, West Branch Susquehanna, Lower Susquehanna, and Potomac basins.
Agricultural Drainage Management direct expenditures are less than $1,000.

Table B5. Annual Expenditures and Economic Impacts of Agriculture BMP Implementation in Maryland's Basins of the Chesapeake Bay Watershed (millions of $2021)

Direct Expenditures	BMP	Economic Impacts: Output	Earnings	Jobs
$6.1	Nutrient Application Management	$10.7	$4.8	156
1.4	Tillage Management	2.5	1.1	36
2.2	Cover Crops	4.1	1.8	59
0	Pasture Alternative Watering	0	0	0
0.1	Prescribed Grazing	0.2	0.03	1
0.1	Horse Pasture Management	0.1	0.02	1
0.2	Forest Buffers	0.4	0.2	6
0.6	Grass Buffers	1.1	0.5	17
0.4	Wetland Restoration	0.8	0.3	4
1.0	Soil and Water Conservation Plans	1.7	0.8	25
0.01	Agricultural Drainage Management	0.02	0.01	<1
2.1	Non-Urban Stream Restoration	3.8	1.4	22
8.1	Waste Management Systems	14	5.2	84
0.1	Barnyard Runoff Control and Loafing Lot Management	0.2	0.1	1
0.4	Manure Transport	0.8	0.2	4
0.2	Land Retirement	0.4	0.2	7
$23.1	**Total**	**$41.2**	**$16.5**	**423**

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Note: Maryland contains portions of the Upper Chesapeake, Lower Chesapeake, and Potomac basins.

Table B6. Annual Expenditures and Economic Impacts of Agriculture BMP Implementation in Delaware's Basin of the Chesapeake Bay Watershed (millions of $2021)

Direct Expenditures	BMP	Economic Impacts: Output	Earnings	Jobs
$4.4	Nutrient Application Management	$8.1	$3.6	123
0.7	Tillage Management	1.4	0.6	21
7.1	Cover Crops	13.0	5.8	198
0.0	Pasture Alternative Watering	0.0	0.0	<1
0.0	Prescribed Grazing	0.0	0.0	<1
0	Horse Pasture Management	0	0	0
0.04	Forest Buffers	0.07	0.03	1
0.6	Grass Buffers	1.1	0.5	17
0.6	Wetland Restoration	1.0	0.4	6
0.02	Soil and Water Conservation Plans	0.03	0.02	1
0.00	Agricultural Drainage Management	0.00	0.00	<1
0.2	Non-Urban Stream Restoration	0.3	0.1	2
10.0	Waste Management Systems	17.3	6.2	103
0.1	Barnyard Runoff Control and Loafing Lot Management	0.1	0.1	1
1.3	Manure Transport	2.2	0.6	12
0.02	Land Retirement	0.04	0.02	1
$25.1	**Total**	**$44.6**	**$18.0**	**486**

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Notes: Delaware contains a portion of the Lower Chesapeake basin.
Pasture Alternative Watering, Prescribed Grazing, and Agricultural Drainage Management direct expenditures are less than $1,500.

Table B7. Annual Expenditures and Economic Impacts of Agriculture BMP Implementation in Virginia's Basins of the Chesapeake Bay Watershed (millions of $2021)

Direct Expenditures	BMP	Economic Impacts: Output	Earnings	Jobs
$29.0	Nutrient Application Management	$45.9	$21.1	706
6.7	Tillage Management	10.1	4.7	161
17.8	Cover Crops	28.3	13.1	434
0.03	Pasture Alternative Watering	0.04	0.01	<1
0.5	Prescribed Grazing	0.8	0.1	5
0.3	Horse Pasture Management	0.4	0.1	2
0.6	Forest Buffers	1.0	0.4	15
0.5	Grass Buffers	0.7	0.3	11
0.1	Wetland Restoration	0.2	0.1	1
6.8	Soil and Water Conservation Plans	10.6	4.8	164
0.05	Agricultural Drainage Management	0.07	0.04	1
20.2	Non-Urban Stream Restoration	34.9	12.4	205
27.3	Waste Management Systems	47.5	17.6	286
3.4	Barnyard Runoff Control and Loafing Lot Management	5.9	2.1	35
1.8	Manure Transport	3.1	0.9	16
1.0	Land Retirement	1.7	0.7	25
$116.1	**Total**	**$191.2**	**$78.6**	**2,067**

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022.
Note: Virginia contains portions of the Potomac, Lower Chesapeake, and James basins.

Table B8. Annual Expenditures and Economic Impacts of Agriculture BMP Implementation in West Virginia's Basins of the Chesapeake Bay Watershed (millions of $2021)

Direct Expenditures	BMP	Economic Impacts: Output	Earnings	Jobs
$0.03	Nutrient Application Management	$0.05	$0.02	1
0	Tillage Management	0	0	0
0.05	Cover Crops	0.09	0.04	1
0.0	Pasture Alternative Watering	0.0	0.0	0
0.2	Prescribed Grazing	0.3	0.05	1
0.0	Horse Pasture Management	0.0	0.0	0
0.0	Forest Buffers	0.0	0.0	0
0.02	Grass Buffers	0.03	0.01	<1
0	Wetland Restoration	0	0	0
0.5	Soil and Water Conservation Plans	0.8	0.4	11
0	Agricultural Drainage Management	0	0	0
1.3	Non-Urban Stream Restoration	2.3	0.9	14
2.2	Waste Management Systems	3.8	1.5	24
0.02	Barnyard Runoff Control and Loafing Lot Management	0.04	0.02	<1
0.08	Manure Transport	0.14	0.04	1
0.02	Land Retirement	0.03	0.01	<1
$4.4	**Total**	**$7.5**	**$2.9**	**53**

Sources: Chesapeake Bay Program, 2020; U.S. Bureau of Economic Analysis, 2022
Notes: West Virginia contains a portion of the Potomac basin.
Pasture Alternative Management, Horse Pasture Management, and Forest Buffer direct expenditures are less than $4,000.

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