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# How Baywide Nutrient Trading Could Benefit Pennsylvania Farms

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## SUMMARY

Chesapeake Bay, the largest estuary in the United States, is a vital economic, cultural, and ecological resource for both the region and the nation. But the water quality and the overall ecology of the bay have been harmed by excess runoff and discharges of nutrients, particularly nitrogen and phosphorus, from farms, pavement, wastewater treatment plants (WWTPs), and other sources responsible for creating excess algal growth.

In response, Congress is considering proposals to improve the health of the Chesapeake Bay watershed.. The "Chesapeake Clean Water and Ecosystem Restoration Act of 2009" (S. 1816, H.R. 3852) would provide significant new resources and tools to help restore the bay, including a baywide (interstate and interbasin) nutrient trading program. With nutrient trading, entities that can reduce below target levels the runoff of nutrients like nitrogen would be able to sell their surplus reductions as "credits" to entities with higher nutrient reduction costs. Nutrient trading thus offers a cost-effective, market-based mechanism for accelerating the achievement of the baywide cleanup goals.

Agricultural sources typically have lower nutrient reduction costs per pound than do other sources of nutrients, such as wastewater treatment plants and municipal stormwater systems.[1] This cost advantage opens a window of economic opportunity for farms to sell nutrient credits to those sources facing more expensive nutrient control options.

The combination of the government's cost-sharing agricultural best management practices (BMPs) and the proposed baywide nutrient trading market could benefit Pennsylvania's farms. First, these cost-sharing programs and conservation payments would cover many of the expenses of the practices that are required before trading can begin. Second, nutrient

trading could be a source of new revenue and profit for many (but not all) farms, with the benefits likely varying according to location, preexisting implementation of BMPs, and other factors. Third, a baywide nutrient trading program could increase the demand for credits generated from Pennsylvania farms beyond that of a nutrient trading program restricted to Pennsylvania.

## GOVERNMENT COST-SHARING FUNDS COULD HELP FARMS MEET BASELINE REQUIREMENTS

Trading programs in Pennsylvania, Maryland, and Virginia have established different "baseline" requirements for best management practices that must be fulfilled before trading can start.

To reach its baseline, Pennsylvania's current trading policy requires farms to meet at least one "threshold" requirement and all applicable regulatory requirements. The threshold requirements are the following:

- The application of manure (or its equivalent) must have a setback of 100 feet, which is achieved when one of the following is met:
  - Manure is not mechanically applied within 100 feet of surface water.
  - There are no surface waters on or within 100 feet of the farm.
  - The farm does not use manure and applies commercial fertilizer at or below the Pennsylvania state's recommended agronomic rates.
- The fields and the surface water (or its equivalent) must be separated by a 35-foot vegetated buffer, or
- The fertilizer is reduced by 20 percent, and all reductions are retired to meet the threshold.

Some Pennsylvania farmers are required to comply with three state laws and one federal law[2] and thus would need to be in compliance with the following laws in order to meet "the baseline of regulatory compliance" requirement before trading:

- All cropland in Pennsylvania must be managed according to an erosion and sediment control plan.
- The Pennsylvania Clean Streams Law requires all animal operations to be run according to a manure management plan that adequately addresses manure storage and management.
- Pennsylvania's Act 38 requires all animal operations over a specific density threshold to adequately store, manage, and apply manure to cropland according to a nutrient management plan.
- Pennsylvania's implementation of the federal Confined Animal Feeding Operation (CAFO) National Pollutant Discharge Elimination System (NPDES) Program requires eligible animal operations to obtain a permit.

Pennsylvania's "threshold" requirement differs from its state tributary strategy requirements, whereas Virginia's and Maryland's baseline requirements are the same. Pennsylvania does, however, cap the number of credits that can be generated in a single watershed at a level meant to ensure that the reductions required to meet the tributary strategy are not "traded away."

Besides using Pennsylvania's baseline approach (the threshold requirement coupled with the watershed cap), we at the World Resources Institute (WRI) considered another baseline approach, which assumes that the tributary strategy reduction requirements apply to individual farms. This approach simplifies the Pennsylvania baseline and at the same time enables a comparison with Virginia and Maryland farms.

Pennsylvania's alternate baseline approach is identical to Maryland's baseline approach. Both require farms first to meet their individual portion of the agricultural tributary strategy loading goal for their watershed before they can become eligible to trade credits. Thus, like Maryland's baseline approach, this individual farm baseline is a performance standard expressed as pounds of phosphorus and nitrogen per acre. Here, the number and type of BMPs that a farm installs to meet and maintain its baseline

Table 1 | **Government Cost-Share Programs and Conservation Payments Could Offset Much of the Cost to Meet Baseline in Pennsylvania**

| Potential Practices to Achieve Pennsylvania's Baseline Requirements | Annualized Costs per Acre | Effective Cost-Share Rate | Government Share per Acre | Farmer Share per Acre |
|---|---|---|---|---|
| Conservation tillage | $8.39 | 75% | $2.54 | $0.85 |
| Nutrient management | $14.18 | 58% | $8.23 | $5.95 |
| Soil and water conservation plan: contour strip cropping | $19.31 | 75% | $14.48 | $4.83 |
| Grass buffer | $205.59 | 80% | $164.47 | $41.12 |
| Forest buffer | $331.77 | 80% | $265.41 | $66.35 |

**Notes: Practice costs are based on the studies cited in note 6. Effective cost-share rates are generalized estimates that take into account federal and state programs and rates applicable to capital, maintenance, and land rental cost components.**

depend on its current management, its location within the watershed, and its current BMPs. WRI's approach also requires that farms meet all applicable regulations and have carried out a nutrient management plan.

Many of the BMPs that farms are likely to use to fulfill Pennsylvania's existing baseline requirement or the alternate baseline approach are eligible for federal and state funds for cost-sharing. But since farms must compete for these funds, not all may receive support. Depending on the program and the practice, government cost-sharing programs typically cover between 50 and 80 percent of the costs to implement BMPs.[3] In fiscal year 2008, the U.S. Department of Agriculture's (USDA) Natural Resource Conservation Service provided approximately $94 million for financial and technical assistance programs to help install BMPs in the Chesapeake Bay watershed. Of this amount, approximately $27 million was allocated to Pennsylvania farms.[4] In that same year, the state of Pennsylvania also provided $10 million for agricultural BMPs.[5]

WRI estimated the potential net costs to farms for meeting both existing and alternate baselines in Pennsylvania, taking into account the cost-sharing assistance and conservation payments that a farm could receive from participating in the Pennsylvania Department of Environmental Protection's (DEP) Chesapeake Bay Financial Assistance Funding Program, the USDA's Conservation Reserve Enhancement Program (CREP), the Environmental Quality Incentives Program (EQIP), and other programs. Included here are the initial capital costs, annual maintenance costs, forgone revenues from production, and farms' transaction costs for participating in these programs. For each element, WRI based its cost estimates on a variety of federal, state, and university sources.[6]

The costs of some practices—such as cover crops, conservation tillage, and nutrient management planning—remain fairly constant each year. The costs of other practices, such as planting forest or grass buffers, are one time and up front. Cost-sharing funds are typically distributed annually. Because of the disparity in the costs' timing, net costs were annualized or "spread out evenly" over the typical life of a cropland conversion contract (e.g., forest buffers), which is 15 years.

Table 1 summarizes the annualized net costs per acre for a group of BMPs that might be used to fulfill either the existing or the alternate baseline, as well as the effective cost-share rates and the resulting government and farm share of expenditures per acre. The alternate Pennsylvania baseline approach does not prescribe the types of practices that should be used to meet the baseline. Instead, farms are free to choose whichever they prefer, as long as they achieve the baseline.

Table 2 | **Potential Gross Revenues from Single Practices to Generate Nutrient Credits in Pennsylvania**

| Credit Generating Practice (After Meeting Baseline) | N-reduction (lbs/ac/yr) | Acres on Typical Farm | Potential Credits | Annual Gross Revenues at $20/lb |
|---|---|---|---|---|
| Early plant cover crops | 2.10 | 198 | 415.80 | $8,316 |
| Nitrogen reduction (15%) on crops | 2.71 | 198 | 535.59 | $10,712 |
| Crop to conservation cover | 4.54 | 1 | 4.54 | $91 |
| Grass buffer | 10.50 | 1 | 10.50 | $210 |
| Forest buffer | 16.90 | 3 | 50.70 | $1,014 |
| Wetland restoration | 31.80 | 5 | 159.00 | $3,180 |

**Note: Nutrient reduction factors are from a sample in the Potomac Basin.**
**Source: NutrientNet, 2010.**

## NUTRIENT TRADING COULD GENERATE NEW REVENUES AND PROFITS FOR FARMS

Once a farm meets and maintains Pennsylvania's baseline requirements, it is eligible to generate nutrient credits by implementing additional nutrient reduction practices, and it can sell these credits in a nutrient trading market. To estimate the potential benefits, WRI analyzed the economics of nutrient trading for farms of different types and locations in Pennsylvania, using a farm profit calculator that considers potential economic impacts on farms from a long-term investment perspective. Our analysis considers only the incremental effects of participating in nutrient trading markets and does not include profits from the agricultural operation of the farm as a whole.

First, we estimated the potential revenue to farms from selling nitrogen credits. The farms' practices vary according to how many credits they can generate and how much land the practices require. Note that Pennsylvania's trading policy does allow farms to receive government cost-share funding for implementing credit-generating practices. But for this analysis, WRI chose to limit cost-share funding to baseline practices in order to be more in line with the evolving baywide trading-program rules and to acknowledge that limited state or federal cost-share funds will likely be exhausted in helping farms first meet their legal baseline requirements. Our analysis also assumes that practices to generate credits must be separate and distinct from those practices used to meet and maintain baseline requirements. For example, a farm that switches from "regular" cover crops to meet the baseline to "early planted" cover crops in order to generate credits will receive credits only for the difference in nutrient reduction between the two practices. Likewise, buffers implemented to generate nutrient credits must be in addition to those buffers required to meet the baseline.

Table 2 summarizes the potential credits and credit revenue on a single-practice basis that could be generated on a 200-acre farm using nutrient reduction factors from the Potomac Basin.[7] The annual revenue estimates reflect an assumed credit price of $20 per pound of nitrogen (lb N) in a mature baywide nutrient trading market. These credit prices reflect WRI's scenario analysis showing $20/lb N as the average minimum credit price that farms would be willing to accept for selling credits.[8] Depending on the demand and supply, credit prices in a mature market could be higher given the higher nutrient reduction costs faced by stormwater systems and some wastewater treatment plants.

Next, our analysis estimated the net effect of those costs associated with meeting the baseline and generating credits, the revenues from government cost-share funds to maintain the baseline, and the revenues from sales of credits. For the credit-generating practices, these include capital costs, annual maintenance costs, forgone revenues from production, and transaction costs that farms must pay to participate in credit-trading markets. The analysis also factored in cost-share funding from existing programs using effective cost-share rates. Figures 1, 2, and 3 show the net impact for three farm scenarios.

Figure 1 shows the net impact of meeting the baseline and generating credits for a 200-acre crop farm in Bedford County in the Potomac Basin using commercial fertilizer and a credit price of $20/lb N.

Figure 2 illustrates the net economic benefits of meeting the baseline and then generating credits on a 60-cow dairy farm with 200 acres of cropland using commercial fertilizer and manure in Lancaster County in the Susquehanna Basin, also with a credit price of $20/lb N.

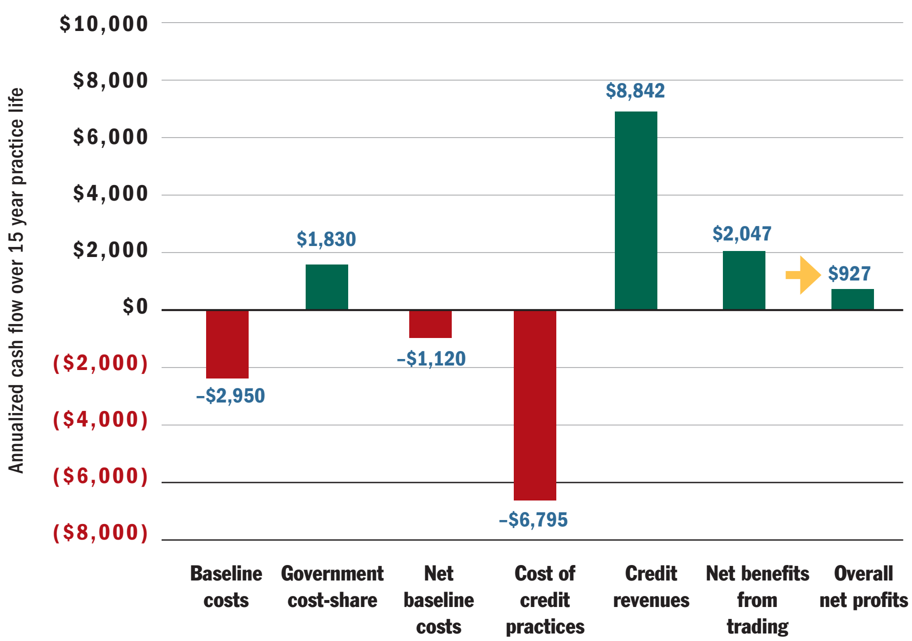
Figure 3 summarizes the net economic benefits of the Susquehanna farm using WRI's alternate baseline assumptions. This baseline requires one additional practice—cover crops—and a more stringent management of nutrients to meet the tributary strategy's goals. Because our alternate Pennsylvania baseline approach is based on performance, the type of fertilizer used (e.g., commercial and/or manure sources) is relevant. Although the cost-share funds for cover crops were assumed to be zero, in a mature baywide program, cost-sharing for this practice is likely to be offered, since this practice would be widely used throughout the watershed. Because the alternate baseline approach assumes that significantly more baseline nutrients are reduced, the reductions achieved after the baseline BMPs will therefore be smaller. This in turn cuts the number of credits supplied and the associated revenues and profits for the Susquehanna "existing baseline" scenario presented in figure 2.

These scenarios reflect the varying degrees of effort needed to achieve the baseline, depending on current farm practices. All three scenarios assume that the farm has not yet implemented any baseline practices (i.e., the farm is starting "from scratch"). Because many farms in Pennsylvania already follow one or more of these "baseline" practices, this analysis represents the most conservative cost estimate. In

Figure 1 | **Potential Economic Benefit of Baywide Nutrient Trading to a Crop Farm with 200 Acres of Pasture in the Potomac River Basin**

***Key assumptions***
*(practice units):*

- Credit price: $20/lb N.
- Practices to meet baseline include nutrient management (200 ac), conservation tillage (200 ac), and soil and water conservation plan—buffer strip cropping (10 ac).
- Credit-generating practices include upland forest buffer (2 ac), early plant cover crops (193 ac), grass buffer (2 ac), and wetland restoration (3 ac).

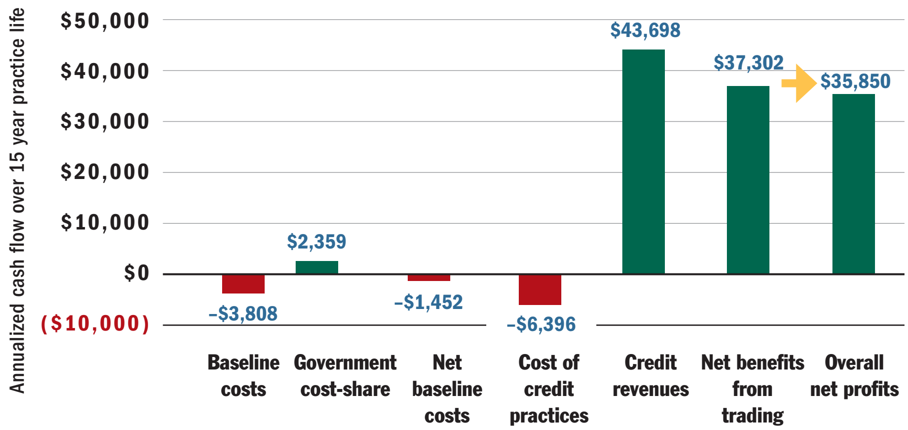



Source: WRI analysis.

Figure 2 | **Potential Economic Benefit of Baywide Nutrient Trading to a Dairy Farm with 200 Acres of Cropland in the Susquehanna River Basin, Existing Baseline Scenario**

***Key assumptions***
*(practice units):*

- Credit price: $20/lb N.
- Practices to meet baseline include nutrient management (198 ac), conservation tillage (198 ac), soil and water conservation plan—buffer strip cropping (10 ac), and forest buffer (2 ac).
- Credit-generating practices include extended forest buffer (1 ac), grass buffer (1 ac), wetland restoration (5 ac), and 15% nitrogen reduction.

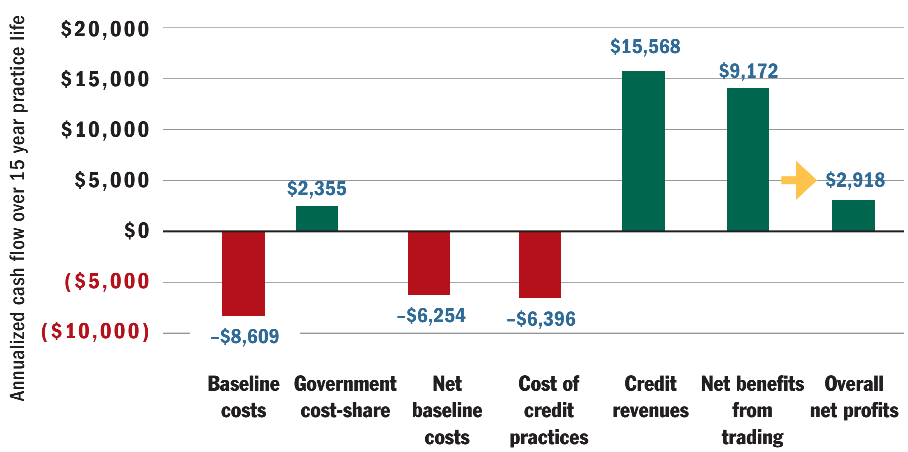



Source: WRI analysis.

Figure 3 | **Potential Economic Benefit of Baywide Nutrient Trading to a Dairy Farm with 200 Acres of Cropland in the Susquehanna River Basin, Alternative Baseline Scenario**

***Key assumptions***
*(practice units):*

- Credit price: $20/lb N.
- Practices to meet baseline include nutrient management (198 ac), conservation tillage (198 ac), soil and water conservation plan—buffer strip cropping (10 ac), and forest buffer (2 ac).
- Credit-generating practices include extended forest buffer (1 ac), grass buffer (1 ac), wetland restoration (5 ac), and 15% nitrogen reduction.




Source: WRI analysis.

addition, our analysis is not necessarily scalable, since even if the size of the farm increases, the acreage of certain practices such as constructing wetlands will not necessarily increase at the same rate. Moreover, WRI chose to represent only the nutrient load and reduction efforts on the crop production area of the livestock farm in the Susquehanna Basin scenario because Pennsylvania's state-trading program does not yet account for nutrient loads or reductions from in the animal production area. Accordingly, we restricted our scenario to representing the use of dairy manure as a fertilizer source for the crop production area only.

## POTENTIAL BENEFITS TO FARMS WILL DEPEND ON MANY FACTORS

For farms in Pennsylvania, the potential economic benefits of nutrient trading will differ depending on many factors, including the following:

*Location:* For each farm, the amount of nitrogen reduced by BMPs will vary according to differences in proximity to the bay, soil hydrology, and other factors. Thus, the economic benefits of trading will vary between river basins and within river basins. Generally, though, farms located closer to the bay have a greater potential for nitrogen reduction than farms do farther from the bay.

*Type of farm*: Crop- and pasture-based operations use different credit-generating practices. For example, using less fertilizer applies only to cropland, and animal exclusion zones usually are relevant only to pastures. Crop- and pasture-based operations also have different nutrient reduction factors.

*Current practices:* The cost and time required for a particular farm to reach the baseline depend on its current practices, including crop types, application rates, incorporation methods, type of fertilizer used (commercial/organic), and BMPs implemented. Farms that already are using BMPs will have less to do to achieve lower nitrogen baseline loads and will have lower associated costs than will farms that have not implemented any BMPs and are "starting from scratch." Many farms in Pennsylvania and around the bay have already begun using conservation practices.

*Cost-share funding availability*: The scenarios in our analysis are based on average effective cost-share rates of existing programs, which range between 50 and 80 percent (table 1). If the availability or use of cost-share funding were capped at lower levels, the farms' net economic benefits would decline as well. Therefore, regardless of trading, adequately funding the government's agriculture conservation cost-sharing programs is important to nutrient-trading markets and to restoring the bay.

*Credit price:* Credit price will have a significant impact on the profitability of nutrient trading to farms, with higher credit prices yielding higher net profits.

*Trading ratios:* Trading ratios will affect the costs and benefits to farms participating in the trading program. Trading ratios are used to adjust nutrient credits in order to account for factors such as uncertainty, overall environmental benefits, and risk. The states' current trading ratio policies vary widely. For instance, Pennsylvania and West Virginia require a 10 percent and a 20 percent reserve ratio, respectively, to hedge against risks related to any failure of BMPs; Maryland has a 10 percent retirement ratio to ensure an overall water quality benefit; and Virginia has a two-to-one trading ratio for point-to-nonpoint source trades to account for uncertainty (i.e., buyers must purchase two credits for every pound of nutrient offset needed). Although an interstate program would allow existing state programs to continue operating in their current form, policymakers would probably choose to combine certain aspects of the states' trading programs into a larger, baywide trading program. They are likely to reexamine trading ratios because they can create comparative advantages for buyers and sellers in states with low trading ratios and comparative disadvantages for buyers and sellers in states with high trading ratios. For this reason, our analysis does not model the impact of existing trading ratios. Instead, we simply assume that a pound of nutrient reduction equals one nutrient credit available for sale or purchase.

## A BAYWIDE NUTRIENT TRADING PROGRAM COULD INCREASE DEMAND FOR CREDITS FROM PENNSYLVANIA FARMS

The Chesapeake Clean Water and Ecosystem Restoration Act of 2009 would establish a *baywide* nutrient trading program, thereby allowing generators of nutrient credits to sell credits to buyers throughout the Chesapeake Bay watershed.

In summary, a baywide nutrient trading market combined with other programs could benefit Pennsylvania farmers. Existing government agriculture conservation cost-sharing programs could cover many of the costs associated with meeting the baseline requirements, and nutrient trading could be a source of new revenue and profit for many (but not all) farms. Furthermore, baywide nutrient trading could increase the demand for credits generated from Pennsylvania farms beyond the demand generated by a Pennsylvania-only trading market.

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## NOTES AND SOURCES

1. For details, see Jones, Cy, et al. 2010. "How Nutrient Trading Could Help Restore the Chesapeake Bay." WRI Working Paper. World Resources Institute. Washington, DC. Available at: www.wri.org; Chesapeake Bay Commission. 2004. *Cost-effective Strategies for the Bay: 6 Smart Investments for Nutrient and Sediment Reduction*. Annapolis, MD: Chesapeake Bay Commission; Office of Inspector Generals of the United States Environmental Protection Agency and the United States Department of Agriculture. 2006. "Saving the Chesapeake Bay Watershed Requires Better Coordination of Environmental and Agricultural Resources." Available at http://www.epa.gov/oig/reports/2007/20061120-2007-P-00004.pdf.
2. See the Clean Streams Law**,** chapter 91 of the Pennsylvania Code, available at http://www.pacode.com/secure/data/025/chapter91/chap91toc.html, Pennsylvania Code § 102.4; and Pennsylvania's *Manure Management Manual*, available at http://panutrientmgmt.cas.psu.edu/pdf/rp_manure_mgmt.pdf. See also Pennsylvania's Nutrient Management Law, Act 38, available at http://panutrientmgmt.cas.psu.edu/pdf/lr_Act38_Reg_Sum0609.pdf; and the Clean Streams Law. For erosion and sediment control requirements, see http://www.pacode.com/secure/data/025/chapter102/s102.4.html. Also see Pennsylvania's Rules and Regulations Environmental Quality Board [25 PA. CODE CHS. 91 AND 92]; Concentrated Animal Feeding Operations and Other Agricultural Operations [35 Pa.B. 5796]; http://74.125.155.132/search?q=cache:IOPUwP6VdQgJ:panutrientmgmt.cas.psu.edu/pdf/rp_CAFO_regulations.pdf+panutrientmgmt.cas.psu.edu/pdf/rp_CAFO_regulations&cd=1&hl=en&ct=clnk&gl=us&client=firefox-a.
3. American Farmland Trust. *A Landowner's Guide to Conservation Buffer Incentive Programs in Pennsylvania.* Available at http://www.pa.nrcs.usda.gov/news/FTPPublications/LandownersGuide.pdf.
4. U.S. Department of Agriculture Natural Resources Conservation Service. 2009. "Conserving Natural Resources in the Chesapeake Bay." Available at http://www.nrcs.usda.gov/news/pdf/chesapeake_bay_regional_accomplishments_report_2008.pdf. The funding estimate includes spending from the following programs: Agricultural Management Assistance, Conservation Reserve Program, Conservation Security Program, Conservation Technical Assistance, Environmental Quality Incentives Program, Farm and Ranchlands Protection Program, Wildlife Habitat Incentives Program, and Wetlands Reserve Program.
5. Chesapeake Bay Foundation, Personal communication, November 30, 2009, pertaining to estimate of FY2008 state agricultural best management practice cost-share spending within the Chesapeake Bay watershed.

6. Annualized costs take into account those for capital, maintenance, land, and transaction. Sources include Pennsylvania Department of Environmental Protection. 2004. "Pennsylvania's Chesapeake Bay Tributary Strategy." Available at http://www.depweb.state.pa.us/chesapeake/lib/chesapeake/pdfs/tribstrategy.pdf; Natural Resource Conservation Service. 2009. "Average Cost Estimates for Conservation Practices for FY2010: Average Cost/ Unit and Estimated Total Costs;" University of Delaware, Christina Basin Tributary Action Team. 2006. *Agriculture BMP Cost Calculations Handbook*; Wieland, Robert, Doug Parker, Will Gans, and Andrew Martin. 2009. *Costs and Cost Efficiencies for Some Nutrient Reduction Practices in Maryland*; Wainger, Lisa and Dennis King. 2007. "Establishing Trading Ratios for Point–Non-Point Source Water Quality Trades: Can We Capture Environmental Variability without Breaking the Bank?" University of Maryland Center for Environmental Science, technical report no. TS-523-07; Stephenson, Kurt, Stephen Aultman, Todd Metcalfe, and Alex Miller. "An Evaluation of Nutrient Trading Options in Virginia: A Role for Agriculture?" Paper presented at the annual meeting of Southern Agricultural Economics Association, Atlanta, January 31–February 3, 2009.
7. Nutrient reduction factors represent pounds of nitrogen per acre reduced for each best management practice based on the farm's location.
8. The amount $20/lb N is based on annualized implementation, operations and maintenance, and opportunity costs for four agricultural practices implemented after a farm meets its baseline. This estimate reflects the average of these costs and practices across the five bay states. WRI acknowledges that credit prices for recent nitrogen trades between WWTPs and farms in Pennsylvania's nascent state-trading program were in the range of $8/lb N. However, the Pennsylvania market is a pre-TMDL market, whereas WRI is modeling future mature market prices after a TMDL is in place. A baywide TMDL would require higher baseline requirements, raising costs for WWTPs and MS4s, which would likely raise the demand for nonpoint source credits. For additional details, see Jones, Cy, et al. 2010. "How Nutrient Trading Could Help Restore the Chesapeake Bay." WRI Working Paper. World Resources Institute. Washington DC. Available at www.wri.org.

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