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Paying for Environmental Performance: Estimating the Environmental Outcomes of Agricultural Best Management Practices

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How can the estimation of environmental outcomes be used to effectively allocate conservation funding, and what additional steps are needed to improve this process?

Recommendations

- Standardize estimation methodologies to quantify the environmental outcomes of agricultural best management practices.
- Conduct site-specific assessments of environmental performance through programs such as the Conservation Effects Assessment Project (CEAP) to:
  - Increase site-specific research on estimating environmental outcomes and environmental co-benefits;
  - Establish a monitoring framework to validate estimation methodologies and test their accuracy; and
  - Create a central repository to provide access to estimation methodologies and monitoring data.
- Utilize online tools to make standardized estimation methodologies widely available.

Agricultural conservation programs that pay for environmental performance are an effective way to allocate limited funds to achieve the greatest environmental outcome.[1] Despite the advantages of these programs, several key areas need to be improved in order for them to be more effective. First, methodologies used to estimate environmental performance must be standardized to ensure accurate and equitable funding allocation. Second, estimation methodologies should be significantly improved through increased research and monitoring. Third, these methodologies need to be widely available using online tools. This Policy Note describes these recommendations in more detail and demonstrates how they can help to maximize the effectiveness of performance-based programs.

Unlike traditional conservation programs which allocate funding based on a particular practice, performance-based conservation programs allocate funding based on the environmental outcome of a practice. For example, consider two farmers who want to install streambank fencing along a grazed pasture—a practice that reduces streambank erosion and improves water quality by preventing livestock from entering the water. The first farmer has a small number of livestock and minimal streambank erosion, while the second farmer has a large number of livestock and severe streambank erosion. The effect of the streambank fencing on water quality is very different for each farmer. In a performance-based program, the limited conservation funds would be awarded to the second farmer, because the environmental outcome of the practice is significantly higher.

This Policy Note focuses primarily on estimating the water quality benefits of agricultural best management practices (BMPs), because agriculture plays a major role in affecting water quality through nutrient and sediment runoff. However, the recommendations presented here could also be applied to other environmental outcomes (e.g., reductions in greenhouse gas emissions) and sectors (e.g., urban stormwater).

Standardizing Estimation Methodologies

Estimation methods for on-farm nutrient and sediment loss are already commonly used by agricultural consultants and conservation technicians. These estimates help farmers minimize soil and nutrient loss and are used as management tools for determining crop fertilizer requirements. On-farm estimates of these losses can also be used to determine the environmental impacts of farming practices on a waterbody when a delivery ratio is applied. A delivery ratio estimates the amount of nutrients and sediment delivered to a waterbody from a site-specific location, such as a farm (see Box 1 for more details on water quality estimation methodologies).

Similar calculations can estimate reductions in nutrient and sediment loss from implementing or installing BMPs. For example, to calculate reductions in phosphorus loss from installing terraces on cropping fields, estimates of soil loss and soil phosphorus concentration before and after the BMP's installation can be used. Soil loss can be estimated using the U.S. Department of Agriculture's (USDA's) Revised Universal Soil Loss Equation (RUSLE) program,[2] while soil tests commonly utilized by farmers to adjust their fertilizer application rates can estimate phosphorus concentration. A delivery ratio is then applied to estimate the amount of phosphorus delivered from the farm to the nearest waterbody.

A number of methodologies to estimate water quality improvements are currently available and can provide reliable information for allocating funds in a conservation program. However, these methodologies are not standardized. The calculations in Box 1 describe only one of many methods to estimate nutrient and sediment reductions. Furthermore, there are a variety of ways to use a single estimation methodology. A nitrogen balance equation, for example, can be calculated in a number of ways depending on whether average or site-specific data is used. Standardizing water quality calculations will allow conservation programs to be more consistent and equitable in allocating funding based on environmental outcomes.

Improving Estimation Methodologies

The complex nature of ecological processes makes estimating the environmental performance of BMPs particularly challenging. Scientific research on the effects of BMPs on the environment is constantly improving; however, no comprehensive set of national standards is currently available. There is also little on-site monitoring and verification of a BMP's effectiveness once it is implemented, which would help improve the accuracy of estimation methodologies. Many best management practices also provide environmental co-benefits that are not as easily quantified—such as wildlife benefits, flood control, and decreases in stream temperature—where more research would be valuable.

Three important components are needed to improve the estimation of environmental outcomes from BMPs, including:

- Increased site-specific research on estimating environmental outcomes and environmental co-benefits,
- A monitoring framework to validate estimation methodologies and test their accuracy, and
- A central repository of estimation methodologies and monitoring data.

The USDA's Conservation Effects Assessment Project (CEAP) could provide the framework to revise and refine estimation methodologies for environmental performance. CEAP was implemented in 2003 to provide national- and regional-level estimates of the effectiveness of conservation practices to aid in policymaking decisions. Expanding CEAP's reach to include site-specific assessments of the environmental outcomes of particular BMPs through increased research, monitoring, and the creation of a central repository of information would provide reliable, consistent data to agricultural conservation programs that pay for performance.

Using Online Tools to Make Estimation Methodologies Widely Available

With the increasing use and power of computers, the Internet is an ideal place to disseminate quantification tools to farmers that estimate the environmental outcomes of BMPs. Web-based tools have distinct advantages over traditional methods, such as using desktop spreadsheets or calculations performed on paper. With online tools, universal access can be provided to users throughout the country and improvements or modifications to calculation methodologies can be quickly disseminated.

BOX 1

Estimating Improvements in Water Quality from Agricultural Best Management Practices

The combined use of equations and models can estimate nitrogen (N), phosphorus (P), and sediment losses from an agricultural operation, estimate the impact of a particular BMP on this loss, and determine how much N, P, or sediment is delivered to the nearest waterway. There are uncertainties involved in using any methodology that estimates N, P, and sediment loss without the use of direct monitoring data. However, outlined below is one of the most widely accepted methods.

Estimating improvements to water quality involves three easy steps:

Estimate N, P, and sediment loss under current conditions. → *Estimate reductions in N, P, and sediment loss from BMP implementation.* → *Apply delivery ratio to determine water quality impact.*

Estimating On-Farm Nutrient and Sediment Loss

A variety of methodologies are currently being used to estimate nutrient and sediment loss in agriculture. The N balance approach, for example, estimates N losses from farm fields by subtracting N leaving a field (e.g., from plant uptake or volatilization) from N inputs to a field (e.g., N fertilizer application). RUSLE can be used to estimate sediment erosion rates from a farm field based on current land management practices. RUSLE can also be used to estimate P losses, as most P is insoluble and attaches to soil.[a] Soil P test results (e.g., the Mehlich-3 P Test, or Bray-1 P Test) can estimate the concentration of P in the soil. Equations to determine nutrient and sediment loss from gully and streambank erosion, as well as nutrients in feedlot runoff have also been developed.[b]

Estimating Nutrient and Sediment Loss Reductions

Once current N, P, or sediment losses have been estimated from agricultural activities, reductions in nutrient or sediment loss from implementing a BMP can then be estimated. If a BMP reduces the amount of fertilizer applied, then the N balance equation and P test can be used to determine the reductions in N and P losses from farm fields. The RUSLE program has built-in performance estimates for some BMPs (e.g., contour stripcropping and terraces) and can be used to directly determine reductions in sediment and P loss from these practices. BMP efficiencies can be used to determine reductions in N, P, or sediment for BMPs that either do not reduce fertilizer application or are not found in the RUSLE program. Efficiency percentages are multiplied by the N, P or sediment loss from agricultural activities before the BMP is implemented (as described in the above section) to estimate reductions in nutrient or sediment loss from its implementation. BMP efficiencies have been developed by a number of sources, including university research centers, the U.S. Department of Agriculture - Natural Resource Conservation Service (USDA-NRCS), and the U.S. Environmental Protection Agency (USEPA).

Estimating Water Quality Impact

Information on the fate and transport of nutrients and sediment as they move through an ecosystem is also required to determine the impact of a BMP on water quality. Delivery ratios estimate what percentage of N, P, or sediment has reached a waterbody from a specific location (such as a farming field), and what percentage has been lost, or attenuated, along the way. As excessive levels of P and sediment are generally a freshwater problem, the P or sediment delivery ratio determines the percentage of sediment (or P attached to sediment) that travels from the source to a nearby lake or stream. Because N is primarily a coastal water problem, an N delivery ratio typically accounts for N losses as water moves from its source to the nearest waterbody, and then as it moves through waterways to the coast. Modeling approaches are generally used to develop delivery ratios. Examples of models that could provide delivery ratios include SEDMOD, the Chesapeake Bay Model, SPARROW, or AGNPS.[c]

Notes:

a. A number of assumptions are made when calculating P loss in agriculture (e.g., the amount of soluble P versus insoluble P in overall total P loss, and the enrichment of insoluble P concentrations in the soil). Due to these assumptions there are limitations to the accuracy of this calculation.

b. For instance, calculations to estimate feedlot runoff, gully erosion, and streambank erosion have been developed by the USEPA Region V and revised by the Michigan Department of Environmental Quality. <http://it.tetratech-ffx.com/stepl/STEPLmain_files%5CRegion%205%20manual05.pdf>

c. For further information on SEDMOD: <http://www.hydra.iwr.msu.edu/iwr/publications/documents/Assessing%20Sediment%20Loading2005.pdf>; The Chesapeake Bay Model: <http://www.chesapeakebay.net/model.htm>; SPARROW: <http://water.usgs.gov/nawqa/sparrow/>; and AGNPS: <http://eco.wiz.uni-kassel.de/model_db/mdb/agnps.html >.

Agricultural consultants and technicians from the USDA Natural Resource Conservation Service (NRCS) and County Conservation Districts, who currently provide technical conservation assistance to farmers, rely heavily on sophisticated technology in their work. Generally, successful farmers are also technologically sophisticated. In 2004, 55 percent of farmers were using the Internet, and the number of users continues to grow.[3] Online tools that estimate the environmental outcomes associated with BMPs could be an effective mechanism for helping conservation consultants, technicians, and farmers decide which BMPs are best to implement depending on performance. After information on current and proposed farming practices is entered into an online estimation tool, underlying calculations could automatically estimate the environmental outcome of the proposed BMP. With the addition of cost information, such a tool could also be used to determine which BMPs are most cost-effective to implement.

One of the most promising applications of online systems is their use as a decision-making tool to help allocate funding in federal and state conservation programs. If environmental outcomes are estimated online, applications could be electronically submitted to a number of relevant programs, resulting in an easier and more efficient tracking process for conservation program enrollment.[4] These online tools could also be used to track nutrient and sediment reductions from BMP implementation at the watershed level. This type of information could help track the agricultural sector's progress towards meeting certain environmental goals, such as a USEPA Total Maximum Daily Load (TMDL) goal for N, P, or sediment in a watershed.[5]

NutrientNet — An Online Calculation Tool

A current example of a standardized estimation tool is NutrientNet,[6] developed by the World Resources Institute for use in several watersheds in the United States. NutrientNet incorporates recognized and accepted methodologies for calculating nutrient and sediment reductions into an easy-to-use web-based application. It has been used for performance-based conservation programs, such as the Conestoga Reverse Auction Project in central Pennsylvania.[7] NutrientNet, or a similar tool, could be used for other programs that pay for environmental performance, and could easily be adapted to calculate other environmental outcomes of BMPs, such as reductions in greenhouse gases.

Estimating nutrient reductions using NutrientNet involves the following steps:

Step 1. Outline the location of the proposed BMP on an interactive map (see Figure 1)

Step 2. Enter farm details, such as acreage and current farming practices (see Figure 2)

Step 3. Select a BMP and enter implementation detail

Step 4. View estimated nutrient reductions (see Figure 3)

The calculations described in Box 1 were programmed into NutrientNet to estimate reductions in nutrient and sediment

FIGURE 1 **NutrientNet's Interactive Map Provides Site-Specific Environmental Data (Step 1)**

FIGURE 2 **Current Management and Cropping Practices are entered into NutrientNet (Step 2)**

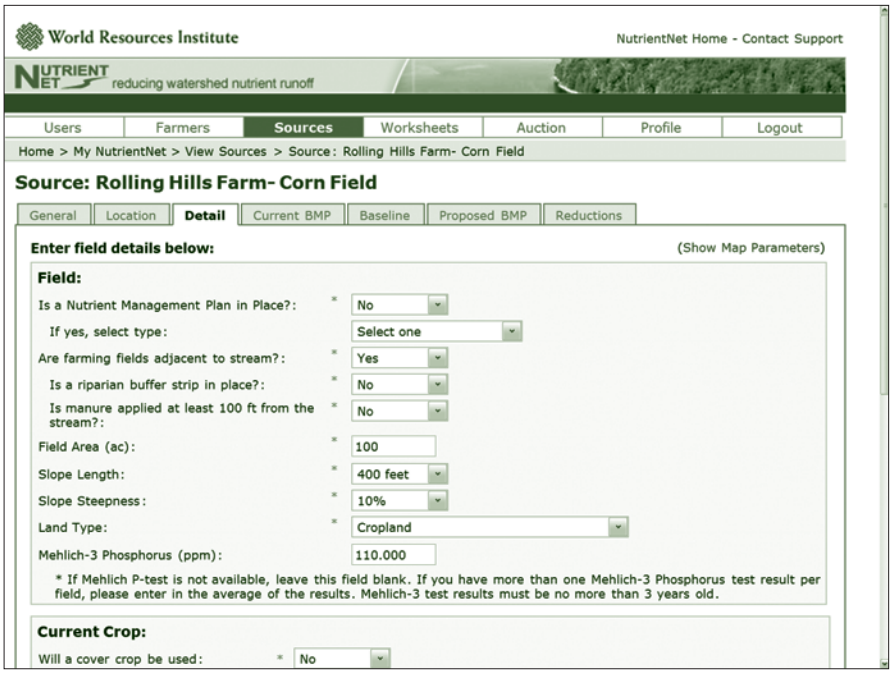
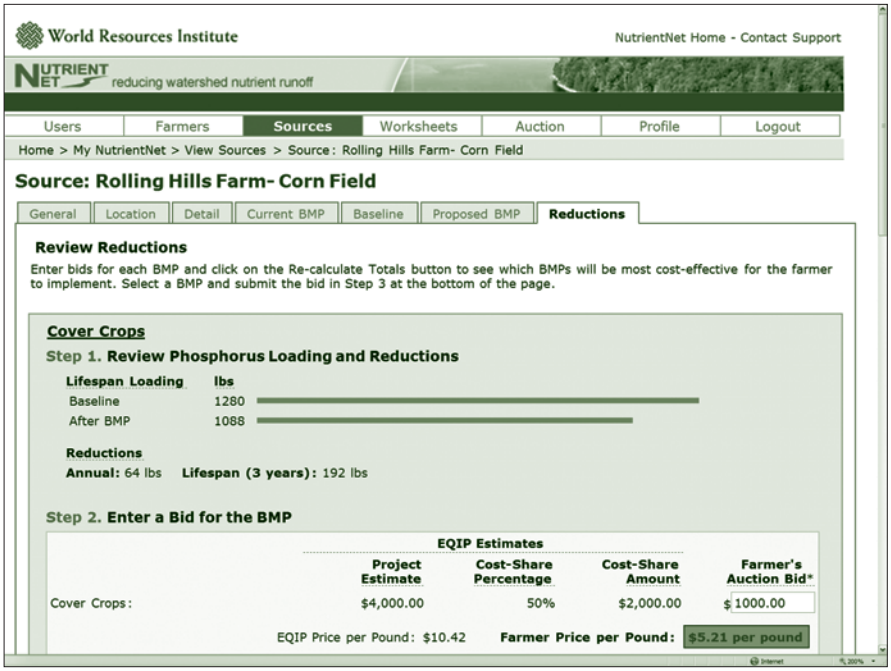


FIGURE 3 **NutrientNet's Estimation of Water Quality Improvement (in Pounds of P Reduced) (Step 4)**



loss, allowing instantaneous and consistent estimates of water quality improvement. The interactive map provides additional environmental information in underlying map data layers that may not be readily available to farmers or technicians, such as delivery ratios, soil type, and rainfall runoff volume. Information entered into NutrientNet can be saved for recordkeeping purposes or could be used to apply to several conservation programs simultaneously.

Other Online Tools

The NRCS is increasingly interested in programs that pay for environmental performance, and is developing an easy-to-use, online calculation tool as part of their efforts. The NRCS Nitrogen Trading Tool, or Nitrogen Calculator Tool, calculates reductions in nitrogen loss from various BMPs to determine the number of credits that could be sold in water quality trading programs.[8] This educational tool will soon become widely available to help familiarize farmers with performance-based programs such as water quality trading.

Putting "Paying for Performance" into Practice

This Policy Note has outlined how the environmental performance of agricultural BMPs can be estimated, and what steps are necessary for improving these estimations--both important elements for effectively allocating conservation funding. Standardized methodologies provide a consistent framework that ensures more accurate and equitable estimations. Improvements in methodologies can be achieved by increasing site-specific research and monitoring. Finally, online tools can be used to ensure the widespread availability and consistent use of methodologies.

The recommendations set forth in this Policy Note could be implemented through a series of pilot projects under existing conservation programs, such as the Environmental Quality Incentives Program, the Wetlands Reserve Program, or the Conservation Security Program. The projects could allocate conservation funding based on water quality improvement in watersheds impaired by nutrients or sediment. Potential watersheds that would benefit from this exercise would be the Chesapeake Bay watershed, areas of the Mississippi River watershed such as the Ohio River Basin, or watersheds with nutrient or sediment goals such as a TMDL. These projects would not only provide valuable information on how best to utilize online tools for estimating environmental outcomes, assessing tradeoffs, and streamlining conservation funding allocation, but would also use smaller areas to conduct research and monitoring to fine tune and verify estimation calculations.

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Notes

1. See the supplementary WRI Policy Note Environmental Markets No. 1, "Paying for Environmental Performance: Investing in Farmers and the Environment", for a broader discussion on using performance-based measures to allocate conservation funding.
2. RUSLE2 is the most recent RUSLE program. Further information can be found at: <http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm>
3. Data is from the 2004 Agricultural Research Management Survey (ARMS) conducted by the USDA Economic Research Service.
4. Applications submitted to conservation programs online could remain confidential by allowing limited, password-protected access to authorized users only. If online applications are used to track the agricultural sector's progress toward meeting watershed-level environmental goals, personal information such as name, address, and location would not need to be tracked and could be kept confidential.
5. A TMDL is a USEPA legislative program that identifies waterbodies impaired by pollutants, such as nutrients or sediment, and places a limit on the amount of the identified pollutant that can enter the waterbody.
6. For more information on *NutrientNet*, visit: <http://www.nutrientnet.org>; For a demonstration of *NutrientNet's* calculation tools, visit: <http://conestoga.nutrientnet.org>.
7. See the supplementary WRI Policy Note Environmental Markets No. 3, "Paying for Environmental Performance: Using Reverse Auctions to Allocate Funding for Conservation", for more information about the Conestoga Reverse Auction Project.
8. A water quality trading program allows regulated sources who can't meet their water quality goals (e.g., municipal wastewater treatment plants) to purchase nutrient and sediment reductions, or "credits," from sources who are able to reduce nutrients or sediment at a lower cost (e.g., agriculture).

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