JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION

AMERICAN WATER RESOURCES ASSOCIATION

Confronting our Agricultural Nonpoint Source Control Policy Problem

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Research Impact Statement: Reform of agricultural nonpoint source pollution policies is necessary to make progress in achieving water quality goals.

ABSTRACT: Federal and state agricultural and environmental agencies have spent enormous sums since the 1990s to reduce nonpoint source (NPS) water pollution from agriculture. Yet, water quality problems are pervasive, and agriculture is a major cause. The lack of progress is often attributed to insufficient funding for pollution control practices relative to the scale of the problem. However, we attribute the lack of progress to shortcomings in agricultural NPS pollution control policy. We illustrate our argument after considering nearly four decades of federal, state, and local efforts to reduce agricultural NPS pollution to the Chesapeake Bay. Additional funding for current programs, absent fundamental program reform, is unlikely to produce reductions from agriculture needed to achieve desired water quality outcomes.

(KEYWORDS: agricultural pollution; nonpoint; cost sharing; nutrient; incentives; targeting; policy reform.)

INTRODUCTION

The 1972 Federal Clean Water Act ushered in a new era of state and federal regulation, supported by enormous public and private spending directed at restoring, in the words of the Act "the physical, biological and chemical integrity of the nation's waters." Now, 50 years later, the goals of the Act remain unmet (Shortle et al. 2012; Keiser and Shapiro 2019). A recent United States Environmental Protection Agency (USEPA) assessment found that 46% of United States (U.S.) rivers and streams are in poor biological condition, 25% are in fair condition, and only 28% are in good condition (USEPA 2017). Agricultural nonpoint source (NPS) pollution is often a principal cause of water quality impairments. The 2017 USEPA National Water Quality Inventory lists agricultural NPS pollution as the leading cause of water quality impairments in rivers and streams, the third-largest cause for lakes, the second largest for wetlands, and a major contributor to contamination of estuaries and groundwater (USEPA 2017). Agriculture is the largest source of nutrients contributing to the eutrophication of the Gulf of Mexico, the Chesapeake Bay, and the Great Lakes (Goolsby et al. 1999; Howarth 2008).

Policies and programs to reduce agricultural NPS pollution rely primarily on agricultural producers voluntarily implementing pollution control practices, encouraged by technical and financial assistance from federal and state programs. These programs have achieved only limited successes in reducing agricultural NPS loads (Sprague et al. 2011; Shortle

Paper No. JAWR-21-0168-C of the *Journal of the American Water Resources Association* (JAWR). Received November 4, 2021; accepted May 11, 2022. **Discussions are open until six months from issue publication**.

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Citation: Stephenson, K., L. Shabman, J. Shortle, and Z. Easton. 2022. "Confronting our Agricultural Nonpoint Source Control Policy Problem." *JAWRA Journal of the American Water Resources Association* 1–6. https://doi.org/10.1111/1752-1688.13010.

et al. 2012; Ator et al. 2020). This widely acknowledged gap between NPS reductions achieved and the amount needed to meet water quality goals often is attributed to insufficient funding for existing technical and financial assistance programs (DeGood 2020).

We argue that increased funding is not enough. The limited success of NPS programs is embedded in the structure of the programs, and how these programs guide and direct choices; choices made by agricultural producers, technical assistance providers who advise producers, and water quality program managers. We illustrate our argument with the Chesapeake Bay Program (CBP) and conclude that fundamental policy reforms will be needed for achieving substantial reductions in agricultural NPS loads.

EXISTING APPROACHES TO ADDRESS AGRICULTURAL NPS POLLUTION

Programs to encourage agricultural NPS load reductions can take a variety of forms (Segerson 2013; OECD 2017; Shortle 2017; Pannell and Classen 2020; Shortle et al. 2021). With some exceptions,[1] conventional agricultural NPS policy in the U.S. rests on the premise that agricultural producers voluntarily decide how to manage their operations and whether or how to reduce to NPS pollution. To encourage producers to implement NPS pollution control practices, information programs inform them of the best management practices (BMPs) intended to improve water quality, and points them to government funding and sometimes private funding available for implementing the practices. Because BMPs can be costly, and in many cases reduce producers' net income, programs typically encourage implementation by sharing implementation costs (Shortle et al. 2021). Federal and state technical assistance providers work with interested producers to develop BMP plans for their operations. The largest of the cost sharing programs is the federal U.S. Department of Agriculture Environmental Quality Incentives Program and there are state programs that also cost-share BMP implementation. Cost sharing is typically for a portion of the cost of BMP installation and in limited circumstances some annual operation and maintenance costs (Ribaudo and Shortle 2019; Ribaudo 2001).

The Limited Success of NPS Programs: Illustration from the Chesapeake Bay

The CBP illustrates the current agricultural NPS pollution policy conundrum. Since the 1980s, nitrogen and phosphorus were identified as the primary pollutants limiting attainment of desired Bay water quality outcomes and agricultural NPS was identified early on as a major contributor of nutrient loads. In 1990, nutrient reduction targets for meeting water quality goals were set, these targets were revised in the 2000s, and brought under federally mandated nutrient limits in 2010.[2] Through all these years, policymakers understood that without agricultural NPS load reductions nutrient reduction targets and desired water quality outcomes would be unattainable.

For over three decades, federal and state governments have been committed to funding the types of conventional technical and financial cost share programs described above, hoping to encourage BMP implementation and meet agricultural NPS reduction targets. In fact, the CBP has been successful in increasing federal and state funding to support these programs, including securing a special federal appropriation of $256 million for the NRCS Chesapeake Bay Watershed Initiative (Natural Resource Conservation Service 2021). Recently, there have been renewed efforts to increase NPS program funding, arguing that more funding for these conventional programs will finally secure Bay water quality goals (Northey 2021).

Also of note is that the CBP has invested substantial resources to build a state-of-the-art model to evaluate and inform water quality managers decision-making (Hood et al. 2021). With respect to NPS pollution, the CBP watershed model is the basis for prioritizing BMP implementation and for crediting progress toward meeting NPS load reduction targets. As BMP implementation is reported, the CBP model credits NPS reductions by multiplying model-based estimates of nutrient runoff (pounds per acre) by an assigned BMP removal efficiency and the number of acres treated by the BMP. The model calculates nutrient runoff as an average over a relatively large area (~20,000 acres) for different land use types (crop, hay, etc.). The BMP pollutant removal efficiencies are generally a single number (e.g., 30% N removal for a riparian buffer) applied across the watershed. In the CBP model, these removal efficiencies are usually generated by expert judgment from a group of subject matter authorities (Stephenson et al. 2018).

[1] Pollution from large confined animal feeding operations is legally classified as point source pollution and regulated as such under the Clean Water Act. States have also made some efforts to regulate aspects of agricultural nonpoint source runoff (Kling 2013).

[2] In 2010, the federal government established Chesapeake Bay TMDL (total maximum daily load) expected to meet specific Bay nutrient water quality criteria, the largest body of water for which a TMDL has been written.

Despite these extensive and long-standing efforts to implement BMPs, agricultural NPSs remain the barrier to attaining desired Chesapeake Bay water quality outcomes. According to the CBP model estimates, all pollution controls (implemented since 1985) have reduced nitrogen (N) loads by nearly 100 million pounds and phosphorus loads 14 million pounds per year. Over three-quarters of N reductions have come from wastewater treatment plants and from reductions in atmospheric deposition (CBP 2021). Point sources have reduced P loadings about 80% since 1985, which represents about 70% of the estimated P reductions achieved since 1985. The CBP identifies a need for another 50 million pounds of N reductions by 2025 to meet water quality standards, noting that these reductions must come primarily from agricultural NPS.

Meanwhile, statistical analyses of monitoring data suggest that the CBP model may be overestimating the nutrient reductions achieved by the cumulative impact of agricultural BMPs. Ator et al. (2019) found little evidence that agricultural NPS loads declined between 1992 and 2012. Another statistical analysis of monitoring data found that while P loads are declining in some regions of the Bay watershed, those improvements were offset by increases in agricultural P sources in other areas (Fanelli et al. 2019; Kleinman et al. 2019; Ator et al. 2020). While the limited response in observed pollutant reductions could be due the time that is required for NPS reductions to produce ambient water quality outcomes, the so-called "lag times," evidence suggests that another cause is at play: our agricultural NPS programs are not as effective as expected. The CBP is not alone in confronting this NPS challenge. Reductions from BMP implementation predicted by models routinely over estimate measured reductions (Osmond et al. 2012; Lintern et al. 2020). The challenge of measuring reductions in NPS loads in response to BMP adoption is one of the most fundamental and common challenges confronting large-scale water quality programs (Osmond et al. 2012; Boesch 2019; Lintern et al. 2020).

CHALLENGES WITH AGRICULTURAL NPS INCENTIVES

The continued failure to meet agricultural NPS reduction goals is not simply due to a lack of funding or a lack of effort. To a significant degree, the problem lies with the incentives inherent in conventional program design. These incentives influence choices made by producers and technical service providers that often limit the implementation of cost-effective BMPs in the locations that produce the greatest NPS loads. The following illustrations of NPS incentive challenges are drawn from the CBP, but these challenges are common across most large-scale water quality programs.

Agricultural Producers Face Limited Financial Incentives to Address NPS Pollution

Conventional cost share programs incentivize producers to install practices (BMPs) rather than to produce quantifiable NPS load reductions. Without a clear focus on load reductions, cost sharing for practices is unlikely to result in producers and technical service providers seeking to identify water quality problem areas, and then implementing the most effective BMPs. Consider a BMP that produces little agronomic benefit to a producer's operation, promises significant low-cost nutrient reductions but requires substantial upfront capital investment and ongoing operation and maintenance expenditures. BMPs such as stream buffers, denitrifying bioreactors, stream fencing, and manure storage/treatment can generate substantial nutrient reductions at relatively low costs (Price et al. 2021; Stephenson et al. 2021). From a strictly financial perspective, agricultural producers will not install and operate a technology with few on-farm benefits and that costs them money (even if cost-shared). The structure of our cost-share programs does not directly pay producers for what is needed: pollutant reductions.

Program Managers Have Limited Ability and Incentives to Target NPS Hotspots

Many studies demonstrate that relatively small portions of the agricultural landscape produce most of the agricultural load. The way NPS loads are counted and reductions are credited is a disincentive for program managers to identify and treat these high loss areas. Suppose that 80% of nutrient losses on a 250-acre farm is coming from only 25 acres. The CBP crediting system and technical assistance programs provide few incentives for technical service providers and producers to focus on those 25 acres. If the 250 acres is in the same land use (say corn), CBP crediting gives the same reduction credit whether the BMP is placed on any of the 225 low loss acres, or the 25 high loss acres. Furthermore, conventional programs typically require that agricultural producers develop conservation plans for the entire farm operation to be eligible for program benefits. A producer willing to aggressively treat only the 25 high loss acres might not want or need a whole farm plan and, under current program guidelines, the producer would be ineligible for financial assistance without a plan that covers the entire farm.

Technical Service Providers Are Not Rewarded for Loads Reduced

Technical service providers serve as the conduit between the entity funding BMP implementation and producers, providing engineering, installation, and maintenance assistance to producers, and facilitating financial assistance. This structure, the technical service provider as a liaison, provides no direct incentive for a service provider to prioritize reductions from difficult and often high loading areas. Suppose a service provider can work with two neighboring producers. One producer has low nutrient losses and willingly adopts conservation practices. The other producer has high nutrient losses and is reluctant to participate in government programs. Such diversity of producer behavior is real and can be substantial (Ribaudo 2015). One recent study in a portion of the Chesapeake Bay watershed showed that P mass balances on adjacent farms can vary by a factor of 10 (Pearce and Mcguire 2020). Agency funding is allocated to staff and their offices that can "get BMPs on the ground" as measured by contracts processed. When programs, as in the CBP, credit nutrient reductions by BMPs installed, the same NPS reduction credit applies to both producers. Spending time with a reluctant, but high nutrient loss producer is a poor investment of the service providers time when the measure of success is participants enrolled and BMPs installed.

Technical Service Providers and Water Quality Managers cannot "Go Big"

Cost-share programs typically cap the amount of assistance that can be received by an individual agricultural producer. While distributing funding over more participants helps engage more producers in the conservation program, such funding limitations restrict what water quality managers and technical service providers can do to address larger scale NPS issues. For example, at a regional level, nutrient losses tend to be highest in areas with nutrient mass imbalances, where nutrient imports, in the form of fertilizers and animal feed, exceed the ability of the local cropping system to utilize the nutrients. The use of conventional BMPs, most of which do not address excessive nutrient mass imbalances, offers limited potential to reduce NPS loads. Regional animal waste management systems (manure conversion, waste to energy projects, transport) offer opportunities to address regional nutrient mass imbalances, but given the large upfront and ongoing maintenance and operation cost, and lack of on farm benefits associated with such systems limit their uptake.

Barriers to Innovation Exist in Current Program Structure

Incentives for innovation in NPS technologies and management are weak. Under conventional cost-share programs, entrepreneurs face limited profit opportunities to develop innovative NPS control practices because conventional agricultural cost-share programs create no buyers for such products. Producers have no incentive to pay for these technologies (unless there are on-farm benefits) and water quality managers have no means to pay for them given the requirement that costs must be shared.

Water quality managers, agricultural producers, and technical service providers have few incentives to invest in actions that produce more certain load reductions. Consider a producer who wants to implement a BMP where pollutant removal can be more readily measured or observed, for example in situ nutrient extraction (measurement of aquatic biomass harvest), direct treatment of runoff or water (influent and effluent from bioreactors), or manure conversion technologies, among others (Rose et al. 2015; Stephenson and Shabman 2017; Stephenson et al. 2018). Consider another example of a producer who is willing to demonstrate intermediate outcomes from conservation activities, such as changes in soil nutrient levels or amount of cover crop biomass achieved. The use of quantifiable, demonstrated outcomes are rarely used because participants get credit for installing practices, not improving outcomes.

POLICY REFORM IS NEEDED TO MAKE PROGRESS IN ADDRESSING NPS POLLUTION

Conventional NPS program designs create limited incentives for program managers, technical service providers, or producers to care about whether BMPs provide the expected NPS load reductions. As a result, it is unlikely that significant progress will be made on NPS load reduction without fundamental policy and programmatic change (Shortle et al. 2012, 2021; Ribaudo and Shortle 2019). The most fundamental change would replace the current program premise that producers decide both whether and how to control their pollution, with a new premise that a producer or group of producers is obligated to limit their pollution but has discretion and flexibility in deciding how that limit is met.

Whatever the program premise, first, reform must shift the focus from practices to outcomes. Incentive systems that reward quantifiable nutrient reductions or observable water quality outcomes, such as "pay-for-performance" ("pay-for-success") systems, may better motivate agricultural producers to seek out and implement practices that result in the largest NPS reductions. Payment for performance programs can be designed in a variety of ways, but all should require that technical service providers also be able and willing to evaluate all NPS reduction options and develop plans for reducing pollutants.[3]

Second, the focus on outcomes through a "pay-for-performance" ("pay-for-success") system will require establishing acceptable practices for quantifying either pollutant reduction or changes in water quality conditions. Outcomes can be documented by direct measurement, by indirect, but observable, indicators of pollutant loss potential (e.g. soil nutrient levels), or by using more sophisticated field-scale models to predict site-specific reductions from implemented BMPs. Measured outcomes can be used for determining when the producers would be paid under the pay for performance system or for determining if the limits are being met. Measured outcomes allow technical service providers to be rewarded for working with high loss producers and for targeting high loss areas, and measured outcomes mean water quality managers' report progress as quantified load reductions, or improvement in ambient water quality conditions.

A shift toward outcome-based program design should involve experimentation with innovative combinations of incentive systems and outcome-based measurement (Shabman et al. 2011). As one example, producer-led watershed cooperatives could be created with the assistance of technical service providers to achieve measurable water quality. Such organizations would be incentivized to achieve specific quantifiable, independently verified, water quality outcomes, for instance, at the outlet of small watersheds by offering reward or bonus payments made to the cooperative and distributed to members for reaching specific water quality outcomes (Maille et al. 2009). The cooperative, with the support of technical assistance providers, would allow producers to identify and direct cost-share funds received from the NPS programs to the investments that yield the most effective, more certain pollutant reductions (Maille et al. 2009).

Third, as noted above, reform may require shifting away from the premise of conventional programs that producers decide based on financial or personal adoption benefits whether to limit NPS pollution, to program designs that obligate producers to limit their NPS pollution. Such mandatory limits must be structured to recognize the diversity in agriculture across scales and across production systems. Consider large regional nutrient mass imbalances from high concentrations of intensive livestock operations. In vertically integrated production systems, such as poultry and swine, manure ownership and management requirements could be assigned to the integrator, rather than individual producers working under contract with the integrator. The integrator would be responsible for meeting manure disposal requirements but would be allowed the flexibility and technical expertise to find cost-effective solutions for the treatment, transport, and use of the manure.

Reform may mean that some agricultural producers accept more responsibilities for delivering pollutant reductions. Reform can mean more funding to existing programs given that funding requests often exceed available program funds, but new funding must be dedicated to paying for outcomes. Reform must mean that water quality managers rely more on measured outcomes, rather than tallying BMPs installed when determining progress. Reform must mean that agencies invest in training technical service providers in new skills needed to execute new program designs and embrace changes to familiar program and reward systems.

The challenges to making this transition are many and transition will not come easily. Reform will meet resistance. Acknowledging the need for change is the first step, and that will require accepting that we cannot simply buy our way out of the problem by spending more money on conventional, voluntary programs.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ACKNOWLEDGMENTS

United States Department of Agriculture, National Institute for Food and Agriculture (NIFA) : 2019-67023-29419

AUTHOR CONTRIBUTIONS

Kurt Stephenson: Conceptualization; writing – original draft. Leonard Shabman: Conceptualization; writing –

[3] Pay for performance will not totally replace cost sharing. Cost-share programs, properly designed, can work to complement pay-for-performance incentives.

original draft. James Shortle: Conceptualization; writing – review and editing. Zachary Easton: Conceptualization; writing – original draft.

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