Economics of Water Quality Protection From Nonpoint Sources: Theory and Practice. By Marc O. Ribaudo, Richard D. Horan, and Mark E. Smith. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 782.

Abstract

Water quality is a major environmental issue. Pollution from nonpoint sources is the single largest remaining source of water quality impairments in the United States. Agriculture is a major source of several nonpoint-source pollutants, including nutrients, sediment, pesticides, and salts. Agricultural nonpoint pollution reduction policies can be designed to induce producers to change their production practices in ways that improve the environmental and related economic consequences of production. The information necessary to design economically efficient pollution control policies is almost always lacking. Instead, policies can be designed to achieve specific environmental or other similarly-related goals at least cost, given transaction costs and any other political, legal, or informational constraints that may exist. This report outlines the economic characteristics of five instruments that can be used to reduce agricultural nonpoint source pollution (economic incentives, standards, education, liability, and research) and discusses empirical research related to the use of these instruments.

Keywords: water quality, nonpoint-source pollution, economic incentives, standards, education, liability, research.

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Executive Summary

What Is the Problem?

The quality of the Nation's surface water has improved since 1972's Clean Water Act, primarily through reductions in pollution from industrial and municipal sources. However, water quality problems remain, especially those associated with nonindustrial sources. The latest EPA Water Quality Inventory reports that, of the water resources assessed by the States, more than one-third of the river miles, lake acres, and estuary square miles suffer some degree of impairment.

Water pollution may be categorized into two types. Point-source pollution enters water resources directly through a pipe, ditch, or other conveyance. Industrial and municipal discharges fall into this category. Nonpoint-source pollution enters water diffusely in the runoff or leachate from rain or melting snow and is often a function of land use. Nonpoint-source pollution has been identified as a major reason for remaining U.S. water quality problems. Despite some progress in reducing agricultural production practices believed harmful to water quality, agriculture is generally recognized as the largest contributor to nonpoint-source water pollution in the United States.

Primary agricultural pollutants are sediment, nutrients, pesticides, salts, and pathogens. A U.S. Geological Survey (USGS) study of agricultural land in watersheds with poor water quality estimated that 71 percent of U.S. cropland (nearly 300 million acres) is located in watersheds where the concentration of at least one of four common surface-water contaminants (nitrate, phosphorus, fecal coliform bacteria, and suspended sediment) exceeded criteria for supporting water-based recreation activities. Well-water sampling by EPA and USGS has found evidence of agricultural pesticides and nitrogen in groundwater resources, possibly threatening water supplies in some areas. Comprehensive estimates of the damages from agricultural pollution are lacking, but soil erosion alone is estimated to cost water users $2 billion to $8 billion annually.

Why Are Nonpoint Pollution Control Policies Needed and What Are the Issues Involved?

Nonpoint-source water pollution is an externality to the production process. Externalities exist when some of the consequences of production (pollution's imposing costs on others) are not considered when production decisions are made. The result is a misallocation of resources from society's perspective.

A fundamental goal of environmental policy is to induce polluters to explicitly consider the costs they impose on society through their production-related activities. An ideal goal of policy is to maximize the expected net economic benefits to society from pollution control, also known as the economically efficient or first-best outcome. Designing policies to achieve efficiency, however, is often impossible because the relationship between economic damages and nonpoint pollution is seldom known. Instead, policies can be designed to achieve specific environmental goals (such as reducing ambient pollution levels or reducing fertilizer applications in a region) at least cost, given the policy instruments available to a resource management agency, relevant policy transactions costs, and any other political, legal, or informational constraints that may exist. Such outcomes are often referred to as cost-effective or second-best.

The process of designing comprehensive policies for controlling nonpoint pollution therefore consists of defining appropriate policy goals, choosing appropriate instruments, and setting these instruments at levels that will achieve the goals at least cost. There are difficulties associated with each of these aspects due to the complex physical nature of the nonpoint pollution process.

Nonpoint emissions (runoff) cannot be measured at reasonable cost with current monitoring technologies because they are diffuse (i.e., they move off the fields in a great number of places) and are impacted by random events such as weather. In addition, the process by which runoff is transported to a water body where it creates economic damages is also impacted by random events. The random nature of these physical processes creates some significant limitations in the way that policy goals with good economic properties are defined, and in the types of policy tools that can be used to attain a cost-effective outcome.

Finally, runoff depends on many site-specific factors. The better that policies and goals can address these site-specific factors, the more efficient nonpoint policies will be. However, obtaining the appropriate information to adequately design and implement policies that address site-specific factors may be quite costly. These costs may limit the types of policies (e.g., to those that are more uniformly applied and informationally less intensive) that can be used to control nonpoint pollution.

What Types of Policy Instruments Can Be Applied to Nonpoint-Source Pollution?

Five classes of policy instrument have either been applied to nonpoint-source pollution, or are feasible tools. These are economic incentives, standards, education, liability, and research. In evaluating a tool's potential, a number of important economic, distributional, and political characteristics are considered. These include economic performance (ability to achieve a goal at least cost), administration and enforcement costs, flexibility (able to provide effective control in the face of changing economic and environmental conditions), incentives for innovation, and political feasibility.

Economic incentive-based instruments include performance incentives (taxes on runoff or ambient water quality), design incentives (taxes or subsidies on inputs and technology), and market-based approaches such as point/nonpoint trading (allowing different sources to trade abatement allowances). Ideally, incentives are directed at an aspect of the pollution process (the instrument base) that is closest to the water quality problem, such as ambient water quality or runoff into a stream (e.g., a runoff tax or subsidy). However, because nonpoint-source discharges cannot be observed, runoff-based instruments are currently infeasible. In this report, we show that the most practical incentive-based instruments are design incentives (including expected runoff incentives that use runoff models), and market-based approaches (also based on design elements). Incentive policies have generally not been applied to agricultural nonpoint-source pollution. Cost-shares and other financial incentives offered by USDA are not subsidies in the traditional sense, in that they are only offered over the short term.

Standards use the regulatory system to mandate that producers meet a particular environmental goal, or that they adopt more socially efficient management practices. In theory, standards can be applied to performance measures, such as runoff or ambient quality, or to inputs and technology. As with incentives, performance-based standards are generally infeasible. Design-based standards, which are feasible, include standards based on expected runoff (which is estimated with information on input use and technology choice through the use of simulation models) and standards based more directly on input use and technology choices.

Design-based standards are being widely applied to agricultural nonpoint-source pollution problems. Some examples include the required use of best management practices on cropland, mandatory establishment of riparian buffer strips, and restrictions on where and at what rates agricultural chemicals can be applied.

Liability rules can be used to guide compensation decisions when polluters are sued for damages in a court of law. Such rules, although they are employed only after damages occur and if victims are successful in their suit, can theoretically provide ex ante incentives for polluters to account for the environmental consequences of their actions. Liability rules can be developed under two different frameworks: strict liability and negligence. Polluters are held absolutely liable for payment of any damages that occur under strict liability. Alternatively, polluters are liable under a negligence rule only if they failed to act with the “due standard of care.”

In theory, an efficient level of pollution control can be achieved for each type of rule. In practice, however, the characteristics of nonpoint-source pollution limit the feasibility of liability tools for achieving efficient control. Liability depends on being able to identify the individual sources of pollution when damages occur. The inability to trace nonpoint pollution back to its source greatly weakens the effectiveness of liability. In addition, liability rules that are based on performance measures require polluters to understand how their choices impact the performance measures. If these impacts are difficult to predict or require an extensive amount of information, liability rules will be less than effective in promoting more efficient production. Liability rules are probably best suited for the control of pollution related to the use of hazardous materials, or for nonfrequent occurrences such as accidental chemical spills. Liability is currently being used in some States to protect groundwater supplies from agricultural chemicals.

Education provides producers with information on how to farm more efficiently with current technologies (minimizing excess use of chemicals, for example), or about new technologies that generate less pollution and are more profitable (conservation tillage). While such “win-win” solutions to water quality problems are attractive, education cannot be considered a strong tool for water quality protection. Its success depends on alternative practices being more profitable than conventional practices, or that producers value cleaner water enough to accept potentially lower profits. Evidence from USDA education programs suggests that net returns are the predominant concern of producers when adopting alternative management practices. Producers have not exhibited interest, in general, in adopting practices that do not benefit them personally. In other words, they do not voluntarily account for any externalities they create. A more appropriate role for education is as a support tool for other policies. Education can shorten the time it takes producers to successfully adopt alternative practices promoted through other policies. Education is widely used by USDA to promote the adoption of alternative management practices.

Research and development can be an important component of a policy for reducing agricultural nonpoint-source pollution because it provides producers and society with more efficient ways of meeting environmental goals. However, producers and private firms will necessarily underinvest in research and development for water quality-improving innovations. Not all the benefits from research result in economic returns to investors.

Public sector involvement is necessary either to carry out this research or to provide producers and the private sector with incentives that result in more efficient research investments. Finally, research cannot independently provide a solution to water quality problems. Research cannot make producers account for the externalities resulting from their production practices. Instead, it serves as a valuable component of other approaches by expanding the set of alternative production practices.

What Is the Guidance for Nonpoint-Source Policy?

The characteristics of nonpoint-source pollution currently render performance-based policies infeasible. Education and research can be valuable in a support role, but cannot stand alone. This leaves design-based policies such as design standards and design incentives (including market-based approaches) as the most viable options. The characteristics of nonpoint-source pollution and the diversity of resource conditions important to agriculture rule against a single tool being applied to all problems. For example, a nitrates-in-groundwater problem might require a combination of fertilizer bans in well recharge areas, reduced application rates elsewhere, the use of cover crops to soak up nitrogen remaining in the soil after harvest, and the use of long-term easements to retire marginal cropland. The tool or combination of tools best suited for a particular problem is an empirical issue based on policy goals, local conditions, and the costs of acquiring information. Policies designed to control the quality of expected or predicted runoff have some of the desirable characteristics of performance-based policies, but depend on models for estimating runoff. Development of models that can estimate agricultural pollutant flows in a variety of geographic and agronomic settings would greatly improve effectiveness of nonpoint-source control policies.