# Chapter 8

# Implications for Policy and Future Directions

*The previous chapters presented an extensive range of policy instruments that can be applied to agricultural sources of nonpoint-source pollution. Performance-based measures are generally infeasible at present because of the difficulty in observing nonpoint-source emissions and the information requirements placed on producers. The characteristics of nonpoint-source pollution (i.e., heterogeneous nature, variability, etc.) and the attractiveness of second-best policies (due to administrative costs, etc.) rule against a single policy tool. The most appropriate tool(s) for a particular problem is an empirical issue based on policy goals, local conditions, and costs of acquiring information. Research in areas such as offsite damages, implementation costs, and simulation models could enhance the performance of nonpoint pollution control policies.*

## Vehicle for Change

President Clinton's charge to chart a new course for nonpoint-source pollution policy recognizes that economic incentives, regulations (standards), education, and research all have a role to play in meeting clean water goals (EPA, USDA, 1998). To date, however, only some of these tools have actually been incorporated into State and Federal water quality programs. Programs designed to address agricultural nonpoint-source pollution have relied primarily on education, technical assistance, and short-term financial assistance. More recently, design standards have been incorporated into some State water quality programs.

This report has systematically presented an extensive range of policy instruments that can be applied to agricultural sources of nonpoint pollution. Unlike the existing economic literature on nonpoint policy tools in which a single study may consider only one or a limited set of nonpoint policy instruments, with varying assumptions across studies, this report has reviewed each policy tool using a unified framework. Consequently, a comparison of each instrument's strengths and weaknesses, with regard to economic efficiency and ease of administration, helps to identify which tools might best underpin a national agricultural water quality policy. In this chapter, we consider the full range of nonpoint instruments presented in this report and, taking the economic characteristics of each into account, we attempt to answer the following questions regarding implementation:

- Which instruments are most likely to achieve water quality goals at least cost, given the information that is likely to be available?

- Under what situations should each instrument be used?

- What information could a resource management agency obtain to improve the performance of the tools?

None of these questions implies that a single instrument or combination of instruments is best. Instead, the most appropriate instrument(s) is best determined case by case due to the heterogeneous nature of nonpoint pollution. At present, a comprehensive empirical assessment of different policy options does not exist. However, the limited economic literature providing empirical comparisons of some instruments is addressed in this chapter. Before assessing policy tools, however, we first review why policies for cost-effective nonpoint-source pollution control are so difficult to design.

## Complexities of Policy Design

Designing comprehensive policies for controlling nonpoint pollution consists of defining appropriate policy goals, choosing appropriate instruments, and setting these instruments at levels that will achieve the goals at least cost. Difficulties with each of these steps derive from the complex physical nature of nonpoint pollution.

Nonpoint emissions (runoff) cannot be measured at reasonable cost with current technologies because they are diffuse (i.e., they move off the fields in a great number of places) and are affected by random events such as weather, as is the process by which runoff is transported to a water body. This randomness narrows the way that policy goals with good economic properties are defined, and limits the types of policy tools that can be used to attain a cost-effective outcome. Finally, runoff depends on many site-specific factors. The more policies and goals are able to address these site-specific factors, the more efficient nonpoint policies will be.

## Assessment of Policy Goals

An economically efficient outcome is generally unattainable because policymakers seldom have information about economic damages. Instead, a cost-effective approach to nonpoint pollution control is typically preferred. A cost-effective outcome is an outcome in which policy goals are achieved at least cost. A variety of policy goals exist; however, the physical nature of nonpoint pollution limits the way in which the goals may be defined and also the economic properties of the goals. Apart from the economist's ideal outcome of economic efficiency, there are in general two types of policy goals: (1) physically based goals (water quality, runoff), and (2) input- and technology-based goals.

Physically based goals are limited in a number of ways. First, the random nature of the nonpoint process requires that these goals be set to attain a probability of occurrence of an outcome as opposed to a specific outcome (i.e., that a mean ambient pollution level be achieved, or that a particular ambient pollution level be achieved 95 percent of the time).

Second, the use of more stringent goals may not result in an expected reduction in damages. If not, then the adoption of more stringent goals (i.e., a 25-percent reduction in pollution levels as opposed to a 20-percent reduction) may actually make society worse off in its attempt to reduce pollution. Some techniques can be used to verify that physically based goals will reduce economic damages; however, the results may not always be conclusive.

Finally, the method of pollution control that achieves a physically based goal with greatest expected social net benefits (the sum of private pollution control costs plus the expected benefits of pollution reduction), known as the *economically preferred* method, will generally differ from the cost-effective method of achieving the same goal. The differences are due to risk effects that arise because the impact of each input on expected damages is not accounted for in the cost-effective outcome. For example, suppose the least-cost method of achieving a particular policy goal (method A) costs $50 and reduces expected damages by $100, for an expected net social gain of $50. Suppose method B also achieves the same goal, but at a cost of $60 and a reduction in expected damages by $120, for an expected net social gain of $60. In this case, method B is socially preferred to method A, even though method A achieves the goal at least cost. However, since damages often remain unknown and the economically preferred and cost-effective methods do not generally coincide, it will not be possible to identify the economically preferred method beforehand. Thus, the notion of cost-effectiveness is limited when policy goals are defined in terms of physical measures.

Input- and technology-based goals offer a practical alternative to physically based goals. For example, instead of designing policies to reduce mean nitrogen loadings, the goal may be a specified reduction in nitrogen fertilizer application rates. Such goals give policymakers more direct control over the factors that determine the distribution of outcomes, and can be chosen to ensure both a reduction in expected damages and an expected improvement in water quality. In addition, these goals can be set such that the cost-effective outcome is preferred to outcomes that achieve the goals at higher cost (i.e., the cost-effective and economically preferred outcomes may coincide). Finally, these goals can be set deterministically, making it easier to verify whether or not the goals are met. In contrast, it may take years to obtain a large enough sample to determine if probabilistic ambient water quality goals are achieved.

# Comprehensive Assessment of Policy Tools

## Performance-Based Instruments Face Insurmountable Problems

Performance-based instruments include those instruments based on the environmental outcomes of producer actions, such as runoff and ambient pollution levels. However, runoff-based instruments are not feasible since runoff cannot be accurately monitored with current technology.

Ambient-based instruments are (seemingly) advantageous because ambient pollution can be monitored (although at potentially high costs) without the resource management agency having to observe the actions of each producer. However, there are several difficulties associated with using ambient-based instruments. For example, ambient-based instruments can be designed to achieve an efficient or cost-effective outcome only under highly restrictive conditions, such as when producers are risk-neutral and producers and the resource management agency share the same expectations about the nonpoint process. This limitation is due to the complex, random nature of the nonpoint pollution process. Other limitations arise because ambient-based instruments depend on group performance. For these instruments to be effective, producers must be able to evaluate how their actions and the actions of others affect ambient pollution levels. Given the large numbers of nonpoint polluters that may exist within a region, and without concerted public sector R&D to resolve monitoring and forecasting technical problems, such instruments are likely to be too complex and information-intensive for producers to obtain all the required information and make accurate evaluations. In that case, producers will receive incorrect incentives from ambient-based instruments.

The resource management agency also has significant informational requirements in setting ambient-based instruments at appropriate levels because to do so requires that the agency understand how producers evaluate the impacts of their decisions on water quality. In other words, the agency must understand each producer's belief structure about the nonpoint process. This information is either not likely to be available, or is likely to be difficult and expensive to obtain.

## Feasible Policies Are Based on Observable Components of Production

If performance-based instruments are not viable instruments for controlling nonpoint-source pollution, design-based instruments are the only potential recourse. Design-based instruments are based on observable aspects of production such as input use or technology choice. In addition, ex ante performance measures such as expected runoff (defined as the level of runoff expected to result from specific production choices and calculated with the use of a runoff model) are included in the set of design bases.

### *Choice of base*

As pointed out in chapters 3 and 4, efficiency requires that design-based instruments be site-specific and applied to each variable input and technology choice. However, efficiency is not likely to be attainable, nor may it be desirable with high administrative (i.e., monitoring and enforcement) costs. Instead, second-best policies, based on a limited set of inputs or on expected runoff and applied uniformly across producers operating in a particular region, may be preferred.

First, consider expected runoff as an instrument base. This base is closer to the externality (pollution) than individual production decisions, allowing producers to remain somewhat flexible in how they control runoff. Producers are able to benefit from their specialized knowledge, to the extent that this knowledge can be captured by a model used to calculate expected runoff levels. In addition, expected runoff-based instruments have an "incentive effect," inducing producers to seek or to demand better technologies.

Expected runoff-based instruments also have a number of important drawbacks. First, the random nature of the nonpoint pollution process limits the types of outcomes that can be attained using expected runoff-based instruments. For example, the only cost-effective outcome that can be achieved with such an instrument is one designed to achieve a mean runoff goal. In addition, the use of each input and each technology choice must be monitored in order to apply the model to determine expected runoff levels. The administration costs are therefore not likely to be significantly reduced relative to other second-best instruments. Finally, producers are forced to use the resource management agency's expectations, as defined by the model, even though their own expectations may actually differ. The Universal Soil Loss Equation is the only model that might currently be accepted as a tool for predicting the runoff of a pollutant (Wischmeier and Smith, 1978). It has been used to assess eligibility for USDA programs, and for enforcing conservation compliance.

Alternatively, second-best, design-based instruments could be applied to a limited (truncated) set of inputs and/or technologies, and the instruments could be applied uniformly within a region. Second-best, design-based instruments could also be designed with limited information on the part of the resource management agency to help control administration costs. Such instruments may be effective in controlling nonpoint pollution if the inputs/technologies chosen as bases are highly correlated with water quality.

### *Design-based incentives vs. standards*

For a given instrument base, economic incentives or standards can be used to achieve identical policy goals. However, use of each instrument type will likely have different consequences for farm profitability by location. Distributional disparities will be greater the greater the heterogeneity of land, the more uniformly instruments are applied across a region, and the more uncertainty the resource management agency has about site-specific information when designing policies. In general, incentives provide more flexibility than standards because producers are free to adjust their production practices to take advantage of personal knowledge and to react to changing market conditions.

Incentives and standards will also have different administrative aspects. The information required by the resource management agency in setting design-based standards and incentives is very similar. However, monitoring may be easier for incentives that can be applied through existing markets. For example, a uniform fertilizer tax can be implemented as a sales tax whereas a fertilizer standard requires that each production site be monitored for fertilizer use. Design taxes have the additional advantage of generating revenue. This revenue could be used to support the administration of the water quality policy, to fund supporting programs such as education and research, or to retire marginal land. For example, a sales tax on fertilizer in Iowa was used to support nutrient management programs in that State (Mosher, 1987). While the tax rate is currently too low to affect behavior, research and education efforts may be increasing the efficiency of fertilizer use. That the nitrogen fertilizer application rate on corn is much lower in Iowa than for the other Corn Belt States is circumstantial evidence that research and education are having an effect (USDA, NASS-ERS, 1996).

Shortle and Dunn (1986) compared input standards, input incentives, expected runoff standards, and expected runoff incentives designed to achieve an efficient solution when asymmetric information exists. Ignoring transaction costs, they found that appropriately specified input incentives generally outperform input standards and expected runoff incentives and standards, given the characteristics of nonpoint source pollution and the information typically available to a resource management agency. These results, however, do not necessarily carry over to the case of multiple farms and/or second-best policies, where administrative costs are considered.

It is not possible to make a general statement about the relative performance of incentives and standards in a world with asymmetric information and second-best policies. Instead, there are situations in which each is preferred.[1] Similar conclusions can be made about the application of uniform policies across heterogeneous land. In general, each situation must be assessed individually.

Miltz, Braden, and Johnson (1988) compared uniform expected runoff standards and uniform expected runoff taxes. These instruments were compared in the context of soil erosion, where the Universal Soil Loss Equation and sediment delivery coefficients were used to estimate sediment discharge to waterways. They found that uniform discharge standards were superior to the uniform tax in achieving least-cost control if there were a strong correlation between the delivery coefficient and abatement cost. Otherwise, the tax is superior. For example, fields along a river on flat land would have higher delivery coefficients and lower ero-

[1] Weitzman (1974) examined price and quantity policies under asymmetric information and showed that, in cases where the marginal cost curve is nearly flat, an error in setting a tax could result in large deviations from the desired result, making standards the preferred instrument. Alternatively, when the benefit function is closer to being linear, price-based policies are superior. However, Malcomson (1978) showed that reliance on such simplistic criteria might result in the choice of incorrect policy tools. Similarly, Stavins (1996) showed the choice to be more complex when the uncertainty associated with the benefits and costs of pollution control are correlated.

sion rates than fields on hilly, upland areas away from the river. The marginal costs of reducing erosion are lower on the upland fields. A uniform tax would provide a greater incentive to reduce erosion on upland fields that may be contributing little to sediment in the river. A uniform standard would provide greater erosion control at least cost. Russell (1982) came to a similar conclusion when comparing similar instruments. Which tool is superior depends on the characteristics of the region, the size of the pollutant source, and the marginal cost of abatement.

Helfand and House (1995) found uniform input taxes to result in lower welfare costs than input standards to meet a desired water quality goal. These results held for taxes and standards applied to all inputs contributing to pollution, and also for the case in which only a single input was targeted.

Lichtenberg (1992) found that standards may be preferable to incentives when a specific input reduction goal is desired. For example, a standard would be preferred in a situation where a particular chemical is clearly detrimental to water quality and application rates need to be limited or the chemical banned from use. Setting a tax to optimally meet an input reduction goal requires knowledge of the farm-specific demand for that input. Such information is not likely to be available to a resource management agency. Design standards, or limits on input use, would be much easier to implement in this case, even though the distributive properties might be poor. Other examples where design standards might be preferred include chemigation (using irrigation equipment to apply chemicals along with water), chemical use on sandy soils, the use of vegetative buffers, and animal waste storage and use.

## Other Instruments Provide A Supportive Role

### *Education*

As shown in chapter 6, education by itself cannot achieve cost-effective water quality control, although it has proven valuable in support of other approaches. For example, Bosch, Cook, and Fuglie (1995) found that education enhanced the performance of a regulation requiring nitrogen testing in Nebraska. The regulation was more effective than education and cost-sharing in promoting adoption. However, producers did not use the information provided by the testing properly unless they received some educational assistance. Education and short-term cost-sharing accelerate the adoption process by providing producers with the means to acquire management skills and overcome short-term risks of new practices. Standards and economic incentives set the stage for producers to change management practices, but adoption and continued use is a multi-stage process that can fail at any of a number of points. Education can help overcome many of these constraints.

Education can also be an inexpensive way of improving the efficiency of input use under current technologies. To the extent that inefficient use of inputs is a source of water quality degradation, improving the management skills of producers enhances both net returns and environmental quality.

### *Research and development*

As with education, research is best suited in a support role for all pollution control policies. Research can provide producers and society with more efficient ways of meeting environmental goals. New inputs and technologies can help producers respond to water quality policies at least cost, while better information, monitoring technology, and models can help resource management agencies design more efficient policies.

## Heterogeneous Nature of Nonpoint Pollution Suggests a Mixed Policy

The wide variety of water pollution problems from agriculture (nitrates in surface- and groundwater, soil erosion, pesticides in groundwater, animal waste) and differences in agriculture and hydrology across regions probably argure against the use of a single policy tool. Multiple instruments have a role when a single instrument is inefficient because of the characteristics of nonpoint source pollution (Braden and Segerson, 1993). In his study of price and quantity-based policies, Weitzman (1974) concluded that mixed policies may give the best results in some situations, depending on the characteristics of the polluters and receiving waters. In a review of pollution policy tools, Baumol and Oates conclude that "...effective policy requires a wide array of tools and a willingness to use each of them as it is required" (Baumol and Oates, 1979, pp. 230-231).

Abler and Shortle (1991) reviewed the merits of a variety of tools (including education, design standards, performance standards, input taxes, input subsidies, performance taxes, and research and development) for reducing agricultural nonpoint-source pollution. Using evaluation criteria based on both economic and administrative attributes, they could not identify a single dominant tool. Each had its strengths and weaknesses. Which tools are actually preferred in a particular setting depends on the weights applied to the various attributes.

Shortle and Abler (1994) evaluated a mixed scheme consisting of marketable permits for polluting inputs combined with a tax on excess input use and a subsidy for returned permits. Such a scheme can be implemented without information on farm profits or offsite damage costs. This approach was generally shown to be superior to policies based solely on design incentives. Optimal implementation could still entail large administrative costs, but the mixed structure should offer opportunities for increased efficiency over input-based tax and license schemes that have been suggested as policies.

Conant, Duffy, and Holub (1993) studied how public policy can be fashioned to better address the perceived conflict between farm profitability and water quality practices. They examined how four different policies performed in achieving three different policy objectives in Iowa. The policies were (1) design standards for nutrient and pesticide management, (2) input taxes on nitrogen and pesticides, (3) technical assistance and cost-sharing for integrated crop management, and (4) research and education. The three policy objectives were to achieve maximum water quality improvement, to achieve greatest improvement in water quality consistent with maintaining farm profitability, and to achieve best overall improvement in both water quality and profitability. Each of the policies was examined, using models of representative farms in six Iowa counties, for impacts on farm profitability, nitrogen runoff, pesticide runoff, nitrate leaching, and pesticide leaching over a range of implementation levels. The major findings of the study, in terms of meeting policy objectives, are as follows:

- Taxation produced the greatest water quality benefit, but proved to be costly to producers.

- Water quality can be significantly improved without losses to farm profitability because of the profitability of alternative practices. Improvements to both can be achieved simultaneously, and in some cases, without high implementation and administrative costs.

- Changes in farming practices that might occur in response to a new policy are highly uncertain. However, this uncertainty affected the magnitude of the changes in water quality and farm profitability, not the direction.

- The impacts on water quality and profitability varied greatly across the State. This result implies that targeting different policies to different areas could improve efficiency.

## Institutional Issues

Coordination of water pollution control programs at the watershed level would promote economic efficiency. This suggests that policy tools should be tailored to the individual watershed wherever possible by State and local authorities. A watershed approach facilitates the identification of pollutants (and their source) that limit desired uses. Using best estimates of contributions from different sources, policy administrators can then select abatement goals and the instruments best suited to achieving those goals. Sunding (1996) shows how welfare losses from second-best policies can be reduced by making use of information that is relatively accessible at the regional level, including data on prices, crop yields, and production costs. These data can be used to tailor regulations on a regional basis to minimize losses in private welfare while achieving a particular environmental goal.

The Clean Water Act establishes a national goal for water quality, and this is reaffirmed by the recent Clean Water Action Plan (EPA, USDA, 1998). The Clean Water Action Plan also stresses the utility of a locally led watershed-based approach to water quality protection. A potential conflict arises because such an approach might not achieve national water quality goals, at least not efficiently. The Federal Government can mitigate this conflict by coordinating with the States to address transboundary problems. Without such intervention, the incentives for local jurisdictions to consider the transboundary implications of their own policies is lacking, and States may fail to meet their own water quality goals because of pollution from upstream activities. The Clean Water Act established a set of procedures for addressing such problems.

The Federal Government may be in a better position than local jurisdictions to support research on nonpoint-source pollution that has widespread benefits to States trying to implement their own programs. Examples would be the development of nonpoint-source pollution models and the development of new management practices. Similarly, by acting as a clearinghouse for scientific information on nonpoint pollution, the Federal Government can lower information costs to local jurisdictions.

In trying to balance Federal water quality goals with local ones, it might be necessary to establish minimum guidelines for water quality or for industry design standards. There might be some economies for a "leveling of the playing field" between jurisdictions. For instance, an industry may benefit if it does not have to meet 50 different sets of standards (Esty, 1996). Even though the guidelines may result in a higher cost to a local watershed for achieving its own water quality goals, the benefits to the economy as a whole outweigh these costs.

Minimum standards may also reduce the movement of more mobile industries to States with weaker environmental laws (Esty, 1996). There is some evidence that the location of large swine operations is at least partly due to differences in environmental regulations (Bacon, 1993; Hurt and Zering, 1993). The recently proposed Unified National Strategy for Animal Feeding Operations establishes national minimum standards for animal waste control for large animal feeding operations. One consequence is that States enacting more stringent laws to protect their water quality from animal waste are not hurt by the loss of business to States with less stringent laws. Minimum standards also protect States that might otherwise be slow to respond to environmental problems associated with polluting industries seeking a more favorable regulatory environment.