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FEATURE

Improving the cost-effectiveness of agricultural pollution control: The use of performance-based incentives

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Agriculture remains the leading contributor of nonpoint source (NPS) pollution to ground and surface waters in the United States (USEPA 2009). One of the most important reasons that the level of NPS pollution from agriculture continues to be excessive is because clear signals to farmers, from markets or policy, are lacking (Ribaudo et al. 1999). The full costs of agricultural NPS pollution generally do not enter into the farm manager's decision-making process because (1) the damages to water quality that stem from farming activities are not incurred primarily by the farm business itself and (2) farming activities are exempted, for the most part, from many water-quality regulations. Therefore, the farmer has little incentive, other than his or her own stewardship values, to reduce the farm's impact on water quality.

Performance-based incentives are designed to reward farmers for achieving specified environmental performance targets. The payments, based on outcomes, are not tied to the use or cost of any specific practice(s). As such, farmers have the flexibility and incentive to seek out and use the most appropriate and cost-effective way(s) to achieve the specified environmental outcome. This approach has the potential to improve environmental quality, enhance farm income, and provide greater accountability to tax payers.

The Performance-based Environmental Policies for Agriculture (PEPA) Initiative (PEPA 2009) is attempting to bridge the gap between economic theory and the current implementation of NPS pollution control programs by exploring the use of performance-based incentives with watershed stakeholder throughout the United States. The PEPA initiative is being implemented as a partnership between Winrock International, the University of Vermont, and Iowa State University. USDA is currently supporting several PEPA projects, including national education and outreach, pilot-testing of performance-based incentives in Iowa and Vermont, as well as extension education programs in Maryland's Eastern Shore. This paper discusses several of the important issues related to the use of performance-based incentives for agricultural pollution control.

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ASSESSMENT OF CURRENT PROGRAMS

Current programs for controlling agricultural NPS pollution in the United States are focused on cost-sharing best management practices (BMP) and compensating farmers for idling selected tracks of working land. While these programs have been important and valuable tools for addressing agricultural pollution, they often neither encourage farmers to utilize the most cost-effective actions nor do they induce innovation on farming operations (Ribaudo et al. 1999; Shortle et al. 2001). The vast majority of programs that address agricultural pollution control are administered by USDA. Participation by farmers in the USDA programs is voluntary. In recent years, the US Environmental Protection Agency has become more active in enforcing previously enacted regulations, such as the Clean Water Act (CWA). At present, the CWA regulations are only applied to the largest livestock operations, referred to as Concentrated Animal Feeding Operations (CAFOs), which constitute a small, but growing, percentage of the US farming sector.

USDA conservation programs have two primary foci—cost-sharing structures and practices on working lands and compensating farmers for temporarily retiring sensitive lands from production. Based on dollars spent annually, the largest program by far is the Conservation Reserve Program (CRP), which currently spends close to $2 billion per year. This program provides annual rental payments, usually over 10 years, to producers to replace crops on highly erodible and environmentally sensitive land with long-term resource-conserving plantings. Although bids to enroll land in CRP are compared using an Environmental Benefits Index (EBI), the resulting payment is not based upon the environmental performance of the actions.

The trend towards conservation activities on working lands (versus land retirement programs) started in the 2002 Farm Bill has been accelerated in the 2008 Farm Bill. If current projections are accurate, more funds will be spent on the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP) combined than is spent on CRP. EQIP, which currently spends over one billion dollars per year, provides cost-share payments to producers and land owners to plan and install structural (e.g., manure storage lagoons, stream bank fencing), vegetative (e.g., cover cropping), and land management (e.g., nutrient management planning, riparian buffers, conservation tillage) practices on eligible lands. The program is designed to alleviate a range of environmental problems associated with agricultural production. The primary deficiencies with this program are that (1) it does not target critical source areas for agricultural pollution, (2) there are no mechanisms in place to measure or estimate effectiveness of the specific practices installed for each specific location, and (3) the choice set of actions to be implemented are limited to those previously approved by USDA and listed in the Field Office Technical Guide (FOTG).

The final rule for CSP has not yet been released; it is expected in spring 2009. CSP is designed to reward farmers for existing conservation activities, thereby recognizing the efforts that many farmers have already made to improve environmental quality. This program has some elements that are related to performance-based incentives. CSP payments are supposed to be based, in part, on the estimated environmental benefits that are expected from a farm's conservation activities. However, until the final CSP rule is issued, it is not clear to what extent the specific environmental outcomes will be estimated or how that will affect the payment structure. Payments will also be based on costs incurred and income foregone by the farmer. Additionally, CSP is a whole-farm program—either your whole farm, including owned and rented land, is in the program or it is not. Focusing on the entire farm reduces the chances of unintended, perverse outcomes, such as increased nutrient losses from fields not included in the program.

The intention of CSP to reward farmers for preexisting conservation measures can be viewed as a double-edged sword. Rewarding farmers for superior land stewardship, achieved through years or, in some cases, decades of proactive conservation efforts, provides a positive policy signal to the agricultural community for enhanced conservation. Rewarding existing stewardship appeals to our public sense of fairness. However, rewarding previous conservation activities does not produce a lot of additional environmental improvement. As such, CSP will not be highly cost-effective.

If maximizing cost-effectiveness is one of the goals for our conservation programs, we may need to consider a program that rewards farmers exclusively for the specific environmental outcomes that can be documented from their fields and farms. It is very important to note that the implementation of any given BMP will have widely varying environmental outcomes from farm to farm and even from field to field. This variation is based on a multitude of factors that include such things as slope, proximity to surface water, and soil nutrient levels. Hence, applying a constant coefficient of effectiveness to the use of a given BMP can be highly misleading of its performance in a specific field. Because the current programs do not directly consider the specific resulting environmental outcomes, the cost-effectiveness of these programs in achieving water pollution control in agriculture is questionable (Shortle et al. 2001).

There are several important reasons why current programs are not adequately controlling pollution from the farming sector. First, current programs do not use the farmer's specific knowledge of the site and the farm business to determine the most economical means of reducing NPS pollution (Batie and Ervin 1999; Ribaudo and Caswell 1999). Federal and state cost sharing often covers a high percentage of the expense for a limited number of design-based structures and practices (often 70%-90% of total cost) that have been approved by USDA Natural Resources Conservation Service. These cost-sharing requirements have effectively limited farmers' choices for NPS pollution reduction strategies to the currently approved set of cost-shared actions. Second, targeting these programs to the farms and fields where they can achieve the greatest positive impact on water quality has been inadequate (Office of Technology Assessment 1995; Sharpley and Beegle 1999). Third, appropriate incentive mechanisms to induce producer innovation for discovering least-cost solutions are lacking (Batie and Ervin 1999).

US farmers have proven themselves to be highly innovative in finding ways to reduce costs of production. This innovation should also be encouraged to reduce the costs of NPS pollution control. According to much of the literature, the current policy approach for controlling environmental pollution in the United States is not cost-effective and does not encourage technological innovation among producers (Shortle et al. 2001; Chertow and Esty 1997; Hausker 1999; President's Council on Sustainable Development 1996). Although farming is often a life-style choice for farmers as much as it is a business or an occupation, US farmers today are business operators. As such, farmers respond to market signals, such as input and output prices, in making management decisions to, in part, maximize profitability. Having the flexibility to substitute inputs for one another in the production process and/or choose to change or forego the production of certain outputs, in response to changes in absolute or relative prices, is paramount for the efficient allocation of resources in the production system. Without such flexibility, innovation is stifled and the ability to improve cost-effectiveness and increase profitability is greatly curtailed.

It is important to keep in mind that farmers are not only producers of market goods, such as food and fiber. They are also producers of nonmarket goods, such as environmental or ecosystem services, and nonmarket "bads," such as emissions of nutrients, sediments, pesticides, and bacteria. As with market goods, financial signals can also be used to guide the allocation of resources within a farm business toward the efficient production of nonmarket goods (and/or reduction of nonmarket bads). However, as stated above, producer flexibility in this process is essential for efficient outcomes. Our current practice-based programs that provide an incentive (i.e., cost sharing) for the implementation of a limited set of predefined actions, without adequate information on the estimated outcome from each practice in each specific location (i.e., farm and field), are not able to deliver efficient outcomes.

THE USE OF PERFORMANCE-BASED INCENTIVES

The development of specific environmental performance measures and incentive mechanisms is a way to provide financial signals to producers of society's demand for environmental conservation (Hausker 1999). The financial signal can take the form of a price to be paid to producers who are able to provide quantifiable levels of ecosystem services and/or pollution reductions. If the resulting payment is larger than the producer's cost, then taking action to reduce NPS pollution will be a good business decision for the farm. This can be taken a step further by inserting society's valuation of environmental quality into the signaling process to producers. This can turn the positive policy question of "how much conservation is being provided from current programs?" into the normative policy question of "what is the socially optimal level of environmental conservation related to agriculture?"

The design of appropriate policy instruments to control agricultural NPS pollution could have immense positive effects on the health of our nation's waterways, farms, and rural communities (Horan and Shortle 2001). Economic theory has been used in recent years to conceptualize new policy approaches for controlling NPS pollution. Performance-based environmental policies for agriculture can take the form of incentives that are designed to achieve specific environmental goals or targets. With such policies, farmers would have the incentive and flexibility to use innovative strategies in the quest for least-cost solutions. The move toward the use of incentives for environmental performance or outcomes and away from incentives that are tied to specific practices could lead to greater efficiency and effectiveness in environmental conservation related to agricultural production. Of course, given the diffuse nature of NPS pollution and the high costs of monitoring and measurement, nontrivial challenges are posed by such a change.

Designing performance-based policies that improve ambient water quality in a cost-effective manner is difficult for several reasons. First, agricultural NPS pollution (i.e., emissions) from a farm or field is diffuse and difficult to measure. Leaching and runoff into ground and surface waters occurs in many places, making monitoring difficult and expensive. Second, random events, such as rainfall, have a large impact on the delivery of NPS pollution to waterways. Such events cannot be accurately predicted. Third, the linkages among agricultural production decisions and practices (i.e., inputs and technologies), NPS pollution, water quality, and social damage costs tend to be site-specific and poorly understood (Ribaudo et al. 1999). Finally, implementing performance-based policies may greatly increase the information needs and administrative burdens placed on farmers and the implementing agencies.

In addition to the significant information demands on farmers and regulatory personnel for successful performance-based policies, the lack of clear environmental performance standards has stymied the development of such approaches (Batie and Ervin 1999). However, dramatic improvements in information systems and technology in recent years, together with the ongoing development of key environmental indicators and performance standards, are making performance-based policy approaches increasingly feasible (Metzenbaum 1998). Improvements in information technologies, such as high-resolution, georeferenced aerial imagery, GIS, and computer simulation and optimization models, may facilitate the development and use of performance-based approaches.

The Issue of Scale. Environmental performance, particularly for water quality issues (as is the focus of this paper), related to agricultural NPS pollution can be defined at various spatial (e.g., field, farm, watershed) and temporal (e.g. daily, monthly, annual) scales. The issue of spatial scale presents several important choices in the design of a performance-based incentives program. Simply put, the decision to measure performance at the mouth of a watershed, in the river, or on the farm has several important implications.

If water quality performance is measured at the mouth of a watershed, the advantages include (1) ease of measurement (and reduced cost); (2) a close relationship with actual ambient environmental conditions, the improvement of which are the ultimate goal of our current programs; and (3) in smaller watersheds (i.e., HUC 14+), enhanced peer pressure among farmers to participate to achieve water quality goals at the watershed level. However, this approach provides significant challenges. First, it will be difficult to determine how to reward farmers in the watershed according to their individual contributions to the performance at the watershed level. Second, farmers may not be confident that changes on their farm will result in improvements measured at the mouth of the watershed due to other agricultural and nonagricultural sources of water quality degradation. Hence, farmers may be reluctant to incur any expense if they perceive the probability of receiving an incentive payment as low or uncertain. Third, farmers may be reluctant to participate in a program which suggests that they know that their farm has discharges in water bodies, as this may be seen as confessing to violations of current law under the Clean Water Act.

At the other end of the spatial scale is the option of rewarding farmers for performance at the farm level, which should include the performance from all fields under the operator's control. The primary advantage of this approach is that farmers should be able to clearly see that changes made on their farm, and only these changes, will affect their farm's performance. This approach will provide greater confidence that a performance-based incentive payment will result from changes made to reduce NPS pollution from the

Ongoing instream monitoring for pesticides in the Goodwater Creek of North Central Missouri is being explored as part of a performance-based incentives program.

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farm. However, measuring NPS pollution from farms and fields is not generally practical due to the high cost. Using simulation models to estimate NPS pollution is less costly than measuring NPS pollution; however, it is also less accurate and can create uncertainty as to the expected and desired impacts at the watershed level. A benefit of using simulation models as a performance measure is that producers can know, before making any changes, what the resulting performance and payment level will be. This increases the ability of the farm to make sound business decisions regarding NPS pollution control.

Examples from the Field. Working in watersheds in Iowa and Vermont, the PEPA Initiative has assembled groups consisting of farmers, agency staff, and scientists to develop recommendations for the use of performance-based incentives. In both states, the groups have unanimously gravitated toward the use of farm-level performance measures, for the simple reason that it is very difficult for farmers to meaningfully respond to incentives for performance to which they are not the only contributing source of pollution. Although we, as a society, are interested in water-quality improvements at the watershed scale, it may be very difficult to use watershed performance measures as a basis for incentives to affect change at the farm level.

To address this issue, field and/or farm-level performance measures can also be used as proxies to the ultimate environmental concern. As an example, to address phosphorus (P) loss the groups in both states decided the state's P Index would be the most appropriate means to measure performance from each farm. The P Index is a simple, science-based model that predicts the average annual loss (lbs/acre) of P from each field. The individual field values are then weighted based on area to provide an estimate of total P loss from the farm. Farmers can then be rewarded for reducing P loss and/or achieving some designated threshold for P loss. This work is currently being pilot-tested through a USDA Conservation Innovation Grant.

It is important to note that the P Index in each state was developed to assess the risk of P loss from a field, not to be an accurate predictor of actual P losses. However, the groups in each watershed decided that the P Index was the best tool to start with to estimate the farm- and field-specific P losses. Improvements in the accuracy of the P Index, based on additional research, will help to strengthen this tool as a performance measure.

Although farm-level performance measures may not be very highly correlated with the results at the mouth of the watershed, they have some important advantages. First and foremost, as mentioned above, farm-level proxy measures are much easier for producers to respond to. As such, farm-level performance measures may be able to provide a usable link between farm business decision making and environmental performance through appropriately designed incentives, whereas watershed-level performance measures may not. In this way, farm-level proxy measures can serve as the missing link for successful implementation of Total Maximum Daily Loads (TMDLs). Additionally, current approaches to water-quality trading involving agricultural NPS pollution are generally focused on the use of a certain, limited set of BMPs. Using farm-level performance indicators could bring an increased level of confidence to potential purchasers of water-quality credits from agriculture, relative to the purchasing of credits based on a static coefficient associated with a BMP. Second, farm-level performance measures that are not tied to a given set of practices will allow the farmer much greater flexibility in meeting the performance measure in the least costly manner, relative to the current, BMP-focused approach. This is an extremely important characteristic that differentiates a performance-based approach from design- or practice-based approaches. However, it is important to note that a model or other tool provides flexibility to farmers only to the extent that the model can handle "unusual" settings. Flexibility may be limited by the imagination and skill of the model developers. This approach may not equate with a genuine performance-based policy built on environmental monitoring.

A particularly valuable approach may be to utilize a combination of farm- and watershed-level performance measures. Such a program could use farm-level performance measure to trigger a primary performance-based incentive payment and use a watershed-level performance measure, such as monitoring at the mouth of

In the Missisquoi River watershed of northwestern Vermont, the Phosphorus Index is used to determine the estimated level of phosphorus loss from each field. For example, expanding this riparian buffer to 50 ft wide will result in an estimated reduction of 14.7 lbs of phosphorus per year.

In the Coffee Creek watershed of Eastern Iowa, Chad Ingels (right) of Iowa State University Extension and Charles Kerchner (left) of University of Vermont assist farmer Marty Schwers (center) in understanding the estimated field-specific phosphorus loss reductions from various actions that he is considering in response to the performance-based incentive payment.

the watershed, to trigger a bonus payment to participating producers. This approach has the ability to create farmer-to-farmer peer pressure for participation within the watershed, but still have a meaningful connection between farmer decision making and the primary (i.e., farm-level) performance measure. A combination of farm- and watershed-level performance measures is also conducive to an adaptive management approach, where adjustments to farm-level incentives can be made based on measured improvements in watershed quality.

The Issue of Bang for the Buck. If applied correctly, performance-based incentives may be more likely to reduce the farm-level costs per unit of NPS pollution reduction than will practice-based approaches. A recent analysis by the Economic Research Service estimates that performance-based conservation programs can generate more than two times the environmental quality per dollar spent compared to practice-based programs (Weinberg and Claassen 2006). Unfortunately, the administrative costs associated with successfully implementing a performance-based incentives program are not well known and could outweigh the benefits achieved at the farm level. It is clear, however, that this approach is very information-intensive and will require significantly more active participation by agency staff than do current programs.

First, to successfully improve cost-effectiveness at the farm level will require that farmers understand the environmental performance, as well as the cost, of each option (i.e., practice) under consideration. This generally requires analysis at the field level. We cannot expect farmers to possess this knowledge a priori. Although they will generally be able to estimate costs quite accurately, it requires an additional skill set to predict the reductions of P, nitrogen (N), or sediment loss resulting from applying a specific practice on a specific field. Adequate staff time will be required within the implementing agency to work with farmer to provide this field-specific information. This level of staff time may be significantly greater than is required to implement practice-based approaches and could potentially offset the gains through increased cost-effectiveness at the farm level.

A very important policy and program design issue related to overall cost-effectiveness is that of paying farmers for reductions in NPS pollution versus rewarding farmers for having achieved a specified maximum threshold level. Clearly, paying for reductions has the potential to result in much greater bang for the buck in terms of changes in ambient water-quality conditions (Weinberg and Claassen 2006). Farms with the most egregious NPS pollution problems are likely to be the ones with the most cost-effective solutions readily available. However, there are several potential downsides to this approach. First, paying for reductions may require more information on past performance to construct an accurate baseline for the farm and its fields. Second, paying for reductions has the potential to create a moral hazard if farmers attempt to reduce their current performance in expectation of future payment for improvements in performance. Third, paying for reductions implicitly penalizes the producers that have previously taken actions to reduce NPS pollution from their farm. These farms, having previously picked the low-hanging fruit, are not likely to have as many cost-effective actions to further reduce NPS pollution.

Learning as an Outcome. One of the most important outcomes of using a performance-based incentives approach is that of the farmers' own increased understanding of the multitude of actions that they can take, the varying impact of each action on environmental performance, and the costs of such actions. Farmers in several Iowa watersheds where performance-based incentives are being pilot-tested have used the incentive payments as an opportunity to conduct informal, on-farm research trials. In some cases, the farmers discover that costs can be reduced without sacrificing yield and prove to themselves that win-win solutions exist for the farm business and the environment. An important example from the PEPA Initiative work in Iowa is that reduced nitrogen (N) applications on corn fields can save money and reduce expected N losses to the environment. In cases where increased costs are incurred, farmers can weigh these costs against the performance-based incentive payment to determine which actions represent good business decisions for the farm.

When farmers in a watershed meet regularly and work together on the topic of environmental performance, the opportunities for learning increase exponentially. Iowa State University Extension has been helping to coordinate farmer-led watershed councils focused on environmental performance. The enthusiasm that has been generated in these groups, where the farmers are assuming responsibility for their group's leadership and functioning, has resulted in impressive participation rates and a new energy from the farmers related to solving their own environmental problems. Performance-based incentives are a logical and integral part of the farm-based learning that results from these watershed councils. Iowa State University Extension is currently attempting to replicate the use of performance-based incentives as part of watershed councils statewide. This approach could be easily replicated in watersheds across the United States.

The role of farmer-led watershed councils provides a valuable vehicle for the implementation of performance-based incentives. This changes the dynamic of agricultural pollution control programs from "government tells farmers" to "farmers lead in finding solutions that work for them." The enthusiasm and learning that result can create an upward spiral toward the mutual goals of increased farm viability, enhanced environmental quality, and greater accountability to tax payers.

CONCLUSIONS

Performance-based incentives have the greatest chance of success by combining sound science and economics with farmers' knowledge, innovation, and practicality. The PEPA Initiative is attempting to bring this concept to stakeholders across the United States and to facilitate the development of recommendations and applied research on the feasibility and cost-effectiveness of this approach. The development of farm-level environmental performance measures that are closely linked to watershed-level outcomes will allow farmers to respond to incentives in the most appropriate manner for their farming operation. Ideally, this will increase farm viability while improving water quality in agricultural watersheds.

However, more work needs to be done to develop usable, accurate, and acceptable performance measures, as well as further economic analysis to determine the total costs of administering performance-based incentive programs. Further exploration of the use of modern information systems and complex simulation models to estimate farm-level environmental performance is warranted. Incorporating performance-based incentives into the current suite of conservation programs will also require the political will to change the ways our agricultural pollution control programs are designed and delivered.

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