Chapter 6

Education

Education is used to provide producers with information on how to farm more efficiently with current technologies or new technologies that generate less pollution and are more profitable. 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 on the notion that producers value cleaner water enough to accept potentially lower profits. Evidence suggests, however, that net returns are the chief concern of producers when they adopt alternative management practices. In this chapter, we review the economic framework behind education, and review the empirical evidence for the potential role of education in a pollution control policy.

Introduction and Overview

Education plays a significant role in many State and Federal nonpoint-source water quality programs, most recently in the Clean Water Action Plan (EPA-USDA, 1998; Nowak and others, 1997). Educational programs are designed to provide agricultural producers with better knowledge about production relationships for current technologies (so that inputs can be used more efficiently) and/or about alternative technologies that may be more profitable and pollution-abating. In addition, producers may be shown how they contribute to nonpoint pollution and how this may affect themselves and others. Methods for conveying information include demonstration projects, technical assistance, newsletters, seminars, and field days.

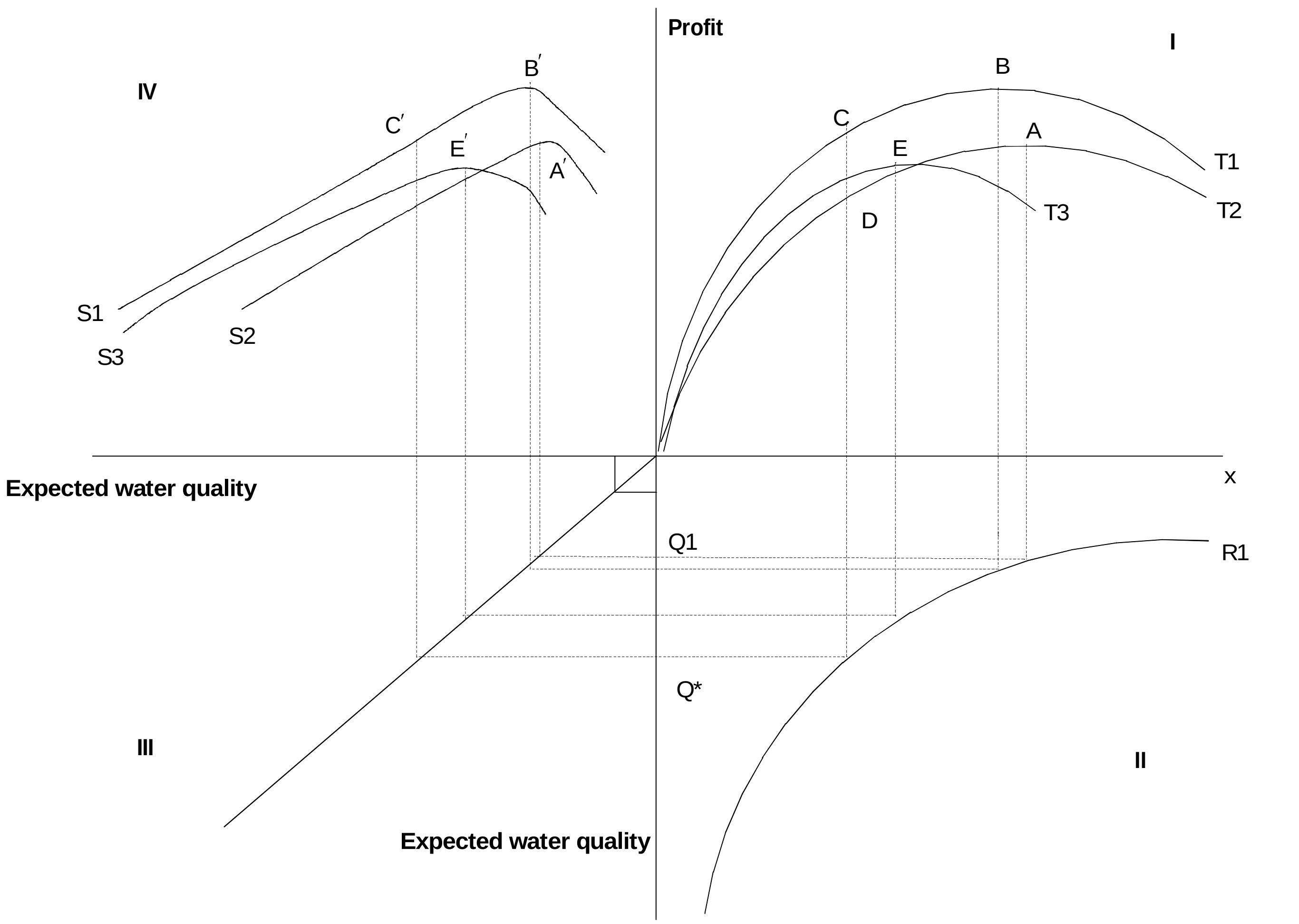
Education is popular as a nonpoint strategy for a number of reasons. It is less costly to implement than a cost-share program, and the infrastructure for carrying out such a program is largely in place (county extension, Natural Resources Conservation Service field offices, land grant universities). Education has been effective in getting producers to adopt certain environmentally friendly practices (Gould, Saupe, and Klemme, 1989; Bosch, Cook, and Fuglie, 1995; Knox, Jackson, and Nevers, 1995). Specifically, educational assistance is often seen as a means of achieving "win-win" solutions to water quality problems, whereby information encourages producers to operate in ways that improve both net returns and water quality (EPA-USDA, 1998; EPA, 1998a). Some practices that have been shown to achieve both aims include conservation tillage, nutrient management, irrigation water management, and integrated pest management (Bull and Sandretto, 1995; Ervin, 1995; Conant, Duffy, and Holub, 1993; Fox and others, 1991).

This chapter begins with education's role in changing producers' expectations about the performance of current technologies. Next, we show how education works under different levels of stewardship or altruism on the part of the producer, and with different levels of private benefits generated by water quality-protecting practices. We then present evidence that education programs have had a limited impact on changing producer behavior when water quality practices are promoted.

Assessing Education as a Water Quality Protection Tool

Figure 6.1 depicts the relationships between production and expected water quality for a single farm, (which may be one of many contributors to nonpoint pollution in a watershed), for the simplified case in which a single input leads to water quality impairment. The relationship between input use and the producer's net returns (i.e., the restricted profit function) is illustrated in quadrant I. Without loss of generality, the profit (y) axis could be thought of as the expected utility of profits for risk-averse producers when there is production uncertainty. Tradeoffs would then be made between expected utility and expected water quality. The relationship between input use on the farm and expected

Figure 6.1
Producer production decisions, without altruism



water quality, taking the actions of all other nonpoint polluters as given, is represented in quadrant II. Finally, the relationship between expected water quality and net returns—or how producers account for water quality in their production decisions—is quadrant IV. A utility indifference map showing the rates at which a producer is willing to trade net returns for increased water quality can be constructed. The point along the water quality–net returns frontier where a producer will operate is at the point of tangency with an indifference curve, or where the marginal rate of substitution (MRS) between net returns and water quality is equal to the slope of the net returns–water quality frontier. At this point, the producer's utility is maximized.

Producers commonly face varying degrees of uncertainty in many aspects of production. For a given production technology, uncertainty about the production frontier (i.e., how to attain the greatest yield or profit levels for a given combination of inputs) may lead producers to use inputs inefficiently. This situation is represented by curve T2, which reflects the production technology the producer is currently using (i.e., the set of tillage, pest control, nutrient management, and conservation practices used to grow a particular crop or set of crops), and the skill with which he is using it. Producers may also have limited knowledge about alternative production technologies and their economic and environmental characteristics, as well as about how their production decisions affect water quality.

The resource management agency's (RMA's) expectations about the relationship between net returns and input x are defined by T1. The RMA's beliefs about the relationship between input use and potential profits are assumed to be more accurate than the producer's due to publicly supported research on how x can be used more efficiently than under the producer's current technology set. The RMA may also have better information about alternative technologies (which could also be represented by T1) and about the relationship between input use and water quality (curve R1).

Suppose the Pareto-efficient level of expected water quality is at Q* (with production occurring at point C on curve T1), but that existing expected water quality levels are well below this. Such inefficiencies arise when (1) producers do not consider the economic impacts of their production decisions on water quality and/or (2) producers face uncertainty or have a limited understanding of the production and environmental impacts of their management choices. The purpose of educational programs is to reduce producers' uncertainty and to improve their knowledge about production and environmental relationships (both for current and alternative technologies). Proponents of such programs believe expected water quality will be improved if the information provided encourages producers to (1) consider the environmental impacts of their choices and/or (2) simultaneously improve expected water quality and profitability by using existing technologies more efficiently or by adopting alternative, more environmentally friendly technologies (Nowak and others, 1997).

Education's Appeal to Profit, Altruism, Efficiency

Below, we discuss the ability of educational programs to provide incentives for improving expected water quality. For simplicity, we ignore shortrun influences such as risk and learning. Instead, we take a longrun view and assume that a practice will eventually be adopted if education can convince producers that it will make them better off (increase expected utility). We note, however, that uncertainty and other factors could slow or prevent the adoption of practices that might, in the long run, increase producers' net returns and improve water quality (see chapter 3). Such factors represent additional limitations that educational programs would have to overcome.

No private benefits from water quality improvement and no altruistic/stewardship motives

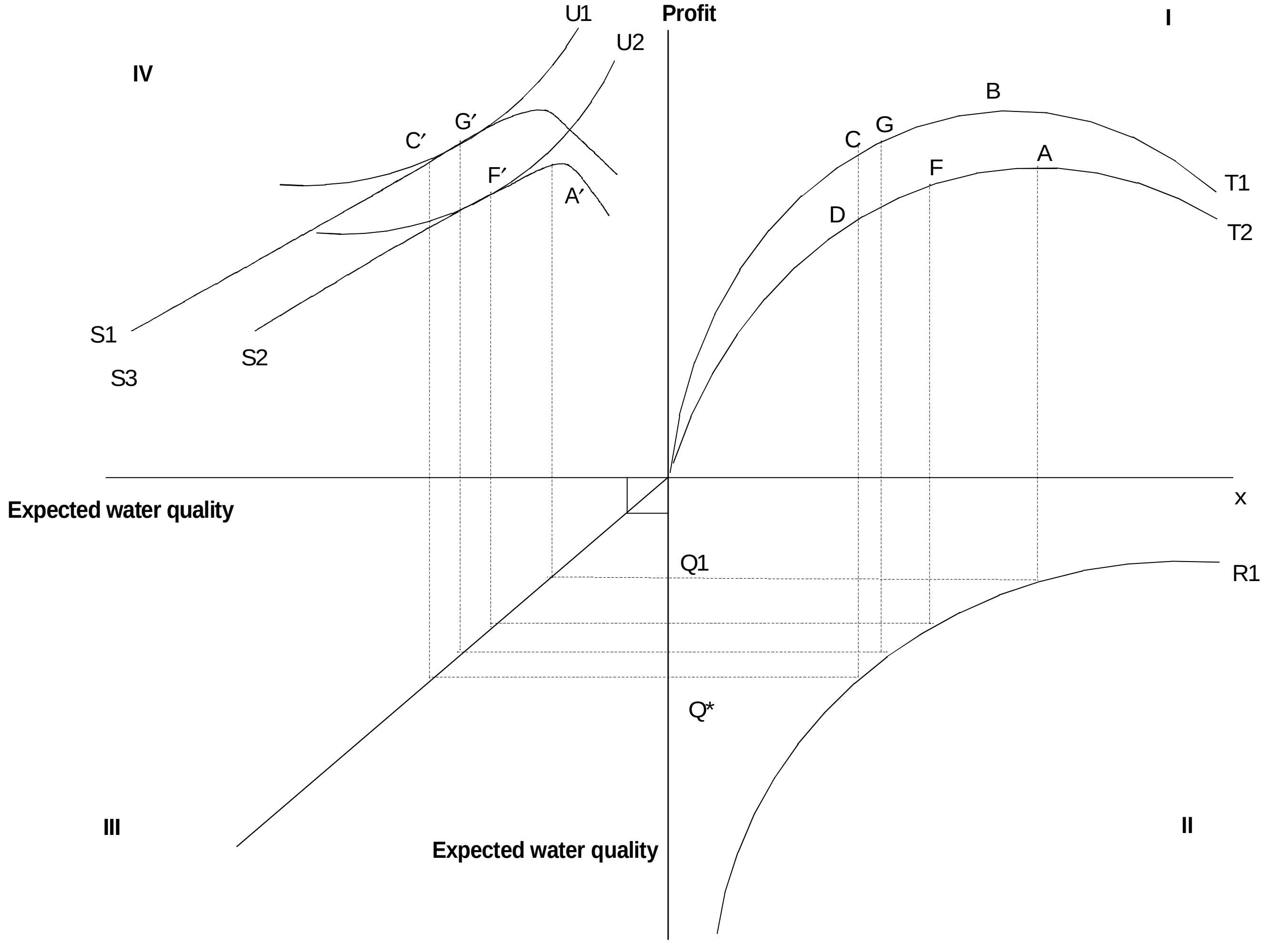
Suppose a profit-maximizing producer who, due to production uncertainty, produces inefficiently along T2 at point A in figure 1. The producer is assumed to receive no private benefits from environmental improvement (i.e., chemical use does not affect the quality of the producer's water supply or of recreation areas the producer visits) and to have no altruistic or stewardship motives (i.e., the producer does not include social damages in his decision set). In this setting and in the absence of any outside programs or intervention, the producer would not voluntarily move to point D so that the RMA's goals are achieved, since net returns would be reduced without any compensating private benefits. In quadrant IV, the MRS between net returns and water quality is 0 (horizontal line), and producers operate at point A′ (where the slope of S2 is 0).

How might education encourage more efficient resource use and improve expected water quality in this situation? It would be pointless for the RMA to educate the producer about the relationships between production and water quality since the producer has no altruistic or stewardship motives. However, by educating the producer about the frontier T1, where profits are higher for each level of input use, the RMA could encourage the producer to use existing management practices more efficiently or to adopt alternative practices so that he/she operates along T1.

Once on T1, the producer could operate at the Pareto-efficient point C to meet the expected water quality goal and at the same time increase net returns relative to operation at point A on T2 (although there may be values of C for which net returns might be reduced). Such an outcome appears to be a "win-win" solution for the farmer. However, even though the producer is producing along a more socially efficient production frontier, his/her goals of production will still generally differ from society's. As long as producers consider only profitability, the producer will operate at point B (note that point C is necessarily to the left of B). The expected water quality levels that correspond to B are an improvement over A, but are still less than efficient. Thus, educational assistance alone is not enough to ensure that the water quality goal is met.

Providing education about production practices might even reduce expected water quality. Suppose the producer originally produced according to T3, so that profits were maximized at E. After receiving educational assistance, the producer would have an incentive to produce at point B on T1. Net returns increase in this case, but so does the use of input x. The result is that expected water quality is worse than it was before education was provided. This result is more than just a curiosity. There is evidence that some IPM practices have actually

Figure 6.2
Producer production decisions, with altruism



increased the amounts of pesticides producers use (Fernandez-Cornejo, Jans, and Smith, 1998).

Altruistic/stewardship motives

Producers may have altruistic or stewardship motives when it comes to the effects of their production decisions on others and on the environment. They may be willing to sacrifice some net returns in order to protect water quality. If so, then education that encourages producers to broadly consider the consequences of polluting practices on water quality and on water users may be somewhat effective. Research has demonstrated that producers are often well informed of many environmental problems, and that most U.S. producers hold very favorable attitudes toward the environment and perceive themselves as stewards of the land (Camboni and Napier, 1994). Educational programs could take advantage of altruism or stewardship by informing producers about local environmental conditions and about how a change in management practices could improve local water quality. This would be accomplished by providing producers with information about T1, and also about the relationship between their production practices and water quality, R1.

Suppose an altruistic producer does not believe he/she is contributing to water quality problems and is not aware of T1 (fig. 2). Production will initially take place along T2 at A (or at A′ in quadrant IV). Since the producer is unaware of R1, the producer's MRS between net returns and water quality is 0. Suppose that the producer is informed of how the use of x is affecting water quality (becomes aware of the relationships expressed by R1 and S2). Where the producer now operates will be determined by his/her willingness to give up some net returns to protect water quality, expressed by the indifference curves in quadrant IV. Production on T2 will now occur to the left of A, at F (F′ in quadrant IV), where indifference curve U2 is tangent to S2. In the example, water quality is improved and utility increased (point A′ lies below U2). This is a win-win situation for the producer in terms of utility, even though net returns are reduced relative to A.

Suppose now the producer is educated about T1. The altruistic producer will have an incentive to make production decisions based on the tradeoffs defined by S1 and U1, operating now at point G. In this example, both water quality and net returns are higher than for points A and F, a win-win situation. However, this need not be the case. The ultimate impacts to water quality will generally depend on the nature of T1 and R1 relative to T2, and on the MRS between net returns and water quality. If expected water quality does improve as a result of education, the degree of improvement relative to the RMA's goal of Q* depends on how strongly the producer values environmental quality. Efficiency is obtained only for the special case in which each producer makes production decisions while fully internalizing his/her marginal contribution to expected environmental damages.

Experience with education programs indicates that altruism or concern over the local environment plays only a very small role in producers' decisions to adopt alternative management practices. Agricultural markets are competitive, and at a time when commodity program payments to producers are being reduced and trade is being liberalized, market pressures make it unlikely that the average producer will adopt costly or risky pollution control measures for altruistic reasons alone, especially when the primary beneficiaries are downstream (Bohm and Russell, 1985; Abler and Shortle, 1991; Nowak, 1987; Napier and Camboni, 1993). A survey of Pennsylvania field crop producers found that private profitability was the motivating force in adopting environmental practices, although altruistism was also a determinant (Weaver, 1996). Camboni and Napier (1994) found that education was not effective in promoting adoption of practices that were less profitable than current practices.

USDA's Water Quality Demonstration Projects—now discontinued—provided educational assistance to producers in 16 areas where agriculture was known to be affecting water quality (Nowak and others, 1997). A study of producer adoption of improved farming practices for protecting water quality was conducted using a sample of these projects. It compared adoption rates of similar management practices in the Demonstration Project areas and in control areas where education was not provided, and found little difference in awareness, familiarity, and adoption. In fact, only 1 case out of 20 showed a significantly greater adoption rate in the Demonstration Projects than in the comparison sites during 1992-94 (Nowak and others, 1997). It is possible that information spillovers from the Demonstration Projects influenced the control sites, but it is just as possible that producers are generally looking for management practices that increase net returns and that education alone was inadequate for accelerating the adoption of practices that protect water quality.

In another example, California's Fertilizer Research and Education Program, a voluntary nitrate management program, has not had much success in altering fertilizer management practices, despite well-publicized groundwater quality problems (Franco, Schad, and Cady, 1994). More public supply wells in California have been closed for nitrate violations than for any other contaminant. Four years of education efforts have not fundamentally changed fertilizer management practices. To date, appeals to stewardship have not overcome concerns over maintaining high yields.

Altruism can motivate change only if producers believe there is a problem that needs to be addressed and that their actions make a difference (Napier and Brown, 1993; Padgitt, 1989). Surveys consistently find that producers generally do not perceive that their activities affect the local environment, even when local water quality problems are known to exist (Lichtenberg and Lessley, 1992; Nowak and others, 1997; Pease and Bosch, 1994; Hoban and Wimberly, 1992). Producers' perceptions about their impacts on water quality did not significantly change over the course of USDA's Demonstration Projects, even though the projects were located in areas with known water quality problems (Nowak and others, 1997). This indicates either a lack of effort to educate producers on their role in protecting local water quality or the difficulty of convincing producers of their role in solving the problem.

Convincing producers of their contribution to a nonpoint-source pollution problem is inherently difficult. Nonpoint-source pollution from a farm cannot be observed, and its impacts on water quality are the result of a complex process and are often felt downstream from the source. If there are many other producers in the watershed, a single producer may justifiably believe that his/her contribution to total pollution loads is very small. This means that producers will have to take as a matter of faith the RMA's description of the relationship between production and water quality, R1. Even if a producer does take appropriate actions to improve water quality, he/she generally will not be able to observe whether these changes in management actually improved water quality. Once again, the producer will have to take as a matter of faith any information the RMA may provide about the impacts of his/her efforts to improve water quality.

Practices generate private benefits from water quality improvement

There are cases in which a producer's practices may affect the farm's drinking water supply and his/her family's health, or in which water quality influences onfarm productivity. A producer in such a situation may be willing to forgo some profit for an increase in expected water quality if the expected onfarm environmental impacts are sufficiently large (expected utility from profits and water quality increase). Therefore, an educational program that addresses these onfarm environmental impacts may motivate the producer to change production practices to improve expected water quality. The analysis is similar to that for altruistic farmers, except the impacts on water quality are felt closer to home and it is probably easier for the RMA to establish the consequences of polluted water. This is illustrated in figure 2 as the producer moves from A toward D on T2 after being informed of the potential onfarm impacts. The actual point of production relative to D depends on the perceived significance of the risk and the value placed on that risk, reflected by the indifference curves. If the producer is also provided with information on T1, he/she will have incentive to operate along T1 somewhere to the left of B. Both producer utility and water quality increase as a result of education.

If onfarm impacts were the only possible water quality problems from farming, then consideration of these impacts in production decisions would result in an efficient allocation of resources (there is no externality). However, if onfarm impacts are being used by the RMA as a proxy for other offsite impacts, then inefficiencies would still exist in the allocation of production resources. An analysis of the impact of user safety concerns over herbicides used on corn and soybeans in four States found that herbicide toxicity did not have a sizable impact on herbicide use decisions (Beach and Carlson, 1993). The herbicides used were generally not very toxic to humans, and productivity effects dominated herbicide use decisions. Decisions based on protecting human health were inadequate for protecting environmental quality.

Producers have been shown to respond to education programs when their own water supply is at stake (Napier and Brown, 1993). This is demonstrated by the Farm*A*Syst program. This program, developed by the Wisconsin Cooperative Extension Service and supported by USDA, teaches producers to assess impacts of farming operations around the farmstead (Knox, Jackson, and Nevers, 1995). Educating producers raises their self-interest for altering certain practices, primarily around private wells. Producer education has succeeded in getting individuals to take cost-effective actions to remediate problems from leaking fuel storage tanks, pesticide spills, and drinking water wells contaminated by runoff from confined animals. Studies from Minnesota, Wisconsin, and Louisiana show producers to be receptivite to Farm*A*Syst and voluntarily willing to take action to reduce high risks by changing management practices and facility design (Knox, Jackson, and Nevers, 1995; Anderson, Bergsrud, and Ahles, 1995; Moreau and Strasma, 1995). The key to the program's apparent success is the ability to identify the source of a threat to the producer, his family, and his employees.

Education and Industry Structure

Educational programs do not influence decisions about entry and exit into the industry. Acreage that would be classified as extramarginal in the efficient or cost-effective solution may still remain in production if educational assistance is the only form of government intervention. It is unlikely that any producer would voluntarily retire land from production if provided information on alternative practices or how his/her operation may be affecting water quality.

Current USDA education programs unwittingly may be disproportionately helping larger farms. Small producers have been found to be less likely to adopt new practices than large producers (Lichtenberg, Strand, and Lessley, 1993; Ervin and Ervin, 1982; Gould, Saupe, and Klemme, 1989; Norris and Batie, 1987). A study of producers around the Chesapeake Bay found that cost sharing and subsidized technical assistance were used much more by larger farms than smaller ones to adopt nutrient management, animal waste management, and soil erosion control (Lichtenberg, Strand, and Lessley, 1993). Smaller farms may face tighter credit constraints and be more risk averse. Education efforts may also be directed more at larger farms, based on the assumption that changing practices on these farms would generate the greatest environmental benefits. If new practices enhance net returns, then larger farms benefiting from education efforts may be putting smaller farms at greater economic disadvantage relative to larger farms. This may conflict with a societal goal of protecting small, resource-limited producers.

Summary

Water quality policies based on education are currently popular because education is a benign form of intervention (i.e., producers are not forced to change their management), it is relatively inexpensive to administer, and it may teach producers how to achieve higher returns. From a practical standpoint, the institutional structure necessary to implement this approach—USDA, State conservation agencies, and land-grant institutions—is already in place (Easter, 1993). If education succeeds in raising a producer's awareness about a local environmental problem, and the producer places a value on protecting environmental health, the effect on producer willingness to adopt alternative practices can be significant.

However, education has some important shortcomings in achieving the water quality levels demanded by the public, even when ignoring the short-term constraints to adoption. Educational programs will improve water quality only if the information provided to producers encourages them to take actions that lead to water quality improvements. Such incentives exist when (1) the actions that improve water quality also increase profitability, (2) producers have strong altruistic or stewardship motives, and/or (3) the onfarm costs of water quality impairments are shown to be sufficiently large. However, none of these three conditions guarantees an expected improvement in water quality. In general, the outcome of educational programs depends on how actual profitability–water quality frontiers compare with the producer's initial understanding of these frontiers. Moreover, in the absence of altruistic or stewardship motives, alternative practices that simultaneously increase expected net returns over the long term and improve water quality are very few.

Many education programs may not devote enough effort to convincing producers of their role in water quality protection. Failure to do so limits the extent to which stewardship influences producer decisions. The influence of stewardship is also probably limited by the longrun financial viability of the farming operation, including current and anticipated risks. If the socially efficient outcome can be achieved only through significant reductions in producer net returns, then education will probably not be effective in achieving the desired water quality goal, even if producers understand the relationship between production practices and water quality.