Chapter 5

Farmers as Producers of Clean Water: A Field Experiment

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1 Introduction

Will there be enough clean water? That is a question that bedevils societies everywhere. In developing countries, both point and nonpoint sources of pollution represent important threats to water quality (Duda, 1993; Tonderski, 1996). Conversely, in developed countries like the US, point sources have been sufficiently regulated such that significant progress has been made in dealing with this source of water pollution (Hetling *et al.* 2003; Murchison 2005). Nonpoint source pollution (NPSP) related to agriculture is now considered one of the largest remaining water quality problems in the US (See US EPA 1998; Ribaudo *et al.* 2001; Ribaudo 2003; Peterson and Boisvert 2004; Poe *et al.* 2004; Millock and Salanie 2005). According to the US EPA (1998), agriculture impacts 48% of impaired rivers and 41% of impaired lakes. These water quality problems have persisted despite billions of dollars spent on voluntary conservation cost-share programs by the federal government over the last two decades (US GAO 1992; US GAO 2005).

To stimulate additional water quality conservation, regulation and ambient tax/subsidy schemes have been proposed as alternatives to voluntary cost-share programs (Segerson 1988). This chapter describes an experimental alternative to regulations or taxes. This experiment examines whether farmers can be induced to cost-effectively abate NPSP when presented with economic incentives that are welfare-enhancing. The objective of the experiment is to reconfigure water quality into a commodity that farmers can choose to produce, thereby converting conservation from a threat into an opportunity. The experiment includes development of an institutional framework and payment formula that rewards a group of farmers based on the quantity and quality of water flowing from their watershed. The experimental watershed is located in a rural area of the Appalachian Mountains of West Virginia in the US.

The remainder of this chapter is organized as follows. There are two parts to Section 2: (1) contains a literature review of ambient-based and group approaches to NPSP control; and (2) presents our behavioral model of farmer responses to economic incentives for NPSP abatement. In Section 3, we describe the development of our field experiment by summarizing water prices and estimated payments in the absence of market prices and measured stream flow data. Section 4 presents experimental data collected to-date and utilizes the behavioral model to explain farmer participation. Section 5 is a discussion of preliminary conclusions and implications for future research.

2 The State of the Art in Modeling Ambient-Based Instruments to NPSP Control

2.1 Literature Review

NPSP abatement remains a problem due to an imposing set of challenges. As Segerson (1988) explains, the effect of abatement on nonpoint source emissions is stochastic and only combined emissions of multiple farms are readily observable. She argues that these challenges make monitoring of individual emissions much too costly. As a result, mechanisms based on observable inputs have been traditionally used to combat NPSP. These include subsidies on conservation inputs like riparian buffer zones, or taxes on polluting inputs like fertilizer. In contrast to these input-based approaches, Segerson (1988) develops an ambient-based mechanism that uses taxes and subsidies to address these challenges.

Building on Segerson's work, researchers have continued to evaluate potential ambient-based approaches to NPSP abatement. Horan *et al.* (1998) consider cases where firms have multiple options for changing their nonpoint source emissions. Vossler *et al.* (2002) conduct experiments that indicate the mechanisms presented in Segerson (1988) can induce farmers to reach the ambient target but cannot assure individual compliance. Spraggon (2002) examines the ability of an ambient-based instrument to address the group moral hazard problem without costly monitoring. Spraggon (2004) relaxes the assumption of homogenous agents and finds that, in an experimental setting, contracts can induce the correct level of abatement but inefficiencies and inequities occur. Segerson and Wu (2006) present a model that combines a voluntary approach with the threat of an ambient-based tax. Their results indicate that when this combination is applied to a heterogeneous group of farmers it may induce cost-minimizing abatement without the need for farm-specific information (see also Suter *et al.* 2006).

A related body of literature has emerged that uses ambient-based instruments in a voluntary setting where farmers cooperate or work in groups to address problems of asymmetrical information. Pushkarskaya and Randall (2002) develop a contract that addresses the contention that regulators know less than farmers about the farmers' cost functions. Isik and Sohngen (2003) argue that the information problem leads to a moral hazard problem, and they investigate contracting mechanisms that bring joint liability to bear. Romstad (2003) argues that farmers are likely to have knowledge of each other's farming practices, and that a group approach to NPSP control can use this knowledge to, for example, allow farmers to shift the abatement burden among themselves. Peterson and Boisvert (2004) discuss the implications of information asymmetries between a regulator and farmers related to farmer risk preferences, technology types, and input use. They find that a regulator needs to account for the diversity in risk preferences to induce farmers to participate.

Poe *et al.* (2004) and Vossler *et al.* (2006) extend Segerson's work with experiments that allow polluters to cooperate through costless, nonbinding discussion prior to making commitments. Taylor *et al.* (2004) anticipate a high information burden to calculating the correct incentives. They propose a team contract combined with an auction to address this problem. Based on focus group results, Sohngen and Taylor (2005) conclude that farmers may not be willing to take on a monitoring role with respect to their neighbors. Millock and Salanie (2005) define cooperation in the context of NPSP abatement as '…the ability to coordinate emissions in order to maximize joint profits…' They develop an approach that addresses the contention that the level of cooperation within a group is hard for a regulator to observe. Hansen and Romstad (2007) describe a mechanism that is robust to unobserved cooperation, and also approximates the correct incentives for firm entry and exit.

2.2 A Behavioral Model

We investigate a version of ambient-based group approaches to NPSP abatement designed to be welfare enhancing to farmers. Our approach is closely aligned with voluntary contracts between a point source of pollution and a group of farmers (Isik and Sohngen 2003; Taylor *et al.* 2004). However, in our case, farmers are responding to a constructed market. We recognize that this confers to participating farmers an implicit limited property-right to discharge pollution. This is something that Weersink *et al.* (1998) cite as a potential way to increase the provision of environmental amenities from agriculture. Thus, in contrast to Segerson (1988), our approach replaces a tax/subsidy system with payments that are an increasing function of improved water quality. We see this as a practical way to address the concerns of risk-averse farmers since there are positive payments even in the face of poor water quality. In addition, Breetz *et al.* (2005) argue that perceived fairness may be an important criterion in a farmer's decision to participate in a water quality program. We think that this endowment of property rights increases the likelihood that our program will be considered fair by farmers. Finally, if water quality conservation can be made welfare-enhancing to farmers, an expanded set of NPSP abatement actions potentially can be brought to bear because the goals of society and the goals of farmers are aligned (Ribaudo *et al.* 1999).

Some agricultural innovations are minor in scope, for example, changing from high tension pasture fencing to single strand electrified fencing. Innovations like this can be evaluated with simple cost-benefit analysis from a farmer's perspective. However, decisions about innovations that introduce a higher level of uncertainty need to be analyzed differently. For example, Ethridge *et al.* (1975) use a model of expected disequilibrium cost in their analysis of optimal seed acreage choice (see also Antle 1983). In the presence of uncertainty, authors have employed models of expected utility to explain farmer decision making (Feather and Amacher 1994; Havlik *et al.* 2005). In a similar vein, Breetz *et al.* (2005), looking at participation in water quality trading programs, cite the importance farmers place on equity and the possibility of negative publicity. They assert that simple profit maximization models do not capture these elements. Also, lifestyle goals enter into a farmer's internal calculus (see Lin *et al.* 1974; Young and Shumway 1991; Tanaka *et al.*, 2005; Breetz *et al.* 2005).

Considering that NPSP abatement may require new technologies, introduce substantial uncertainty, and impinge on existing cultural norms, we developed the model in equation (1) assuming that landowners maximize the expected utility from net income each year.

$$\begin{aligned} &\underset{K_{ag},K_w}{Max}\, EU = \int U(y(K_{ag},K_w) \mid z))\, f(y(K_{ag},K_w)\, d(y) \\ &s.t.\ \overline{K} = K_w + K_{ag} \end{aligned} \tag{1}$$

where y is annual net farm income and is treated as a random variable, z is a vector of socio-demographic variables, K_{ag} represent a bundle of inputs dedicated to current agricultural production, and K_w is the bundle of inputs devoted to water quality improvements.

Equation (1) indicates that farmers maximize the expected utility of annual net income by allocating variable inputs, where net income is a random variable acted on by farmer-determined levels of these inputs. We further assume that this utility function is concave with respect to income. The intuition behind this model is that a farmer optimally invests a given set of variable inputs like labor, fertilizer, and seed, in a way that optimizes the relationship between utility from expected net income and risk. This logic follows the example of Lin *et al.* (1974) who present an expected income versus variance of income (E-V) frontier (see also Buccola and French 1977; Just and Pope 2003). Each point on this E-V frontier represents a production plan with the minimum variance for a given level of expected income. Rational farmers 'choose' a production plan of inputs and outputs that results in their highest expected utility curve being tangent to the E-V frontier. This framework is presented in Figure 1 and is discussed further in section 4.2. This implies that farmers actively manage risk in their production decisions (see also Leathers and Smale 1991), and that a change in K allocated to a given activity will entail changes to both expected income and variance of income.

Equations (2)-(4) present the Lagrangian and first-order conditions for determining optimal allocations of K_{ag} and K_w.

$$L = \int U(y(K_{ag}, K_w) \mid z) f(y(K_{ag}, K_w)) + \lambda(\overline{K} - K_w - K_{ag}) \;\; d(y) \qquad (2)$$

$$\frac{\partial L}{\partial K_{ag}} = \int \left[\left(\frac{\partial U}{\partial y} \frac{\partial y}{\partial K_{ag}} \right) \times f(y(\bullet)) + U(y(\bullet)) \times \left(\frac{\partial f}{\partial y} \frac{\partial y}{\partial K_{ag}} \right) - \lambda \right] d(y) = 0 \qquad (3)$$

$$\frac{\partial L}{\partial K_{w}} = \int \left[\left(\frac{\partial U}{\partial y} \frac{\partial y}{\partial K_{w}} \right) \times f(y(\bullet)) + U(y(\bullet)) \times \left(\frac{\partial f}{\partial y} \frac{\partial y}{\partial K_{w}} \right) - \lambda \right] d(y) = 0 \qquad (4)$$

Manipulating equations (3) and (4) leads to the straightforward conclusion that $\partial EU / \partial K_{ag} = \partial EU / \partial K_w$. However, an important observation is that a change in K_w and K_{ag} affects utility not only through its impact on income, but also through its impact on variance of income (risk). This second effect captures the potential for increased risk that farmers face when altering production practices. While potentially important, unfortunately, if is difficult to anticipate the impact of this term without information on the functional form of $f(\bullet)$.

3 The Field Experiment

3.1 The Experimental Watershed and an Institutional Framework

Cullers Run watershed was selected as our field experiment site. This stream is a tributary of the Lost River in the eastern panhandle region of West Virginia, in the US. Mathes (1995) describes this region as having long narrow valleys with a humid, temperate climate. We selected this watershed based upon three primary considerations: importance of agriculture, small size, and availability of water data.

Agriculture is an important land use in Cullers Run. The watershed is located in Hardy County, West Virginia's largest poultry production county (National Agricultural Statistics Service, 2005). Sixteen per cent of the watershed is devoted to agriculture of which most land is pasture or hay land. Row crops comprise only 3.63 per cent of the agricultural land, mostly in the floodplain (Cacapon Institute 2002). The rest of the watershed is occupied mostly by forest. There are approximately twelve poultry houses conducting intensive poultry production in the watershed. Much of the local demand for agricultural fertilizer is met at a relatively low cost with manure from this poultry production.

Cullers Run watershed is approximately 2,978 hectares so it is small enough to limit the number of farmer households that could participate in the project. Small group size reduces the information burden on farmers (see Weersink *et al.* 1998; Ribaudo *et al.* 1999). Finally, this watershed was included in a previous water quality study (Cacapon Institute 2002). The data during this study enabled an evaluation of water quality conditions prior to the experiment and allowed for realistic projections to be made about watershed payments.

By selecting a small watershed with available water quality data, it was envisioned that the transaction costs of developing economic incentives for NPSP abatement could be kept to a minimum. The importance of keeping the transaction costs of NPSP abatement mechanisms to a minimum is well-established (see Smith & Tomasi, 1995; McCann and Easter, 1999; Ribaudo *et al.* 1999; Lubell *et al.* 2002). Another important aspect of limiting transaction costs is the institutional framework. Unfortunately, the literature provides little guidance in terms of what constitutes an effective institutional framework for a field experiment like the one being tested here.[1] In addition, there are novel elements related to this research that preclude it from fitting neatly into existing institutions. Given this context and observations of watershed groups by Constantz (2000) and Collins *et al.* (1998), we assembled a research team that was able to conduct the multi-disciplinary work involved with a field experiment, and that had a working knowledge of the people and resource base.

Beginning in December 2006, we held five preliminary meetings to present this field experiment to farmers in the experimental watershed. Each of these meetings was attended by twenty to thirty people representing a substantial portion of farmer households in the watershed. Meeting invitees included local, state, and federal government agency personnel plus the county extension agent. During these meetings, the experiment was described as a field test of economic incentives to abate NPSP, and that we would make monthly payments for two years, based on the quantity and quality of water flowing from the watershed, to farmers who chose to participate. The length of the project was later increased to three years.

There were two important outcomes of these meetings: (1) the establishment of a working relationship between researchers and farmers; and (2) a written contract. This contract was discussed and revised a number of times during the meetings. It serves to clarify the institutional framework and outlines the roles and responsibilities of both farmers and researchers. Key stipulations for farmers in this contract are:

- Participation in this project is voluntary and is initiated by signing a contract.

- A participant who has signed a contract can choose to leave the project at any time with no penalty or further obligation.

- Payments will be made monthly to 'The Group'. The initial participants will determine how these monthly payments are allocated among the participants. The resulting allocation rules will be presented to the project investigators, who will use these rules to distribute the monthly payments and be responsible for disbursements.

- Participants are allowed to be enrolled in state or federal cost-share programs.

- A participant is able to select which best management practice (BMP) or other management change to implement in order to impact water quality.

- Signing a contract does not obligate a participant to implement any BMP.

Farmers, along with researchers, have difficulty projecting the amount and timing of pollution reductions resulting from BMP implementation (Park *et al.* 1994; Bracmort *et al.* 2006; Arabi *et al.* 2007). Thus, risk reduction aspects of this contract include the voluntary aspects of participation, BMP selection, and BMP implementation. The three year time frame of the experiment may limit participant interest in BMP implementation so cost share participation is encouraged. In addition, participants have the ability to control for risk by allocating more of the monthly payments to those that implement BMPs. The key stipulations for project investigators include:

- Project investigators are responsible for determining if a potential participant qualifies for participation in the project based solely on the boundary of Cullers Run watershed.

- Participation by project investigators is not voluntary. There are no provisions that permit withdrawal of project funds.

- Project investigators will calculate the amount of each monthly payment to 'The Group' and distribute this payment among participants based on written allocation rules provided by 'The Group'. The amount of the payment will be computed by project investigators based on a payment formula and prices presented to the farmers.[2]

- Project investigators will set-up a water quality and quantity sampling, monitoring, and testing plan. Participants will be allowed to observe any sampling, monitoring, and testing being conducted under this plan.

3.2 Developing a Payment Formula

Correctly specifying a payment formula is critical to establishing proper economic incentives for farmers. A payment formula should have properties that:

- Provide a transparent economic incentive that motivates farmers to pursue the desired behaviors. For the purposes of this experiment these desired behaviors include pollution abatement $[\partial \text{payment} / \partial \text{quality} > 0, (\partial \text{payment})^2 / \partial^2 \text{quality} > 0]$ and stream flow moderation $[\partial \text{payment} / \partial \text{quantity} > 0, (\partial \text{payment})^2 / \partial^2 \text{quantity} < 0]$.

- Accommodate environmental conditions fairly. NPSP is influenced by environmental conditions, and regulating stream flow is difficult for farmers. For example, an approach that penalizes farmers for high levels of pollution after a flood event would be unpalatable to potential participants.

- Transmit budget information to the regulator and the farmers. For example, based on the payment schedule, the regulator should be able to estimate likely budget outlays, and farmers should be able to estimate a range of potential revenues from BMP implementation.

Based on these three properties, we developed a payment formula that allows farmers to evaluate production of water quality as a market opportunity much as they would any other opportunity. This formula is shown in equation (5).

$$\text{Watershed Payment} = \text{volume of water} \times \left(\frac{\text{price}}{\text{unit volume}} \right) \times \text{quality adjustment factor} \qquad (5)$$

Equation (5) states that the watershed payment is the multiplication of three parts: water volume flowing from a watershed, a per unit price based on water volume, and a quality adjustment factor. This factor is computed as the pollutant level in a control watershed divided by the pollution level in the experimental watershed. Inclusion of this factor accomplishes two purposes: (1) it ‘subtracts off’ natural background pollution; and (2) it accounts for weather-related variations in pollution. For discussions see Shortle *et al.* (1998) and Poe *et al.* (2004). The control watershed is similar to the experimental watershed except that the control is almost completely covered with forest. Thus, it was assumed to serve as a weather-sensitive, natural condition baseline for pollution.

We selected nitrate-N loading as our indicator of water quality because: its ambient stream concentration varies more predictably with rainfall than other pollutants, its concentration is positively related to the extent of agricultural land, and it is a relevant pollutant with respect to water treatment costs and stream degradation (Morgan & Nicole, 2001; Cacapon Institute 2002). However, nitrate-N has disadvantages of: being present under natural conditions, not being visible, and residing in subsurface water, thus producing a time lag between when it is generated and when it contributes to ambient stream concentrations. The adjustment factor accounts for the first disadvantage, and we provided detailed water testing information to farmers to reduce the impact of the second. Due to limited information, the third disadvantage remains in the experiment.

A key issue is how to put this payment formula into operation so that farmers can visualize themselves as producers of clean water. Below we describe how we derived the estimates needed to inform farmers of the payments they could expect.

3.3. Estimating Payments

Estimating watershed payments required two primary steps. The first step was to determine the minimum water prices that would induce farmers to abate nitrate-N. The second step was to use these minimum prices along with estimates of stream discharge and water quality to project monthly farmer payments.

Deriving water prices involved estimating stream flow discharges from the experimental watershed and developing an economic optimization program for farmer behavior. Water prices were set at a minimum level where implementation of BMPs (in the form of riparian buffer strips) to achieve nitrate-N abatement was more profitable than agricultural production. This work is described in detail in Maille and Collins (2006) and the results are summarized below.

The prices generated by our optimization model are shown in Table 1. They make intuitive sense from both economic value and pollutant loading perspectives. During the growing season (May-September), the discharge is lower due to low rainfall and loading of pollutants is decreased. Thus, higher per unit water prices are needed to induce BMP implementation. Conversely, high discharges and non-growing season leads to lower prices as marginal water values are low and pollutant loads are higher. By using different prices, payment risk to both landowners and the regulator is reduced. A sensitivity analysis of the optimization program projected only small changes in payments between rainfall regimes (Maille & Collins 2006).

[TABLE 1 HERE]

However, when deciding to participate, farmers need an estimate of actual payments, not just prices. Using equation (5), we simulated four years of monthly watershed payments using estimated discharges based on rainfall data, nitrate-N concentrations as proxies for loads in the adjustment factor, and prices from Table 1. The annual average of these payments was $7,721 with a range of $4,593 to $9,400. We also estimated payments based on a 25 per cent reduction in nitrate-N. With this level of abatement the payments were $9,595 annually, ranging between $5,898 and $11,480. The difference between the payments with versus without additional abatement represents an estimated opportunity cost incurred by farmers when they do not abate NPSP.

3.4. The Incentive Scheme

Underlying our incentive scheme is the right to pollute implicit in equation 5 and the institutional arrangement summarized in section 3.1. As Ribaudo et al. (1999) show, economic efficiency of pollution abatement depends upon marginal profit from input use being set equal to marginal expected damage from input use across all farmers. In order for our incentive scheme to achieve economic efficiency, a regulator must develop a payment formula such that the marginal expected damage from input use across all farmers equals the marginal decrease in the watershed payment. We find that efficiency under watershed payments can result so long as farmers make a collective decision to base each individual farmer's share of the watershed payment on that farmer's pollution contribution to the stream (Maille and Collins 2008). Maille and Collins (2008) also show that when payment shares are not based on individual pollution contribution, but are equally shared among the farmers, then the watershed payment at efficient abatement is N times the marginal expected damage, where N is the number the participating farmers.

Finally, farmers may choose to dedicate a portion of the watershed payment to cost sharing for adoption of pollution runoff-reducing production technologies. This collective strategy is acceptable to individual farmers who want to maintain current levels of input use (particularly fertilizer) and agricultural production while still addressing pollution. However, economic efficiency under this approach does not seem to be technically feasible to achieve, and a regulator is faced with the problem of overpayment to farmers at efficient abatement (Maille and Collins 2008). The result is that the economic efficiency envisioned under pure tax or subsidy incentives may not be strictly achievable with watershed payments when farmers are allowed to collectively decide how to allocate these payments among themselves. However, this loss in theoretical efficiency is offset by allowing for meaningful farmer decision-making, thereby enhancing farmer "buy-in" to our incentive scheme and motivating their interest in addressing the pollution problem.

4 Results: Post Sign-up Experience-to-Date

4.1 Modeling

How closely did estimated payments approximate actual payments? This question has important practical implications to anyone considering implementing a field experiment like this one. Table 2 compares estimated versus actual payments. Estimated payments are the average payment for that month over four years of simulated payments. The actual payments are based on direct measurements of watershed discharges and nitrate-N loads during 2007.

[TABLE 2 HERE]

We see that actual discharge and the adjustment factor in April were very close to the estimates. Since April, rainfall, and consequently discharge, has fallen well below average.[3] In the face of this decrease, higher prices and adjustment factors helped to maintain payment levels, and therefore incentives, close to those based on preliminary estimates. Over the first three months of the project, actual payments were $2,486, 8% higher than simulated the payments.

4.2 Farmer Response

Farmers were able to sign a written contract to participate in the experiment beginning 1 April 2007. To date, a total of fourteen farm households have signed a contract. As a group, participating farmers have made two important decisions: (1) allocation of watershed payments; and (2) a request for a watershed-wide sampling to ascertain sources of nitrate-N. Their innovative payment allocation involved: (a) a $50 signing bonus to each participant, (b) 10% of each monthly payment is to be distributed equally among all participants, (c) the remaining 90%

is reserved to financially assist farmers who engage in N-nitrate abatement, and (d) any remaining funds at the end of the year are to be paid out as a bonus to all participants. This allocation addresses issues of risk from BMP implementation by individual farmers and provides immediate rewards for participation. The results of the watershed-wide nitrate-N sampling were presented to farmers at a June 2007 meeting. These results agreed with prior water quality data that showed the majority of nitrate-N originated from the lower section of the watershed.

The fourteen participating farmer households own or operate approximately 32% of the land in the watershed. However, this land is not evenly distributed throughout the watershed. Cullers Run watershed can be divided into two main sections. The lower section is where most of the row cropping takes place. In this section, about 5% of the land is owned or operated by one participating farmer. In the upper section, hay fields and pasture predominate. Participating farmers operate on approximately 34% of the land in this section. Based on hectares, a simple Chi-squared test of independence indicates that the likelihood of a given hectare of land being included in the project is not independent of location ($p<0.01$). Our interpretation is that farmland in the lower section is significantly less likely to be enrolled in the project than farmland in the upper section.[4]

Figure 1 helps us explain why farmers who own or operate farmland in the lower section of the watershed are less likely to have signed up for the project. E-V1 represents the pre-field experiment frontier of minimum variance levels that can be achieved at given expected incomes. The tangency point ‘A’ represents the highest level of expected utility (U1) that a rational farmer can achieve given the trade-offs that exist between expected income and variance.

[FIGURE 1 HERE]

E-V2 represents a shift in minimum variance due to new farm production possibilities that increase risk (income variance) more than expected income. In this case, the efficient point, ‘B’, has shifted upward and to the left. Such a move would represent a decrease in expected income and an increase in variance, thereby decreasing expected utility. Conversely, an E-V3 shift is the result of adding production possibilities to a farm that reduce income variance. A rational farmer’s optimal choice of expected income and variance in this case would shift downward and to the right resulting in a higher expected utility, point ‘C’.

This framework may shed light on the differences in participation that we observe between farmers in the lower section versus the upper section of the watershed. In the lower section, row cropping occurs on productive soils adjacent to the stream and farmers use more fertilizer inputs. We postulate that these farmers consider participation in this experiment, and any resulting NPSP abatement, as likely to increase risk for them given that participation may lead to decreases in fertilizer use. Such a reallocation of inputs could represent an E-V2 shift by increasing their minimum possible variance levels due to an increase in farm income variance overwhelming any additional water quality income. Even though participating farmers are not required to implement BMPs, farmers in the lower section may anticipate social pressure from the other participants reduce fertilizer use thereby incurring additional risk in order to reduce nitrate-N.

A different situation faces farmers in the upper section. Their land is often further from streams and they use fertilizer less intensively. For them, one NPSP abatement strategy is the construction of storage sheds for poultry manure used as fertilizer. While these sheds can be costly to build, government cost-share programs are available, the sheds take little if any land out of production, and they do not require reallocating inputs among other income producing activities. Therefore, we propose that farmers in the upper section face a situation more like that of the shift from point ‘A’ to ‘C’ when deciding whether or not to participate in the project. Without having to face the possibility of abatement that could alter their production processes, for them the experiment represents a means of earning a small amount of additional income with few production risk consequences.[5] Thus, we observe that farmers in the upper section participate at greater rates.

5 Conclusions

We are encouraged with the sign-up results to date. One-third of the land in the watershed and about one half of farmers attending the meetings are participating in the experiment. Payments for water quantity and quality are being made to farmers based on a payment allocation scheme that they developed and approved. At the farmers’ request, detailed water quality sampling of the watershed has taken place, and this has already led to one farmer initiating NPSP abatement. To facilitate information sharing between researchers and farmers, we have a project website.[6] To date, no group decision has occurred with respect to cost sharing from project funds for NPSP abatement. We expect this to be the next significant action in the experiment.

Looking at our behavioral model and empirical results, our initial results seem to support the model and accompanying E-V framework. The framework encompasses income risk and expected utility in a way that we can use to sharpen the focus on tradeoffs that farmers make in choosing between payments for water and NPSP abatement. We will work to confirm the usefulness of this model with additional data as the experiment proceeds.

Given their low participation rate, a practical research question involves how to bring farmers in the lower section into the experiment. To the extent that Figure 1 correctly represents the directional impacts of this project on expected utility, it gives us a basis for evaluating the payment allocation between farmers. For example, this may provide a rationale for allocating a greater share of the payments to farmers in the lower section. We can also investigate the role that information on soil nutrients may play in determining farmer response. For example, Feather and Amacher (1994) find that information can increase farmer willingness to adopt BMPs. A potentially relevant example is presented by Fuglie and Bosch (1995). They determined that corn farmers decreased fertilization rates when provided with information from soil tests indicating that they could fertilize less without introducing additional production risk. In an E-V framework, such information serves to alter farmer perceptions of an E-V frontier shift due to participation from a leftward shift to rightward shift, resulting in expected utility gains rather than losses.

Finally, our hope is that by sharing this approach and early work we will stimulate additional discussion and research on the promising area of payments for environmental services (PES). In developing countries, the use of PES is increasing (see Mayrand & Paquin 2004; Wunder 2007).

Our experiment resembles PES although, rather than paying for conservation inputs, such as hectares of forest conserved, we are paying for a conservation output, clean water. Segerson and Miceli (1998) list three potential benefits to output-based voluntary environmental agreements: they encourage pro-active cooperation; they provide freedom to find cost-effective solutions tailored to circumstances, and they meet environmental targets more quickly. Given these advantages, we think that PES programs should strive for payments based on outputs rather than inputs. We suggest that the case for an output-based approach is strongest when the desired outcome can be readily measured, such as in our experiment where water flows and nitrate-N loads at the bottom of the watershed form the basis for monthly payment calculations. Input-based payments may be more appropriate when desired outcomes are more difficult to quantify as with biodiversity conservation and climate change mitigation.

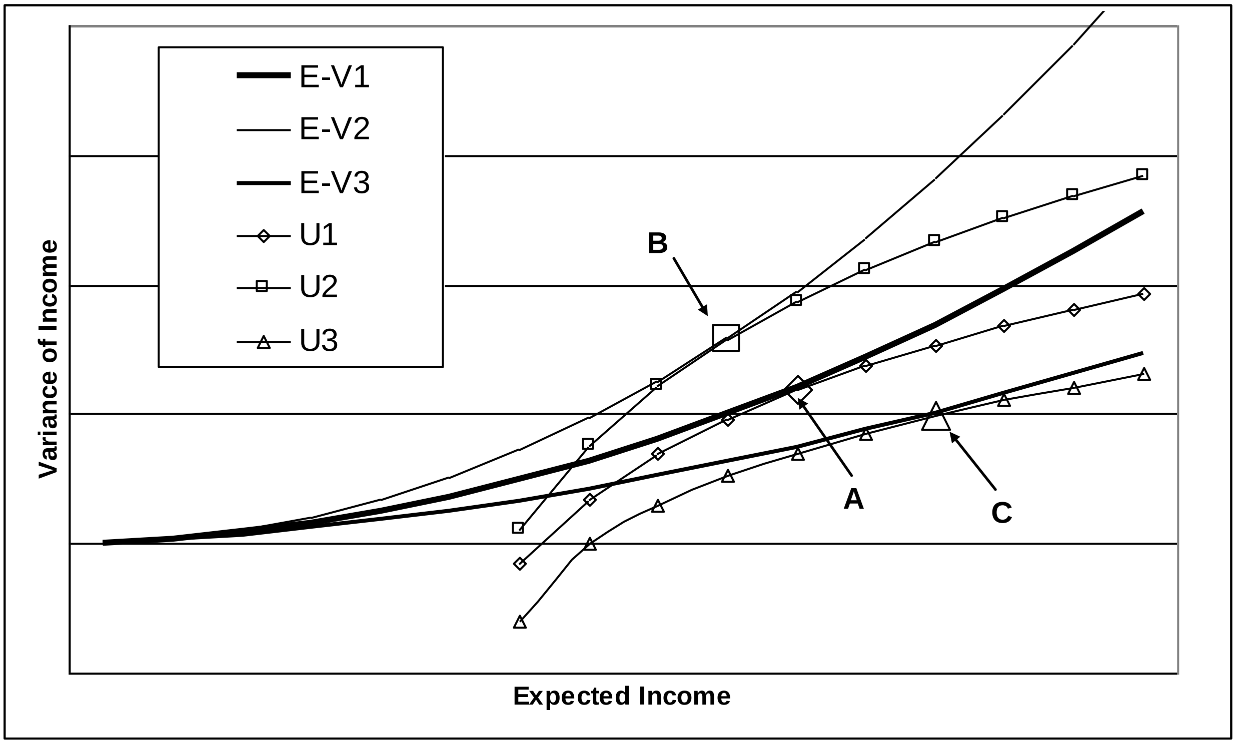
Table 1: Water Prices

May through September		October through April	
Monthly Discharge (acre-feet)	Dollars per Acre-Foot	Monthly Discharge (acre-feet)	Dollars per Acre-Foot
Up to 320	18	Up to 740	8
321-800	8	Over 740	5
Over than 800	5		

Table 2: Monthly Watershed Payments

Month	Actual			Simulated		
	Adjustment Factor	Discharge (acre-feet)	Payment ($)	Adjustment Factor	Discharge (acre-feet)	Payment ($)
April	0.23	1076	1,128	0.20	1228	1,234
May	0.38	140	978	0.13	241	328
June	0.36	58.6	382	0.25	369	724

Figure 1: Shifts in the E-V Frontier



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Notes:

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[1] Notable exceptions are presented by Wunder (2007) and Mayrand and Paquin (2004) who summarize field research on payments for environmental services, which takes place mainly in developing countries. While informative, this does little to shed light on the practical aspects of instituting a program to abate NPSP in a developed country.

[2] The payment formula in the contract is equation (5) and the prices are presented in Table 1 of this report.

[3] Although Hardy County is not included, the Governor of West Virginia placed most of the State under a drought emergency in June 2007.

[4] Use of this test assumes that each hectare is a separate management unit, which is not the case. Rather, land ownership is grouped by tracts ranging from 15 to more than 320 hectares in size. We also conducted a test for independence between farm location and participation based on all farmers who attended a preliminary meeting. This test was significant (p=0.05) indicating that participation and farm location were not independent.

[5] As anecdotal evidence, one participating farmer in the upper section has applied for federal cost-share assistance to construct a manure storage shed. He did this in response to the watershed-wide sampling results showing that his farm was located in a sub-watershed with a higher than average nitrate-N loading on a per hectare basis.

[6] This website can be accessed at http://www.cacaponinstitute.org/wvunri.htm.