Farmers as Producers of Clean Water: Getting Incentive Payments Right and Encouraging Farmer Participation

Alan R. Collins
Professor
Agricultural and Resource Economics
P.O. Box 6108
West Virginia University
Morgantown, WV 26506
304-293-4832 x4473
304-293-3752 (FAX)
alan.collins@mail.wvu.edu

and

Peter Maille
PhD Candidate and Graduate Research Assistant
Agricultural and Resource Economics
P.O. Box 6108
West Virginia University
Morgantown, WV 26506

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Orlando, FL, July 27-29, 2008.

Farmers as Producers of Clean Water: Getting Incentive Payments Right and Inducing Farmer Participation

Abstract

This research involved a field experiment using watershed payments as an incentive for farmers to address agricultural non-point pollution (ANP). Objectives were to: (1) describe how payments were estimated for a field experiment; (2) explain why a team approach is needed for ANP; (3) discuss the essential elements used for recruitment of farmers into a field experiment setting; and (4) address whether or not farmers were motivated to participate and pursue ANP abatement. One year into the experiment, the results are encouraging. About one-half of farmers who attended meetings are participating. They own or operate approximately 41% of the agricultural land in the watershed. Farmer actions to date have included determining an allocation formula for the payment, requesting watershed wide sampling, and cost sharing of ANP abatement.

Key words: field experiment, team approach, agricultural non-point pollution, performance-based incentives

The current approach to addressing agricultural non-point pollution (ANP) has focused on voluntary conservation measures that are implemented by farmers with cost-share assistance and technical support from the government (Ribaudo et al.). These conservation measures are generally directed by federal agencies and require farmers to conform to strict behavioral guidelines to receive the assistance. In addition, State governments are moving towards increased regulatory control of agricultural operations. For example, the state of Maryland, under the Water Quality Improvement Act of 1998, now requires all farms to have a nutrient management plan. In either case, farmer input into water quality improvement strategies is limited.

As total maximum daily load planning and implementation clearly demonstrate, water quality represents a watershed-wide problem that cannot be solved one farmer at a time. Rather, a coordinated action at a watershed level is preferred. In order to induce a coordinated, team approach to ANP control among farmers, economic or regulatory incentives are required. Segerson, Horan et al., and Segerson and Wu describe ambient-based tax and subsidy approaches. Performance-based payments at the watershed level are another example of economic incentives that can be provided to farmers. These payments provide an opportunity to change farmer perspectives of water quality conservation from an operational constraint to an income generating opportunity. In order to be effective, however, watershed-level payments need to induce interaction and decision-making among farmers within the watershed (i.e. a team approach).

The literature on team approaches to water quality improvement has examined theoretical and laboratory experiment aspects (see Spraggon; Romstad; Poe et al.; Taylor et al.; Millock and Salanie; and Vossler et al.). In contrast, the research discussed in this paper involves a field experiment using actual farmers and real monetary payments. Therefore, there are real consequences for farmers from participation. Thus, the participant recruitment aspect of this paper covers an unexplored area in previous research on water quality economics.

The study site for this field experiment is Cullers Run watershed. This stream is a tributary of the Lost River in the eastern panhandle region of West Virginia. It occupies 2,978 hilly hectares in Hardy County, West Virginia's largest poultry production county (USDA National Agricultural Statistics Service). Sixteen percent of the watershed is devoted to agriculture, mostly pasture or hay land. Row crops comprise 3.63% of the agricultural land, primarily in the floodplain (Cacapon Institute). The rest of the watershed is forest. There are approximately twelve poultry houses conducting intensive poultry production in the watershed. Most agricultural fertilizer use in the watershed is provided by poultry litter.

The Cullers Run watershed has the advantage of being small enough to limit the number of farmer households that could participate in the project. Small group size reduces the information burden on farmers (Ribaudo et al.). In addition, this watershed was included in a federally-funded research project that generated water quality data prior to the experiment (Cacapon Institute).

The objectives of this paper are to: (1) describe how payments were estimated for the field experiment; (2) explain why a team approach is needed for ANP; (3) discuss the essential elements used for recruitment of farmers into a field experiment setting; and (4) address whether or not farmers were motivated to participate and pursue ANP abatement. The next section applies the theory of teams to this field experiment. We then examine how prices and water payments were estimated prior to the field experiment. After summarizing and comparing simulated with actual payments, we discuss the methods used to encourage farmer participation. This paper finishes with sections on farmer participation and conclusions.

Theory of Teams

Figure 1 provides a schematic description of traditional technical assistance and cost share programs provided by the government for ANP. Acting as a principal, the government provides information and cost share opportunities to farmers and treats farmers as autonomous units with regard to their impacts on water quality. Farmers, acting as individual decision making units, decide whether or not to undertake water quality protection actions. Only a portion of farmers (C and F in Figure 1) decide to undertake these actions. These actions lead to water quality outcomes which do not directly relate back to the recipient of government cost share and technical assistance.

Figure 1 ABOUT HERE

There are motivations, however, for both the principal and for farmers to engage in a team approach. From the perspective of the principal acting for society as a whole, these include: (1) non-point pollution is difficult and costly to identify from individual sources so it is more feasible from an informational perspective to measure pollution at a watershed basis; (2) farmers potentially have information about their own and/or their neighbors' pollution contributions that regulators would have difficulty obtaining; (3) a potential for dealing with fewer entities; and (4) teams allow for farmers to influence the water quality protection behavior of other farmers, for example, through the use of moral suasion. From a farmer perspective, watershed level decision-making is a reasonable approach to problem solve if farmers perceive a water quality problem from ANP pollution or want to take advantage of water payments. In addition, Romstad describes economic incentives for farmers to join a team approach under the threat of more costly individual regulation.

The economic incentives provided for team participation can be either negative (threat of individual regulation or taxation) or positive (provide a subsidy to participate). Threats imply that society operates from a polluter pays principle and/or that citizens have a right to clean water. Subsidies imply the property right to clean water lies with the agricultural landowner. A combination of negative and positive incentives can be used, for example, when water quality standards are implemented with pollution in excess of the standard being taxed, and subsidies provided when pollution levels are below the standard (Segerson). In our field experiment, we take a different approach. Payments are strictly positive, and increase with increasing water quality. This conveys a low-risk negative incentive in the form of an opportunity cost to pollution.

Figure 2 depicts the principal's role under a team approach. Here the principal interacts with farmers as a team, thereby recognizing that interconnections exist between farmers in how they may impact water quality. The team decides which actions to take regarding water quality and then the water quality outcomes can influence team decisions (for example via watershed wide sampling and determination of sub-watershed pollutant loading) and payment levels.

Figure 2 ABOUT HERE

As shown in Figure 2, farmers can be connected in terms of their water quality protection actions as Farmer C impacts Farmer B and D's water quality protection actions. The farmer interactions presented in Figure 2 occur in the Cullers Run watershed in terms of poultry litter used for fertilizer. In this example, assume Farmer C is a poultry grower without a sufficient land base to utilize the nutrients in poultry litter. To dispose of litter, Farmer C transfers litter to Farmers B and D (with or without cash compensation) to apply on their agricultural land. In this case, team decision making at a watershed level has the potential to improve water quality by enhancing cooperation between farmers. Since our field experiment involves nitrate-N pollution impacting a watershed level payment distributed to farmers, under a team approach Farmer C has an incentive to encourage Farmers B and D to determine if the litter applied contains nutrients in excess of crop needs. If excess nitrate is being land applied, this could reduce the watershed level payment to all participating farmers. Thus, under excess land application, these three farmers may be better off transferring a portion of Farmer A's litter elsewhere rather than only transferring it to Farmers B and D. In our field experiment, Cullers Run farmers are presented with such an incentive to work within a team approach to investigate issues related to land application of litter.

Calculating Prices and Payments

Numerous authors have discussed the challenges posed by ANP (Cabe and Herriges; Smith and Tomasi; Shortle et al.; and Ribaudo et al.). The premise underlying our research is that if farmers are paid as a group based on water quantity and ambient water quality measured at the watershed level, then they will respond in a way that cost-effectively reduces ANP. To examine our premise in the field, we need a payment schedule that indicates to farmers how much they can expect to earn. However, developing such a payment schedule is difficult when prices for water are absent and data on water quality and stream flow are lacking.

In general, payments need to satisfy four conditions: 1) motivate farmers to participate in the experiment, 2) provide sufficient incentive to pursue ANP abatement, 3) sensibly reflect environmental conditions, and 4) be seen as fair and likely to enhance the well-being of participants. Varian describes conditions 1) and 2) as incentive compatible conditions within principle-agent case. Condition 3) means that payments need to make allowances for natural fluctuations beyond the control of farmers. For condition 4), we assume that issues of fairness and equity enter into the mental calculus of farmers (Breetz, Fisher-Vanden, et al.). Thus, we think that payments need to sensibly reflect both environmental conditions and local sensibilities.

Given these conditions, we developed a payment formula:

$$(1)\quad \text{Watershed Payment} = (\text{volume of water}) \times \left(\frac{\text{price}}{\text{unit volume}}\right) \times (\text{quality adjustment factor})$$

Equation (1) has intuitive appeal. Like a traditional agricultural commodity, the greater volume of water that farmers "produce", the more they get paid as water volume flowing from a watershed is multiplied by a per unit price for water. Also, as explained below, the quality adjustment factor makes payments an increasing function of improving water quality. However, for farmers to evaluate the feasibility of participating and pursuing ANP abatement, they need to know how large the payments are likely to be prior to the experiment, and how sensitive the payments are to ANP abatement. Thus, we need to simulate payments by estimating each of the three components of equation (1).

Estimating Discharge

With no existing flow gauge, we needed to estimate the acre-feet of water per month "produced" by Cullers Run watershed. Using 32 months of mean monthly flow data from the US Geological Survey (USGS) for a nearby watershed of comparable size, and monthly rainfall data from Cacapon Institute (unpublished data), we generated "best fit" non-linear equations with Microsoft Excel 2003 that relate this watershed flow data to rainfall. Two seasonal equations (growing and non-growing) provided estimates of watershed level flow based on rainfall ($R^2 = 0.42$, and $R^2 = 0.48$ respectively). Thus, given rainfall, we can roughly estimate Cullers Run discharge.

Solving for a Water Price

Water prices were estimated based on the opportunity cost incurred by farmers from using land to produce water quality improvements rather than agricultural production. To derive this opportunity cost, we assumed that 10% of the agricultural land in the watershed could be set aside as grass riparian buffers to produce water quality improvements. Implementation of these buffers was assumed to reduce pollution loading of nitrate-N by 75% based on expected reductions to sediment and bacteria (Palace et al.). The loss of agricultural income was approximated with crop net revenue from the USDA census of corn and hay production costs and returns for the Eastern Uplands between 1996 and 2004 (USDA National Agricultural Statistics Service), standardized using the Bureau of Labor Statistics consumer price index (US Bureau of Labor Statistics). Estimates for pasture revenue are based on the average pasture rental values as presented by Whittle and Stanley.

Using this information, we set up an optimization program using the CONOPT nonlinear programming solver within GAMS Integrated Development Environment (GAMS) software. Our objective function assumed net revenue maximizing farmers who were subject to constraints on acreage, their ability to shift land between pasture and cropland, and non-negativity from water revenue. Intuitively, our model selects agricultural production until payments for water quality are sufficiently high to induce conservation. We ran separate GAMS models for each season and at different rainfall levels to compute water prices under different conditions. Minimum prices were determined that could be offered per acre-foot of water to induce Cullers Run farmers to undertake water quality conservation.

The prices generated from the 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 and Collins).

Table 1 ABOUT HERE

Incorporating Water Quality

Based on water quality data from the study area for bacteria, turbidity, various forms of phosphorus, and nitrate-N (Cacapon Institute) we selected nitrate-N as an indicator of water quality changes. Monitoring data from the Cacapon Institute showed that nitrate-N concentration in streams, and therefore load, varied more predictably with rainfall than other pollutants and was positively related to the extent of agricultural land in a watershed. Nitrate-N does, however, entail some disadvantages. Unlike turbidity, nitrate-N resides in subsurface water, thus potentially producing a time lag between generation and contribution to ambient stream concentrations. Finally, it is present naturally which can introduce "noise" to the incentive scheme.

Recalling that the payment schedule needs to be sensible and fair, payment levels should account for the background fraction of nitrate-N contamination that farmers do not control. To account for background nitrate-N, an "index watershed" approach was used:

$$\text{(2)} \quad \text{Quality Adjustment Factor} = \frac{\text{Index Watershed nitrate-N}}{\text{Experimental Watershed nitrate-N}}$$

Waites Run watershed was utilized as the index watershed in equation (1). It is 96% forested with very little agricultural land, located in the same county as the experimental watershed, and is approximately the same size. Thus, it serves as a weather-sensitive baseline measure of nitrate-N loads.

In order to utilize equation (2) to estimate prices, we needed estimates of nitrate-N loading in the watershed as a function of land use. For the current pasture and forest nitrate-N contributions, we generated a system of three simultaneous equations with pollutant contribution for forest and pasture as the independent variable using watershed-level data from Cacapon Institute. We estimated the pollutant contribution from cropland based on Randall and Vetsch.

Since water quality monitoring data show that nitrate-N concentration increases during periods of high rainfall (Cacapon Institute), we related our rainfall data to Cullers Run nitrate-N concentrations with Excel 2003 providing the best fit non-linear equations for non-growing season and growing seasons ($R^2 = 0.53$, and $R^2 = 0.48$ respectively). We formed a ratio of estimated nitrate-N during periods of low, average or high rainfall, over the expected nitrate-N concentrations during average rainfall and used this ratio as a simple multiplier. Our low, average, and high rainfall levels correspond with the monthly rainfall totals for each season exceeded by 25%, 50%, and 75% of the months respectively. Thus, our estimate of Cullers Run nitrate is shown in equation (3) as the sum of current nitrate contributions for each land-use, increased or decreased slightly by a rainfall multiplier.

$$(3)\quad \frac{\text{Lbs. nitrate-N}}{\text{month}} = \sum_i \left[\left(\frac{\text{Lbs. nitrate-N}}{\text{acre landuse } i} \right) \times (\text{acres landuse } i) \right] \times \left(\frac{e^{0.3188 \times \text{rainfall level}}}{e^{0.3188 \times \text{ave. monthly rainfall}}} \right)$$

The resulting nitrate-N estimated loads from equation (3) make up the denominator for the operational version of the adjustment factor shown by equation (4) based on the non-growing season rainfall multiplier. The numerator in the adjustment factor is the average Waites Run nitrate-N load.

$$(4)\quad \text{Adj. Factor} = \frac{\text{Average nitrate-N load Waites Run}}{\sum_i \left[\left(\frac{\text{Lbs. nitrate-N}}{\text{acre landuse } i} \right) \times (\text{acres landuse } i) \right] \times \left(\frac{e^{0.3188 \times \text{rainfall level}}}{e^{0.3188 \times \text{ave. monthly rainfall}}} \right)}$$

Resulting Payments

Payment simulations

Farmers need estimates of likely payments, not just prices, before deciding to participate. With this in mind, we used estimated monthly water quantities (discharge) based on rainfall, prices from Table 1, and a ratio of nitrate-N concentrations as the adjustment factor, within equation (1) to simulate four years of monthly watershed payments. Data were from regional rainfall and nitrate-N concentrations in Cullers and Waites Run from 1999 to 2002 (Cacapon Institute, unpublished data).

These simulated payments are represented by data points in Figure 3. The trend lines “Table 1 Prices” show the relationship between estimated payment and discharge at low, medium and high discharge levels using Table 1 summer prices. The “One Price” trend lines show the price-discharge relationship that would exist at these three discharge levels if price was held constant at $8 / ac-ft. We observe that, on average, payments are boosted at low discharge and decreased at high discharge by using prices that are sensitive to discharge. We also note that payments are still an increasing function of discharge. Thus, the schedule of prices in Table 1 appears to maintain the desired incentive, while diminishing the risk of overly low or overly high payments caused by variation in rainfall.

Figure 3 ABOUT HERE

Figure 3B shows how increasing abatement affects the payments. Looking at the payment for a single month (hollow triangle just above $500 at a discharge of 950 ac-ft from Panel A) and maintaining the original price, payments increase at an increasing rate as nitrate-N decreases. Assuming that total and marginal abatement costs are convex, we think that the shape of the payment function shown in Panel B is appropriate.

When simulated payments were totaled on an annual basis, these payments averaged $7,721 with a range of $4,593 to $9,400. We also estimated payments based on a 25% reduction in nitrate-N. At this level of abatement, payments were $9,595 annually, ranging between $5,898 and $11,480. The difference between the payments with and without additional abatement represents an opportunity cost to watershed farmers of not abating nitrate-N.

Lastly, the extent to which the adjustment factor reduces the influence of natural variation of nitrate-N on payments was assessed. Nitrate-N concentration was regressed on estimated monthly discharge for Cullers Run over 48 months of data (Cacapon Institute, unpublished data). We found that the two are significantly related ($R^2 = 0.25$, $p<0.001$). However, when the adjustment factor (measured as the ratio of Waites Run nitrate-N concentration over Cullers Run nitrate-N concentration) was regressed on monthly discharge this relationship was statistically insignificant ($R^2 = 0.03$, $p<0.23$). Including a seasonal dummy variable to account for effects of growing season had very little impact on this result. Our conclusion is that the adjustment factor effectively eliminated the influence of fluctuating background nitrate-N on payment levels.[1]

Comparing Estimated with Actual Measurements

Figure 4 compares estimated values for discharge, adjustment factors, and simulated payments with the actual measurements from the first year of our field experiment beginning April 1st. Data are presented by quarter for simplicity. We note that over the first quarter and the last quarter, the simulated payments and adjustment factors were closer to the actual values than those for quarters 2 and 3. We attribute some of this divergence between actual and estimated values to be the result of dry conditions that prevailed during this period. Abnormally dry conditions were documented in the area that includes Cullers Run from July of 2007 through October of 2007 (USDA, DOC, NOAA).

Figure 4 ABOUT HERE

Given the limited data and abnormal weather, it is difficult to draw conclusions from Figure 4. Looking at the comparison in general, the modeling that produced the estimates seems to have performed better when rainfall was approximately average. When pushed by dry conditions, the adjustment factor values increased dramatically. In fact, two months had adjustment factors greater than one. For this to be true, nitrate-N in Cullers Run would have to be less than natural background nitrate levels. The most

---

[1] Using twelve months of direct measurements of flow, Cullers Run nitrate-N, and Waites Run nitrate-N from the first year of the experiment resulted in the same conclusion..

plausible explanation for the high adjustment factor values, is that flow in Waites Run was higher than anticipated, thus delivering greater loads of nitrate-N. This could result from more productive springs in Waites Run that are able to maintain a greater flow in the face of dry conditions. Alternatively, summer rainfall includes localized thunderstorms. It is possible that there was a significant rainfall differential between Waites Run and Cullers Run.

Overall, total payments during the first year were $5,630, about 27% less than the simulated average, but within the range of simulated payments ($4,593 to $9,400). The discharge was 64% below the average estimated based on the four years of data, while the adjustment factor was nearly triple the estimate, averaging 0.369 per month instead of 0.133.

Communicating with Potential Participants

In December 2006, we began to advertise and inform local farmers about this field experiment project. These efforts included: a presentation at the Mathias Ruritan Club (many of the watershed residents are members of this community service organization), articles in community newspaper about the project, and a letter sent to all agricultural landowners (based on agricultural land use tax exemptions) in the Cullers Run watershed inviting them to an introductory meeting.

During the winter of 2007, four meetings were organized by project researchers. Local community resources were used for a meeting place and to provide meals at each meeting. Aerial photo maps of Cullers Run watershed were prepared by the Natural Resource Analysis Center at West Virginia University. These maps were displayed and copies were given out to all attendees. These maps proved to be very popular among attendees.

Each of these meetings was attended by twenty to thirty people. Overall, a substantial portion of farmer households in the watershed attended at least one meeting. We also made efforts to involve community elites in the project. The county extension agent attended a meeting, and a county commissioner was recruited to lead one of the meetings. State and federal government conservation agency personnel attended meetings and assisted with presentations.

During these meetings, the project was described as a unique field experiment involving economic incentives to abate ANP. We expected that these incentives would take the form of monthly payments over a period of two years, based on the quantity and quality of water flowing from the watershed, to farmers who chose to participate. The introductory meeting included a presentation about water quality as an issue in Cullers Run and the Lost River watershed in general.

There were two important outcomes from these meetings: (1) a written agreement was created with the input of farmers; and (2) a farmer advisory committee was established to determine how to allocate the watershed payments among participants. The agreement was discussed and revised a number of times during the meetings. It served to clarify the institutional framework of the experiment and outlined the roles and responsibilities of both farmers and researchers. Comments and suggestions about this agreement were obtained from a lawyer on the Agricultural and Resource Economics faculty at West Virginia University. Key stipulations for farmers in this agreement included:

- Participation in this project is voluntary and is initiated by signing an agreement.
- A participant who has signed an agreement 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 researchers, 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 an agreement 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.; Bracmort et al.). Thus, risk reduction aspects of this agreement include the voluntary aspects of participation, BMP selection, and BMP implementation. Participants can mitigate risk by allocating more of the monthly payments to those farmers that implement BMPs.

Creation of an advisory committee emerged as a suggestion by farmer attendees during the meeting that was led by a county commissioner. The purpose of this meeting was to assist farmers in determining how they would organize themselves as a group in this project. This advisory committee consisted of five farmers from the watershed, each who had attended most of the meetings. The committee met only once. At this meeting, they developed recommendations regarding payment allocation that were subsequently presented at a follow-up meeting just prior to the beginning of project sign-up. These recommendations were formally approved at the first meeting of project participants.

Observed Farmer Participation

Farmers were able to sign a written agreement to participate in the project beginning April 1, 2007. To date, fifteen farm households have signed an agreement. This sign-up represented about one-half of the farmers who attended the series of meetings introducing the project to farmers. Using farmer reported agricultural use information as well as aerial photo data, we computed that participating farm households own or operate approximately 41% of the agricultural land in the watershed.

Participation was found to be unevenly 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, only about 10% of agricultural land is farmed by a project participant. In the upper section, hay fields and pasture predominate. Participating farmers operate 49% of the agricultural land in this section. Based on participating hectares, a simple Chi-squared test of independence indicated that the likelihood of a given hectare of land being included in the project is not independent of location ($p<0.01$).[2] 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. Maille and Collins (forthcoming) surmise that the lower participation rate for farmers in

[2] 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.

this section is the result of the greater risk to agricultural production that these farmers face when participating in the project because fertilizer use is greater in this section.

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 verify source areas of nitrate-N. As suggested by the advisory committee, their payment allocation involved: (a) a $50 signing bonus to each participant who signed up prior to June 1st, 2007, (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 provides early participants with immediate rewards, and addresses issues of risk from BMP implementation by individual farmers.

A watershed-wide nitrate-N sampling was conducted in April 2007. The results 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. A second watershed-wide sampling in January 2008 produced similar results showing that the lower section of the watershed generated the greatest nitrate-N loading in both absolute and per unit area amounts.

As for nitrate-N abatement , the detailed sampling run in April showed three locations where nitrate-N contributions were highest on a per-square mile basis., The farmer responsible for one of these has, with the support of federal cost-share assistance, built a feeding and manure shed for his cattle. Another of these areas is the lower section of the watershed. This section is farmed by multiple households, only one of which is currently participating. This complicates abatement strategies in this area. Currently, participating farmers are recruiting more lower section farmers into the project.

In March 2008, the group developed a simple procedure to assess how to utilize the accumulated watershed payments for ANP abatement cost-sharing. To date, one proposal has been put forth: one participant has requested cost-sharing for a winter cover crop. Another participant has discussed construction of streamside fencing and improved livestock watering facilities.

Conclusions

Looking at both the estimated prices and payment simulations, we are encouraged by the results of the field experiment to date. The payment formula seems to have conveyed an appropriate incentive as a significant portion of farm households in the watershed are participating, and there has been some nitrate-N abatement. Payments for water quantity and quality are being made to farmers based on a payment allocation scheme that they developed and have twice revised slightly.

Despite the simplified nature of our watershed modeling, actual payments have been reasonably close those simulated prior to the experiment. However, we need to better understand the reasons behind the divergence between the expected and actual values for the adjustment factors presented in Figure 4. We expect continued water quality and flow data will help us in this respect.

To facilitate information sharing between researchers and farmers, we have established a project website (http://www.cacaponinstitute.org/wvunri.htm). Also, anticipating that the initial two year time frame of the experiment may limit farmer interest in ANP abatement, a third year for the experiment was committed to by the researchers during the first year. This third year was made possible when lower than expected first year payments resulted in extra project funds being available.

With respect to participation, an important challenge has been encountered. Water quality data indicate that the area contributing the most nitrate-N is the lower section which is farmed by multiple households. Participation and/or cooperation of farmers in this area are crucial to achieving meaningful nitrate-N abatement in this experiment. Given their low participation rate, a practical research question involves how to bring farmers in the lower section into the field experiment. Participants have approached farmers in this section about participating, but so far there have been no additional sign-ups.

Given the characteristics of this section, we can also investigate the role that information on soil nutrients may play in determining farmer response. For example, Feather and Amacher find that information can increase farmer willingness to adopt BMPs. A potentially relevant example is presented by Fuglie and Bosch. 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.

With this possibility in mind we invited a Nutrient Management Specialist from Cooperative Extension to a meeting during 2007. He discussed some of the alternatives open to the farmers for more tightly managing soil nitrogen including stalk nitrogen tests to determine post-side dressing nitrogen needs. Farmers have not responded to these possibilities yet, although, they have requested the materials needed for soil testing.

Acknowledgements

Support for this research comes from National Research Initiative Grant USDA/CSREES # 2006-35102-17261. Assistance for this project was provided by Tom Basden (Nutrient Management Specialist, WVU Cooperative Extension Service), Gretchen Cremann (Conservation Specialist, WV Conservation Agency), Ed Kesecker (NRCS District Conservationist), the Mathias Ruritan Club, Stanly Moyer (Hardy County Commissioner), and David Workman (Hardy County Extension Agent).

References

Bracmort, K.S., B.A. Engel, J.G. Arnold, M. Arabi, and J.R. Frankenberger. "Modeling Long-Term Water Quality Impacts of Structural BMPs." *Transactions of the ASABE* 49(2006): 367-74.

Breetz, H.L., K. Fisher-Vanden, H. Jacobs, and C. Schary.. "Trust and Communication: Mechanisms for Increasing Farmers' Participation in Water Quality Trading." *Land Economics* 81(2005):170-190.

Cabe, R. and J.A. Herriges. "The Regulation of Non-Point-Source Pollution Under Imperfect and Asymmetric Information." *Journal of Environmental Economics and Management* 22(1992):134-146.

Cacapon Institute. *Final Report to the U.S. Fish and Wildlife Service on Water Quality Studies in the Cacapon River's Lost and North River Watersheds in West Virginia*. Cacapon Institute. High View, West Virginia, 2002.

Feather, P.M. and G.S. Amacher. "Role of Information in the Adoption of Best Management Practices for Water Quality Improvement." *Agricultural Economics* 11(1994): 159-70.

Fuglie, K.O. and D.J. Bosch. "Economic and Environmental Implications of Soil Nitrogen Testing: A Switching-Regression Analysis." *American Journal of Agricultural Economics* 77(1995): 891-900.

Horan, R.D., J.S. Shortle, and D.G. Abler. "Ambient Taxes Under *m*-Dimensional Choice Sets, Heterogeneous Expectations, and Risk-Aversion." *Environmental and Resource Economics* 21(2002):189-202.

Maille, P. and A. Collins. "Farmers as Producers of Clean Water: A Field Experiment." In U. Pascual, A. Shah, J. Bandyopadhyay, eds. *Water, Agriculture and Sustainable Well-being,* Delhi, India: Oxford University Press, Forthcoming.

Maille, P. and A. Collins. "Converting Conservation from a Potential Production Constraint into an Opportunity: A Field Test of Performance Based Payments." Paper Prepared for the International Society of Ecological Economics Biannual Meeting, New Delhi, India, December 13-17, 2006.

Millock, K., and F. Salanie. "Nonpoint Source Pollution When Polluters Might Cooperate." Topics in Economic Analysis & Policy, 5(1):Article 12, Berkeley, California, The Berkeley Electronic Press, 2005.

Palace, M. W., J. E. Hannawald, L. C. Linker, G. W. Shenk, J. M. Storrick, and M. L. Clipper.. "Tracking Best Management Practice Nutrient Reductions in the Chesapeake Bay Program." *Chesapeake Bay Watershed Model Application and Calculation of Nutrient and Sediment Loadings*, Appendix H. Annapolis, Maryland, Chesapeake Bay Program, 1998.

Park, S.W., S. Mostaghimi, R.A. Cooke, and P.W. McClellan. "BMP Impacts on Watershed Runoff, Sediment, and Nutrient Yields." *Water Resources Bulletin* 30(1994): 1011-1023.

Poe, G.L., W.D. Schulze, K. Segerson, J.F. Suter, and C.A Vossler. "Exploring the Performance of Ambient-Based Policy Instruments when Nonpoint Source Polluters Can Cooperate." *American Journal of Agricultural Economics* 86(2004):1203-1210.

Randall, G.W. and J.A. Vetsch. "Nitrate Losses in Subsurface Drainage from a Corn-Soybean Rotation as Affected by Fall and Spring Application of Nitrogen and Nitrapyrin." *Journal of Environmental Quality* 34(2005):590-597.

Ribaudo, M. O., R. D. Horan and M. E. Smith.. "Economics of Water Quality Protection from Nonpoint Sources: Theory and Practice." AER782, USDA Economic Research Service, Washington, D.C. 1999.

Romstad, E. "Team Approaches in Reducing Nonpoint Source Pollution." *Ecological Economics* 47(2003):71-78.

Segerson, K. "Uncertainty and Incentives for Nonpoint Pollution Control." *Journal of Environmental Economics and Management* 15(1988):87-98.

Segerson, K., and J. Wu.. Nonpoint Pollution Control: Inducing First-Best Outcomes Through the Use of Threats. *Journal of Environmental Economics and Management* 51(2006):165-184.

Shortle, J.S., R.D. Horan, and D.A. Abler. "Research Issues in Nonpoint Pollution Control." *Environmental and Resource Economics* 11(1998):571-585.

Smith, R. B. W. and T. D. Tomasi. Transaction Costs and Agricultural Nonpoint-Source Water Pollution Control Policies. *Journal of Agricultural and Resource Economics* 20(1995):277-290.

Spraggon, J. "Exogenous Targeting Instruments as a Solution to Group Moral Hazards." *Journal of Public Economics* 84(2002):427-456.

Taylor, M.A., B. Sohngen, A. Randall, and H. Pushkarskaya. "Group Contracts for Voluntary Nonpoint Source Pollution Reductions: Evidence from Experimental Auctions." *American Journal of Agricultural Economics* 86(2004):1196-1202.

US Bureau of Labor Statistics. Consumer Price Index. December 2005.

USDA, DOC, NOAA. "U. S. Drought Monitor." National Drought Mitigation Center, Lincoln, Nebraska. Website: www.drought.unl.edu/DM/monitor.html. Accessed April, 2008.

USDA National Agricultural Statistics Service,. "Table 1: Historical Highlights: 2002 and Earlier Census Years." West Virginia State and County Data, Volume 1 Part 48, 2002 Census of Agriculture Washington D.C., USDA, 2004

USDA National Agricultural Statistics Service. "West Virginia Bulletin No. 36.", Washington D.C., USDA, 2005.

USGS, 2005. NWISWeb, Data for the Nation. Website: http://nwis.waterdata.usgs.gov/nwis. Accessed on November 12, 2005.

Varian, H.A. *Microeconomic Analaysis*, 3rd ed., New York, W. W. Norton & Company, 1992.

Vossler, C., Poe, G. L., Schultz, W. D, and Segerson, K. "Communication and Incentive Mechanisms Based on Group Performance: An Experimental Study of Nonpoint Pollution Control." *Economic Inquiry* 44(2006):599-613.

Whittle, B. and T. Stanley. "2003 Land Rental Guide for the Shenandoah Valley." Farm Business Management Update, April/May 2003. Blacksburg, Virginia, Virginia Tech, 2003.

Table 1. Computed seasonal water prices.

<table>
<tr><th colspan="2">May through September</th><th colspan="2">October through April</th></tr>
<tr><th>Monthly Discharge (acre-feet)</th><th>Dollars per Acre-Foot</th><th>Monthly Discharge (acre-feet)</th><th>Dollars per Acre-Foot</th></tr>
<tr><td>Up to 320</td><td>18</td><td>Up to 740</td><td>8</td></tr>
<tr><td>321-800</td><td>8</td><td rowspan="2">Over 740</td><td rowspan="2">5</td></tr>
<tr><td>Over 800</td><td>5</td></tr>
</table>

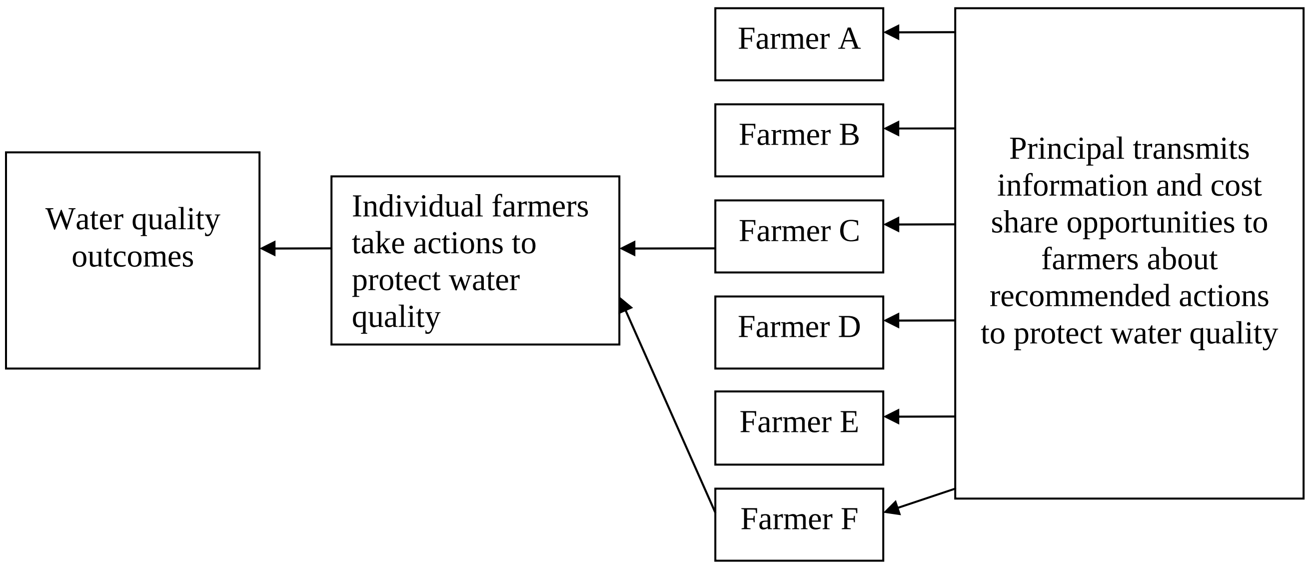


Figure 1. Cost share approach to water quality protection.

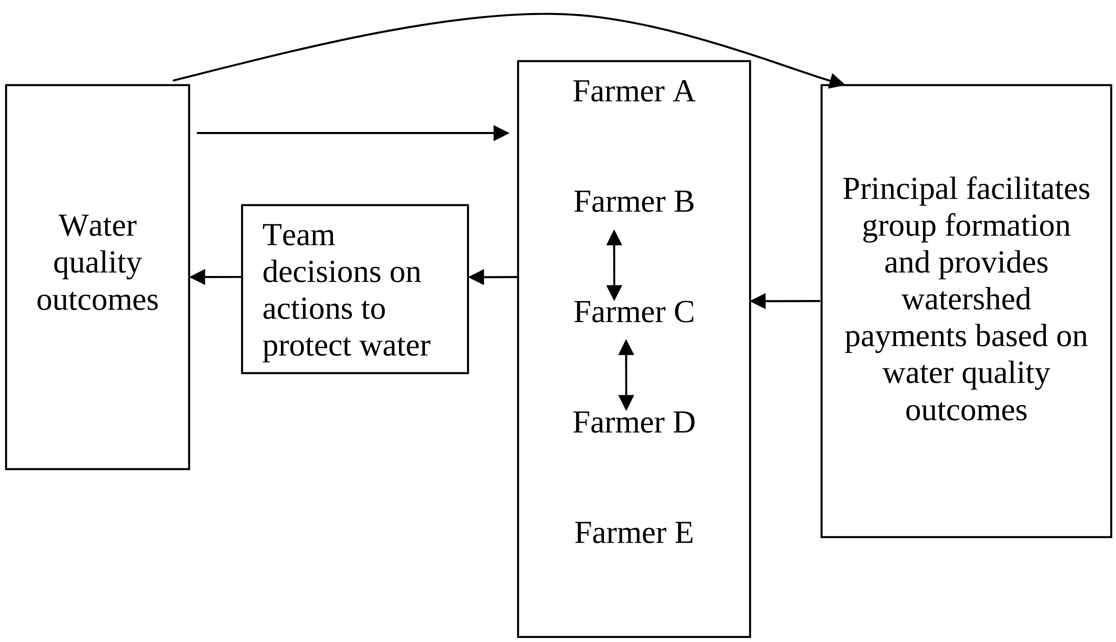
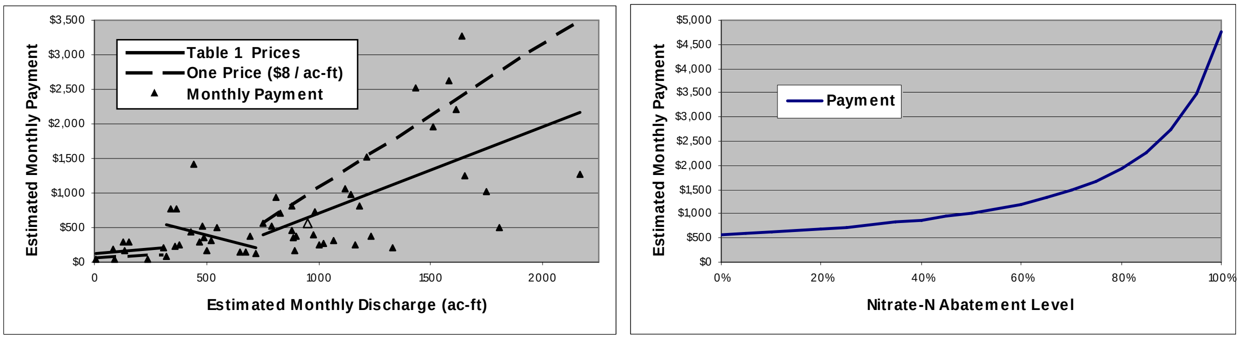


Figure 2. Team approach to water quality protection.



(A) (B)

Figure 3. Payment simulations from data collected prior to the field experiment.

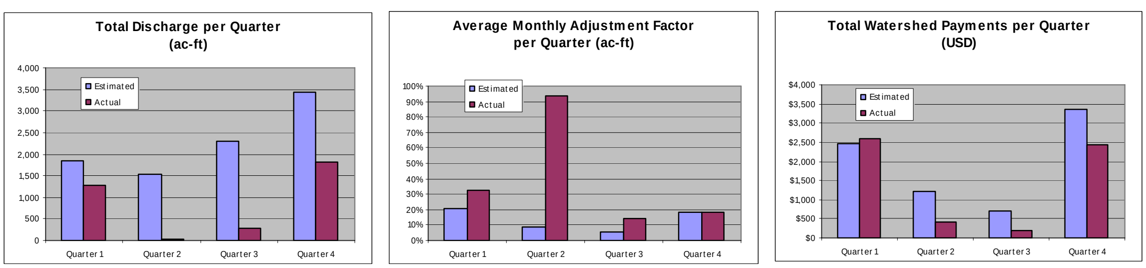


Figure 4. Comparison of actual and estimated values.