Do baseline requirements hinder trades in water quality trading programs?

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The Environmental Protection Agency and the U.S. Department of Agriculture are promoting point/nonpoint trading as a way of reducing the costs of meeting water quality goals while giving nonpoint sources a larger role in meeting those goals. Farms can create offsets or credits in a point/nonpoint trading program by implementing management practices such as conservation tillage, nutrient management, and buffer strips. To be eligible to sell credits, farmers must first comply with baseline requirements. The EPA defines a baseline as the pollutant control requirements that apply to a seller in the absence of trading. EPA guidance recommends that the baseline for nonpoint sources be management practices that are consistent with the water quality goal. A farmer would not be able to create credits until the minimum practice standards are met. An alternative baseline is those practices being implemented at the time the trading program starts. The selection of the baseline has major implications for which farmers benefit from trading, the cost of nonpoint source credits, and ultimately the number of credits that nonpoint sources can sell to regulated point sources. We use a simple model of the average profit-maximizing dairy farmer operating in the Conestoga (PA) watershed to evaluate the implications of baseline requirements on the cost and quantity of credits that can be produced for sale in a water quality trading market, and which farmers benefit most from trading.

Keywords: nonpoint pollution, emissions trading, management practices

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Water quality trading is now of much interest as a mechanism to improve the efficiency of water pollution control allocations among and between point and nonpoint sources in the U.S. Under the Clean Water Act, point sources (e.g. factories, sewage treatment plants) are regulated through a non-tradable permit system. A permit specifies how much of a particular pollutant the permit holder can discharge. Traditionally, permittees were required to meet their permit obligations through effluent reductions for the permitted source. New U.S. Environmental Protection Agency (EPA) policy guidelines on water quality trading now allow points sources to meet their permit requirements through offsets from other sources (US EPA 2004).[i] Under the EPA policy guidelines, those sources may be regulated point sources, or unregulated nonpoint sources. The guidelines encourage States to consider agriculture as a source of offsets in water quality trading programs, and many states are either implementing or considering water quality trading programs that allow point-nonpoint source trading (Environmental Trading Network, 2009; U.S. EPA, 2009).

The U.S. Department of Agriculture (USDA) is also very interested in water quality trading. In 2006, a new Department policy on market-based environmental stewardship was announced (USDA, 2006). The goal of the policy is to broaden the use of markets for providing environmental and ecosystem services through market mechanisms, such as credit trading. Such markets could provide a source of income to farmers and reward them for engaging in conservation activities. Farms can create offsets or credits for the market by implementing management practices such as conservation tillage, nutrient management, and buffer strips. Since the price is determined in the marketplace, payments are not limited to the cost or a fraction of the costs of the practice, as in most conservation programs. Farmers can also receive a payment for a much longer period of time than the 2 to 5 years of a standard conservation program contract.

Point/nonpoint trading has not been very successful to date, at least in terms of the participation of potential traders and the number of trades between regulated sources and farms (Breetz et al., 2004). Much has been written about various issues related to point/nonpoint trading, including uncertainty, trading ratios, and validation issues (King, 2005; King and Kuch ,2003; Woodward and Kaiser, 2002; Ribaudo and Nickerson, 2009). One area of program design that has not received much attention is the establishment of a baseline. To be eligible to sell credits, farmers must first comply with baseline requirements. The selection of the baseline has major implications for the cost of nonpoint source credits in the market, and ultimately the number of credits that nonpoint sources can sell to regulated point sources.

In this paper, we use a simple model of the dairy farms operating in the Conestoga watershed (Pennsylvania) to evaluate the implications of baseline participation requirements on the cost and quantity of credits that can be produced for sale in a point/non point water quality trading market. The Conestoga is a major source of nutrients entering the Susquehanna River, which is in turn a leading source of nutrients entering the Bay (Belval and Sprague, 1999). Reducing agricultural nutrient loads in the Conestoga has long been an objective of water quality agencies concerned with water quality in Pennsylvania and the Chesapeake Bay. Since 2007, farmers in the watershed have had the opportunity to participate in a nutrient credit trading program established by the Pennsylvania Department of Environmental Protection for the Susquehanna Basin in

2007. Although the program has received much attention as innovation in point/nonpoint trading, analogous to other programs, participation and trade volumes limited.

Baseline rules in water quality trading programs

The EPA defines a baseline participation requirement (BPR) as the pollutant control requirements that apply to a seller in the absence of trading (U.S. EPA, 2007). A seller must meet its baseline requirements to be eligible to generate credits. EPA guidance recommends that where a Total Maximum Daily Load (TMDL) is in place, the "load allocation" for nonpoint sources should serve as the threshold for nonpoint sources to generate credits (U.S. EPA, 2007). A load allocation defines the nonpoint source load reductions necessary to achieve water quality standards, and where available, can be applied to individual nonpoint sources or, more commonly, to the sector as a whole. EPA guidance states that it would not support a trading program that allows nonpoint sources to sell credits if the discharge is contributing to water quality impairments (U.S. EPA, 2007). However, EPA recognizes that there are difficulties associated with estimating loads from nonpoint sources.

In watersheds where a TMDL does not exist, or where the load allocation is uncertain, the program can establish other baseline requirements, including practices existing at the time the trading program was established, or implementation of a minimum set of best management practices (BMP).

The potential for a baseline to require something other than current practices presents an interesting dilemma for program managers. Under the Clean Water Act, there are no requirements for nonpoint sources to adopt BMPs, even in the presence of a

TMDL. By requiring a minimum practice standard (MPS) as the BPR to participate in the market, the regulatory agency may be disqualifying the “lowest hanging fruit”; the least costly reductions cannot be offered as offsets. It is possible that the incentives present in a credit market will be insufficient to induce farms that have not already voluntarily adopted the minimum set of practices, so called “good actors,” to incur the cost of meeting the BPR. This entry cost would therefore potentially limit participation and adversely affect the efficiency of the market.

One beneficiary of a MPS is prior adopters, or good actors, who are protected from competition from farms that can provide pollution abatement at a lower cost, because “bad actors” choose not to participate in the market. This would result in higher credit prices for point sources, and fewer credits being purchased from agriculture. If nonpoint source participation is a secondary goal of the program, then the minimum-standard baseline would appear to work against it. Water quality problems associated with “bad actors” will remain unaddressed, at least through the trading program.

Pennsylvania Water Quality Trading Program

The Pennsylvania Department of Environmental Protection (PADEP) has clear criteria for point source and nonpoint source participation in nutrient trading programs specific to the Chesapeake Bay watershed (PADEP, 2008a). The criteria for agricultural nonpoint sources take the form of baseline and threshold requirements. The baseline requirement is that on-site operations must be in compliance with Chapter 102 Erosion & Sedimentation Regulations, Section 91.36 (Agricultural Operations), Act 38 Nutrient Management Regulations, and Chapter 92 (CAFOs), as applicable. Compliance is determined by a site visit by PADEP staff or a PADEP approved entity and verified by PADEP, the Conservation District or other PADEP-approved entity.

Threshold requirements are met when one of three conditions is met. The first condition is that a 100 foot mechanical setback or equivalent is implemented on-site. It either requires that no surface waters exist within 100 feet of the farm *or* that manure is not mechanically applied within 100 feet of surface water *or* that manure is not applied at all and that commercial fertilizer application rates are below Penn State recommended agronomic rates. The second condition is that a 35 foot buffer or equivalent is planted between the field and surface water. The buffer is a swathe of permanent vegetation maintained between the field and surface water. Common types of buffer are riparian forest buffers and riparian grass buffers. The third condition is that the farm's overall nutrient balance be reduced by 20% below what is required by the baseline requirement presented earlier. For the purposes of our analysis, and for the sake of simplicity, we assume that all simulated farms meet their threshold requirements by satisfying the second condition, i.e. a 35 foot strip of permanent vegetation is planted between the field and surface water.

Analytical model

The numerical analysis uses a model of agricultural production and pollution control based on characteristics of the Conestoga River watershed in Lancaster Co., PA. The Conestoga is a major source of nutrients from agricultural production entering the Susquehanna River, which is in turn a major source of nutrients entering the Chesapeake Bay. Reducing agricultural nutrient loads in the Conestoga has long been an objective of water quality agencies concerned with water quality in Pennsylvania and the Chesapeake Bay. The model simulates nitrogen pollution loads from agricultural sources from sub-watersheds of the Conestoga. The model is not intended to be a highly explicit representation of agricultural production in the watershed. Instead it is intended to serve as a platform for testing the effects of alternative specifications of BPRs on the efficiency and equity of water quality trading.

Agricultural nutrient loads in the watershed are especially associated with livestock agriculture. Dairy production is very important in the Conestoga watershed in terms of land use, farm income, and nutrient loads. The Conestoga watershed is located primarily in Lancaster County, PA (figure 1). The 2002 Census of Agriculture (USDA, NASS, 2002) reported that sales of livestock related products accounted for approximately 89% of the total market value of production for the county. Milk and other dairy products account for the largest fraction of livestock related products in Lancaster County. Generating baselines for dairy farms is also important because to a greater extent than poultry and hog operations, dairy farms participate in farm programs that may affect incentives to participate in trading. Accordingly, we focus our model on dairy production.

The dairy production model is highly stylized and simplified to maintain focus on the mass flow of nutrients and the management of manure and runoff, which are the main concerns for water quality management, water quality trading, and conservation programs. The nutritional needs of dairy herds are met through nutrients in purchased feeds, nutrients from crops produced on the farm, and from pasturing. Dairy herds are poor processors of nutrients with 50-75 percent of the nutrients in the feed ending up in the manure (CAST, 2002). Traditionally, manure is spread on crop land. Nitrogen applied to crop land can have several fates. Some is taken up by crops, some is volatized, some leaches into ground waters, and some runs off into surface waters. In the Conestoga watershed, the volume of nutrients applied is substantially in excess of what is taken up in crops, leaving a large pool of nutrients to move into air and water.

In the stylized model, profits from milk production are described by a restricted profit function conditioned on herd size or number of cows, K , and corn produced onsite, C . The herd's feed requirement is completely met by corn grown onsite. All corn is assumed to be fed, thus there is no marketing of corn. This is consistent with the structure of Lancaster Co. farming, where corn is produced mainly as an animal feed. The animal manure (M) is spread on crop land and, supplemented by purchased fertilizer (N), to provide nutrients to the corn crop. The farm size, in terms of land, is fixed. In the baseline model (without trading), the continuous production variables in the stylized farm models are the herd size, onsite corn production, and purchased fertilizer. The proportion of pasture land is fixed. Land in corn production is continuous up to an upper bound. Discontinuous variables are manure management practices and runoff control practices.

Nutrient losses to the water resources from a farm can be reduced by:

(1) *Reducing the volume of nutrients applied to crop land.* This can be accomplished through feeding strategies that reduce the volume of nutrients in manure, storage strategies that increase the volatilization of nitrogen, disposing of nutrients off-site, reducing the volume of manure production, and thus the herd size, and reducing applications of commercial fertilizer.

(2) *Increasing the utilization of nutrients.* This can be accomplished by developing crop strains that have higher nutrient absorption capabilities, changing soil chemistry, and changing manure chemistry to facilitate nutrient uptake.

(3) *Reducing nutrient runoff.* This can be accomplished by implementing on-field tillage practices and off-field interception practices. Reduced tillage reduces surface runoff, allowing water and associated nutrients to percolate into the soil profile. Filter strips absorb nutrients not absorbed by the crop and so reduce runoff.

In our analysis we focus on three best management practices (BMP): conservation tillage, nutrient management plan (NMP), and riparian grass buffers (RGB).

Mathematical Structure: No trading – no explicit representation of BMPs

Farm behavior is modeled using a dual approach that allows the number of choice variables to be limited to the policy relevant set. The restricted profit function for the profit maximizing dairy farm is

$$\pi(C,K) = R(C,K) - C_C(C,K) - P_K K - Q(B) \tag{1}$$

where $R(C,K)$ represents revenues from milk sales, $C_C(C,K)$ is the corn production cost function, P_K is the unit cost of herd maintenance and $Q(B)$ is the cost of implementing conservation practice B . P_K captures all non-feed costs and includes the costs of acquiring and housing cattle. The linear form implies that the marginal herd maintenance cost is constant. This specification reflects our focus on long run equilibrium responses. We expect farm profits to be increasing and concave in both C and K .

The revenue function for milk sales approximated by a second order Taylor's Series expansion about the pre-trading levels of C and K.

$$R(C,K) = a + b_C C + b_K K + \lambda_C C^2 + \lambda_K K^2 + \lambda_{CK} CK \qquad (2)$$

where a, b_C, b_K, λ_C, λ_K and λ_{CK} are parameters associated with the Taylor's Series expansion. The second order Taylor's Series expansion allows flexibility in modeling revenue response to the input variables, C and K. Differentiating $R(C,K)$, the first order conditions with respect to C and K are $b_C + 2\lambda_C C$ and $b_K + 2\lambda_K K$ respectively. The signs on the first order conditions will determine the marginal response of revenue to the inputs respectively. *Ex ante* we expect corn production and herd size to have positive effects on farm revenue: we expect that $b_C + 2\lambda_C C \geq 0$ and $b_K + 2\lambda_K K \geq 0$.

We assume that the only feedstuff fed to the herd is corn.[1] We also assume that all feedstuff necessary for herd sustenance is grown onsite. The farmer does not buy any corn on the open market. The corn production cost function $C_C(C,K)$ is determined analytically by solving an expenditure minimization problem (EMP), where expenditure is on market inputs needed for corn production. It is assumed that the only input needed for corn production is nitrogen, as a nutrient. Some of the nitrogen is obtained from manure produced onsite by the herd. The rest is bought from the market. The relationship between corn, C, and nitrogen, N, is often modeled as quadratic or as a linear plateau (Fox and Piekielek, 1983; Dillon and Anderson, 1990). Following the recommendation in Ghosh (2004), in this study the relationship between C and N is captured by a bounded exponential function (3), which retains salient features of the

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[1] Or it can be assumed that non-corn feed units are transformed into equivalent corn feed units, allowing all nutrient calculations to be made in terms of corn

quadratic and linear plateau functions. The initial response of corn yield to nitrogen is similar to the quadratic formulation and the asymptotic response is similar to the linear plateau.

$$C(N) = \beta_0 + \beta_1 [1 - \exp[(1 - \beta_2 N)]] \exp\square \tag{3}$$

β_0, β_1 and β_2 are model parameters, the values of which are determined through calibration and presented in Ghosh (2004). The parameters vary by land capability class (LCC). Since there are four LCCs in the Conestoga watershed, there are four sets of values for the β s.

The nitrogen (N) needed for corn production is obtained from two sources: from manure obtained onsite and from fertilizer purchased in the open market at price P_N. If N_F is the nitrogen content of onsite manure and N_M is the nitrogen content in the fertilizer bought in the market, then total nitrogen input $N = N_M + N_F$. Let M be the manure produced by the herd and let ζ be the proportion of nitrogen in manure. It follows that the nitrogen content in manure, $N_F = \zeta M$. If ϕ is the quantity of manure produced by each cow and K is the number of cows then manure $M = \phi K$. Let H be farm size. The farmer minimizes corn production costs by minimizing expenditure on N_M, the only market input. If C is the minimum amount of corn needed to feed the herd, then the farmer faces the constraint $C(N) \geq C$. The farmer's constrained EMP for food production is set out in (4) and (5) and the farmer optimizes over N_M. The optimum level of fertilizer purchase per hectare, N_M^*, is given in (6).

$$\min_{\mathrm{N_M}} P_N N_M H \tag{4}$$

$$\text{subject to} \, \beta_0 + \beta_1 \left[1 - \exp\left(\frac{\beta_2}{H}(N_M + \zeta\phi K)\right)\right] \geq \frac{C}{H} \tag{5}$$

$$N_M^* = -\frac{1}{\beta^2}\ln\left(\frac{\beta_0 + \beta_1 - {}^{C}/_{H}}{\beta_1}\right) - \zeta\phi K \tag{6}$$

By substituting N_M^* into the objective function of the EMP, the minimized cost function for corn production is

$$C_C(C^*, K^*) = P_N N_M^* H = -\frac{P_N H}{\beta^2}\ln\left(\frac{\beta_0 + \beta_1 - {}^{C}/_{H}}{\beta_1}\right) - P_N H\zeta\phi K^* \tag{7}$$

From Euler's Theorem, it is known that $C_C(C^*, K^*) = C^* \cdot {}^{\partial C_C}/_{\partial C} + K^* \cdot {}^{\partial C_C}/_{\partial K}$, where C^* and K^* are the farm's corn production cost-minimizing levels of corn and herd size. The partial derivatives are evaluated at their optima. As is common in the literature, ${}^{\partial C_C}/_{\partial C}$ and ${}^{\partial C_C}/_{\partial K}$ are interpreted as the shadow or implicit prices of corn (S_C) and herd size (S_K) *when considered as inputs in corn production*. S_C and S_K are calculated by taking the partial derivative of C_C, as defined in (6), with respect to K and C

$$S_K = \frac{\partial C_C(C,K)}{\partial K} = -P_N H\,\zeta\phi \tag{8}$$

$$S_C = \frac{\partial C_C(C,K)}{\partial C} = \frac{P_N H}{\beta_2(H\beta_1 + H\beta_0 - C)} \tag{9}$$

Specific values of S_C and S_K, which are necessary for the calibration, will be known if the optimal values of C, K, P_N, ζ, ϕ and the β s are known. If the farmer is an optimizer then the Euler's Theorem can be used, which implies that instead of (8), $S_K K^* + S_C C^*$ can be substituted into (1) instead. The substitution is useful because the nonlinearity of $C_C(C^*, K^*)$ in C^* would have complicated the calibration process.

Calibration

Some model parameter will be assigned values obtained from the literature. Other model parameters will be calibrated. Parameter values obtained from the literature include herd maintenance unit costs (P_K), herd size (K), costs of conservation tillage ($Q(T_S)$), and costs of nitrogen (P_N). An estimate for non-feed herd maintenance costs was obtained from Bailey (2008): $P_K = 3600$. Hence the total cost of herd maintenance, $P_K K = 3600K$. The average herd size for Conestoga herds as listed in the 2002 Census of Agriculture (USDA, 2003) is 56. We assume that the herd is composed of Holsteins, which implies that the average herd size is 62.2 animal units (AU).

Comparison of conventional till, reduced till, and no-till in corn production reveals total variable costs for conventional till (T_V) to be \$4 to \$8 less per acre than variable costs for no-till (Pennsylvania State University, 1996). No-tillers are referred to as conservation tillers in this report. The midpoint of \$6 per acre is chosen as the extra cost of implementing conservation till (T_S). Since there are 40 acres under corn production, $Q(T_S) = 240$.

Statistics for the manure generated per cow per year ($\phi = 19.45$ tons) and the nitrogen proportion in manure ($\zeta = 4.54$ kg / ton) are obtained from the 2007-2008 Agronomy Guide (Penn State, 2007b). The cost of nitrogen (P_N) is set to the official April 2007 price for nitrogen fertilizer (USDA, 2008). The values assigned to β_0, β_1 and β_2 and total nitrate use, N, are taken from Ghosh (2004). The βs vary across LCCs to reflect heterogeneity in soil quality and fertility. C is obtained by substituting the optimal values of the βs and N into (3). C varies by LCC because the βs, as calibrated in Ghosh (2004), vary by LCC.

The other model parameters are a, b_C, b_K, λ_C, λ_K and λ_{CK}, all associated with the milk revenue function (2). a is simply a scaling variable and ensures that calibrated results approximate real world revenues and profits for real dairy farms in the Conestoga watershed. b_C, b_K, λ_C, λ_K and λ_{CK} capture the quadratic relationship between revenue and inputs and are calibrated.

The model has five unknown parameters needing calibration, λ_C, λ_K, λ_{CK}, b_C, b_K. The final unknown parameter a acts as a scaling variable and is easily calculated when the other parameter values are known. The first and second equations are obtained from the first order necessary conditions for profit maximization, which are obtained by differentiating (1) with respect to C and K. Rearranging these first order conditions demand functions for C and K are obtained.

$$K^* = \frac{\lambda_{CK} b_C - 2\lambda_C b_K + 2\lambda_C (S_K + P_K) - \lambda_{CK} S_C}{4\lambda_C \lambda_K - \lambda_{CK}^2} \tag{10}$$

$$C^* = \frac{\lambda_{CK} b_K - 2\lambda_K b_C + 2\lambda_K S_C - \lambda_{CK}(S_K + P_K)}{4\lambda_C \lambda_K - \lambda_{CK}^2} \tag{11}$$

As (10) and (11) indicate, optimal levels of C and K are linear in the prices of K and C. S_C and S_K are the marginal implicit prices of corn and herd size in the production of corn and are given by (7) and (8). P_K is the unit non-feed cost of the herd and hence $S_K + P_K$ is the total unit cost of herd maintenance.

For the last three equations we derive the farmer's own and cross price supply elasticities from (10) and (11) with respect to corn production and herd size.

$$\varepsilon_{K,P_K} = \frac{\partial K}{\partial P_K}\frac{S_K + P_K}{K} = \frac{2\lambda_C}{4\lambda_C \lambda_K - \lambda_{CK}^2}\frac{S_K + P_K}{K} \tag{12}$$

$$\varepsilon_{C,P_C} = \frac{\partial C}{\partial P_C}\frac{S_C}{C} = \frac{2\lambda_K}{4\lambda_C \lambda_K - \lambda_{CK}^2}\frac{S_C}{C} \tag{13}$$

$$\varepsilon_{C,P_K} = \varepsilon_{K,P_C} = \frac{\lambda_{CK}}{4\lambda_C \lambda_K - \lambda_{CK}^2}\frac{S_K + P_K}{C} \tag{14}$$

The own price elasticity of dairy production with respect to corn costs, ε_{C,P_C}, was obtained from Chavas and Klemme (1986), who estimate short-run, medium-run and long-run elasticities. Their numbers for medium-run elasticity – the medium-run is defined as ten years – are used, which implies that $\varepsilon_{C,P_C} = -1.5$. We were unable to find estimates of the own price elasticity of dairy production with respect to herd costs and the cross price elasticities. We set $\varepsilon_{K,P_K} = -0.5$. ε_{K,P_K} is negative because it is assumed that *K* is a normal good and hence *ceteris paribus* herd size will diminish as costs increase. Also, since $\square|\varepsilon\square_{\perp}(K,P_{\perp}K)| < 1$, herd size is relatively inelastic in its response to price, which is explained as follows: There are fixed and variable costs associated with the herd. The fixed costs are sunk and unchanging in the medium-run. They are associated with the physical infrastructure needed to maintain the herd. The physical infrastructure will maintain a herd of a given size and to use this infrastructure to the maximum, the farmer will try to keep his herd as large as he can. Variable cost changes in the medium-run and hence ε_{K,P_K} measures the effect that changes in variable costs have on milk supply. A rise in variable cost will exert a downward pressure on herd size and milk supply, but this pressure is mitigated by the incentive that the farmer has to not reduce herd size and utilize his physical infrastructure optimally. These conflicting incentives will manifest in a relatively inelastic herd size response to increases in medium-run herd maintenance costs.

We set $\varepsilon_{C,P_K} = \varepsilon_{K,P_C} = -1.0$ because it is assumed K and C are complements rather than substitutes. The magnitude of the cross price supply response is unknown, but sensitivity analysis did not reveal much variation in the calibration results when $\varepsilon_{C,P_K} = \varepsilon_{K,P_C}$ was varied about one. We solve the system of five equations [(10)—(14)] to calibrate the five unknown parameters, b_C , b_K , λ_C , λ_K , and λ_{CK} .

Pre-market conditions

For the purposes of this analysis, we define a farm as having 40 acres of arable land with a lake or stream adjacent to the field. Prior to the trading program, a farm can be one of 12 general types:

- plant on all 40 acres, using conventional tillage (Q), conservation tillage (QC), a NMP (QN), or both conservation tillage and a NMP (QNC);
- have a riparian grassed buffer (RGB) around a lake, taking two acres out of production, and using conventional tillage (S1), conservation tillage (S1C), a NMP (S1N), or both conservation tillage and a NMP (S1NC);
- have an RGB on both sides of a stream, taking four acres out of production, and using conventional tillage (S2), conservation tillage (S2C), a NMP (S2N), or both conservation tillage and a NMP (S2NC).

Farms with RGBs are defined as good stewards, since they are meeting the PADEP minimum standards. Farms without RGBs are defined as poor stewards, even though they may be using conservation tillage or nutrient management; they have not adopted the riparian buffers required to meet the PADEP guidelines.

The farms in the Conestoga watershed are on one of four land capability classes (LCCs), which measure land quality. LCC1 land has the highest quality and LCC4 has the lowest quality. We modeled each farm type on each LCC, giving us 48 farm types before market entry. The potential for each farm type to participate in the market under the two baseline scenarios is evaluated with the economic model.

For the remainder of this paper we refer to farm types before and after market entry by their LCC and BMP codes. For example, an LCC4 farm with a riparian buffer around a lake and using conservation tillage prior to market entry is referred to as L4S1C. If this farm adopts nutrient management after market entry, its designation is L4S1CS1CN.

Minimum Standard Baseline

Under the Minimum Standard Baseline (MSB), farmers with RGBs (S1 or S2 type farms) prior to market entry are eligible to sell credits on any additional changes in management they make. These are the good stewards. Farms without RGBs (Q-type farms) cannot enter the market until RGBs are installed. These are the poor stewards. For the purposes of this analysis, farmers are not allowed to discontinue a conservation practice (conservation tillage or a nutrient management plan) they are using in the pre-market situation.

Table 1 summarizes the trading possibilities. All farm types designated by a "Q" before market entry are the "poor" stewards. There are 16 in all, accounting for the four LCCs. Those farm types designated by "S1" or S2" are the good stewards. There are 32 of these. Those actions that result in tradable credits are denoted by a "y" in the cells; 40 by good stewards and 40 by poor stewards (4 LCCs for each cell). The table also shows acres in production before and after market entry. The shaded cells show the baseline for calculating credits. For example, a farm planting on all 40 acres and using conventional tillage (Q) can enter the market only by installing an RGB and then adopting another conservation practice (conservation tillage or nutrient management). No credits are earned by simply adopting the RGB. Note that QNC, S1NC, and S2NC type farms cannot take any actions to produce credits in our model.

Figure 2 shows the estimated market entry price for each farm type. It reflects the minimum credit price at which each of the original farm types will adopt practices necessary to create and market credits, as well as the practice that was adopted. The results from the model are as expected. Almost all the good stewards (designated with a "G" in front of the farm-type code) can enter the market at a lower price than poor stewards (designated with a "B"). Poor stewards are at a distinct disadvantage in the MSB. The lowest entry price (for farm type BL4QS1NC) is much higher ($34.85) than for almost all the good steward types. Depending on the actual mix of farms in the watershed, and the demand for credits from regulated sources, poor stewards may not be able to enter the market at all.

Timed baseline

The alternative to the MSB is a baseline based on the status quo; farms can enter the market and earn credits by adopting conservation practices, regardless of whether they were meeting the PADEP guidelines before or after market entry. This means that so-called poor stewards under the MSB can enter the market and create credits by adopting conservation practices other than RGBs. Table 2 summarizes all the trading possibilities.

The number of scenarios that could result in tradable credits has increased to 132. All the additions are from so-called poor stewards who were limited in what they could do to generate credits under the MSB. Not only can poor stewards enter the market without having an RGB, implementing an RGB will now generate saleable credits. Previously, an RGB would only allow entry into the market; credits were generated only with the implementation of additional practices. Unit costs for reducing N runoff are much lower for many of the poor stewards, enabling them to enter the market at a lower price than most good stewards (figure 2). For example, under the MSB, farm type BL4Q would adopt an RGB and both nutrient management and conservation tillage to enter the market (BL4QS2NC). Its market entry price is $73.15. Under the TB, the same farm would enter the market by simply adopting nutrient management (BL4QQN). Its market entry price is now only $2.23.

It is worth noting that under the TB, the only poor stewards to adopt RGBs, the PADEP minimum standard for stewardship, would be those that have already adopted nutrient management and conservation tillage prior to market entry; the only step these farm types can take to enter the market. These farm types had the highest market entry prices of all the farm types under TB.

Conclusions

Baseline conditions in a water quality trading program have a profound impact on the make-up of farm types that will likely succeed in a market. A baseline that requires a minimum level of stewardship prior to market entry will benefit those good stewards who had already adopted those practices. Poor stewards are at a distinct competitive disadvantage, and would most probably not find it in their interest to enter the market.

Under a timed baseline, where there are no practice pre-conditions for market entry, farm types that were labeled poor stewards in the MSB can now readily compete with the good stewards, and would likely supply a major share of the credits in a market. Good stewards are not eliminated from the market; however, as some farm types can still produce credits for a low cost by adopting nutrient management or conservation tillage.

The analysis shows that selecting the MSB eliminates many low cost credits from the market. While this might benefit prior-adopting good stewards, it raises the overall cost of credits and likely reduces the number of credits traded in the market. It also fails to provide an adequate incentive for poor stewards to adopt best management practices. If one of the goals of point/nonpoint trading is to encourage farms most in need to conservation to adopt BMPs, then this goal is better served by the timed baseline. If the MSB is used in a trading program, then there is role for conservation programs such as EQIP to assist poor stewards reach the level of management that is required to allow them to trade in the market.

Table 1 - Minimum Standard Baseline scenarios

			After market entry											
		ACRES	40	40	40	40	38	38	38	38	36	36	36	36
	ACRES		Q	QC	QN	QNC	S1	S1C	S1N	S1NC	S2	S2C	S2N	S2NC
Before market entry	40	Q	n	n	n	n	n	y	y	y	n	y	y	y
	40	QC	n	n	n	n	n	n	n	y	n	n	n	y
	40	QN	n	n	n	n	n	n	n	y	n	n	n	y
	40	QNC	n	n	n	n	n	n	n	n	n	n	n	n
	38	S1	n	n	n	n	n	y	y	y	-	-	-	-
	38	S1C	n	n	n	n	n	n	n	y	-	-	-	-
	38	S1N	n	n	n	n	n	n	n	y	-	-	-	-
	38	S1NC	n	n	n	n	n	n	n	n	-	-	-	-
	36	S2	n	n	n	n	-	-	-	-	n	y	y	Y
	36	S2C	n	n	n	n	-	-	-	-	n	n	n	y
	36	S2N	n	n	n	n	-	-	-	-	n	n	n	y
	36	S2NC	n	n	n	n	-	-	-	-	n	n	n	n

Shaded cells are the after-entry baselines for calculating credits
y = credit generation allowed
n = credit generation not allowed

Table 2 – Timed Baseline scenarios

			After market entry											
		ACRES	40	40	40	40	38	38	38	38	36	36	36	36
	ACRES		Q	QC	QN	QNC	S1	S1C	S1N	S1NC	S2	S2C	S2N	S2NC
Before market entry	40	Q	n	y	y	y	y	y	y	y	y	y	y	y
	40	QC	n	n	n	y	n	y	n	y	n	y	n	y
	40	QN	n	n	n	y	n	n	y	y	n	n	y	y
	40	QNC	n	n	n	n	n	n	n	y	n	n	n	y
	38	S1	n	n	n	n	n	y	y	y	-	-	-	-
	38	S1C	n	n	n	n	n	n	n	y	-	-	-	-
	38	S1N	n	n	n	n	n	n	n	y	-	-	-	-
	38	S1NC	n	n	n	n	n	n	n	n	-	-	-	-
	36	S2	n	n	n	n	-	-	-	-	n	y	y	Y
	36	S2C	n	n	n	n	-	-	-	-	n	n	n	y
	36	S2N	n	n	n	n	-	-	-	-	n	n	n	y
	36	S2NC	n	n	n	n	-	-	-	-	n	n	n	n

Shaded cells are the after-entry baselines for calculating credits
y = credit generation allowed
n = credit generation not allowed

Figure 1 – Study area

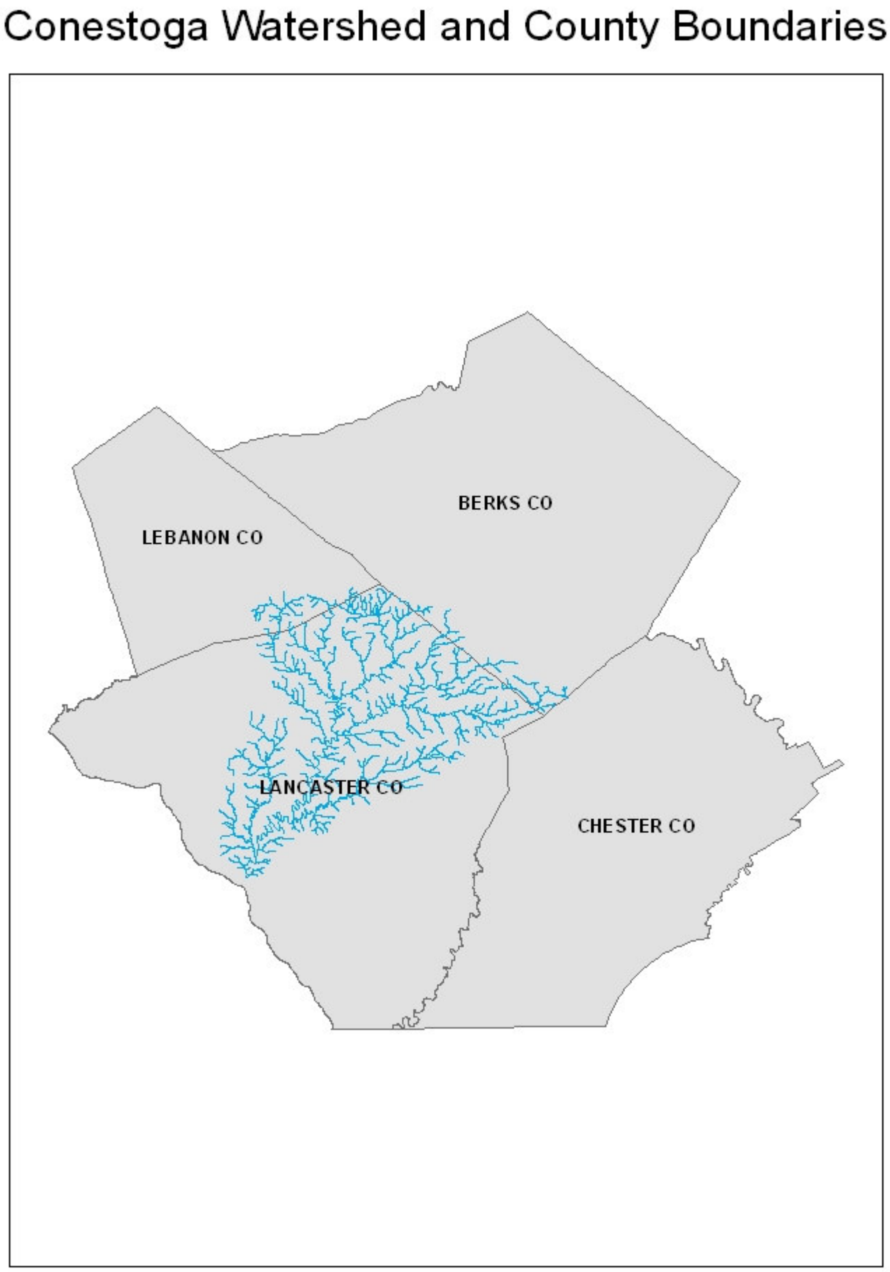


Figure 2 – Minimum Standard Baseline

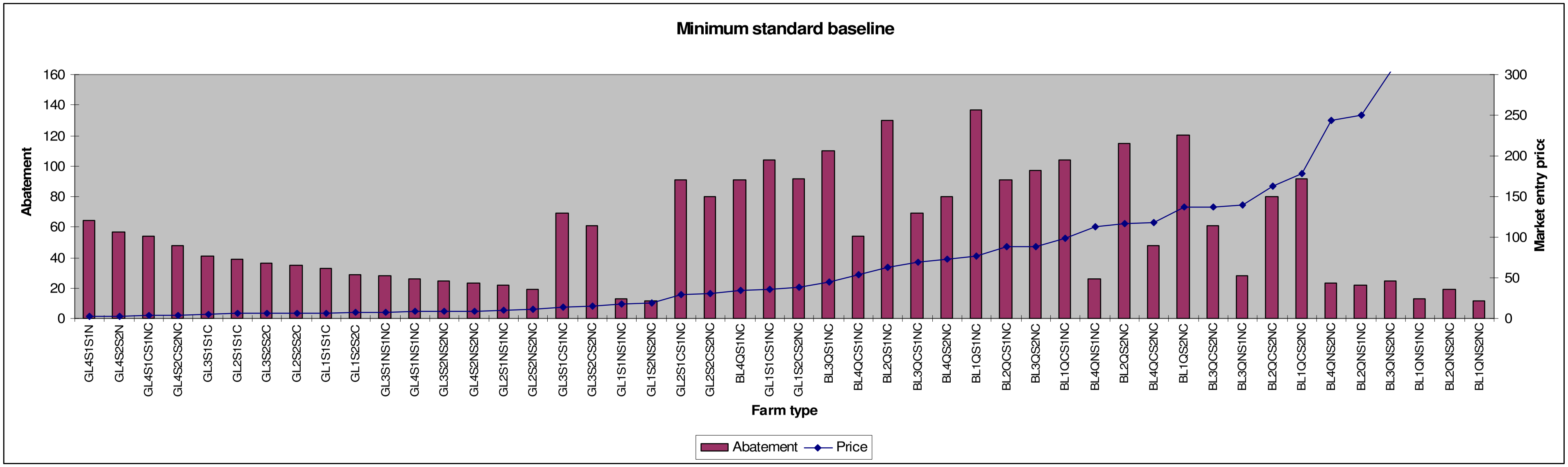
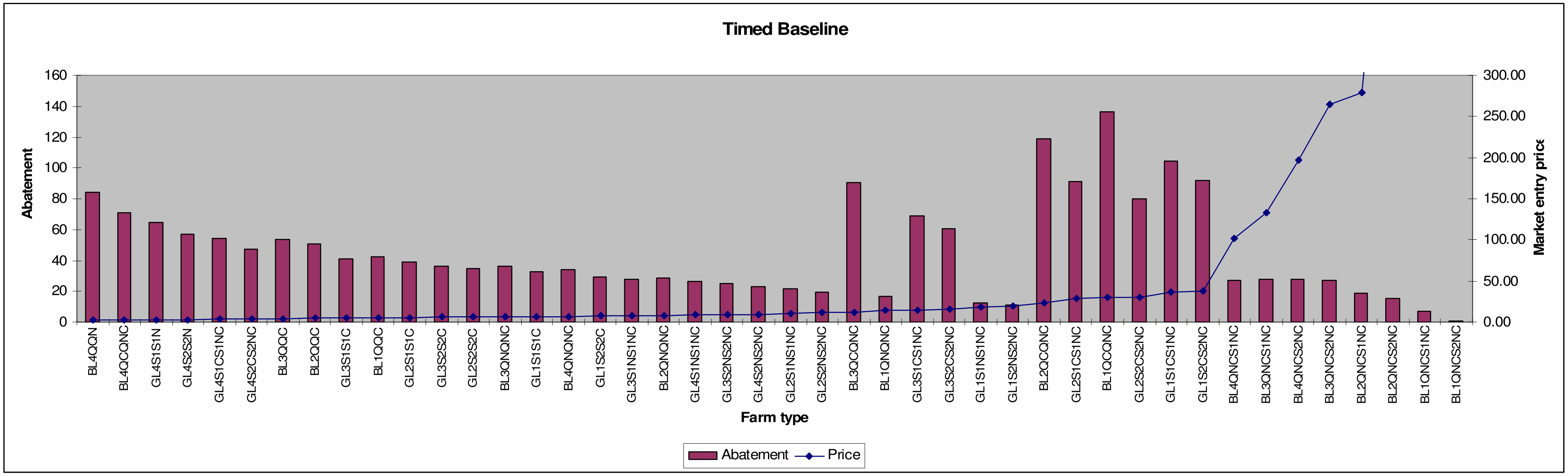


Figure 3 – Timed Baseline



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[i] Such offsets can be used to meet the “Water Quality Based Effluent Limitation” of an NPDES permit, but not the “Technology Based Effluent Limitation” (citation).