Farmer Response to Nutrient Credit Trading Opportunities in the Coastal Plain of Virginia

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ABSTRACT

The purpose of this study is to evaluate agricultural producer response to opportunities to generate nutrient credits under Virginia's water quality trading program. In 2005 the Virginia legislature passed legislation authorizing trade of nutrient reduction credits from nonpoint to new/expanding point source dischargers. A mathematical programming model of a typical commercial cash grain farm operation in the coastal plains of Virginia is constructed to model farmer credit supply response under the trading program. A corn, barley, and soybean crop rotation with the implementation of a no-tillage Best Management Practice (BMP), was the BMP used to maximize profits and generate nutrient credits for the model farm. Contrary to common assumptions that agricultural nonpoint source credits will be a low cost compliance option, the results show that the supply of credits is limited at modest credit prices and high nutrient credit prices will be necessary to induce additional farm level reductions.

INTRODUCTION

Excessive nitrogen and phosphorus discharges have accelerated eutrophication of many coastal waterbodies, including the Chesapeake Bay. The Environmental Protection Agency has identified that nutrient discharges adversely impact many important species in the Bay including submerged bay grasses, blue crab, oysters, and fish species (EPA, 2010). While nitrogen and phosphorus loads come from a wide range of point and nonpoint sources, including sewage treatment plants, industrial facilities, agricultural runoff, urban nonpoint sources, and the atmospheric deposition; agriculture has been identified as the largest single source of nitrogen and phosphorous loads delivered to the Chesapeake Bay Watershed (Chesapeake Bay Program, 2013). Virginia is now in the process of implementing a wide ranging set of programs to comply with new federal nutrient reduction targets established for the Chesapeake Bay.

As part of the state's Bay restoration efforts, Virginia established a nutrient credit trading program in 2005 (called the *Chesapeake Bay Watershed Nutrient Credit Exchange Program)* and substantially amended these provisions in 2012. The statute authorized the creation of nutrient nonpoint source credits by agricultural producers for possible sale to regulated "point source" dischargers. In the Virginia program, agricultural producers can generate nutrient credits by implementing a number of state approved best management practices (BMPs) (DEQ, 2008). The potential buyers of these credits include regulated "point" sources (wastewater treatment plants and industrial sources) and urban stormwater runoff from land development activities. Agriculture, however, has limited opportunities to participate in the stormwater trading provisions since all credit producing activities must create a permanent stream of reduction (effectively limiting credit generating activities to permanent land conversion). Current demand for nutrient reducing agricultural BMPs will come from point sources.

Research often reports that agricultural nonpoint sources will be a low cost trading partner for point sources (Faeth, 2000; Ribaudo, Heimlich, and M. Peters, 2005; Hanson and McConnell, 2008; Van Houtven et al., 2012). These findings often suggest that the sale of nutrient nonpoint source credits will be a significant new source of conservation incentives. Yet, nationally trading programs often generate very few nonpoint source trades (Stephenson and Shabman, 2011). The objective of this research is to evaluate how grain producers in Virginia might respond to nutrient credit trading opportunities. The model will be used to estimate a supply curve for nutrient credits.

NONPOINT SOURCE NUTRIENT CREDIT GENERATION IN VIRGINIA

Virginia has implemented one of the largest scale nutrient trading programs in the United States. The Virginia program establishes strict annual mass load limits (called wasteload allocation or WLA) on nitrogen and phosphorus discharge for all municipally owned waste water treatment plants (WWTP) and industrial point source dischargers. By statute, a new or expanding point source must acquire WLA from either: 1) an existing point source, 2) agricultural sources implementing best management practices (BMPs), or 3) by other means approved by the Virginia Department of Environmental Quality (DEQ) (§62.1-44.19:15.B.1). Existing point sources, however, are expected to achieve compliance through on-site compliance or by purchasing point source credits.

Agricultural operations can participate in trading as credit suppliers. To become eligible to generate credits Virginia requires agricultural operators to meet a number of baseline requirements. Virginia Department of Environmental Quality (VDEQ) defines baselines as five minimum best management agricultural practices be installed before agricultural sources are eligible to generate credits (VDEQ, 2008). These minimum control measures include implementing an approved nutrient management plan, soil conservation plan, cover crops, livestock exclusion from streams, and riparian buffers (35 ft. minimum).

Once baseline requirements are met, agricultural operations can generate nonpoint source credits by implementing a limited number of approved best management practices (DEQ, 2008). The approved practices include continuous no-till, 15% yield reserve (applying 85% of recommended nitrogen application rate), and early cover crops, or combinations of these practices. Nutrient credits can also be produced by converting land to less nutrient intensive uses (e.g. converting agricultural land to forest or converting cropland to pastureland). Nutrient reductions (annual credits) for each practice or land use change are estimated and explicitly listed in the DEQ guidance document in a series of "look up" tables (DEQ, 2008).

Nutrient agricultural nonpoint reduction credits are calculated for each major tributary (watershed) in the Chesapeake Bay and across two major physiographic regions. In Virginia, nutrient trading program is segmented based on watersheds, allowing for no cross-basin trades. The four major Chesapeake Bay watersheds in Virginia are the Shenandoah-Potomac, Rappahannock, York, and James. Nutrient load reductions for eligible BMPs are also calculated for two general physiographic regions, uplands and coastal plain (areas generally west and east of Interstate 95). Tables 1 shows approved nitrogen and phosphorus reductions (lbs/ac/yr) for the Rappahannock Basin, which is used to represent the coastal plain region in Virginia. For example, a 15% reduction in nitrogen fertilizer application below approved rates will reduce nitrogen loads by 2.7 pounds per acre per year (see Table 1). After farmers calculate how many tradable credits they can generate through BMPs, they must identify an offset broker to facilitate the trade. The broker verifies that the baseline requirements are met and helps identify point source trading partners. All point-nonpoint trades are then subject to the 2:1 trading ratio.

Table 1: Agricultural Nutrient Reductions (lbs/ac/yr) for Rappahannock Basin BMPs (East of I-95)

Single BMP	**Nitrogen Credit**	**Phosphorous Credit**
Early Planted Cover Crops	0.68	0
15% Nitrogen Reduction on Corn	2.7	0
Continuous No-Till	0.86	.12
Land Conversion BMPs		
Cropland to Forest	6.51	0.62
Cropland to Hay	0.69	0.09
Cropland to Mixed Open (fallow)	3.86	0
Hay to Forest	5.83	1.04
Hay to Mixed Open (fallow)	3.17	0.38
Pasture to Forest	2.3	0.67

Combination BMPs		
Early Planted Cover Crops & 15% Nitrogen Reduction on Corn	3.14	0
Early Cover Crop & Continuous No-Till	1.26	0.12
15% Nitrogen Reduction on Corn & Continuous No-Till	3.28	0.12
Early Cover Crop & 15% Nitrogen Reduction on Corn & Continuous No-Till	3.68	0.12

METHODS AND REPRESENTATIVE GRAIN FARM

A farm level profit maximizing math programming model was developed to estimate a possible farm-level nutrient credit response to the nutrient trading program. A representative grain producing farm in the coastal plain of the Rappahannock watershed was selected to be modeled, because it is the major grain growing region in Virginia, located in the coastal plain.

Eleven Virginia counties comprise the Rappahannock Watershed East of I-95 (Caroline, King George, Essex, Westmoreland, Richmond, Middlesex, Lancaster, Northumberland, Gloucester, Mathews, and King and Queen). In 2007 approximately 30% of the farmland comprised in these counties was between 260 and 999 acres (USDA, 2008). Given this information, the model uses a commercial size farm of 625 acres, roughly the median size between 260 and 999 acres.

The model assumes all land was available to take part in the nutrient trading program, and forms a two-year model of crop rotation. A typical farm in the coastal plain uses either a corn/wheat/soybean or a corn/barley/soybean two year crop rotation (Groover, 2012). These rotations are used in the 2 year model. With the exception of BMPs which include a 15%

nitrogen reduction on corn, BMPs generate credits in both years. Due to the lack of information on farms reaching the baseline, the analysis assumes that the farm already implemented the necessary practices to meet the baseline, and none of the BMPs used to reach the baseline limited the farmer's trading of additional BMPs. In some cases, the soil conservation plan requires farms to reach the baseline with the implementation of no till on farm required by the soil conservation plan. This model assumes that the no-till BMP is not part of reaching the baseline, and therefore can generate nutrient credits on all acres.

When considering costs, all 625 acres are assumed to be previously cropped by conventional tillage practices allowing no need for fixed costs to be accounted for in the model. The base variable production costs came from the 2007 Crop Budget computed by Virginia Cooperative Extension (VCE). Budgets are used for corn grain conventional tillage and minimum tillage, barley grain/soybeans double cropped, and wheat grain/soybeans double cropped (VCE, 2007). Yield per acre was updated to reflect relevant yields. Since the prices are in 2007 dollars the US inflation calculator was used to put costs in to 2013 terms.

The USDA estimated prices of the crops in 2013/14 were used to calculate farm revenue. Corn prices for 2013/14 season projected by the USDA are between $4.30 and $5.10 per bushel (USDA, 2013). The model uses the average price of $4.70 per bushel of corn. Soybean prices for 2013/14 were projected to be between $9.50 and $11.50 per bushel (USDA, 2013). The model uses the average price of $10.50 per bushel of soybeans to calculate the revenue from soybean production. Wheat prices for 2013/14 were projected to be between $6.15 and $7.45 per bushel (USDA, 2013). The model uses the average price of $6.80 per bushel of wheat to calculate the revenue from wheat production. Barley prices for 2013/14 were estimated to be between $5.30 and $6.30 per bushel (USDA, 2013). The model uses the average price of $5.80 per bushel of barley to calculate the revenue from barley production.

The farm model also allows the representative farm to earn profit by producing and generating and selling nutrient credits. Nutrient credit prices are varied in the model to estimate farm credit supply response. The model initially starts at a nitrogen credit price of $5 per pound (approximately the nitrogen credit price paid by existing point sources in point-point trades), however, marginal costs have been estimated for to be as high as $50 per pound for some point source upgrades (Jones et al., 2010). Phosphorus credits are initially set at $20/pound. Since the model farm is assumed to be all cropland with no livestock, some of the land conversion BMPs do not apply to the model, such as: Hay to Forest, Hay to Mixed Open (fallow) and Pasture to Forest.

The BMPs listed in Table 1 are used in the model to generate credits: early planted cover crops, 15% nitrogen reduction on corn, continuous no-till, cropland to forest, cropland to hay, and cropland to mixed open (fallow) are calculated. Combination BMPs were calculated by combining single BMP changes on costs and revenues.

Early planted cover crops limit nitrate leaching from soil making them a good potential BMP for nutrient reduction (Delgado, 1998). Planting an early cover crop does not have a negative effect on corn yields because farmers choose an earlier maturing corn hybrid. Some farmers have been known to even plant some early maturing corn and normal maturing corn in order to spread risk due to weather and in order to account for machinery constraints. Early harvested corn hybrids are harvested about 30-days before normal maturing corn. When corn is harvested earlier it is wetter, making it more difficult to dry and store. There is roughly a $0.15

increase in cost of production per bushel per percent moisture, making a $0.50 increase in cost of production of corn per Bu an appropriate figure for early planted cover crop BMPs in the model (Thomason, 2012). There was little information on the effects of early-planted cover crops on wheat and barley yields. However, winter barley is more suitable as an early cover crop than wheat. Winter wheat planted before late September is susceptible to disease and premature death (Cogger, 1997). Due to this finding, BMPs including an early planted cover crop in the model only have options of a corn, barley, and soybean rotation.

A 15% nitrogen reduction on corn means a 15% reduction on cost of nitrogen fertilizer. American Farmland Trust studied the effects of nitrogen reduction on corn yields in Pennsylvania and found that an average of 15% nitrogen reduction on corn resulted in an average of 7.3% yield decrease (Green, 2011). There was no information found on the affects that nitrogen reduction on corn has on yields or costs related to wheat/soybean or barley/soybean included in the rotation.

No tillage corn production conserves soil and water and reduces labor costs and costs associated with machinery. No-tillage systems can improve corn yields. In a three-year University of Maryland study, no-tillage corn in a small-grain/double-crop soybean stubble out yielded conventional tillage corn by 28 Bu/acre (Thomason, 2009). A study summarizing the cost-effectiveness of no tillage practices found a 54% reduction in labor costs for no-till corn in Pennsylvania (Boyle, 2006). The Conservation Technology Information Center reported that because no-till requires less frequent use of farm machinery, it cuts fuel costs for corn-soybean production by an average of 3.2 gallons per acre. Since no-till systems use less machinery for fewer hours the Conservation Technology Information Center estimated a savings at $5/acre when choosing no-till over conventional tillage (CTIC, 2012). No-till can increase other costs including pesticide costs, cost of killing prior crop mechanically, and the time cost of learning a new production method (DCR, 2010). It is suggested that with the adaption of no-till practices, the variable cost of production for corn increases 6.95% per bushel (VCE, 2007). Despite the increase in variable cost the marginal benefits of increasing production with no-till makes it a more preferable choice even without the credits, which should be considered when analyzing the results of the model.

Winter wheat yields are not affected by tillage (Balkcom, 2012). A study done in North Dakota found that no-till barley yields 7% higher than conventionally tilled barley (Swenson 1980). Differences in costs of production with no tillage practices of wheat and barley could not be found. However, the input cost of conventional tillage system for soybean production is approximately \$18 – \$25 per acre more than no-till in 2009 (Al-Kaisi, 2009). Meaning no-till soybean production was on average \$21.5 per acre less costly that conventional till soybean production in 2009. Putting \$21.5 into 2012 dollars; soybean no-till production is approximately \$23.18/acre less expensive than conventionally tilled soybeans. A study done in Kentucky showed that no-till soybeans yielded a 5.8% increase over conventionally tilled soybeans (Murdock, 2005).

Yield estimates of barley/soybean and wheat/soybean rotations are based on Virginia unpublished yield trials. In a barley-soybean rotation barley yields are on average 90 Bu/acre and soybean yields are on average 33 Bu/acre. In a wheat-soybean rotation wheat yields are on average 70 Bu/acre and soybean yields are on average 26 Bu/acre (Holshouser, 2010).

The Virginia National Resource Conservation Service provides the average cost for cropland to forest and cropland to hay land conversion practices. It costs \$1515 per acre when converting cropland to forest (110 Hardwoods and 120 mixed shrubs) and $500 per acre when converting cropland to hay (VNRCS, 2011). The average cost of converting cropland to open fallow is approximately $6.61 per acre, using estimated labor costs of $12 per hour (Grisso, 2012).

A profit maximizing linear programming model was formulated to solve for the optimal production choice on the farm. A corn, barley, and soybean crop rotation and a corn, wheat, and soybean rotation have calculated net returns for all of the cropping options (both with and without BMPs in place).

Variables were assigned to account for nitrogen and phosphorous reductions credits for each crop rotation and land conversion BMP. Separate costs of land conversion and land conversion credits received were also included. The resulting objective function is as follows:

(1)

$$MAX\pi = (NR_i * CROP_i) + \Sigma (NR_{ik} * CROP_{ik}) + \Sigma (P_{ncredit} * REDUCTION_{ik}) + \Sigma (P_{pcredit} * REDUCTION_{ik}) - \Sigma (COST_{landconv}) + \Sigma (P_{ncredit} * REDUCTION_{landconv}) + \Sigma (P_{pcredit} * REDUCTION_{landconv})$$

Where:
$CROP_{ik}$ = cropping rotation i with BMP k
NR_{ik} = per acre net returns for crop rotation i with BMP k
$P_{ncredit}$=credit price of nitrogen (multiply by 2 for every BMP except for 15% nitrogen reduction on corn)
$P_{pcredit}$ = credit price of phosphorous (multiply by 2 for every BMP)
$cost_{landconv}$= the cost of land conversion BMPs

Constraints for the math-programming model consist of a land constraint and 25 nutrient credit constraints. Credit constraints are added in order to assign the correct amount of nutrient reduction credits to each BMP and land conversion technique.

RESULTS AND DISCUSSION

The results of the math-programming model show that the farmer chooses a corn, barley, and soybean rotation using the no-tillage BMP on all 625 acres. Table 2 shows the BMPs that the model farmer would supply given different nitrogen credit price. The modeled farm would produce 537.5 nutrient credits using no-till regardless of the price of the credits. Using the prices and production response data used in the model, no-till increases net revenue with or without the trading program.

Table 2: Nutrient Credit Supply Response for Representative Grain Farm (Rappahannock)

Nitrogen Credit Price*	# Credits Generated	BMPs used to generated
$5	537.5	No Till
$10	537.5	No Till
$15	537.5	No Till
$20	537.5	No Till
$25	537.5	No Till
$30	2587.5	15% Nitrogen Reduction on Corn and No Till
$35	2587.5	15% Nitrogen Reduction on Corn and No Till
$40	2587.5	15% Nitrogen Reduction on Corn and No Till
$45	2587.5	15% Nitrogen Reduction on Corn and No Till
$50	2587.5	15% Nitrogen Reduction on Corn and No Till
$55	2587.5	15% Nitrogen Reduction on Corn and No Till
$60	2587.5	15% Nitrogen Reduction on Corn and No Till
$65	2587.5	15% Nitrogen Reduction on Corn and No Till
$70	2587.5	15% Nitrogen Reduction on Corn and No Till
$75	2587.5	15% Nitrogen Reduction on Corn and No Till
$80	2587.5	15% Nitrogen Reduction on Corn and No Till
$85	2587.5	15% Nitrogen Reduction on Corn and No Till
$90	2587.5	15% Nitrogen Reduction on Corn and No Till
$95	2587.5	15% Nitrogen Reduction on Corn and No Till
$100	2587.5	15% Nitrogen Reduction on Corn and No Till

*Assuming P credit = $20

This research suggests that a representative grain operation located in the Rappahannock Watershed (East of I-95) would choose to take part in the 2005 Nutrient Credit Exchange Program under very limited circumstances. The model calculates that prices would need to exceed $25/credit before the farm would be willing to supply additional credits beyond no-till (see Table 2). Even at very high credit prices, the model suggests farmers would not participate in the trading program by providing early crops.

In many respects, these are best case scenarios for farmer participation. Many assumptions were made in this model that minimized farmer participation costs. The model assumes that the model farm is already at the baseline when most farmers would have costs associated with implementing necessary nutrient reduction enhancements in order to reach the baseline. Virginia state baseline specifications may even require farmers to convert to no-tillage farming as a procedure to reach the baseline, which eliminates the ability to use the no-tillage BMP in the trading program. The model also assumes zero transaction costs for participating in the credit trading program.

Even under these best case scenario conditions, nutrient credits generate a very small fraction of the total revenue from the farm operation. Limited price data suggests that nitrogen credit prices in the $5 to $10 range. At these prices, the nutrient trading program generates between $2,500 to $5,000 per year in total revenue for a farm operation that generates about $2,500 per acre in total revenue (excluding fixed costs). Transaction costs for establishing even simple contracts could easily exceed total credit revenue.

The information used to determine the differences in yields and costs with different BMPs were not all from Virginia or done in one comprehensive study. Thus, adjustments made to yields and costs may not all be appropriate for the Rappahannock area. It is particularly important to note that the cost of adapting no-tillage farming which may not be representative of the true cost making the no till BMP more appealing in the model than in actuality.

The low participation level is likely due to the high cost of entry through reaching the baseline, opportunity costs associated with high crop prices, and a 2:1 trading ratio. The results are consistent with the lack of participation observed in other point-nonpoint source trading programs implemented across the country. Given that point source credits are trading for less than $5/lb/yr in Virginia and Pennsylvania suggests that the frequent assumption that nonpoint source credits are low cost compliance option for regulated sources may not the be case in some nutrient trading programs.

FURTHER RESEARCH

In order for farmers take part in the Nutrient Credit Exchange Program they must at least break even monetarily. This research suggests a farm at the baseline will have net losses with all but one BMP. Additional research should consider the cost of reaching baseline. More information is also needed on the transaction costs of participating in the trading program. A more comprehensive, specified research project could help inform policy-makers in Virginia about the credit prices necessary to induce widespread agricultural particiatipion in a trading program. A more comprehensive study of all Nutrient Credit Exchange Program BMPs in the Virginia area would also investigate the credit supply sensitivity to changes in costs, yields, and crop prices.

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