THE EFFECT OF BASELINES ON PERFORMANCE BASED WATER QUALITY TRADING PROGRAMS

by

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Agriculture and Resource Economics

Summer 2015

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ACKNOWLEDGMENTS

I would like to thank Dr. Joshua Duke for all his help and support throughout my time at the University of Delaware. I would also like to thank Tianhang Gao, Jenny Egan, Wenbo Liu, and Zhongyuan Liu for all their help as well.

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ABSTRACT

Nonpoint source pollution has become a problem in the United States and around the World. The Clean Water Act of 1972 does not regulate nonpoint polluters, but it does regulate point source polluters. As nonpoint source pollution has worsened and become more visible many different economic approaches have been tested to reduce pollution levels. One approach is nonpoint to point trading. This research focuses on nonpoint to point water quality trading in the Chesapeake Bay, and specifically the baseline level set to meet in order to qualify to trade. This research will argue and show that performance set baselines perform better than practice set baselines. This will be shown using theoretical models as well as collecting empirical data through Maryland's water quality trading website. Contrary to previous research, this research will show that high load or "dirty" farms will participate in the trading market if there is a performance baseline not a practice baseline, also some high load fields will perform better in the market than low load fields. The performance baseline improves the efficiency of the market, as well as increases participation, and brings down the cost of credits sold on the market.

Chapter 1

INTRODUCTION

Since the establishment of the Clean Water Act in 1972, point source polluters have had their pollution emissions regulated. The Act, however, does not regulate nonpoint source polluters. This lack of regulation has created a problem of finding an effective and efficient way to control nonpoint source pollution. Because of this nonpoint source pollution has become a much debated topic within the environmental economics community. Nonpoint source pollution is a major hindrance to the improvement of water quality. In the Chesapeake Bay, 42% of nitrogen and 54% of phosphorous loads in the bay are attributed to agricultural nonpoint sources (Van Houtven et al. 2012). In 2010, the EPA announced a TMDL (total maximum daily load) of nitrogen, phosphorous, and sediment for the Chesapeake Bay (Van Houtven et al. 2012). Nutrient trading has been identified as an efficient option to reach the TMDL goal (Van Houtven et al. 2012). However, there may be unanticipated problems with nutrient trading.

Chapter 2

ECONOMIC APPROACHES TO REDUCE NONPOINT POLLUTION

2.1 General Approaches

There have been many different proposed economic instruments to deal with nonpoint pollution, emission proxies, input-based instruments, and ambient pollution levels have all been analyzed as ways to control nonpoint sources (Shortle and Horan 2001). Recently, nutrient trading has become a focus of research in the attempt to improve water quality. Nutrient trading has been used in other aspects of pollution including SO2 and carbon emissions. Trading has been accepted by some as a potentially cost effective approach to meeting environmental goals and, therefore, is being studied further as a way to reduce water pollution (Shortle and Horan 2001).

2.2 Point-Non Point Trading

The intuition behind point-nonpoint water quality trading is that the nonpoint sources will be able to reduce emissions at a lower cost than point sources. Nonpoint sources are believed to have lower marginal abatement costs than point sources. This is because it is assumed that point sources will need a large investment in new technology or infrastructure to reduce emissions, while nonpoint sources can make small changes such as planting a small strip of grass on farmland. Therefore, the nonpoint source will reduce emissions and earn tradable permits that they would sell to the points at a cost lower than the cost for the point source to reduce emissions itself. This intuition is the driving force behind trading because it is believed that this will lead to environmental goals being met at the lowest social cost (Shortle and Horan 2001).

Regional trading programs have been established throughout the United States and internationally. Many of these trading programs have limited participation with little trading activity. This was mostly due to the lack confidence and high uncertainty with the programs (Shortle 2013). However, many attribute this to the design of the programs, but they can be improved to increase the amount of trading and have markets perform as intended (Shortle 2013). One important factor that may improve these trading programs is whether the baseline is set by a performance or practice standard.

2.2.1 Program Design

Trading is being used in the Chesapeake Bay watershed, but no watershed-wide trading program has been announced. Instead, each state within the watershed is developing its own watershed implementation plan to meet its specific TMDL (Van Houtven et al. 2012). In Maryland, Virginia, and Pennsylvania the markets operate differently because of heterogeneous program design (Branosky et al. 2011). Baseline selection is one of the major aspects of program design that lead to differing market behaviors. The baseline level or requirements are the minimum performance goals or practices that need to be met in order for a farmer to be qualified to trade credits (Wainger 2012). Baselines are beginning to receive more attention in research because of the importance setting a baseline has on trading programs.

The main reason for setting baselines is to try to help meet the TMDL goal (Wainger 2012). A baseline may require a nonpoint to reduce emissions to a set level before permits can be traded. Another reason for baselines is to limit the amount of non-additional credits awarded to farmers. Non-additional credits are those awarded for emission reductions that would have occurred even if no trading program was established (Marshall and Weinberg 2012). "Giving credits or payments for changes that have already been implemented, or are likely to be implemented soon even in the absence of the program, can undermine the environmental gains expected from the program" (Marshall and Weinberg 2012). If there is a weak baseline that does not cause farmer to lower emissions beyond existing future plans, then non-additional credits can be awarded and environmental goals may not be met. In other words, if the baseline is not strict enough to cause the farmer to reduce emissions beyond a level that was previously planned the farmer will be awarded for something they would have done without trading. Also the farmer will trade credits with the point source that were already removed therefore adding emissions back into the water source. This occurs because a trade involving a non-additional credit gives the purchaser of the credit the right to add the loading which has been previously removed prior to baseline being set, back into the water body (Miller and Duke 2013; Duke et al. 2014).

2.3 Carbon Markets

Carbon trading markets have also been analyzed to determine whether baselines can affect the performance of trading programs. Carbon markets differ in how the baseline level is set when compared with water quality trading. Carbon markets use mostly historical, average industry or future emissions when setting baselines (Fischer 2005). But many similar problems arise within water quality and carbon trading markets. The clean development mechanism (CDM) was established under the Kyoto protocol to be an offset trading program for the carbon market (Strand and Rosendahl 2012). The trading that occurs in the carbon market is similar to the water quality market, the trades occur between annex B countries that have a cap, which resemble point sources, and non-annex B countries that do not have a cap which resemble nonpoint sources.

As with water quality trading the carbon trading market is worried about additionality as well. If the baseline is not stringent enough to where countries will limit their emissions to a level lower than planned, non-additional credits will be awarded and emissions may increase. If the baseline is too strict countries may not participate in the program (Fischer 2005). The carbon market literature also finds that when setting a baseline, there is a balance between efficiency of the market and environmental damage. This result is also seen within the water quality trading markets (Millard-Ball 2012).

Chapter 3

PERFORMANCE VS. PRACTICE BASELINES

In the Chesapeake Bay watershed, there are two main baselines used. The first is performance based. Each farm is required to meet a specific quantity of nutrients that need to be reduced in order to trade (MD). The second baseline is the practice based baseline. Under the practice baseline, all farms must establish certain pollution control practices or BMPs before trading can occur (PA, VA) (Wainger 2012). PA and VA do have different BMP requirements. For example PA requires a 100 ft. manure setback while VA requires cereal cover crops (Branosky et al. 2011). Performance and practice baselines are part of a subset of baselines called minimum standards or “M” baselines (Ghosh et al. 2011). These baselines require that some minimum standard of performance or practice be achieved before trading can be allowed. Another type of baseline is the date based or “D” baseline in which any changes made to reduce emissions after a specific date are considered creditable (Ghosh et al. 2011). A description of baselines can be found in Appendix A on page 28 in Table 1.

These different baseline options cause different outcomes with regards to credit generation and additionality (Marshall and Weinberg 2012). Equity and efficiency are also affected, which directly impact participation and environmental quality (Miller and Duke 2013). The M baseline is more equitable because it rewards those farmers who meet all requirements necessary to trade (herein, termed “low load farms”) while forcing those farms who do not qualify to trade to meet the requirements (termed “high load farms”) (Ghosh et al. 2011). Because of this high load farms must incur some cost to meet baseline and, therefore trade their credits at a higher price than low load farms. This gives low load farms an advantage in the market because their credits can be supplied at a lower price. However, because there is an extra cost to high load farms, some may chose not to participate in the program. The D baseline could be more efficient but less equitable than the M baseline; this is because more load reduction will be available at a lower price (Ghosh et al. 2011). Those farms that probably can reduce the most load at the cheapest price are high load farms under the M baseline, but they may not participate because there is a cost to meeting baseline. The high load farms, if able to provide the low cost credits, will have an advantage in the market, but this is how the D baseline is less equitable. It gives the advantage to the high load farms and not the low load farms that have a low load prior to the program being established. The analysis of equity and efficiency within water quality trading will be discussed further in the discussion of the research done by Ghosh et al. (2011).

Nonpoint sources should be able to reduce emissions cheaper than point sources but the selection of baseline can greatly affect the cost of nonpoint source credits (Ribaudo and Gottlieb 2011). If baselines are too strict and farmers forego participation, the TMDL goal will not be met and the cheapest credits will not be available (Wainger 2012). The entry cost to meeting this strict baseline will adversely affect the efficiency of the market and participation (Ribaudo and Gottlieb 2011; Shortle 2012). “Economic theory and research suggest that trading programs are more efficient when barriers to entry in the form of baseline pollution-reduction requirements are eliminated” (Shortle 2013). This thought suggests that the baseline that is the least restrictive on participants while still achieving the environmental goals of the program is best. However, this may lead to non-additional credits being awarded because farmers may have already considered reducing emissions to the less restrictive baseline level.

Chapter 4

EXISTING BASELINE RESEARCH

Many researchers that have studied baselines have done so theoretically, without any empirical data to test theories. One analysis that does use a real life example is the examination of one of the earliest water quality trading programs, which was developed in the Tar-Pamlico estuary of North Carolina. This program used a performance baseline rather than a practice baseline. This led to reduced costs of compliance of meeting baseline as well as encouraged innovation to meet emission goals, leading to higher participation levels (Wainger 2012). However, there is no comparison as to what would have occurred if a practice baseline was used instead.

The main research on baselines was done by Ghosh et al. (2011) when they compared the M and D baseline for Pennsylvania's practice base trading program. They established that the choice between M and D baseline became a choice between efficiency and equity (Ghosh et al. 2011). They theorized that under the M baseline the poor steward (high load) farms, those who did not meet the minimum requirements and therefore could not trade, were priced out of the market. They derived this theory because they felt the cost of meeting baseline so costly to high load farms that in turn they would have to sell their credits at a high price to pay for the cost of implementing the BMPs. The high load farms would therefore be selling their credits at a higher price than the good steward (low load) farms, which would make the expensive high load farm credits undesirable to potential buyers. Low load farms are those that meet all M baseline criteria. For Pennsylvania's trading program this means adopting all necessary BMPs. The M baseline is equitable but not efficient because the low farms are rewarded for having a low load (Ghosh et al. 2011). Under the D baseline the high load farms can provide their credits cheaply because they have all options available to reduce emissions. They are not forced to adopt certain BMPs as with the M baseline. The farms can choose the best option for themselves. The low load farms under the D baseline are nearly priced out of the market because the high load farms will now be able to provide credits cheaper than the low load farms. Some low load farms still may be able to provide cheap credits by taking advantage of any "low hanging fruit" that are available. Low hanging fruit are cheap BMPs that low load farms can use to earn low cost credits. The cheaper credits cause the D baseline to be more efficient but less equitable than the M (Ghosh et al. 2011). The D is less equitable because the low load farms who adopted BMPs voluntarily and met all requirements do not receive much benefit for their actions, while the high load farms who took no previous action receive most of the benefit.

Ghosh et al. (2011) tested their theory using stylized dairy farms in the Conestoga watershed. A model used to test the theories found similar results. The D baseline is more inequitable but not as much as previously thought; the low load farms are still competitive because of low hanging fruit. Also the M baseline eliminates many low cost credits, raises the cost of credits, reduces the number of credits for trade, and does not give incentive for high load farms to join the trading program (Ghosh et al. 2011). More credits were available and at a cheaper price under the D just because of the change from M to D baseline, proving that baselines have major effects on trading programs. Ghosh et al. (2011), therefore, support the use of a D baseline.

Chapter 5

THE PROBLEM

Low load and high load farms are vague terms used to categorize prospective nonpoint traders. It is assumed that low load farms have adopted BMPs or changed their farming practices to meet an M baseline, but this may not be true. A farm may have little ability to change its classification. The low load of a “clean” farm may be the result of many different factors. Two possible reasons for a low load may be the soil of the farm absorbs nutrients well and the type of crops that are planted may require less fertilizer. The high load of a “dirty” farm may be caused by poor soil, the farm may also raise cattle which would lead to high levels of nutrients. Because of these factors, the equity of a baseline and trading program should be a secondary concern. The ultimate goal should be cost effectiveness. But regulators choose a baseline to maximize results they deem most important, which can have efficiency implications (Miller and Duke 2013).

This research will examine the effect of baselines on Maryland’s performance based nutrient trading program, as well as the differences between performance and practice based trading programs. Previous research by Ghosh et al. (2011) was done in Pennsylvania, which has a practice-based baseline. No research has been done to look at the effect a change in baseline would have on a performance baseline such as in the Maryland nutrient trading program.

To test how baselines affect performance based trading programs, this study will first use theoretical models. The goal of the theoretical model is to demonstrate how high load farms may behave differently in performance-based programs as compared to practice-based trading programs. Specifically the model's purpose is to show that it is possible that some high load farms might supply credits cheaper than low load farms under the performance M baseline. This frames a theoretical hypothesis. With the hypothesis, empirical data collected from Maryland's nutrient trading program website will be used to test the validity of the hypotheses. The data will be used to compare the differences in behavior between low and high load farms under a performance-based and practice-based M baseline. Also, the models and data will be used to show how inefficiencies within trading programs can be corrected using policy, such as a subsidy.

Chapter 6

METHODS

6.1 Building the Model

Ghosh et al. (2011) assumed that high load farms would not participate in an M baseline-trading program because the cost to meet the baseline would be so high that supplying credits would be too costly to compete with low load farms. But this may not be true in practice. Under both a practice and a performance baseline a high load farm may reduce pollutants at a lower cost than a low load farm. This may occur more frequently under a performance baseline because of the options available to farmers. The ability of the farmer to use any option to meet baseline will cause the cost of meeting baseline to drop, therefore the farmer will be able to sell credits at a cheaper price. This causes high load farms to be more competitive in the market than first thought.

The pollution control model (figure B.1) can be used to show how a high load farm can supply credits cheaper than a low load farm within a performance baseline. The model is set with the horizontal axis representing abatement of nutrients and emissions of nutrients. As the farm moves toward the origin emissions fall and abatement rises. The vertical axis represents the cost to the farm to abate emissions. The MAC is the farm's individual marginal abatement cost curve, and the M baseline is the maximum level of emission a farm may have to trade credits under a performance baseline.

6.2 The Model

Figure B.1 on page 29 shows a low load farm under a performance baseline and figure B.2 on page 30 shows a high load farm under a performance baseline. Both figure 1 and 2 show two possible MAC curves for each farm. In figure 1, both MAC curves start with the same emissions below the baseline level but the curves both have different slopes. In figure 2, both MAC curves have the same emission level above the baseline level and the MAC curves also have different slopes. These farms are given different slopes because it is not known what the exact MAC curve is for each farm. What is known is their initial level of emissions. One reason for the heterogeneity in slopes or cost to reduce emissions is that the performance baseline allows the farmer to use any means to reduce emissions. This differs from implementing specific BMPs which occurs under a practice baseline. The initial level of emissions is also very important in determining the cost in which a farm may provide credits. If a farm is near the baseline level, whether above or below, the farm will be able to supply credits cheaply, but if the farm is drastically above or below baseline providing credits may be expensive. If a farm is drastically above baseline the cost to reach baseline will be high because the load that needs to be reduced, causing the credit prices to be high. If a farm is far below baseline reducing load any further may prove to be difficult and therefore costly, causing credit prices to rise, these results are unique to an M baseline.

Figure 1 shows a low load farm far below the baseline with a MAC that rises quickly as it becomes more difficult and costly to reduce emissions. It becomes more difficult to reduce emissions because farmers have fewer options and fewer emissions to abate. The farmer may have implemented BMPs already. Also a given BMP is likely to have a greater effect in reducing emissions on a high load farm than a low load farm. Figure 2 shows a high load farm that is just above baseline that can supply credits at a cheaper price than a low load farm that is below baseline. Using MAC2 in figure 2 the high load farm will supply one credit at a cost of the area C+E, which is the area from the initial emission level (e2) above baseline to e* designating an emissions reduction that earns one credit to the farm. While the low load farm supplies one credit at cost A. The area of A in figure 2 is greater than C+E, showing that it is more costly for the low load farm to provide one credit. This insight was first developed by Dr. Joshua Duke and will be expanded in this research.

6.3 Comparison of Low and High Load Farms

This result demonstrates that under a performance M baseline, high load farms can supply cheap credits that are not possible under a practice M baseline. As previously noted in the model constructed by Ghosh et al. (2011) high load farms did not supply credits because of the high cost to meet baseline. The specific BMPs that had to be adopted may not be the most efficient. This causes the credit price of high load farms to be high and reduces participation. With the performance baseline high load farms can use any option to reduce load. The farmer will choose the most efficient way to reduce load and achieve the most reduction at the lowest cost. With the ability to supply cheap credits high load farms will be given the proper incentive to participate in the trading program because they can compete with low load farms. This result may not hold for all high load farms and the difference between a performance-based and practice-based may not be drastic, but the use of a practice-based M baseline does cause a loss in efficiency as compared to a performance-based M baseline.

These results show that high load farms might be competitive in the trading market under M baselines that previously thought. Figure B.3 on page 31 shows a representation of the model of a practice-based M baseline used by Ghosh et al. (2011) where high load farms do not supply credits because of their high cost to meet baseline. Ghosh et al. (2011) represents this by having the intercept of the high load farms under a practice based M baseline so high that the dirty farms cannot participate in the market at all because of their high price relative to the low load farms. This high intercept is due to all the initial costs farmers must undertake to meet the practice baseline.

Figure B.4 on page 32 shows that the intercept under a performance M baseline may not be as high as assumed by Ghosh et al. (2011). This is because of the low-cost or highly responsive BMP options available to high load farmers. The high load farms may be able to compete with the low load farms in this market. The intercept is lower because some high load farms may have lower MAC curves than assumed by Ghosh et al. and generate credits at a lower cost than low load farms. The lower MAC curve of some high load farms will cause the TAC of high load farms to be lower in figure 4 than figure 3. Also, the slope of the high load farms is expected to be flatter than that of low load farms because of the ability for high load farms to reduce emissions cheaply. These two factors can be seen in figure 4 when compared with figure 3. In figure 3, no credits are supplied by the high load farms. Figure 4 shows the lower intercept and slope of high load farms that allows them to supply credits.

6.4 Empirical Method

The data being used for this research will be collected using Maryland's Nutrient Net website. The website is used for calculating how many credits a farmer has earned, or how far above baseline a farm is. To test the previous hypothesis that some high load farms will be able to supply credits at a lower cost than low load farms, all farms in the sample will have their load calculated by nutrient net using agronomic data that will be entered into Nutrient Net. The load is the amount in lbs. of Nitrogen (N) and Phosphorous (P) that each farm is adding to the Chesapeake Bay. This will show what farms are below baseline and what farms are above baseline by calculating each load and comparing that to the baseline level set by Maryland. After it is established who is above and below baseline, a grass buffer will be added to each farm to determine how many credits the farm earns. Using the calculated number of credits of N and P earned and the cost of implementing the BMP, which was estimated using multiple reports, a cost per credit of N and P can be derived for each farm (Duke et al. 2013). The cost for supplying the credits is also used as a minimum price a farmer would be willing to accept for the credit. The cost per credit must be derived for both N and P separately because N and P cannot be aggregated together. For this study, only the cost per credit of N will be analyzed. The equation used to calculate cost per credit is represented here (Duke et al. 2013):

Equation 1.1:

$$c_i^n = \frac{a_i \cdot c_f}{(E_0 - E_f) \cdot dr_i}$$

c_i^n: Unit cost for producing N credits for farm *i* (*i*= 1, 2, . . 189)

a_i: Acreage of grass buffer for farm *i* (*i*= 1, 2, . . 189)

c_f: Cost of grass buffer per acre

E_0: Initial emissions level

E_f: Emissions level with grass buffer

$\left(E_0 - E_f\right)$: Creditable emissions reductions

dr_i: Delivery ratio for field i (i= 1, 2, . . 189)

Using the cost per credit values, we can derive how much it will cost each farm to generate credits. This cost is simply calculated by dividing the cost of generating credits by the amount of credits earned. Using the cost per credit values, we can compare the values of A and C+E from figures 1 and 2. The costs per credit values represent the values of A for low load farms and C+E for high load farms. If A is greater than C+E, the hypotheses from this research will be incorrect and the Ghosh et al. (2011) research will be correct. But if C+E is less than A, the hypotheses of Ghosh et al can be rejected, showing that high load farms can supply credits at a lower price than low load farms.

This research can also be expanded to help create policy to fix the inefficiency created by the trading programs. Inefficiencies arise in these trading programs with M baselines because high load farms that have high costs to meet baseline will not participate. This occurs in both practice and performance baselines. But this research shows that a performance baseline is more efficient than a practice baseline because some high load farms have lower costs than low load farms and therefore will participate. The inefficiency within the performance baseline can be fixed with a subsidy. This subsidy will only be paid to high load farms whose C+E value is higher than every low load farm's A value. These farms will not be expected to participate because of their high costs. Therefore a subsidy will be given to these farms to cover the cost of the E region, which is the cost to meet baseline. The subsidy allows these farms to meet baseline and lower their unit costs for supplying credits. The transfer from tax payers to farmers corrects the inefficiency.

Chapter 7

DATA

Overall, there were data collected on 213 farm fields for this study, 77 were located in Dorchester County and 136 fields were located in Somerset County Maryland. The data will be referred to as fields not farms because whole farms were not collected, only fields within each farm. The sampling was done by selecting a Zip Code in each county and selecting every field in that Zip Code. The agronomic data used in Nutrient Net for this study was collected from a University of Maryland survey conducted by Dr. Josh McGrath, which collected agronomic data from Maryland farmers in various counties throughout Maryland (see Duke et al. 2014). These data give this study a more accurate depiction of what may occur on these fields. Using the data collected an average specific to each county was used for each category in Nutrient Net. For example the amount of Phosphorus in the soil entered into Nutrient Net was an average of each field in that county. All data collected through Nutrient Net was done after the changes done to the site on May 1, 2014.

The only alteration made to the agronomic data for this study was the amount of manure fertilizer applied to each field. This was done because on May 1, 2014, Nutrient Net launched its latest version which significantly reduced the load of pollutants each field produced. So, because of this the amount of manure had to be increased by 100lbs per acre to have some fields be above baseline load for N for this study to be conducted properly. The Maryland Nutrient Management Manual recommends no more than 250lbs of N per acre for corn fields (Maryland Department of Agriculture 2012). All fields in this study were corn fields. Originally, this study was going to use three different levels of N applied 200, 250, and 300lbs per acre. This would represent farmers who follow the Nutrient Management manual, and those who use more and less N than recommended. However, because of the alteration to Nutrient Net the levels had to be increased to 300, 350, and 400lbs per acre.

Of the 213 fields 56 were below baseline for N and 157 were above baseline before the use of a grass buffer. 101 of the 157 above baseline fields earned credit when they applied the grass buffer. So 56 of the fields (26%) never earned any credits available for trade. The average size of each field was 7.52 acres. The average grass buffer size for each field was .74 acres. Each grass buffer had a mandatory width of 45ft. The length of each buffer was specific to each field. The buffer was placed next to any waterway on the field or on the edge of the field.

Chapter 8

RESULTS

Using the equation described earlier the unit cost per credit for each field that earned credits was calculated. The costs per credit for low load field fields had an average of $8.21, and ranged from a high of $17.93 to a low of $6.26, a graphical depiction of this can be seen in figure B.5 on page 33. The costs per credit for high load fields had an average of $16.31 with a range of $91.08 to $6.25; a graphical depiction of the high load fields can be seen in figure B.6 on page 34. These results are not surprising; the average cost is expected to be lower for the low load fields. But as this research hypothesized, some high load fields do supply credits at a lower cost than low load fields, therefore, the hypothesis of Ghosh et al can be rejected. Seventy-seven of the high load fields have a lower credit cost than the highest cost low load field of $17.93. So with these cost figures, 24 of the high load fields will be priced out of the market and unable to compete in the market. These fields will receive the subsidy, which will be analyzed later. Also 28 of the high load fields have a credit cost lower than the average credit cost of low load fields, $8.21. Most importantly the lower cost to provide credits will lead to lower credit costs, which will cause the market to perform properly because the credits will be sold at a low enough cost that the point sources will buy them and allow the market to function. Because of these low costs the high load farmers can provide credits, therefore, this will lead to more credits being available for trade to point sources.

This research shows that a performance baseline does perform differently than a practice baseline. Ghosh et al. (2011) through their research assumed that high load farmers would not participate in the nutrient trading market because the costs would be so high, but that research was done on a practice baseline. This research shows that a performance baseline is more competitive and will lead to a stronger market with more credits and lower cost credits. Also, this research was limited to only adopting grass buffers, under a performance baseline farmers would be able to adopt any practice to limit nutrient load, this would further increase the competitiveness in the market and help high load farmers reduce their costs further. States are moving forward with nutrient trading and they want to ensure that there is participation in these markets. This research shows that a practice baseline can give States the participation they want as well as equity, and better efficiency.

There is some inefficiency within a performance baseline nutrient trading system. This occurs when high load farmers can earn credits but their cost is so high that they are unable to participate in the market. There are 24 fields that fall under this category in this research. These fields will all receive a subsidy to fix the inefficiency and make these fields more competitive in the market. The average size of the subsidy would be $19.29 per credit; the range is $73.14 and $ 0.12. This distribution can be seen in figure B.7 on page 35. For 12 of the fields, the subsidy would be less than $9 per credit, so the subsidies will be cheap and limit the burden on the taxpayer. These few subsidies further the efficiency of this market and further increase the competiveness to have more complete participation at a low cost.

Chapter 9

CONCLUSION

In the limited nutrient trading literature, it has been widely assumed that high load farmers will not participate in any sort of nutrient trading program. Ghosh et al. (2011) is the influential work within the nutrient trading community. Through their research they have derived this same thought that high load farmers will not participate, but they did not account for the type of baseline used in their research. These researches has, and, in doing so has shown that high load farmers will participate in nutrient trading within a baseline set by performance levels and not practice adoption. In many cases, the high load fields will provide credits at a lower cost than low load fields. This result should cause every state to adopt a baseline set by performance standards to increase the levels of participation to the levels they want. The performance baseline also will lower the cost to provide credits and most importantly increase the efficiency of the market.

Nutrient trading is still being developed an analyzed as a potential economic approach to reduce pollutant loads from agricultural sources. There is no general consensus on the best way to implement a trading program to achieve the best results. As noted in this research there has not been many studies done on these trading programs, and their specific details that may alter market performance. In the years to come, as nutrient trading markets are established and become operational more research needs to be done to analyze how these markets perform. But for now we can only conduct research in a theoretical way without any real data to work with, hopefully in the near future nutrient trading will become a success and used throughout the country, and the world, to limit pollution levels.

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Appendix A

TABLES

Table A.1 Description of Baselines

	Performance Baseline	Practice Baseline	“M” Baseline Minimum Standard	“D” Baseline Date Based
Requirements to meet baseline	Meet a specific quantity of nutrients that need to be reduced in order to trade. Subset of “M” baseline	All farms must establish certain pollution control practices or BMPs in order to trade. Subset of “M” baseline	Requires a minimum standard of performance or practice be achieved in order to trade	Any changes to reduce emissions after a specific date are considered creditable

Appendix B

FIGURES

Figure B.1 Marginal Abatement Cost Curve Low Load Farm

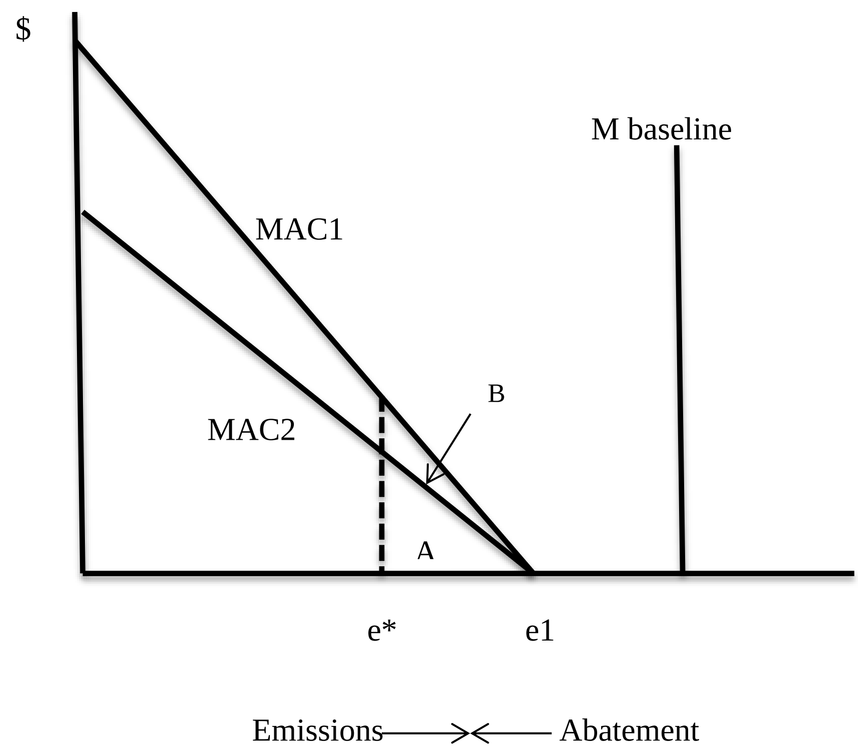

Figure B.2 Marginal Abatement Cost Curve High Load Farm

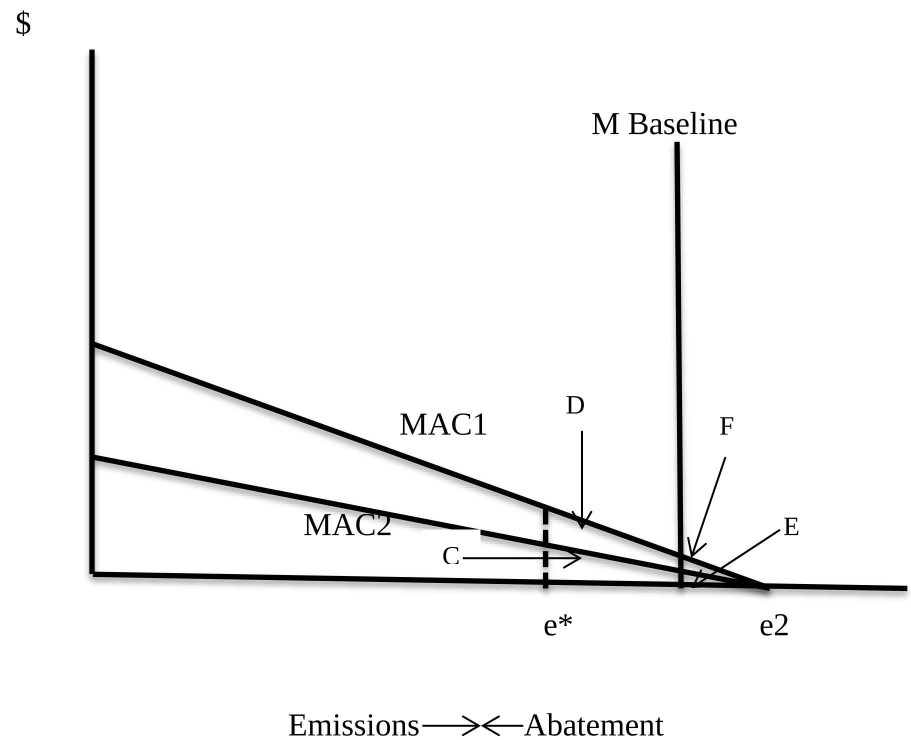

Figure B.3 Permit Market Assumed by Ghosh et al.

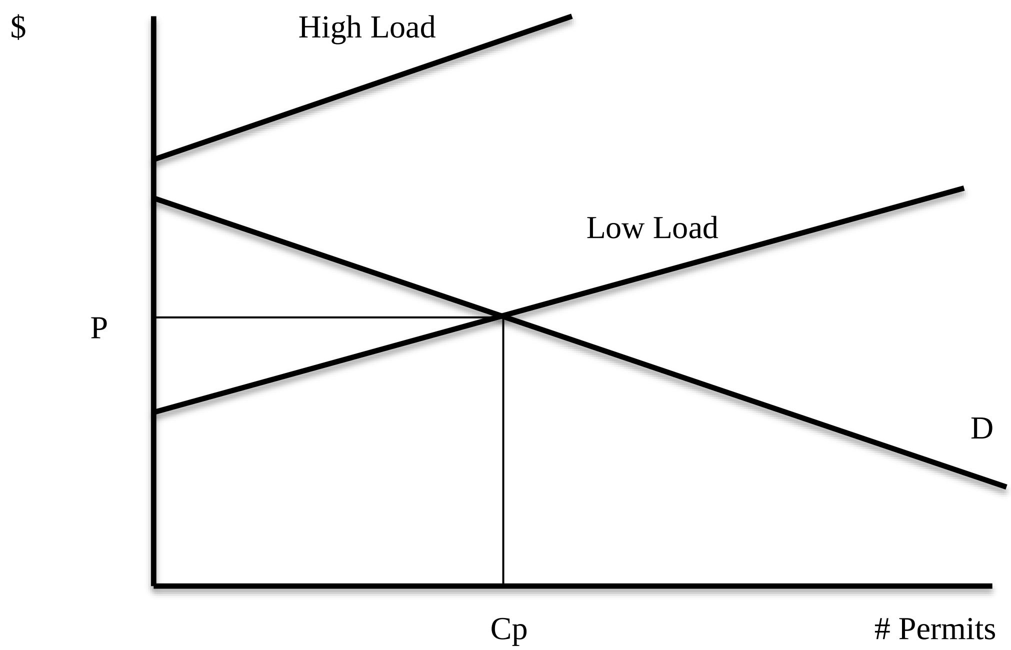

Figure B.4 Permit Market Performance Baseline

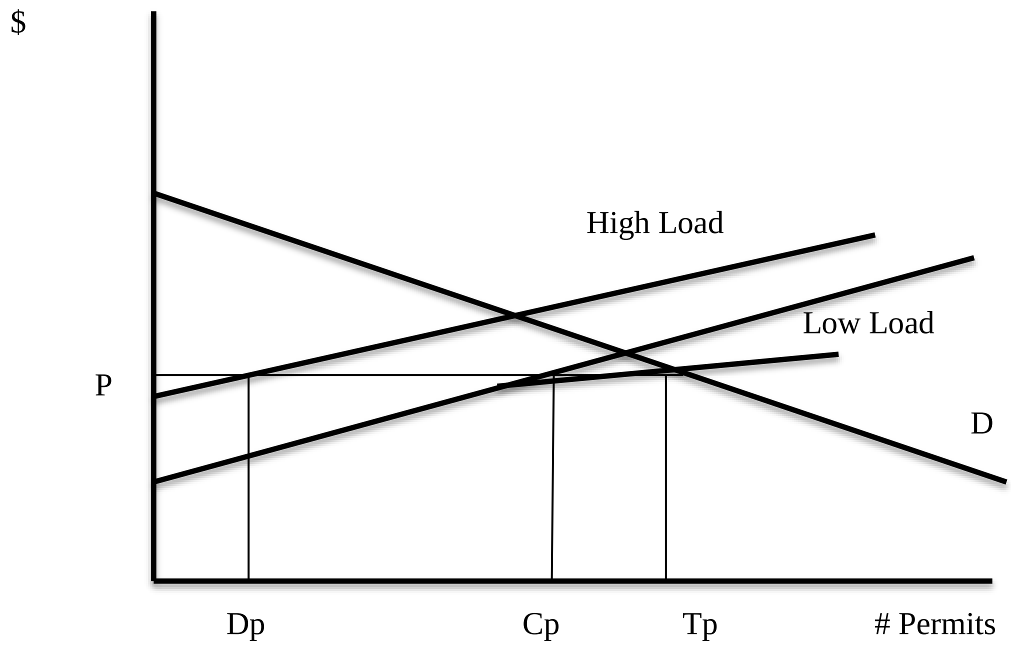

Figure B.5 Cost per Credit distribution of Low Load Fields

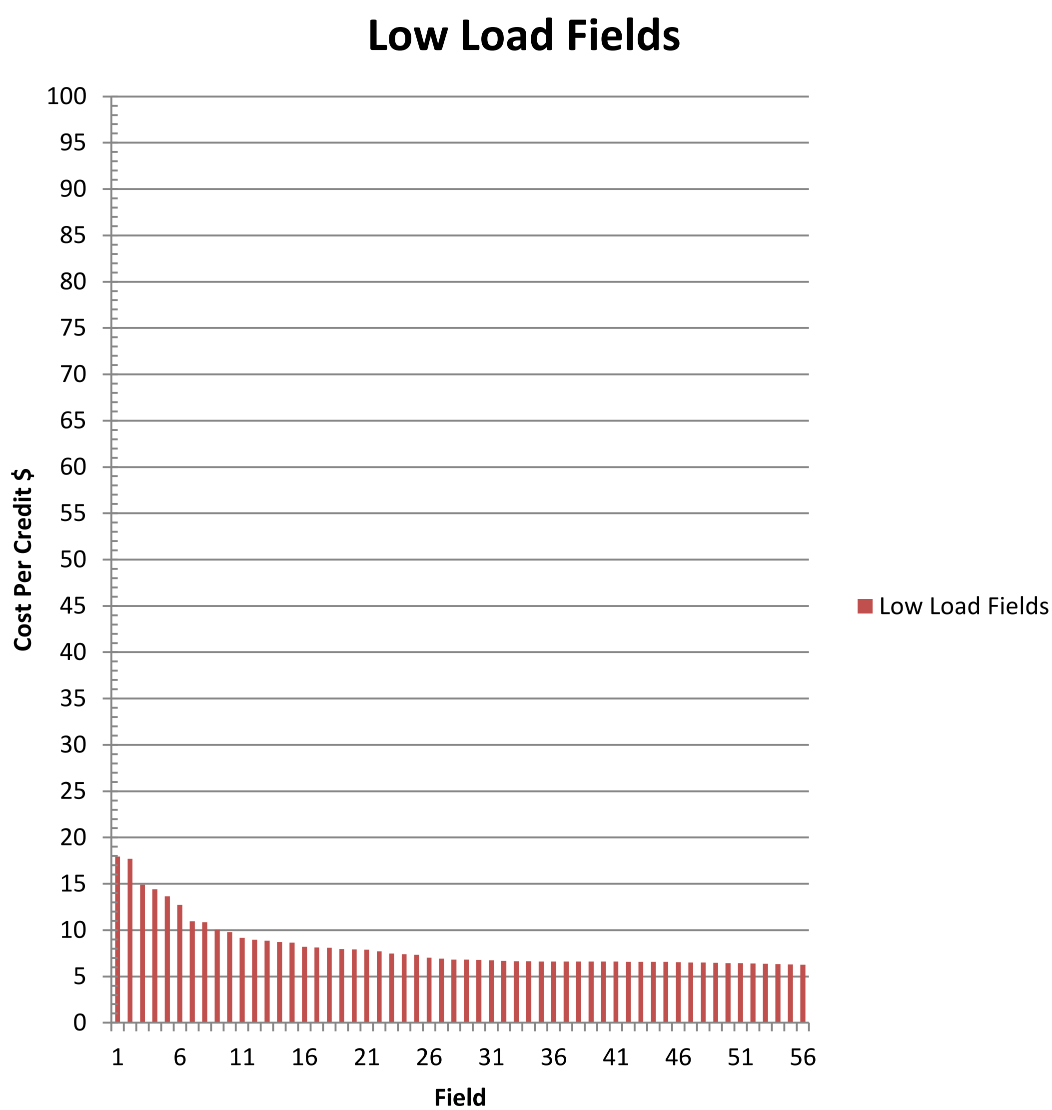

Figure B.6 Cost per Credit Distribution of High LoadFields

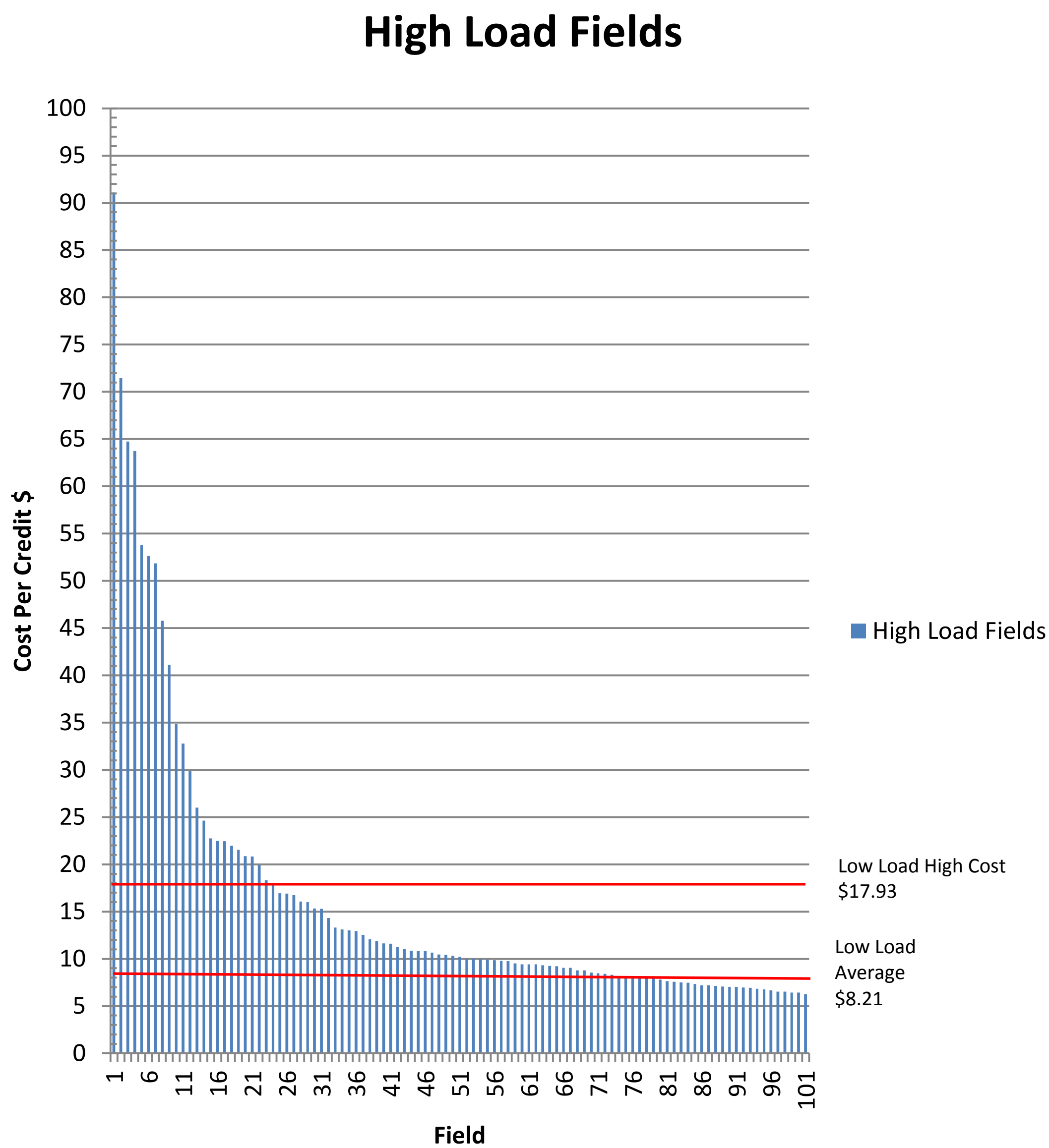

Figure B.7 Subsidy Cost Distribution for High Load Fields