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Nitrogen Permit Trading in North Carolina's Neuse River

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Executive Summary

Definition of the analysed EPI and purpose

This EPI case study analyzes Nitrogen permit trading in North Carolina's Neuse River Basin. This case study was selected to inform the regulation of water quality in the United States under the Clean Water Act. The Clean Water Act covers literally thousands of point sources of water pollution across the United States. Moving from the traditional regulation of these point sources to a properly designed EPI with active trading could potentially generate hundreds of millions of dollars in net benefits to society.

Introduction

The environmental goal of the EPI was to reduce emissions of Nitrogen into the Neuse from municipal waste water treatment plants (WWTP). The EPI was extremely successful in meeting the environmental goal, as actual emissions are 52 percent below the emission target. The economic goal was to minimize the aggregate cost of meeting the emission target by allowing WWTP to trade emission permits. The EPI did not successfully meet the environmental goal for theoretical and practical reasons. The design of the EPI could be improved by restricting trading to occur within zones, rather than having only one single large zone. The practice of the EPI could be improved by encouraging WWTP to make trades. As it stands, very few trades were executed between the WWTP.

Legislative setting and economic background

Under the United States' Clean Water Act, the Neuse River Estuary in North Carolina has been declared a section 303(d) impaired water. In the EPI, the state of North Carolina, in conjunction with the EPA, has crafted a more flexible program than the typical 303(d) regulation. A wastewater plant is given a permit to emit Nitrogen into the Neuse River. This implicitly defines a property right, which the plant may permanently sell or temporarily lease. The trading of these rights is approved by North Carolina statute.

Brief description of results and impacts of the proposed EPI

The EPI met the environmental goal but did not meet the economics goal. Although the EPI did not actually improve economic efficiency, it did generate benefits on several social equity dimensions. In particular, stakeholders report improved public image, information sharing, political representation, and social benefits from participating in the EPI.

Conclusions and lessons learnt

The main lessons learned from the analysis of the EPI are: (1) the cost savings from emissions trading predicted in theory will not be attained in practice unless the stakeholders fully endorse the concept of trading, and (2) cooperation between stakeholders and the various levels of government has the potential to create innovative market approaches to environmental regulations.

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1 EPI Background

Baseline

The impetus for implementing an EPI for nitrogen trading in the Neuse River Basin has its origin in the major fish kills that occurred in 1995 (NCEE 2011). In response, the State of NC government developed a regulatory structure to reduce the flow of Nitrogen into the river. Rulemaking for the reduction of nitrogen was developed by the Environmental Management Commission and administered by the Division of Water Quality (Hamstead 2008). Reduction was targeted from both point and non-point sources, but the rules for point sources contained an interesting provision that generated the EPI. Rather than require that each point source meet an individual emission requirement, the rules allowed polluters to jointly meet an aggregate group emission requirement by forming an association. The members of the association would not be fined by the State of NC as long as the total aggregate emissions of pollution were below the required level (Hamstead 2008). Thus it appears that the Environmental Management Commission was well award of the cost advantages of a "cap and trade" EPI. This case study focuses on a set of 22 point sources known collectively as the Neuse River Compliance Association (NRCA). These are almost entirely WWTP. This association was formed in 2002 in response to the Nitrogen emission rules described above.

The baseline level of emissions for members of the NRCA in 1995 was 1.78 million pounds of Nitrogen per year. This Nitrogen was contained in an outflow of 83,000 MGD from the treatment plants. By 2006, the emissions had been reduced to 0.54 million pounds from an outflow of 102,000 MGD (all data from Hamstead 2008). Although some of the increase in the flow was due to an increase in membership of the NRCA, we can use this data to approximate the counterfactual level of emissions by simply assuming the pound/gallon rate would have remained constant over time. This implies that in the absence of the EPI there would have been 2.19 million pounds of Nitrogen emitted in 2006. This implies the EPI led to a 75% reduction in emissions. As discussed in detail below, the actual levels of trading in the EPI have been low, and so it is likely that a similar level of reduction would have been obtained without the EPI.

Key features

Under the United States' Clean Water Act, the Neuse River Estuary in North Carolina has been declared a section 303(d) impaired water. The typical regulation of 303(d) impaired waters does not meet the criteria for an EPI. The Environmental Protection Agency (EPA) issues an individual emission requirement to each treatment plant which specifies a maximum Nitrogen emission level from that plant. The state of North Carolina, in conjunction with the EPA, has crafted an innovative

EPI that gives the WWTP more flexibility. If a WWTP wants to emit more pollution than it's individual requirement, in can do so provided that it secures a corresponding decrease in emissions from another plant. In this way the WWTP are effectively trading emissions. Through this process of trade, an individual WWTP may no longer meet it's individual requirement, but the aggregate requirement is still met. The intention of the EPI is to lower the costs of compliance with the Clean Water Act by allowing NRCA members to trade emissions.

The trade process is formalized by giving each WWTP a quantity of emissions permits equal to their individual Nitrogen emission requirement. These permits implicitly define a property right, which the plant may permanently sell or temporarily lease. Trading of these rights is approved by a North Carolina statute, although such trading is not explicitly condoned by the Clean Water Act. The WWTP are often owned by local municipalities, so they are not necessarily profit maximizing firms. Even so, it is not unreasonable to assume that their goal is to trade permits in such a way as to minimize their total costs of abatement activities and permit purchases.

There are two levels of enforcement of the EPI. At the external level, the State of NC imposes fines if the aggregate emissions of pollution of the association exceed the aggregate nitrogen emission requirement. At the internal level, the NRCA has a complicated system for allocating fines to its own members if they exceed their individual pre-trade Nitrogen emission requirement. It is important to note that this internal fine system is at odds with the typical pollution permit trading scheme in which firms are fined only if they exceed their post-trade emission requirement. The goal of these internal fines seems to be to induce the individual members to upgrade their facilities, as much of the fine is returned once such improvements are made (Hamstead 2008).

The major stakeholders in the EPI are the WWTP. They were instrumental in convincing the state of North Carolina to implement the aggregate compliance structure found in the EPI (Hamstead 2008).

2 Characterisation of the case study area

Environmental characterization

The Neuse River Basin covers approximately 9% of the state of North Carolina, or 15959 km^2. The land provides multiple uses as 35% is agriculture, 34% is forest, 22% is wetlands and open water, 4 % is scrub growth and barren land, and 5% is developed (NCSU 2011). This region has experienced significant growth over the last 10 years with a decrease in forest land and an increase in development. This trend is expected to continue over the next 10 years (UNRBA 2011).

The Neuse River Basin is NC's third largest. It includes approximately 5000 kilometers of freshwater streams and 228 kilometers of saltwater streams. There are 16 major reservoirs and lakes comprising an area of approximately 75 km^2. The Neuse River itself flows approximately 200 miles. Cities in the Basin receive approximately 127 cm of precipitation per year. (All data from NCDWR 2010).

The main withdraws from the river are for 10 public water systems and two commercial users. Some of these public water systems are expected to experience 50-100% increase in use by 2030. There are 26 municipal wastewater treatment plants (WWTP) that discharge into the Basin. Many of these are expected to experience 50-100% increase in discharges by 2030, due primarily to increases population (All data from NCDWR 2010). In addition to these point sources, emissions from non-point sources also lead to decreases in water quality. The main non-point source emissions are from storm water and agricultural runoff. In particular, there has been a large increase in agricultural runoff from concentrated animal feed operations over the last decade (NCDWQ 2009).

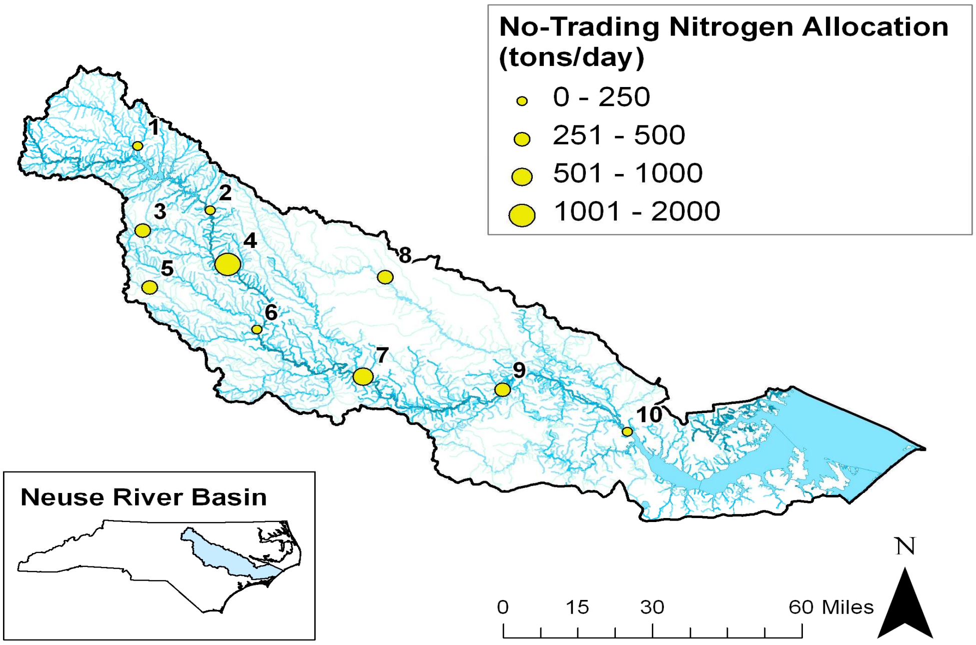
Economic characterization

The Neuse River Basin is home to 1.32 million residents (NCDWQ 2011) which implies a population density of 82.7 people/km^2 . GDP information is typically not available in a form useful for exact calculation for a river basin. Given that the Neuse River Basin incorporates a variety of land use and contains several of the largest cities in the state, it is appropriate to estimate the GDP based on the state level data. This gives a 2010 GDP per capita of $44,500 (calculation from data in BEA 2011 and USCensus 2011).
In 2009, the top 5 economic sectors (with shares of GDP) for North Carolina are: manufacturing (18%), real estate (10%), finance (10%), healthcare (7%) and retail trade (5%) (NCSUIES 2011).

Geographical characterization: United States, North Carolina, Neuse River Basin.

The geographical characterization of the Neuse River Basin is given in Figure 1.1. The main river channel flows southeast and ends at the Estuary. The WWTP are distributed throughout the system with the largest emitter located near the upper end of the main channel.

Figure 1.1
Neuse River Basin and Major Emitters of Nitrogen



3 Assessment Criteria

3.1 Environmental outcomes

The fundamental environmental outcome in this case study is the pounds of Nitrogen emitted by the members of the NRCA. As shown in Table 3.1, there has been a 70 percent reduction in actual emissions of N from 1995 to 2006 (Hamstead 2008). The NRCA was formed in 2002, however, and using this year as an alternative baseline yields a 32 percent reduction in emissions. At face value, this suggests that the EPI has been dramatically successful in reducing emissions. But the aggregate Nitrogen emission requirement assigned to the NRCA is 1,137, 171 pounds. Thus the members are emitting 52 percent less Nitrogen than they are allowed to emit. This indicates significant over compliance, and suggests that there are other reasons for the marked decline in emissions rather than just the EPI.

In particular, it appears that the WWTP are motivated by the dynamic between future population growth and increasingly strict future regulations (Hamstead 2008). Many of the municipalities anticipate significant population growth in the next 20 years. They also anticipate significantly stricter emissions controls over the same time period. In response to this dynamic, they perceive their optimal strategy is to take steps to install abatement capacity now to be ready to meet these future challenges. Hamstead 2008 suggests that this unusually forward-looking behavior on the part of the WWTP is due to a combination of risk aversion, public image incentives, and altruism.

Table 3.1
Yearly Emissions of Nitrogen by Members off NRCA

Year	Total Flow (MGD)	Total Estimate Pounds N to the Estuary
1995	83.808	1,784,130
1996	85.675	1,741,492
1997	81.444	1,653,262
1998	93.442	1,387,717
1999	94.659	1,123,169
2000	92.582	1,056,202
2001	86.818	907,381
2002	89.926	797,991
2003	107.463	711,398
2004	101.203	558,553
2005	101.757	566,627
2006	102.970	542,205

3.2 Economic Assessment Criteria

There is no evidence that a formal cost-benefit analysis of the EPI was performed before implementation. It is clear, however, that the stakeholders explicitly considered the EPI in relation to the existing command and control regulation. Under the Clean Water Act, the Neuse River is classified as a section 303(d) impaired water. In the typical regulation of 303(d) impaired waters, the EPA issues an individual emission requirement to a WWTP which specifies a maximum emission level from that WWTP (Yates et al 2011). This gives the WWTP very little flexibility to meet the requirements of the regulation. In contrast, the EPI is centered around an aggregate emissions requirement. This specifies the total emissions across all members in the NRCA. As long as the total emissions are below this requirement, the group is considered to be in compliance with the regulation. An important feature, however, is that each member is still given an individual emissions requirement, and, as discussed above, the internal system of fines within the NRCA is based on this individual requirement. The members of the NRCA were instrumental in convincing the EPA and the Division of Water Quality in NC to set up the group permit system (Hamstead 2008).

Regulation with an aggregate emissions requirement has the potential to generate significant cost savings for the members of the NRCA relative to the command and control alternative. If one WWTP faces high costs of abating pollution, then it can simply buy emission reductions from another WWTP which presumably has lower costs. This generates abatement costs savings relative to the alternative in which each WWTP has to meet their own individual emission requirement. A simple aggregate emissions requirement, however, is not the least cost EPI available. Yates et al (2011) describe a system in which the aggregate emissions requirement is further subdivided into zones. WWTP within a zone may trade emissions with one another, but WWTP in different zones may not. The zonal system strikes a balance between reduced abatement costs and increases in "hot spots". (One can think of the actual EPI, with a simple aggregate emission requirement, as a special case of the zone system in which there is only a single zone.) Allowing WWTP to trade within a zone reduces abatement costs in the manner described above: high cost WWTP can trade with low cost WWTP to the benefit of both. Using zones rather than a single aggregate emission requirement allows a greater control over the spatial distribution of emissions. This reduces the likelihood of a large concentration of emissions in a specific part of the river.

In theory, the ability to trade means that some WWTP would not have to undertake costly abatement. In actual practice, there has been very little trading in the EPI. Apparently the WWTP do not view trading as a method for reducing aggregate abatement costs. Rather, they view trading as a short-term measure. If a WWTP is emitting more than their individual emissions requirement, they can use trading as a temporary fix until they can reduce their emissions (Hamstead 2008). As a result, there have been very few actual trades and so the cost savings of the EPI seem to be minimal.

In the absence of abatement cost savings, the primary benefit of the EPI seems to be related to risk reduction, both in the short term and the long term. In the short term, despite the provisions for trading, the WWTP seem to view it as their responsibility to meet their own individual emission requirement. (This is reinforced by the internal fine structure described above.) The few trades that took place appear to have been motivated as "insurance" against the possibility that they might be temporarily out of compliance with their individual requirement. In the long term, due to the increases in population and the stringency of anticipated future regulation, the WWTP like having the option of trading in case they have trouble meeting future emission requirements (Hamstead 2008).

The EPI did not generate any revenues for the local or national government. The few trades that took place simply transferred money from one WWTP to another. Alternatively, the individual emissions requirements could have been sold the WWTP at the start of the program to generate revenue for the State of NC.

The EPI seems to have provided the correct incentives in theory, but not in practice. In the case of this EPI, the correct incentives would lead the WWTP to meet the group emission requirement in the least cost way. All of the theoretical requirements for this to happen are found in the EPI. In fact, the EPI seems to be a classic example of a cap and trade permit market. The actual experience, however, shows that there is a subtle requirement needed to insure that the EPI is successful. In particular, the WWTP have to fully accept the group emission concept. It appears that they did not, as they still felt bound to meet their individual requirement. It will be interesting to see if this changes over time. At the current time, in light of the data in Table 3.1, it appears that it is rather easy for the WWTP to meet their individual emission requirements. Thus the WWTP were not really forced to consider how abatement costs could be reduced by moving from individual to group compliance. This will probably change in the future, as the regulations become increasingly stringent. Thus one would expect there to be an increase in trading activity as emission constraints become more binding and WWTP come to realize that trading will enable them to reduce abatement costs.

3.3 Distributional Effects and Social Equity

This EPI is tightly focused on the WWTP in the NRCA. The distributional effects and social equity are therefore defined solely with respect to the WWTP. Based on qualitative interviews with participants in the EPI summarized by Hamstead (2008), we can identify four components of distributional effects and social equity. The directions of change for these components are summarized in Table 3.2. A more detailed explanation for these assessments is as follows:

1. Public Image. Participants recognized that public image associated with the EPI could be positive or negative, depending on the emissions outcomes. In practice, the emissions have decreased significantly, so the effect is considered to be positive.
2. Information Sharing. The EPI has provided a forum for both formal and informal information sharing between WWTP. The information includes specific abatement practices and technology as well as insight into the regulatory process.
3. Political Representation. The EPI has created a unified group that represents the interests of the WWTP. This group has more political influence than the individual members would have if they acted alone.
4. Social Benefit. Before the EPI, the WWTP has isolated individual relationships with each other. After the implementation of the EPI, the WWTP began to feel united in working toward a common goal. Interestingly, this common goal seems have been viewed as helping each other meet their individual emission requirements.

Table 3.2 Distributional Effects and Social Equity

Stakeholders: WWTP	Type of Measure	Direction of Change
Public Image	Qualitative	+
Social connections	Qualitative	+
Political representation	Qualitative	+
Information sharing	Qualitative	+

3.4 Institutions

In the United States, emissions of water pollution from point sources are governed by the Clean Water Act. This was enacted in 1972, but the origin can be traced to the 1948 Federal Water Pollution Control Act. Under the Clean Water Act, an emitter must obtain a National Pollutant Discharge Elimination System (NPDES) permit (USEPA 2011). The actual administration of the NPDES permit is usually undertaken by individual states, as is the case in North Carolina. In North Carolina, the Division of Water Quality is the responsible state agency (NCDENR 2011).

In 2003, the EPA officially issued a new water quality policy to encourage trading between point sources in watersheds with an approved aggregate emission requirement (known as the Total Maximal Daily Load, or TMDL) (Boyd et al 2003). This policy can be viewed within the context of wider use of pollution permits by the EPA after the successful implementation of S02 permit trading in the previous decade.

The TMDL for the Neuse was approved by the EPA in 2002. In that same year, the General Assembly for the state of North Carolina approved a Wastewater Discharge Rule. This rule enabled the formation of the NRCA and allowed it to jointly meet the TMDL rather than strictly comply with the individual NPDES permit (USEPA 2007). Although these developments pre-date the official EPA policy that supported trading, it is likely that the EPA was already encouraging trading in advance of the official policy statement.

The interactions between the EPI and the institutional setting are summarized in Table 3.3. The interactions between the EPI and level 2 institutions are positive. The agreement between the EPA and the legislative and executive branches of the NC state government greatly supported the design and implementation of the EPI. The level 3 institutions had a negative effect on the operation of the EPI. As documented above, there were very few trades that took place. Finally, for the few trades that did take place, prices played their accustomed role in trade. So we rate this a positive interaction for level 4 institutions at the operation phase.

Table 3.3

Interactions between EPI and the Institutional Setting

	Level 2 EPA, NC Division of Water Quality	Level 3 Trading	Level 4 Prices
Design and Implementation	+		
Operation		-	+

3.5 Policy Implementability

The EPI is very flexible, and can easily be adopted widely in other river systems. In these other systems, each large point source is typically allocated a fixed level of Nitrogen emissions (a NPDES permit) by the EPA. To implement the EPI, these individual amounts can be aggregated to determine the total cap on Nitrogen among all the point sources. From this a permit trading system can be set up, either with the type of internal and external enforcement system found in the NRCA, or with a simple external enforcement system more typical of other permit markets. Here each firm must hold enough permits to cover their own emissions or face external fines. Indeed, moving toward this latter type of enforcement may help overcome the problem of limited trading, as it moves the emphasis from meeting requirements on Nitrogen before trading takes place to meeting requirements on Nitrogen after trading takes place.

The EPI can easily be adjusted following a review of its performance or in response to new information about the damages from Nitrogen emissions. For example, if new information reveals that damages are more severe than previously thought, then the size of the aggregate emission requirement can be reduced.

The major stakeholders in the EPI are the WWTP. They were quite successful in influencing the development of the EPI. Their influence seems to stem from the fact that they had cultivated a long relationship with state regulators. Before the NRCA was formed, many of the WWTP belonged to another group called the Lower Neuse Basin Association (LNBA). This group formed in 1994 to monitor emissions of Nitrogen in the Neuse and worked with the state of NC in this capacity. (Hamstead 2008).

The EPI would not have been possible without the cooperation of the North Carolina Division of Water Quality (NC DWQ) and the EPA. The group permit compliance strategy used in the Neuse allows for more flexibility in meeting the requirements of the Clean Water Act.

3.6 Transaction Costs

Unfortunately, little direct information is available about transactions costs of the EPI, so we must rely on indirect evidence. In the absence of the EPI, the DWQ and the NRCA would still have to monitor, report, and enforce emission levels in the Neuse. So for this analysis we focus on just the incremental transactions costs associated with actual trading of emissions. Miller and Wolverton (2005) qualitatively classify transactions costs in a variety of water quality trading programs. Trading in the Neuse River is classified as having a "low" level of transactions costs. The authors further note that most of the transactions costs are assumed by the State of North Carolina, presumably by the DWQ. Other indirect evidence comes from a study of point-nonpoint source trading of water quality permits in Minnesota (Fang et al 2005.) Here the total transactions cost of a single trade across both the permitting and implementing phase is determined to be $105,000. Of this total, approximately $19,000 was incurred by the point source and the vast majority of the rest was incurred by the state agency. For the Neuse, actual transactions costs for point source to point source trading between members of the NRCA should be small (Breetz et al 2004). So we interpret the figure from Fang et al 2005 as a very crude estimate for the upper bound of the costs per trade. As of 2007, there appears to have been only 6 trades in the history of the EPI (Hamstead 2008), giving an upper bound of $114,000 dollars of transactions costs incurred by the members of the NRCA.

The EPI design, implementation, and monitoring involved primarily North Carolina's DWQ, although the EPA played an advisory role and supported the development of trading through its policy. The total time for the development of the EPI was seven years, from the 1995 fish kill to the formation of the NRCA and approval of permit trading by the General Assembly in 2002. The EPI was applied as a particular implementation of the Clean Water Act.

3.7 Uncertainty

The direct environmental objective of the EPI was for the members of the NRCA to emit no more than a total of 1,137,171 Pounds of Nitrogen into the Neuse River System. As shown in Table 3.4, the members of the NRCA exceeded this objective by 52 percent.

Table 3.4
Environmental Objective

	Policy Target	Policy Deadline	Reference
	1,137,171 Pounds	2006	542,205 Pounds
Pedigree	1	2	1

The economic performance of the EPI is characterized by the cost savings relative to the benchmark of individual emission requirements and no trade. As there has been very little trade, it appears that the EPI generated little, if any, cost savings.

4 Conclusions

4.1 Lessons learned

The results of this EPI are decidedly mixed. On one hand, compared with the typical 303(b) regulation, the aggregate emission requirement and attendant trading system is a big improvement. It offers WWTP the opportunity to greatly reduce the total cost of meeting the Clean Water Act regulation. On the other hand, there was not much actual trading. The WWTP never fully endorsed the group compliance concept, and remained focused on meeting their individual emission requirements. Thus there was very little cost savings associated with the EPI. Moreover, even in theory, the EPI was not the most efficient type of regulation. A system of trading zones would perform better.

4.2 Enabling / Disabling Factors

The support of the EPA for more flexible trading based regulation was a significant enabling factor for the EPI. In addition, the long established relationship between the stakeholders and regulators at the state level was strong positive influence on the EPI design.

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