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THE NEUSE RIVER BASIN AGRICULTURAL NITROGEN REDUCTION STRATEGY: A PROGRAMMATIC ANALYSIS

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ABSTRACT

In 1997, North Carolina adopted the Neuse River Basin Nutrient Sensitive Waters Management Strategy to cut nitrogen inputs to the Neuse by 30%. The strategy includes two rules targeting agricultural producers. The agricultural rule is an innovative pollution control approach that allows farmers to work collaboratively to achieve nitrogen reductions through use of nutrient management and targeted installation of BMPs. The nutrient management rule requires certain producers to develop nutrient management plans or participate in training. This project employs quantitative and qualitative research methods to investigate the implementation and impact of these rules. It uses information from published reports and program staff to assess whether the agricultural rule is a more flexible and cost-effective approach than a standard regulatory requirement. It uses data from a telephone survey of farmers in the basin to describe their knowledge of the agricultural rules, attitudes toward the strategy, and management behaviors.

Available data about the agricultural rule indicate that the collaborative approach is more flexible than a standard regulatory requirement, but do not allow a thorough evaluation of cost-effectiveness. The survey results indicate that most farmers have adopted nutrient management practices and that the Neuse Strategy is likely responsible for some of this behavior. In addition, farmers generally support the strategy's agricultural requirements, though most lack understanding of their details. Cost-share funding has encouraged adoption of nutrient management practices, improved farmers' understanding of the agricultural rules, and reduced resentment toward them. However, in order to increase farmer cooperation with the strategy and ensure its continued success, several improvements are needed: the quality and breadth of public data about the program should be enhanced, educational efforts about the rules and nutrient management practices should be increased, and farm inspections should be targeted more strategically to ensure broad and continued compliance with the rules.

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SUMMARY AND CONCLUSIONS

In this study, we investigate the implementation of the agricultural requirements of the Neuse River Basin Nutrient Sensitive Waters Management Strategy. We evaluate the success of the Neuse Strategy's agricultural rule in achieving its goal of a 30% nitrogen loss reduction in a manner that is more flexible and cost-effective than a one-size-fits-all requirement for best management practice ("BMP") implementation. We also explore how agricultural producers in the Neuse Basin have responded to the Neuse Strategy's agricultural rule and nutrient management rule in terms of their attitudes, knowledge, and management behaviors.

To answer these questions, we analyzed both quantitative and qualitative data that have been reported about the rules concerning the installation of BMPs, changes in average nitrogen application rates, attenuation of cropland, reductions in nitrogen losses from cropland, and implementation of the rules on the ground. We also analyzed data from a telephone survey of 315 farmers in the basin.

RESEARCH OBJECTIVE 1 – HOW SUCCESSFUL HAS THE NEUSE AGRICULTURAL STRATEGY BEEN IN ACHIEVING ITS GOALS?

Sources of Nitrogen Loss Reductions

As measured by Nitrogen Loss Estimation Worksheet ("NLEW"), the agricultural requirements of the Neuse Strategy have been very successful in achieving the 30% nitrogen loss reduction goal for agricultural lands in the Neuse Basin. In 2003, the year the agricultural rule was to have been fully implemented, the Neuse Basin Oversight Committee ("BOC") reported that the counties in the basin had achieved a nitrogen loss reduction of 42% compared to the baseline years of 1991 to 1995. Though all counties in the basin reportedly met their nitrogen loss reduction targets, the means they used to do so varied significantly across the three geographical regions of the basin and to some extent among the counties within each region.

In the Piedmont region, all six counties lost BMPs between the baseline years and 2003, but still reduced their nitrogen losses by an average of 39.5%. Significant cropland attenuation and reduced nitrogen application rates overcame the BMP losses. All six counties experienced relatively rapid growth and population increases during the implementation period, which are expected to continue into the future. Thus, continued loss of active cropland in this region is likely to occur.

In the Upper and Middle Coastal Plain region of the basin, the seven counties averaged a 41.5% nitrogen loss reduction. Based on reported numbers, each of the seven counties in this region added BMPs to an average of 35,000 acres of cropland during implementation of the agricultural rule. Apparently, some of the BMPs reportedly installed during implementation were already in place during the baseline years, however. These counties also reported reducing their average nitrogen application rates to a greater extent than the Piedmont counties. Cropland loss played a proportionately smaller role in reducing nitrogen losses in this region than in the Piedmont and it varied more across the counties within the region. Five of the seven counties lost cropland, but two actually added small amounts. Thus, the success of this region in achieving its nitrogen loss reduction goal appears to be attributable to a mix of new BMPs, reductions in nitrogen application rates, and loss of active cropland.

The four counties in the Lower Coastal Plain region reported an average nitrogen loss reduction of 44.5%, the highest average reduction in the basin. This reduction is attributable primarily to the implementation of two types of BMPs: water control structures and nutrient management. Nutrient management appears to have been very successful in this region as its counties reported the most significant average nitrogen application rate reductions in the basin. Cropland loss played a much smaller role in this region’s success than in the Piedmont or in the Upper and Middle Coastal Plain areas.

According to the BOC, cropland attenuation accounted for almost a third of the nitrogen loss reductions achieved by agricultural producers in the basin in 2003 and exactly one-third came from reduced nitrogen application rates. It is important to note that neither of these sources of nitrogen loss reduction is necessarily permanent. The majority of land taken out of production by 2003 was simply left idle or planted with grass or trees, either of which could be reversed in future years. In addition, nitrogen application rates depend on numerous factors including the price of fertilizer and the types of crops grown, both of which can fluctuate greatly over time and are beyond the control of the Neuse Strategy. Therefore, two of the primary sources of nitrogen loss reduction for agricultural lands in the basin may not be dependable in the long run.

Another important issue that the Neuse Strategy needs to address in future years is how to account for land that moves from one category of the strategy to another. For example, land that is taken out of agricultural production for development purposes represents a nitrogen loss reduction for agriculture. If the development occurs in specific geographic locations targeted by the Neuse stormwater rule, it should be picked up as a new source of nitrogen losses in that category. However, if the development occurs outside of those designated areas, it will become a source of nitrogen loss that is no longer accounted for by the strategy. In any pollution control effort that strives to control all key sources, it is important to avoid potential holes like this that can frustrate achievement of the overall policy goal – improving water quality.

One of the most significant challenges facing the Neuse Strategy agricultural rule is its reliance on potentially unreliable data for measuring success. For state policy makers, the success of the agricultural rule is tied to a specific number that is calculated from NLEW: the total nitrogen loss reduction achieved by agricultural lands in the basin. However, since many of the key values that NLEW uses to calculate this number are based on aggregated estimates and professional judgments, it is not clear how accurate the reported nitrogen loss reductions actually are. While some cost-share records related to BMP installation in the basin do exist, even these records are unlikely to accurately capture the full extent of BMP use. This is because some farmers install BMPs without financial assistance and records of federally-supported BMPs have become more difficult to obtain. The nitrogen application rate data are even more likely to be problematic because farmers are not required to keep records on fertilizer use. In addition, the estimates that go into NLEW have to be aggregated across entire counties for each crop type. Though extensive record-keeping requirements could increase the administrative costs associated with the Neuse Strategy, it seems reasonable to require farmers who opt to participate in the local strategy option of the agricultural rule to submit some basic data on their practices in exchange for the flexibility granted by this option.

A final issue related to the success of the agricultural rule in achieving the required nitrogen loss reduction goal concerns those who did not sign up for the local strategy option of the rule, and thus opted into the standard BMP option by default. Reportedly, 11% of agricultural land in the basin was not enrolled in the local strategy option, and yet no information was found about what has happened with this land. It appears that the county nitrogen loss estimates include all cropland in the county, not just the land enrolled in the local strategy option. It seems likely that those who did not sign up for this option have been ignored in the program's implementation because the counties have successfully met their goals. If this is true, it is important to consider the effect this will have on future policies that include a choice of compliance options. For example, it would seem that allowing some producers to act as "free-riders" would serve as a disincentive for others to actively participate in future efforts. While it is possible that those who opted for the standard BMP option already were in compliance with those requirements, without public information about these farmers and their practices, there is no way to confirm that.

Rule Flexibility and Efficiency

In order to try to increase the flexibility and cost-effectiveness of achieving the 30% nitrogen loss reduction, the agricultural rule was designed to give farmers a choice in how to comply with the law and to allow local committees of farmers and agricultural officials to collaboratively determine what BMPs should be used and where they should be targeted.

After examining the rule's language, the NLEW tracking tool, and other information about how the rule has been implemented, it is clear that the agricultural rule is more flexible than a requirement for all farmers to implement standard BMPs. By including the local strategy option and allowing decisions about how to achieve nitrogen reductions to be made by collaborative bodies at the county level, the rule allows both differential levels of action by participating farmers and the selection of BMPs that are more tailored to local conditions. It also gives nitrogen reducing credit to two BMPs that are not included in the standard BMP packages, expanding the number BMPs from which participating farmers can choose. Finally, because 89% of cropland in the basin was voluntarily enrolled in this option, it is apparent that farmers generally preferred the local strategy option, which indicates that most farmers perceived it to be the more flexible option.

Drawing conclusions about the rule's cost-effectiveness is more difficult. We assume that targeting BMPs to the areas where they are likely to achieve the largest nitrogen reductions is the best indicator of whether or not those implementing the rule considered cost-effectiveness in their decisions. Such areas would include the counties closest to the Neuse Estuary and agricultural lands within the counties that are closest to the Neuse River and its key tributaries. If this is true, the fact that the counties closest to the estuary were allocated larger reduction targets than those further away indicates that those making decisions about implementing the rule across the basin did try to enhance efficiency.

Based on existing data about the rule, we cannot determine whether the inclusion of the local strategy option led to higher levels of cost-effectiveness within the counties, however. It is not clear if the county Local Advisory Committee's ("LACs") considered cost-effectiveness in their decisions about where BMPs should be located because they do not report information about where BMPs were targeted or where they were implemented.

Based on what we have learned about the implementation of the agricultural rule, we do not believe that cost-effectiveness factored into the decision-making processes of the LACs to a significant extent. We draw this conclusion based largely on the fact that the LACs were not given clear incentives to pursue this as a goal in their decisions nor were they given technical tools to enable them to do so.

Ambient Water Quality Changes

Existing studies of changes in nitrogen concentrations and loadings to the Neuse Estuary identify some reductions in various nitrogen measures over the past decade or two. However, the findings of these studies are not entirely consistent and in some cases can easily be explained by climatic events or the timeframes selected by the studies. Even if the nitrogen reductions they find are accurate, these studies are not able to attribute the reductions to management actions taken by agricultural producers in the basin. Therefore, these studies are not able to validate the cropland-based nitrogen loss reductions reported by the BOC for the counties in the Neuse Basin.

RESEARCH OBJECTIVE 2 – HOW ARE FARMERS RESPONDING TO THE NEUSE AGRICULTURAL AND NUTRIENT MANAGEMENT RULES?

The survey of farmers in three Neuse Basin counties analyzed in this study focuses on five issues: (1) the extent of nutrient management practice adoption, (2) knowledge of the Neuse rules, (3) attitudes toward the Neuse rules, (4) development of nutrient management plans and participation in training, and (5) attitudes and experience regarding farm inspections and penalties.

Nutrient Management Practice Adoption

According to the survey results, nutrient management practices including soil testing, fertilizer equipment calibration, cover crop planting, and nutrient management planning are widely used in the counties covered by the survey. The majority of farmers reported using three or four practices and only 4% reported using none.

In the statistical models predicting use of nutrient management practices, two findings were most notable. First, factors such as farm size and income had the most impact on the use of practices most likely to have clear financial benefits for producers based on their potential to reduce expenditures on fertilizers: soil tests, calibration of fertilizer application equipment, and not fertilizing cover crops. Higher incomes make it easier for farmers to adopt these practices, and these practices are likely to pay off the most for larger farms. Second, the receipt of cost-share funds had a very strong, positive influence over the use of the two practices with less obvious financial benefits for the producers: development of nutrient management plans and planting of cover crops. Though nutrient management plans are meant to result in more judicious and appropriate use of fertilizer, their impact may appear less direct than some of the other practices. The benefits of planting cover crops are likely even less clear to producers. Cover crops may help reduce soil erosion, but their nitrogen reduction benefits do not accrue to the farmer and the farmer does not harvest the crop. Because the payoffs from these practices may be indirect or may not accrue to the farmer at all, financial incentives were the key factor in encouraging their use.

It appears that the Neuse Strategy's agricultural requirements are encouraging the use of nutrient management practices since only 4.4% of the sample reported not using any of the identified practices. However, since some of these practices have obvious financial benefits for producers and some of them are qualified to receive cost-share funds, it is not clear how much these practices would have been used in the absence of the Neuse requirements. In order to try to answer that question, the survey asked respondents how likely they would be to use the same nutrient management practices if the Neuse nitrogen regulations had not been passed. The majority of respondents reported that they would be somewhat likely (35%) or very likely (51%) to use the same practices without the rules in place. However, given the fact that 49% of those surveyed said something other than "very likely," it appears that the Neuse rules are actually encouraging some adoption of nutrient management practices. There is the potential that these responses are somewhat biased since the respondents may not want to appear to support regulations that affect them. However, if such a bias does exist in the responses, it would dampen the apparent impact of the rules, not exaggerate it.

Knowledge of the Neuse Rules

Findings that large proportions of the survey respondents answered the three knowledge questions concerning the Neuse agricultural rule and nutrient management rule incorrectly indicate the need for more education of farmers about the Neuse Strategy and its pertinent requirements. The statistical models tested for the knowledge items identify several important factors that were predictive of a respondent's level of knowledge. Farm size, receipt of cost share, and education were all positively associated with a respondents overall level of knowledge about the rules. These results suggest that future educational efforts should specifically target smaller farms, farmers who are not already participating in cost share programs, and those with lower levels of education. Also, it is possible that the direction of influence between cost share and knowledge runs the other way, with knowledge about the collective 30% nitrogen reduction requirement encouraging farmers to obtain cost share funds, rather than the other way around. If true, this would indicate another way in which the agricultural rule is positively impacting BMP adoption.

Attitudes Toward the Neuse Rules

Respondents were asked about the extent to which they agree with three statements: whether the Neuse regulations are reasonable, whether the regulations targeting farmers in the Neuse Basin are improving water quality, and whether regulators were unfairly targeting agriculture for pollution problems in the basin. The vast majority of respondents feel that the rules are reasonable and are improving water quality. However, most respondents also feel that agriculture is being unfairly targeted. In testing factors that may influence the level of agreement with these three items, none were found to be significant for the first two items. For the third item, higher levels of income and nutrient management practice adoption increased the likelihood that a respondent agreed strongly that agriculture was being unfairly targeted. Receipt of cost share funds decreased the likelihood that a respondent strongly agreed with the statement. It appears from these results that some of the farmers who have adopted multiple nutrient management practices feel overburdened. It may be that cooperative farmers are being asked to do too much, which is creating resentment toward the rules. If true, this could hamper future efforts to improve environmental practices in the basin. It is clear that providing cost share funds to farmers significantly reduces their feelings of resentment toward the rules.

Nutrient Management Plans and Training

The survey results were also analyzed to determine roughly how many farmers are in compliance with the Neuse Strategy nutrient management rule. This rule requires that those who apply fertilizers to 50 acres of land or more complete nutrient management training or develop a nutrient management plan. Thus, farmers with operations that are 50 acres or larger who have completed one or more of these activities are considered to be in compliance. According to the survey results, three-quarters of regulated farmers are in compliance or in "over-compliance," meaning that they completed both activities. Approximately one-quarter of regulated farmers seem to be out of compliance with the nutrient management rule.

In general, it appears that the nutrient management rule has had a positive impact on the completion of these two nutrient management-related activities. However, the relatively high rate of completion of these activities also found among farms smaller than 50 acres (56.1%) suggests that the rule is not fully responsible.

In the statistical models, several factors were found to have a significant influence over the compliance status of farms. For farms of 50 acres or more, older farmers were less likely to be in compliance and those with higher levels of knowledge about the agricultural rules and higher incomes were more likely to be in compliance. Income appears to play the most significant role in determining whether an unregulated farm has undertaken either activity. While those implementing the Neuse Strategy have no influence over age or income, they can work to improve knowledge about the Neuse Strategy and its requirements, which may increase compliance levels among regulated farmers.

Of the respondents who reported having nutrient management plans, 61.8% claim to always rely on their plans when making nutrient application decisions. Only 3% reported never using their plans. This indicates that developing a nutrient management plan is not just a paper exercise for farmers in the basin. If those implementing the agricultural rules can encourage more farmers to develop nutrient management plans, those plans are likely to have a significant impact on the farmers' fertilizer application decisions.

For the model testing factors that influence reliance on nutrient management plans, only education was found to be significant. Respondents who have only completed high school or less education were more likely to rely on their plans for making nutrient application decisions than those with higher levels of education. When combined with the finding that those who have completed only high school or less education are less likely to have a nutrient management plan in place, this result is informative. Basically, farmers with only a high school education or less are less likely to have a nutrient management plan in the first place, but those who do have them rely on them heavily when making fertilizer application decisions. Clearly, focusing more attention on helping less educated farmers develop nutrient management plans would pay off in terms of influencing their fertilizer application decision-making. This finding is particularly important because more than 42% of the farmers in the survey fall into this education level.

Attitudes and Experience Regarding Farm Inspections and Penalties

According to the survey results, most farmers have a high level of concern about the likelihood of inspections and penalties under the Neuse agricultural rules. These findings suggest that the rules are having a deterrent effect and are likely encouraging compliance among farmers. In testing factors that may influence respondents' fears of inspections and penalties, only one factor was found to have an influence. Not surprisingly, those who had experienced a farm inspection in the past were more apt to believe that the government is likely to inspect their nutrient management practices.

About half of the respondents reported that their farm was inspected between 2000 and 2005. In testing factors that might be predictive of which respondents were most likely to have experienced a farm inspection, two interesting results emerged. First, whether a farm is regulated under the nutrient management rule did not influence whether a farm had been inspected. Second, higher levels of practice adoption make a farm more likely to be inspected even when controlling for the receipt of cost share funds. These findings may indicate that farm inspections are not being targeted effectively. Inspections appear to be targeted at the farms that are already adopting practices, not those that should be but may not be in compliance. Targeting inspections in this way could eventually undermine the use of a regulatory requirement in the nutrient management rule. Though many farmers in the basin appear to be concerned about inspections and penalties, if these never materialize, particularly for farms that are not in compliance, the rule is likely to become less and less effective in encouraging the adoption and maintenance of nutrient management practices over time.

RECOMMENDATIONS

Based on our findings, we offer a number of recommendations for both the Neuse Strategy and for other similar agricultural nonpoint source pollution control efforts. These recommendations fall into four categories: (1) tracking and reporting programmatic data, (2) encouraging cost-effective solutions, (3) improving knowledge and understanding of the Neuse Strategy, and (4) encouraging cooperation and compliance.

Tracking and Reporting Programmatic Data

- The quality of the data reported by the counties and put into NLEW that are used to track compliance with the 30% nitrogen loss reduction goal should be improved so that they are more reliable and verifiable. One way to improve the data would be to require farmers who have signed up for the local strategy option to report the crops they use, their fertilization rates, and the BMPs they install. Random field surveys could also help validate the reports.
- In their local strategies and annual reports, the LACs should report which farmers have agreed to implement BMPs, what types and quantities of BMPs they have agreed to implement, and where they are located.
- The LACs should also report any information that is available about the costs of implementing the BMPs and they should report their BMPs in terms of acres installed, not just acres of cropland treated.
- Even though the counties in the basin have reportedly exceeded their nitrogen loss reduction goals to date, they should continue to track changes in cropland use, fertilization application rates and BMPs installation and maintenance into the future to ensure there is no backsliding.

Encouraging Cost-Effective Solutions

- To encourage the LACs to consider cost-effectiveness in their decision-making, they must be provided with both incentives and user-friendly technical tools to do so.
- Those implementing the agricultural rule may also want to consider developing a mechanism that allows farmers to compensate each other for BMP installation so the burden is more evenly distributed. A formal trading program within each county is probably too complicated, but ideas such as requiring each farmer in the LAC to pay into a fund based on the relative proportion of nitrogen their farm contributes and then using that money to fund BMP installation should be investigated.

Improving Knowledge and Understanding of the Neuse Strategy

- Farmers in the basin appear to need more education regarding the requirements of the agricultural rule and the nutrient management rule. Improving understanding of these rules should encourage more participation and higher levels of compliance. Based on our findings, educational efforts should specifically target farmers who are not already receiving cost share funds, those who have lower levels of education, and those who have smaller farms.
- Educational efforts should also strive to educate farmers about the entire Neuse Strategy approach. Farmers need to understand that all major sources of nitrogen runoff in the basin

are covered by the rules, not just agriculture. This may reduce feelings of resentment and encourage farmers to be more cooperative.

Encouraging Cooperation and Compliance

- Cost-share funds make a clear and significant impact on the development of nutrient management plans and most respondents with nutrient management plans rely on those plans frequently or all of the time when they make fertilizer application decisions. Since nutrient management is one of the key sources of nitrogen runoff reductions in the basin, more funding should be allocated to encourage this practice.
- Program staff should also offer farmers in the basin additional technical assistance with nutrient management plan development. In particular, they should target these opportunities to less-educated farmers, who are least likely to have plans, but most likely to make use of their plans when making fertilizer application decisions.
- State and county agricultural officials should investigate the apparent high levels of noncompliance with the nutrient management rule found in this study. They should specifically target some inspections to farms that are not receiving cost share funds and are not already known to be using nutrient management practices.
- The BOC should investigate the farmers who did not sign up for the local strategy option to ensure they are complying with the standard BMP requirements.

1. INTRODUCTION

1.1 PROBLEM DEFINITION

Nonpoint source water pollution is an increasingly important issue across much of the United States. In many areas, such as coastal North Carolina, nutrient-rich runoff has caused considerable eutrophication of aquatic systems, generating significant ecological, aesthetic, and economic damage.

According to the North Carolina Department of Environment and Natural Resources ("N.C. DENR") Division of Water Quality ("DWQ"), nonpoint source pollution is the primary cause of degradation of freshwater rivers and streams in the state. Agriculture alone is responsible for more than half of nonpoint source-related water quality impairments, contributing both nutrients and sediment to the state's waters. Concern over excessive nutrient inputs has been particularly acute in the Neuse River Basin, where numerous algal blooms in the 1970s led to studies that identified nitrogen and phosphorus as the main problems.

The Neuse River Basin, shown in Figure 1, is the third largest in North Carolina, encompassing 6,192 square miles in 19 counties (N.C. DWQ "Basinwide" 2006). In 1988, the North Carolina Environmental Management Commission ("EMC") classified the entire Neuse Basin as "Nutrient Sensitive Waters," and targeted early regulatory efforts on major sources of nutrient inputs, such as phosphate detergents and wastewater treatment plants. Despite these efforts, major fish kills in the Neuse River in 1995 showed that more needed to be done, particularly with regard to nitrogen.

In December 1997, the state responded by establishing a goal of a 30% nitrogen input reduction from all major sources in the basin. Agricultural sources were targeted specifically through two rules supporting the state's Neuse River Basin Nutrient Sensitive Waters Management Strategy: the "Agricultural Nitrogen Reduction Strategy Rule" and the "Nutrient Management Rule." The first of these two rules lays out a general agricultural strategy and the second focuses specifically on nutrient management planning and training. This report investigates the implementation and efficacy of these rules. It also addresses issues related to policy design.

The design of nonpoint source water pollution control policies is important because of the unique challenges inherent in regulating pollution sources that are impossible to pinpoint and difficult to monitor. Nonpoint source pollution loads are very difficult to predict as they vary by season, weather conditions, crop type, soil type and other important factors. In addition, nonpoint source pollution reduction strategies can be expensive to implement and difficult to track. As a result, most efforts to reduce agricultural nonpoint source pollution have relied on voluntary cost-share programs that encourage rather than require the use of best management practices. These programs have achieved some success, but are necessarily limited by their strictly voluntary nature.

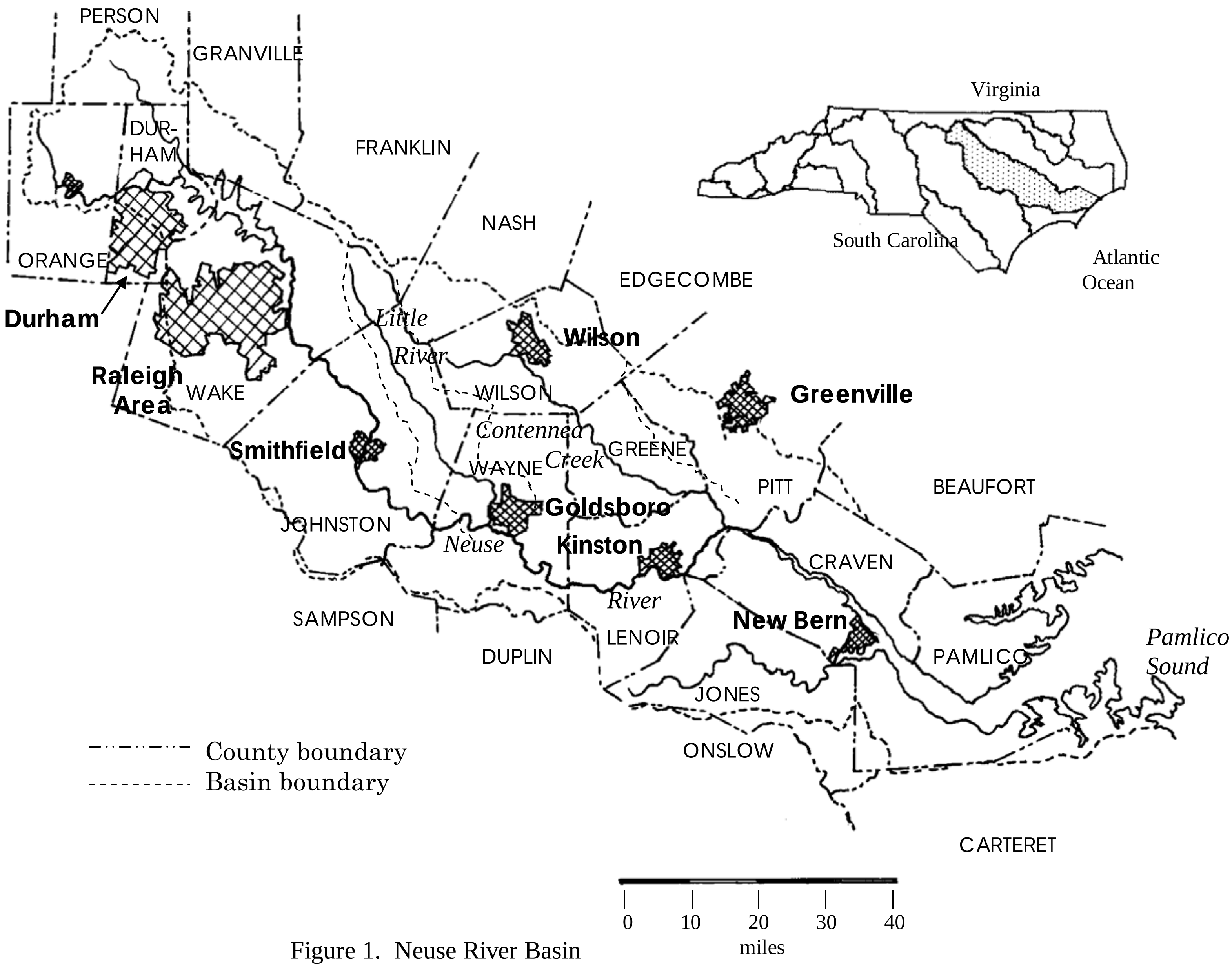

Figure 1. Neuse River Basin

As detailed in this report, the portions of the Neuse River Basin Nutrient Sensitive Waters Management Strategy ("Neuse Strategy") that affect agriculture differ from both traditional voluntary approaches and strict regulatory approaches to pollution control. By writing nutrient reduction requirements into law, the Neuse Strategy is intended to achieve a higher level of pollution abatement than a voluntary approach likely would achieve. At the same time, by providing farmers with some choices in how to comply with the reduction requirements, the Neuse Strategy is intended to be more flexible than a strict regulatory approach, improving both the efficacy and efficiency of the requirements. Though this novel approach has technically met the required 30% nitrogen runoff reduction, little has been reported about how the portions of the Neuse Strategy that affect agriculture have operated and whether they have lived up to the goals of increased flexibility and cost-effectiveness. In addition, little is known about how agricultural operators are responding to these rules in terms of their attitudes toward and understanding of the rules as well as their management behaviors.

This study investigates the implementation of the agricultural requirements of the Neuse Strategy in order determine how successful this approach has been in achieving its stated goals and how the agricultural producers targeted by the rules are responding to them. This study provides important information for practical efforts to design and implement management schemes that effectively control agricultural nonpoint source pollution. The information provided in this report should benefit not only North Carolina environmental and agricultural officials concerned with the success of the Neuse Strategy, but also those working to reduce agricultural nonpoint source pollution in other areas of the state and nation.

1.2 RESEARCH OBJECTIVES

This study pursues two primary research objectives. The first objective is to evaluate the success of the Neuse Strategy in achieving its stated goals of reducing nitrogen losses from agricultural operations in the Neuse Basin by 30% and achieving this goal in a way that is more flexible and cost-effective than a strict regulatory requirement. The second objective is to describe how farmers in three Neuse River Basin counties have responded to the Neuse Strategy in terms of their knowledge of the strategy's agricultural requirements, their attitudes concerning the strategy and its impacts, and their reported management behaviors. Discussions related to these two research objectives also identify key issues that have arisen during implementation of the agricultural portions of the Neuse Strategy and, where possible, offer suggestions for addressing these issues.

1.3 ORGANIZATION OF THE REPORT

This report is organized into six chapters. Following this introduction, chapter two provides critical background information on the Neuse Strategy and the programs and activities that have been used to implement it. Chapter three contains a review of the key literature related to the two research objectives. Chapter four describes the basic methods of data collection and analysis used in the study. Chapters five and six report and discuss the key results related to research objectives one and two respectively.

2. BACKGROUND INFORMATION

2.1 THE NEUSE RIVER BASIN NUTRIENT SENSITIVE WATERS MANAGEMENT STRATEGY

The Neuse River Basin Nutrient Sensitive Waters Management Strategy is comprised of several components targeting both point and nonpoint sources of nutrient pollution in the Neuse Basin. The point sources are targeted by a wastewater discharge rule and nonpoint sources are covered by rules addressing urban stormwater management, riparian buffer protection, agricultural runoff reduction, and nutrient management. Agricultural sources of nutrient pollution are primarily targeted by these last two components: the "Agricultural Nitrogen Reduction Strategy Rule" and the "Nutrient Management Rule."

More detailed information on the structure of these rules, their requirements, and some of the programs that support their implementation follows.

2.1.1 Agricultural Nitrogen Reduction Strategy Rule

2.1.1.A Program Design. The North Carolina EMC put the Agricultural Nitrogen Reduction Strategy Rule (15A NCAC 2B .0238) ("agricultural rule") into effect on August 1, 1998. The rule affects "all persons engaging in agricultural operations" in the Neuse River Basin and required a mandatory 30% reduction in total nitrogen loading from a baseline calculated as the average annual load from 1991 to 1995. This reduction was to be achieved within five years of the effective date of the rule, or by August 1, 2003.

The agricultural rule provides farmers with two options for reaching the reduction goal. The first option is to follow the default "Standard Best Management Practice Strategy," in which farmers must individually implement prescribed combinations of riparian area protection, water control structures, and nutrient management plans. This option is equivalent to a regulatory requirement for farmers. The second option is for farmers to participate in a "Local Nitrogen Reduction Strategy" that allows a group of farmers to achieve the required reduction collectively. In this option, a Local Advisory Committee ("LAC") that includes local farmers and governmental representatives develops collective strategies to meet the local area's reduction goal.

According to DWQ, the LAC approach was developed to allow agricultural agencies and farmers to work cooperatively to develop strategies tailored to local conditions and to be more cost-effective by focusing resources on the most critical areas. Presumably, improved cost-effectiveness derives from the fact that the marginal costs of nitrogen reduction efforts vary among farms. On some farms, it may be very costly to achieve only a slight nitrogen load reduction; whereas on other farms, it might be relatively inexpensive to achieve large load reductions. A "one-size-fits-all" strategy that requires all farmers to implement the same management practices ignores these differences and results in lower nitrogen reductions than could be achieved for the same cost through more targeted efforts.

2.1.1.B Establishment and Operation of the Local Advisory Committees. During implementation of the agricultural rule, one LAC formed in each affected county. Each LAC is required to include at least two local farmers in its membership along with representatives of the DWQ, the county Soil and Water Conservation District ("SWCD"), the Natural Resources Conservation Service ("NRCS"), the N.C. Department of Agriculture and Consumer Services, and the N.C. DENR Division of Soil and Water Conservation ("DSWC"). According to Natalie Jones (CREP Manager, N.C. DENR, pers. com. 2006), who has worked closely with the program, potential farmer members were identified by the directors of the county SWCDs and members were officially appointed by these directors and the N.C. DWQ. The farmer members are not compensated for their participation.

Each LAC's initial responsibilities included conducting the sign-up process for farmers who wanted to participate in this option of the rule and developing the "Local Nitrogen Reduction Strategies" to meet the nitrogen runoff reduction goal. The LACs are also charged with submitting annual progress reports to the Basin Oversight Committee, which they continue to do.

According to Natalie Jones (pers. com. 2006), the LACs met regularly when first established, but they operated primarily as feedback mechanisms rather than the primary planning and decision-making bodies. Typically, the program's field staff, called "Neuse Technicians" would develop estimates for nitrogen application rates, best management practice use, and cropland acres and the LAC would provide feedback on those numbers. Over time, however, as the LACs have officially met their nitrogen reduction goals, participation by the farmer members has diminished. Though the LACs still meet, current meetings are generally only attended by the agency representatives. The farmer members are sent the annual progress reports for review by mail, and if they do not respond within two weeks, they are assumed to concur.

2.1.1.C Role of the Basin Oversight Committee. The agricultural rule also established a Basin Oversight Committee ("BOC") comprised of representatives from the DWQ, the agricultural community, the environmental community, the scientific community, the DSWC, the NRCS, the N.C. Department of Agriculture and Consumer Services, and the N.C. Cooperative Extension Service. Over the course of implementing the agricultural rule, key responsibilities of the BOC have included: developing a method for tracking nitrogen loadings and reductions from farms, allocating nitrogen reduction goals for each county in the basin, reviewing and approving county nitrogen reduction strategies, and presenting this information to the EMC.

2.1.1.D Similarity to the Wastewater Discharge Rule. It is important to note that the design of the agricultural rule was meant to parallel the design of the Neuse Strategy "Wastewater Discharge Rule." The wastewater discharge rule applies to approximately 180 facilities that have discharge permits from the N.C. DWQ. The rule requires the covered facilities to reduce their nitrogen discharges by 30% from a 1995 baseline. Dischargers are divided into groups depending on their permitted wastewater flows and their location within the Neuse Basin. Those with permitted flows of 0.5 million gallons per day ("MGD") or more were given two options for complying with the rule. The first option was to meet individual mass-based discharge limits, based on the facility's proportion of the group's total permitted wastewater flow. The second option was to join a nitrogen trading coalition called the Neuse River Compliance Association, which allows the dischargers to meet the 30% reduction collectively. The compliance association was established in 2002 and has a single, collective discharge permit for nitrogen based on the sum of the members' individual nitrogen allocations (Breetz et al. 2004). The members of the association are allowed to trade nitrogen allocations with each other or with non-member dischargers in order to remain under the total nitrogen discharge cap.

The wastewater discharge rule also requires dischargers with permitted flows of less than 0.5 MGD to meet their collective 30% reduction target. These dischargers are allowed to join the compliance association, but they do not have nitrogen limits written into their discharge permits. The wastewater discharge rule also includes a program of offset payments to compensate for any exceedances of the collective limit and to allow for new or expanding dischargers who are not able to obtain nitrogen allocations from existing dischargers. These offset payments go to the Wetland Restoration Fund to pay for nonpoint source controls (N.C. DENR "Wastewater Rule"). However, no offset payments have been made to date because the compliance association has easily met its 30% reduction target on its own (Breetz et al. 2004).

Allowing for large wastewater dischargers in the Neuse River Basin to collectively meet the required nitrogen discharge reductions through participation in the compliance association was meant to improve the acceptability, flexibility, and efficiency of the discharge rule. This idea was carried over into the design the agricultural rule. Though not explicitly stated as a goal of the Neuse Strategy, having comparable rules targeting point sources and agricultural nonpoint sources in the Neuse Strategy may enhance how fair and equitable the program is perceived to be by those covered by the rules.

2.1.1.E The Aggregate Nitrogen Loss Estimation Worksheet. The agricultural rule required the BOC to develop a scientifically valid tracking and accountability methodology to estimate total nitrogen loading from agricultural operations in the Neuse Basin and to track progress in implementing best management practices ("BMPs") and achieving the required total nitrogen loading reduction. In response to this requirement, a multi-agency task force developed the Aggregate Nitrogen Loss Estimation Worksheet ("NLEW").

According to Osmond et al. (2004), NLEW has three key objectives: to estimate a baseline nitrogen loading for agriculture for the baseline years of 1991-1995, to allocate nitrogen reduction goals to the counties in the basin, and to assist the county LACs in determining the distribution of BMPs in their area. NLEW was approved by the EMC in 2000 (N.C. DWQ "Neuse River" 2002).

NLEW makes several important simplifying assumptions. It assumes that most of the nitrogen lost from cropland moves as soluble nitrogen and that most of the available nitrogen in the soil system is either used by crops or moved through the soil into shallow groundwater. NLEW does not account for all nitrogen sources, nor does it account for nitrogen cycling such as net mineralization and denitrification (Osmond et al. 2004).

To use NLEW, counties must input the number of acres of different crops in the county, the average fertilizer application rate for each crop, the number of acres of cover crops, and the number of acres affected by particular BMPs. NLEW aggregates soil types, distribution of crops across different soil types, and applied nitrogen rates by crop across each county. Once these parameters are specified for each county, NLEW reports several numbers for each crop in the county, including:

- the total nitrogen needed by the crop based on realistic yield expectations (lbs.);
- the total nitrogen applied to the crop (lbs.);
- the amount of excess nitrogen, if more is applied than needed;
- the portion of the excess nitrogen that is lost from the soil surface (set at 5%);
- the portion of the excess nitrogen that is in the subsurface soil (set at 95%);
- the amount of subsurface nitrogen not removed by the crop (lbs.);
- the total amount of subsurface nitrogen, including that not removed by the crop and the portion of the excess nitrogen in the subsurface;
- the amount of nitrogen transformed or intercepted by cover crops or BMPs (lbs.);
- the amount of subsurface nitrogen that is lost from the targeted area (lbs.); and
- the total estimated amount of nitrogen leaving the targeted area, which includes the amount of subsurface nitrogen that is lost plus the excess surface nitrogen.

In the aggregate version of NLEW, the targeted area is the entire county's cropping system.

2.1.1.F Estimation of County-Level Data for Input into NLEW. NLEW was used to determine each county's baseline nitrogen loss, the yardstick against which the 30% required nitrogen loss reduction is measured. It has also been used to track compliance with the 30% nitrogen loss reduction requirements in each county. However, much of the data that goes into NLEW to calculate these figures consists of estimates developed by program staff.

For the baseline data, county agency staff had to estimate the baseline nitrogen fertilization rates for different crops using their best professional judgment (Osmond et al. 2003). County staff also had to estimate the amounts and types of BMPs that existed in the baseline, due to a general lack of records. Crop acres were determined from Farm Service Agency records, however (Osmond et al. 2003).

As the agricultural rule has been implemented, estimates of BMPs have improved due to the use of cost share program records. However, according to Natalie Jones (CREP Manager, N.C. DENR, pers. com. 2006) information on farmer participation in federal programs became more difficult to obtain following passage of the 2002 Farm Bill, which contains a privacy provision. According to the U.S. Department of Agriculture ("USDA") Economic Research Service, this provision states that:

> *Information provided to the Secretary for the purpose of providing technical or financial assistance to a producer through a natural resources conservation program cannot be considered public information and cannot be disclosed to any person or entity outside of USDA, except to the Attorney General for the purpose of enforcing natural resources conservation programs.* (USDA "Farm Bill").

According to Ms. Jones, this provision has been interpreted to prevent the public and state officials from accessing information about individual participation in federal conservation programs. In fact, this research team found that data about conservation payments on the USDA website do not include any individual farm-level information and only report aggregate information for counties or watersheds when there are at least four cost share recipients in the same area. Though this privacy provision makes it difficult for state agency staff to obtain information about the use of federally-cost shared BMPs through formal channels, because federal USDA employees often share local offices with county SWCD staff, some of this information is still shared informally (Natalie Jones, pers. com. 2006).

2.1.1.G NLEW-Approved Best Management Practices. In calculating nitrogen loss reductions, NLEW gives nitrogen reduction credits only to select BMPs. Though numerous other BMPs have positive impacts on water quality through reduction of sediment in agricultural runoff, because NLEW assumes that most of the nitrogen lost in the Neuse Basin is coming from shallow groundwater, these BMPs do not receive credit for nitrogen reductions. In general, four categories of BMPs have been shown to reduce nitrogen losses from cropland in all or parts of the Neuse River Basin: riparian buffers, controlled drainage, nutrient management, and conservation tillage. Within each category, particular BMP designs can receive NLEW credit. The types of BMPs receiving credit in NLEW and the average nitrogen removal efficiencies of each type are detailed in Table 1.

Table 1. Average Nitrogen Removal Efficiencies for BMPs in the Neuse Basin

Best Management Practices	**Average Nitrogen Removal Efficiency**
20' Vegetated (grass) buffer	40%
30' Vegetated (grass) buffer	65%
20' Forested or shrub buffer	75%
50' Riparian buffer	85%
Water control structure	40%
Nutrient management	Highly variable
Cover crops	Depending on crop type, 5-15%

Riparian buffers:

Riparian buffers consist of land that is located between cropland and a surface water body such as a stream or river. A properly functioning riparian buffer can trap sediment, pesticides, organic matter, and nutrients before they can enter the water body. Particularly relevant to the Neuse agricultural strategy, riparian buffers are also effective in denitrifying nitrate as it passes through the buffer in shallow groundwater.

Buffers are classified primarily by width and vegetation type. In general, buffers that consist of trees and/or shrubs are considered to be more effective in reducing nitrogen than buffers consisting only of grass. In addition, wider buffers are generally more effective than narrower ones.

The following types of buffers receive nitrogen reduction credit in NLEW:

- 20-foot grass buffers, which are also called filter strips. These buffers are generally only considered effective if the slope of the land being drained is between 1 and 10% and they are planted with permanent herbaceous vegetation such as grass or legumes.
- 30-foot grass buffers
- 20-foot forested or shrub buffers
- 50-foot riparian buffers, which consist of 30 feet of trees and/or shrubs adjacent to the stream and 20 feet of grass adjacent to the trees

Controlled drainage:

Used in areas with flat slopes and where drainage ditches are found, controlled drainage reduces nitrogen losses from cropland by managing the water table. This BMP uses water control structures consisting of a flashboard riser installed in the drainage ditch outlet. These flashboard risers are raised or lowered to control the water table in the fields above the ditch outlet. When the water table in the field is kept relatively high compared to natural conditions, less nitrogen is transported out of the field due to increased crop uptake and increased denitrification. This BMP is most appropriate in the lower portions of the Neuse Basin (Gilliam, Osmond, and Evans 1997).

Nutrient management:

Nutrient management seeks to properly balance nutrient applications with crop needs in order to reduce the runoff of nutrients from cropland. Information about soil type, realistic yield expectations for the crops, and nutrient availability in the soil guides farmers in applying the correct types and amounts of nutrients. Nitrogen reductions from nutrient management practices vary widely. NLEW accounts for these reductions in the estimated fertilizer application rates.

Conservation tillage:

Conservation tillage leaves at least 30% of the soil surface covered with plant residue at all times and generally includes the use of a fall cover crop that is not harvested, such as wheat, triticale, barley, rye, or oats. After the cover crop is killed off, the farmer uses either a no-till or strip-till crop production system. No-till production leaves the field essentially undisturbed. Strip-till disturbs only narrow strips of the field where seeds are planted. The primary benefit of conservation tillage is a reduction in soil erosion, which can reduce the amount of nutrients in runoff when the nutrients are bound to soil particles. However, no-till and strip-till practices have less impact in the Neuse River Basin because most of the nitrogen of concern is found in the shallow groundwater, not bound up in sediments.

In general, no-till and strip-till practices are not given credit for reducing nitrogen in NLEW unless they are associated with the use of cover crops. Only no-till corn in the Piedmont is considered to reduce nitrogen losses due to increases in productivity and nutrient uptake. To account for this, NLEW assumes that no-till corn in the Piedmont has a higher nitrogen use efficiency than in the Coastal Plain. Cover crops are given credit in NLEW with the nitrogen reduction efficiency varying by crop type (Osmond et al. 2004).

Cropland loss:

In addition to these BMPs, NLEW includes the loss of active cropland as a nitrogen reducing measure. Some of the cropland that is "lost" each year is permanently taken out of production, such as for development. Some of it is merely idle and may be put back into production in the future.

2.1.2 Nutrient Management Rule

In addition to the agricultural rule, a second major Neuse Strategy rule affects agricultural producers in the Neuse Basin. The "Nutrient Management Rule" (15A NCAC 2B .0239) also went into effect on August 1, 1998. It targets anyone who applies fertilizer to or manages 50 acres or more of cropland in the Neuse Basin, unless the cropland is covered by a certified animal waste management plan (N.C. DWQ "Nonpoint" 2002). Farmers affected by this rule are required either to complete training and continuing education in nutrient management or to develop a written nutrient management plan for all property where nutrients are applied in a calendar year. Farmers who intended to complete nutrient management training were required to sign up for training within one year of the effective date of the rule, and to complete the training within five years. Those who did not sign up for the training were required to develop a nutrient management plan. These plans could be written by the farmer or a consultant and were required to meet particular federal or state standards. The plans are kept on site with the farmer, but upon request by the N.C. DWQ, must be produced for inspection within 24 hours (N.C. DWQ "Nonpoint" 2002). Nutrient management training in the Neuse Basin was offered by N.C. Cooperative Extension Service agents on a county-by-county basis in 2001 and 2002.

2.2 SUPPORTING COST SHARE PROGRAMS

Numerous programs provide financial support for farmers who are interested in implementing or installing BMPs that help protect water quality. Two of the key programs that have been used to support implementation of the Neuse agriculture rules include the North Carolina Agricultural Cost-Share Program and the USDA's Conservation Reserve and Enhancement Program. These programs provide financial incentives for use of BMPs and provide basic compliance mechanisms through their practice inspection requirements.

2.2.1 North Carolina Agricultural Cost Share Program

The North Carolina Agricultural Cost Share Program ("N.C. Cost Share Program") was established in 1984 as a pilot program and was expanded to cover the entire state in 1989. The program has four goals: (1) reducing agricultural nonpoint source pollution in the state's waters, (2) increasing technical assistance to help landowners install BMPs that improve offsite water quality, (3) providing cost share funds to assist in implementation of BMPs, and (4) providing BMPs that improve water quality and also provide production benefits (N.C. DSWC "Cost Share

Manual" 2004). The program was created and is supervised by the North Carolina Soil and Water Conservation Commission. This commission consists of political appointees as well as representatives selected from the appointed and elected supervisors of each SWCD. The program is administered by the N.C. DSWC and is carried out by the state's 96 SWCDs (N.C. DSWC "Cost Share Manual" 2004).

The N.C. Cost Share Program provides cost share funding for specific practices that reduce off-site water quality impacts from agricultural operations. These practices may be funded up to 75% of the average cost for each practice, with the farmer providing the other 25%. The farmer's contribution can consist of in-kind support. Each applicant is limited to $75,000 per year of cost share funding. If the applicant is a limited-resource or beginning farmer, the cost share funding may increase to up to 90% and the total limit per applicant may increase up to $100,000 (N.C. DSWC "Cost Share Manual" 2004).

Participation in the N.C. Cost Share Program is voluntary, and projects are selected for funding based on their potential to improve water quality. In order to prioritize potential projects, the supervisors in each SWCD must develop a strategy plan that identifies what needs to be done in the district to reduce agricultural nonpoint source pollution, prioritizes the most critical areas, and determines how much money is needed to solve the problems with BMPs. These strategy plans are submitted to the Soil and Water Conservation Commission, which allocates funding to the districts based on their needs (N.C. DSWC "Cost Share Manual" 2004). Once the districts receive their allocations, which average about $75,000 per year per district, the supervisors then review applications from landowners and determine who will receive funding for BMP installation.

Once funded and implemented, the district supervisors must certify that the BMPs meet NRCS standards. To ensure ongoing operation and maintenance for the life of the contract, the supervisors are required to perform spot checks on 5% of participating farms each year. They are also required to spot check 5% of cost-shared nutrient management plans each year (N.C. DSWC "Cost Share Manual" 2004). BMPs that are found out of compliance during the spot checks are reported to the DSWC along with a report of how the noncompliance was resolved. Operators found out of compliance must be notified in writing about their need either to reimplement the practice or refund the cost share allocation (N.C. DSWC "Cost Share Manual" 2004). Districts are not allowed to approve cost share contracts for operators found to be out of compliance with the N.C. Cost Share Program at another site, field, or operation.

2.2.2 Conservation Reserve and Enhancement Program

The Conservation Reserve and Enhancement Program ("CREP") is a joint federal and state land retirement conservation program. The North Carolina CREP targets agricultural lands in three river basins that drain into the Albemarle-Pamlico Estuary, including the Neuse River Basin. CREP is intended to help protect the estuary from nutrient and sediment-related problems from agricultural nonpoint source runoff. (USDA Farm Service Agency 1999). In the Neuse Basin, it is specifically meant to help farmers meet their mandatory 30% nitrogen reduction goal. It does this by providing financial incentives for voluntary use of conservation practices such as hardwood tree planting, installation of filter strips and riparian buffers, restoration of wetlands, and use of controlled drainage on lands near rivers, streams, drainage ditches, and wetlands ("BMPs in the Neuse").

CREP supplements payments made under the federal Conservation Reserve Program. Applicants may choose to enter into contracts that vary in duration from ten years to permanent. Cost-share payments increase as the contracts get longer, with 10-year contracts qualifying for a 75% cost-share payment for practice installation and permanent contracts qualifying for 100% payment. In addition to funding for installation, CREP also provides producers with annual payments that include the annual rental rate of the land, an annual incentive rate that varies by the practice installed, and $5 per acre for maintenance. There are also one-time bonus payments available if the land is put under a permanent contract or if it is enrolled for hardwood tree planting ("BMPs in the Neuse").

North Carolina's CREP will cover up to a total of 100,000 acres of land in the targeted river basins. Enrollment began in 1999. Land that is enrolled in CREP is subject to annual status reviews by the NRCS for the first three years of the contract period to ensure compliance. If contracted conservation practices have not been established by the third review, the contracts are subject to termination. After the first three years, Farm Service Agency personnel are responsible for conducting annual practice spot-checks (USDA "Audit Report" 2001).

3. LITERATURE REVIEW

3.1 POLICY INSTRUMENTS RELATED TO AGRICULTURAL NONPOINT SOURCE POLLUTION

3.1.1 The Policy Challenge of Nonpoint Source Water Pollution

According to James McElfish of the Environmental Law Institute (2000), "Nonpoint source pollution is perhaps our greatest water quality problem, and it remains one of our greatest problems of environmental governance." Despite its pervasiveness, effective control of nonpoint source water pollution by government policies has been limited by several key factors. Nonpoint source water pollution is both diffuse and stochastic in nature, making it difficult to design effective and efficient control policies. It is impossible to pinpoint pollution sources and pollution loads tend to vary by season, weather conditions, land use activities, soil type and other factors. These physical characteristics make monitoring nonpoint source pollution at its source challenging and cost-prohibitive (Malik, Larson, and Ribaudo 1994, Shortle and Horan 2001). They also make it difficult to clearly link pollution loads with specific land management practices. Due largely to these features, regulators have been hesitant to impose mandatory controls on nonpoint sources (Hale 2001).

Regulation of nonpoint source pollution is also limited by economic and political concerns. Regulations for diffuse pollution control tend to have less political support than those for point source control because they directly affect landowners' use of their land (Warkentin 2001) and they often target activities that contribute to local economies (Hale 2001). Regulation of nonpoint source pollution can also be hampered by overlapping agency jurisdictions, conflicting agency goals, and low public awareness (Gannon et al. 1996).

Given these difficulties, the primary government response to this problem has been to use financial and technical assistance to encourage voluntary actions such as the implementation of BMPs (McElfish 2000). However, it is apparent from ongoing water quality problems that these approaches have not been sufficient.

In the effort to move beyond a strictly voluntary approach to nonpoint source water pollution control, various groups have advocated the use of alternative environmental policy instruments. Some of these instruments have significant strengths, but most also have important weaknesses when applied to nonpoint source water pollution problems. Because of these weaknesses, some authors argue that more innovative mixes of policy tools should be investigated (Osborn and Datta 2006, Shortle and Horan 2001). One of the key policies investigated in this report, the Neuse Strategy agricultural rule, is such a mix.

The agricultural rule pursues a mixed policy approach in an attempt to harness the positive aspects of different policy instruments while overcoming their flaws. Like a traditional command and control approach, the agricultural rule sets a legally mandated level of pollution reduction. It also requires farmers to use prescribed types and combinations of BMPs if they choose to follow the standard BMP option to comply with the rule rather than the Local Nitrogen

Reduction Strategy ("local strategy") option. On the other hand, the local strategy option borrows aspects of its design from a pollution credit trading approach. It assigns collective responsibility to participating farmers to reduce their total nitrogen runoff levels by 30%. It does this by allowing farmers to work together to achieve the required nitrogen reduction in a more cost-effective manner by targeting pollution control practices to the sources that contribute most to the pollution problem and have the lowest abatement costs. This approach is much less formal than a market-based permit trading system, but has the potential to achieve the same outcomes. The agricultural rule also builds upon existing voluntary, incentive-based pollution control approaches that are traditionally used in agriculture, such as federal and state cost-sharing programs for the implementation of nutrient-reducing farming practices. Finally, by allowing farmers a choice in how they will comply and by giving them an opportunity within the local strategy option to shape the actions each county takes to achieve its required nutrient reduction, the agricultural rule opens up the possibility of improving farmer buy-in to and cooperation with the rule, two benefits often attributed to collaborative decision-making in environmental management efforts.

In order to provide background for the analysis of the agricultural rule, this chapter will review the key design elements of the policy instruments from which the rule borrows, including command and control, pollution trading, and incentives. It will discuss the primary strengths and weaknesses of each approach and will highlight key empirical findings related to their use for nonpoint source pollution control. It will also briefly discuss collaborative decision-making approaches.

3.1.2 Command and Control Environmental Policy Instruments

Direct regulation of pollution and polluters, frequently referred to as the command and control approach ("CAC"), typically entails the imposition of standards that are either performance-based, technology-based, or process-based (Gunningham and Sinclair 1998). For example, the standard BMP option of the agricultural rule is a technology-based standard that requires the use of particular management practices. In theory, CAC standards are applied consistently to all sources covered by the policy and are backed by regulatory mechanisms that can detect and punish violations.

Though the CAC approach can be very effective at achieving particular environmental outcomes, the approach has several potential drawbacks. Most often, CAC approaches are criticized as being overly expensive. Regulated entities frequently complain that by dictating the use of particular technologies or processes, the government forces them to reduce pollution in a way that is not cost-effective. For instance, a firm may believe that it could reduce its emissions by the desired amount more cheaply by using different means than the ones prescribed by the regulation. Performance-based CAC approaches can also be costly to implement because they require firms with different pollution control costs to reduce their pollution by the same amount (Tietenberg 2000a). This approach is inefficient because in the aggregate, the same amount of pollution reduction could be achieved for less cost by requiring firms with lower abatement costs to reduce their pollution more than those with higher abatement costs.

Regulators can attempt to improve cost-effectiveness of CAC approaches by requiring different actions by different pollution sources. However, to do this effectively, regulators need comprehensive and accurate knowledge about the regulated entities, which they generally lack (Gunningham and Sinclair 1998). In addition, applying different rules to different pollution sources can make enforcement efforts much more difficult (Scholz 1994).

Bardach and Kagan (1982) and Gunningham and Sinclair (1998) identify a second potential problem with this approach. When CAC regulations are strictly applied, they can be counterproductive to achieving desired policy outcomes. In some cases, strict rules can create resistance among those targeted and reduce their willingness to share needed information and to comply.

CAC instruments also are often criticized over the potentially significant administrative burdens their implementation can place on both regulators and firms. In order for CAC instruments to function, those implementing the policies must be able to ensure compliance, which requires effective reporting and monitoring systems. As discussed above, these requirements are a particular problem in the context of nonpoint source pollution. Rule enforcement is also problematic because the pollution sources are not always identifiable or accessible and because the pollutants themselves are mobile and sometimes transfer between environmental media (Gunningham and Sinclair 1998).

Attempting to overcome the potential economic efficiency and implementation problems inherent in applying CAC approaches to nonpoint source water pollution generally involves a tradeoff between these two goals (Gannon et al. 1996). Policies that emphasize economic efficiency are likely to require significant amounts of information about pollution sources, which will increase information and administrative burdens. On the other hand, attempting to simplify a CAC approach by imposing a consistent, easy-to-monitor standard is likely to increase compliance costs because it will not account for variation among polluters.

In general, the direct regulation of nonpoint source pollution is rare. Though CAC instruments are currently used in the Clean Water Act's National Pollution Discharge Elimination System Stormwater Program and in some erosion and sedimentation control laws, they have not traditionally been used to address agricultural sources of nonpoint source pollution. However, there are agricultural studies that have explored the use of CAC approaches through simulation or have used hypothetical CAC approaches as points of comparison for the evaluation of other types of policy instruments. Several of these studies are discussed below.

3.1.3 Nonpoint Source Pollution Trading Instruments

Tradable permit policy instruments are often advocated as alternatives to CAC approaches. In the tradable permits approach, regulators identify the pollutant and geographic area to be targeted and set an overall level of allowable emissions. This total amount is then divided into discrete units that are represented by permits. Permits are distributed by various means to the pollution sources targeted in the program. The sources can then buy and sell permits to each other, creating a permit market. If the permit market functions well, and a sufficient number of sources participate, the equilibrium price of permits should equal the average abatement costs of all firms in the market (Pindyck and Rubinfeld 2000). A permit system can also be established using emissions reduction credits, where firms receive one emission reduction credit for every unit of pollution they reduce beyond a set emissions standard. These credits can then be banked for future use, bought and sold among firms in a credit market, or used to offset new emissions sources (Tietenberg 2000a).

The marketable permits approach has several potential strengths. Like the CAC approach, a permits market can achieve a specific desired level of pollution reduction. The market is designed so that in aggregate the available permits add up to the desired pollution cap. Additionally, a permits market offers firms the ability to make their own decisions about how much to control their pollution and by what means (Pindyck and Rubinfeld 2000). This reduces the need for regulators to have detailed information about the regulated entities (Hanley, Shogren, and White 1997) and can reduce compliance costs at both the firm level and market-wide. Firms will maximize economic efficiency by reducing their pollution up to the point where their marginal costs of abatement equal the market price of the permits. This allows firms with high control costs to purchase permits for less than it would cost them to reduce emissions and firms with lower control costs to sell excess permits at a profit. Because the market price of permits will mirror the average abatement costs of all firms in the market, this approach ensures that the marginal costs of control are equalized across all pollution sources and the overall cost of reaching the overall pollution target is minimized.

Despite these potential strengths, the marketable permits approach still needs a regulatory framework in which to operate, which can generate significant implementation costs. Like the CAC approach, regulators must still determine the desired level of pollution abatement. In addition, marketable permits approaches do not escape the need for adequate regulatory monitoring and enforcement activity. In a review of market-based approaches, Stavins (2001) finds that where monitoring and enforcement were deficient, the policies were not effective. Tietenberg (2000b) also finds that without adequate enforcement, pollution permit holders may gain more by cheating than by following the limits in their permits, which could cause a pollution cap to be exceeded (Tietenberg 2000b). Monitoring and enforcement issues remain particularly challenging for pollution trading instruments targeting nonpoint sources (Boyd et al. 2003, Letson 1992).

In addition to administrative costs, tradable permit markets can also generate transaction costs that are unique to this approach and particularly challenging in the context of nonpoint source pollution trading. When there are differences in the types of pollutants, the location and timing of their release, and uncertainties in the costs and effects of control technologies, regulators also must establish what constitutes an “environmental equivalent” in trading (Boyd et al. 2003; EPA 1996; Malik, Larson, and Ribaudo 1994). Developing appropriate trading ratios may be particularly difficult if trading is between nonpoint sources and point sources. Also, since nonpoint sources tend to be smaller in size and larger in number, the number of trades could be significant, and according to Tietenberg (2000b), regulators need to validate every one of them. As explained by Thurston et al. (2003), one necessary condition for a successful trading scheme is that the transaction costs of such programs be no greater than the gains achieved. Whether this condition could be met for nonpoint sources given current monitoring limitations is an important question.

Another weakness of this approach is that even though it can operate well when the targeted pollutants are conservative and uniformly mixed, when they are not, some areas may receive higher pollution burdens than others (Stavins 2001, Tietenberg 2000b). For example, in the case of water pollution, pollutants tend to accumulate downstream (Thurston et al. 2003). While there are some variations on the basic marketable permits approach that attempt to address this concern, these approaches tend to be "excessively complex to implement" (Tietenberg 2000b).

Another challenge stems from the need for sufficient differences in control costs across potential trading partners (Thurston et al. 2003, Gannon et al. 1996, Schwabe 2000). As discussed above, the economic superiority of the tradable permits approach is predicated largely upon the existence of variable pollution abatement costs among pollution sources. When these sources have similar abatement costs, potential cost savings are diminished.

Current use of nonpoint source pollution trading in the U.S. is limited primarily to pilot programs (Boyd et al. 2003). In the programs that do exist, most trades are actually offsets rather than actual trades, where a point source is allowed to reduce a certain amount of nonpoint source pollution rather than further controlling its own effluent (Boyd et al. 2003). For example, the Neuse Strategy wastewater discharge rule incorporates an offsetting component, where point source dischargers may purchase offsets from agricultural pollution sources if they exceed the point source cap.

Given the potentially significant barriers to this approach, several authors suggest that its potential future use is quite limited. Letson (1992) argues that this approach is at best only a partial solution to nonpoint source problems. In fact, according to the Environmental Protection Agency, existing trading systems have not consistently delivered the benefits they promised. In many trading systems, there have been very few if any actual trades and the cost savings have been smaller than predicted (Stavins 2001, U.S. EPA 1996).

3.1.4 Financial Incentive Instruments

Incentives, such as subsidies, grants, loans, and tax allowances, are a form of financial assistance provided by regulators to firms either to encourage pollution control activities or to mitigate the costs of complying with regulations (Hanley, Shogren and White 1997). Typically, incentives are used to help pay for the installation of pollution control equipment or practices or simply to pay a firm directly for the amount of pollution reduced (Lesser, Dodds, and Zerbe 1997).

As a policy instrument, incentives have been used extensively to target agricultural nonpoint source pollution. In this context, subsidies typically are used to encourage participation in voluntary environmental programs. Provision of financial incentives is meant to lower two potential barriers to voluntary participation. First, farmers often do not experience the benefits of their conservation practices directly or in the short-run. Second, they may face financial opportunity costs for taking land out of production or devoting time and resources to new practices (Breetz et al. 2005).

The use of incentives to encourage pollution control can be subject to important theoretical, practical, and financial challenges. In theory, subsidies can leave regulatory agencies open to extortion because firms can threaten to pollute more in order to receive a subsidy not to pollute (Bromley 1991). Also, subsidies can theoretically lead to higher overall levels of pollution by reducing production costs for firms and encouraging new firms to enter the industry (Bromley 1991). In the aggregate, the impact of an increasing number of polluters has the potential to overwhelm the pollution reductions achieved by existing firms.

The use of incentives to encourage pollution reduction can also face more practical challenges. Foremost, the impact of incentives on pollution levels cannot be ensured. Participation in incentive-based programs is typically voluntary and there is no guarantee that it will be sufficient to reduce pollution to desired levels. Many issues may limit participation in these programs despite the incentives. For example, a qualitative study conducted on behalf of the North Carolina Corn Growers Association in 2002 found several issues limiting the voluntary implementation of BMPs including the perception among farmers that management practice design standards are overly strict, complications in dealing with landowners over rented farmland, and privacy concerns. In addition, even among those who do voluntarily participate in these programs, it can be difficult to ensure ongoing performance because the government is often unwilling to terminate incentives (Ingram 1977). It can also be difficult to know whether the incentives are actually responsible for encouraging the pollution-reducing activities or whether participants would have performed these activities anyway. For example, the N.C. Corn Growers study (2002) found that many farmers used BMPs without cost-share assistance, including some of the farmers with the highest levels of BMP implementation.

Finally, the financial costs of implementing incentive-based programs can be significant. Providing subsidies costs the government money and in many cases the subsidies must be substantial to encourage action. For example, according to Lesser, Dodds, and Zerbe (1997), subsidies for pollution-reducing equipment will not work unless they pay the full cost of the equipment or unless the pollution reductions are mandated. This is because new equipment typically increases a firm's operating costs and a firm will not have an incentive to do this unless the costs are fully covered or they have no choice.

Incentive-based programs that target nonpoint source pollution also face administrative costs similar to those that encumber the CAC and marketable pollution permits approaches. Babcock et al. (2001) claim that the design and implementation of successful conservation payment programs need to account for potentially significant transaction costs and that in cases involving nonpoint source pollution, "verification, monitoring and enforcement costs could be greater than the value of the environmental benefits obtainable from farmers." Shortle argues that when using a subsidy approach to pollution control, costs related to information, administration, and enforcement essentially require that there be a limited number of allowable practices that are relatively easy to monitor and are correlated with ambient environmental impacts. In writing about agricultural nonpoint source control issues, Malik, Larson, and Ribaudo (1994) argue that based on the significant challenges inherent in monitoring nonpoint source pollutant loadings, there should be "no immediate presumption that economic incentive policies are more efficient than command and control policies."

Despite these numerous challenges, the use of financial incentives has been found in many cases to have a positive impact on the adoption of environmental farming practices and participation of farmers in conservation programs. For example, in a study of participants in the Rural Clean Water Program, farmers cited cost-share financial assistance as the second most important reason for participating (Gale et al. 1993). In a study of farmer participation in the British Environmentally Sensitive Areas Scheme, 69% of participants cited financial incentives as the main reason for joining the scheme (Wilson 1997). In addition, the North Carolina Corn Growers Association study (2002) found a strong relationship between the receipt of cost-share payments and the implementation of BMPs.

3.1.5 Empirical Findings Related to Policy Instrument Efficacy and Efficiency in the Context of Agricultural Water Pollution

To date, much of the literature on policy instruments related to agricultural nonpoint source water pollution control is theoretical in nature and provides inconsistent guidance in terms of which instruments are best suited for this purpose. Though some studies provide important insights into particular features of different policy instruments, in aggregate, the practical usefulness of these studies is limited in a number of ways. First, most of the studies are ex ante, comparing idealized versions of the different instruments using simulations or models rather than focusing on policies that have actually been implemented. Second, most of the studies do not focus on practical aspects of how these policies are or should be implemented. For example, though many of the studies identify administrative matters and transaction costs as potentially significant issues, none explicitly incorporate them into their analyses. Third, there is often inconsistency in the findings among or even within studies in terms of which approaches are best. Finally, the studies typically do not analyze potential hybrid or mixed approaches. A brief review of the key findings of the most relevant studies follows.

In the most applicable study, Schwabe (2001) uses a computer simulation to compare two nitrogen reduction strategies in the Neuse River Basin: a hypothetical CAC approach mandating that all farmers install vegetated filter strips and an approach that mandates a specific nitrogen reduction. He finds that the latter rollback approach is more cost-effective, but he finds that whether or not strategies to achieve the roll back standard account for heterogeneity in soils and locations of pollution sources can lead to substantially different estimates of control costs and nitrogen loadings.

Also based on his Neuse River Basin model, Schwabe (2000) offers three conclusions regarding the use of CAC or market-based instruments in controlling water pollution. First, market-based policies can be significantly more cost-effective than CAC policies, but the magnitude and distribution of costs can vary significantly depending on the sources that are targeted and how background residuals are treated. Second, systems that use both approaches, depending on transaction costs, can achieve substantial cost savings. Third, targeting both point and nonpoint sources can be more cost-effective than targeting either type individually due to greater variation in control costs.

Another study uses computer simulations to compare two different forms of a CAC approach for reducing nutrient runoff pollution. Randhir and Lee (2000) compare the impacts of a technology-based standard against a farm-based standard on farm income, income variability, and overall water quality. The technology-based standard consists of a given set of cropping practices and the farm-based standard allows for flexibility in cropping practices if farmers comply with an emission standard that is measured at the farm boundary. The authors find significant differences in the impacts of these policies on the generation of other types of pollutants, depending on whether the standard is based on nitrogen or phosphorus. In each case, some pollutants increase and others decrease. They also find significant differences between the farm-boundary versus technology standard, but no superior approach emerges.

Two studies generally criticize incentive-based approaches for being inefficient and ineffective. In their study of a Lake Erie watershed, Forster and Rausch (2002) show that incentive payments intended to reduce agricultural water pollution were not used efficiently in terms of being targeted at the worst problems (areas with highest erosion rates) or spent on most cost-efficient practices. Likewise, Wu et al. (2003) argue that conservation payments are not likely to be very cost-effective in terms of reducing nutrient loading problems in the Mississippi River Basin. They simulate changes in the adoption of crop rotations and conservation tillage in the Upper Mississippi River Basin under a range of conservation payment levels, and then translate these changes into likely impacts on nonpoint source pollution, including nitrate leaching and runoff and water and wind erosion. They generally find higher levels of adoption under higher payments, but the effects of the incentives are inelastic and very small for the adoption of crop rotation. In addition, the two approaches have different impacts on the pollution problems addressed, with crop rotations increasing runoff but reducing leaching and the opposite being true for conservation tillage. Overall, the changes in the four pollutants are very small even at the highest payment levels.

Other studies (Shortle and Dunn 1986; Wu and Babcock 1999; Whittaker, Srinivasan, and Scott 2003) find a slight advantage for incentive-based approaches over CAC approaches. For example, in their theoretical discussion of the expected net benefits of four potential agricultural nonpoint source pollution reduction strategies, Shortle and Dunn (1986) argue that a management practice incentives approach is preferable to economic incentives applied to estimated runoff levels, runoff standards, or standards applied to farm management practices for several reasons. First, management practice incentives give farmers the flexibility to apply their specialized knowledge of their own farm operations in order to choose optimal practices. Second, they are more politically acceptable than the alternatives. Third, they do not require the measurement or estimation of runoff.

In their comparison of a mandatory penalty-based program and a voluntary incentive-based program intended to encourage farmers to adopt particular practices, Wu and Babcock (1999) argue that the implementation costs of the voluntary program are less than that of the mandatory program because it provides more flexibility, incurs smaller enforcement costs, and should reduce conflicts and formal legal procedures. The difference in costs is assumed to increase with the number of farms and program acreage and with monitoring costs. Wu and Babcock conclude that a hybrid approach where a fine is imposed on nonadopters and government services and incentive payments are provided to adopters would be the most efficient.

In another study that supports the use of incentive-based approaches over CAC approaches, Whittaker, Srinivasan, and Scott (2003) compare an economic incentive policy with a CAC policy in terms of controlling N fertilizer application on wheat and barley crops on the Columbia Plateau. They find that the economic incentive policy, a fertilizer tax, was less costly to farmers and more efficient in reducing emissions than a required fertilizer application reduction of 25percent, but there were some locations where the policies performed equivalently. Consistent with previous studies, they find fertilizer to be highly inelastic and that a 300% tax is required before every farm in the sample reduces fertilizer application. Based on the variability in their findings, they argue that targeting policies at the 8-digit HUC level would be more efficient than a uniform basin-wide policy. However, the authors ignored transaction costs in their analysis, which they claim could potentially overwhelm any theoretical efficiency gains associated with such targeting.

A final study does not find a clear winner between CAC approaches and incentive-based approaches. Feng et al. (2003) compare the efficiency of the Conservation Reserve Program ("CRP"), a program that provides incentives to farmers to retire highly erodable lands from production, with two forms of hypothetical CAC policies, failing to find a superior approach. One CAC policy treats all sources the same regardless of the compliance costs or the benefits provided by compliance. The second CAC policy is more "enlightened" in that it treats all sources equally in terms of either costs or benefits, but allows for variation in the other (9). The authors compare what actually happened under the CRP to the two CAC policies under two baselines: one where the total amount of land put into the CRP is fixed and one where the total program budget is fixed. Their simulations do not show any of these policies to be clearly advantageous relative to the others.

3.1.6 Collaborative Processes

Another aspect of the design of the agricultural rule that is relevant to this analysis is its inclusion of a collective or collaborative approach to achieving the required nitrogen reductions. Though empirical support is not easy to find, the collaborative management literature often asserts that allowing stakeholders to participate in environmental policy decision-making increases their support for management plans and eases implementation. For example, Gunningham and Sinclair (1998) state that a potential benefit of allowing firms to participate in the design of regulations is that they will be more committed to abiding by them. Tietenberg (2000b) explains that co-management of environmental resources is often presumed to increase compliance.

In at least two studies, the positive effect of participation on compliance was found to be true. In a study of alternative phosphorus pollution control policies in Minnesota, farmers reported that the process by which the policies were set would affect their compliance (McCann and Easter 1999 as cited in Breetz et al. 2005). The authors of this study conclude that a sense of equity influences farmers' behavior regardless of the policy. In a study of collaborative fishery management, Hatcher et al. (2000) find that fishermen who felt more involved in the design and implementation of the management system were less likely to violate quota restrictions. However, the relevance of the Hatcher et al. study to the Neuse agricultural rule may be limited since, according to Tietenberg (2000b), incentives for collective action differ between resources where users are directly impacted by their actions, such as fisheries, and those where there are externalities, such as water pollution.

By including a collaborative decision-making mechanism, the Neuse agricultural rule has the potential to result in higher levels of farmer support for the rule and thus higher levels of participation in achieving its goals. However, it is important to note that these types of outcomes are much more likely to be realized when collaborative processes have a representative membership and there are clear mechanisms for accountability to the greater community (Lynn and Busenberg 1995), neither of which are very apparent in the LAC approach.

3.2 THE ROLE OF FARM AND FARMER CHARACTERISTICS IN THE ADOPTION OF BEST MANAGEMENT PRACTICES

Another area of literature with direct relevance to this investigation involves studies that explore the influence of different personal and farm-related factors on farmers' adoption of environmental farming practices or participation in conservation programs. These factors are particularly important in the context of voluntary programs and are relevant here because the Neuse Strategy relies largely on the voluntary actions of farmers to achieve its mandated nutrient reductions. The most commonly explored farmer and farm characteristics in previous studies include: age, level of education, income, farm size, years of farming experience, and farm tenure. These variables were measured in the survey analyzed in this project and are included as independent variables in all of the statistical models tested.

Age is consistently included as a variable in studies of BMP adoption, though many studies have not found it to have a significant effect (Wilson 1997, Gale et al. 1993, Smithers and Furman 2003). One study found older farmers to be less likely to adopt modern nutrient management practices and suggested that older farmers are more reluctant to invest in new practices because they have a shorter time horizon in which to experience the anticipated benefits (Caswell et al. 2001). Another found that even though age did not affect participation in the British Environmentally Sensitive Areas Scheme, younger farmers tended to participate more for conservation purposes whereas older farmers participated for more practical reasons such as income enhancement (Wilson 1997).

Education has also been included in previous studies as a potentially influential factor, with some studies find it to have no effect on practice adoption (Wilson 1997, Gale et al. 1993). However, other studies have found it to have a positive influence, with more educated farmers being more likely to adopt environmental practices or participate in environmental farm programs (Smithers and Furman 2003, Caswell et al. 2001). One study, conducted in the Neuse River Basin in 1998, found that more educated farmers are more likely to use BMPs than less educated farmers (Hoban and Clifford 1999).

Income and farm size are both consistently found to have a positive impact on environmental practice adoption and program participation (Gale et al. 1993, Wilson 1997, Caswell et al. 2001). These two variables are often related, with larger farms tending to provide farmers with higher incomes. Higher incomes are believed to provide farmers with more flexibility in their decision-making and higher risk tolerance than farmers with fewer resources (Gale et al. 1993).

Years of farming experience has also been discussed in the literature. Neither Smithers and Furman (2003) nor Gale et al. (1993) found significant differences between program participants and nonparticipants in terms of experience. However, in their study of nutrient management practice adoption, Caswell et al. (2001) found experience to have a negative effect on the adoption of modern practices such as soil nitrogen testing, split nitrogen applications and micronutrient use. They found experience to have no significant impact on the adoption of more traditional practices including the use of organic sources of nutrients such as planting legumes in rotation with other crops. Caswell et al. (2001) argue that experience can have positive or negative impacts on practice adoption because farmers with a lot of experience may be more efficient at incorporating new practices or they may be more reluctant to switch away from familiar approaches.

Land tenure, or land ownership versus rental, has also been studied previously. Gale et al. (1993) state that the amount of rented land generally has not been found to have a consistent impact on BMP adoption. In their study, participants in the Rural Clean Water Program were found to be more likely to have a mix of rented and owned land rather than all owned or all rented land. Caswell et al. (2001) hypothesized that land owners could be expected to be better stewards of their land and more willing to adopt technologies with higher fixed costs. However, they found that land ownership did not impact adoption of modern nutrient management practices and actually had a significant, negative impact on the use of legumes in rotation. Wilson (1997) did not find any relationship between tenure and participation in the British Environmentally Sensitive Areas Scheme.

4. METHODOLOGY

4.1 RESEARCH OBJECTIVE 1 – HOW SUCCESSFUL HAS THE NEUSE AGRICULTURAL STRATEGY BEEN IN ACHIEVING ITS GOALS?

In order to evaluate the impacts of the Neuse agricultural rule, this project investigates a number of factors. These include: the implementation of BMPs, changes in nutrient application rates, losses of active cropland, changes in ambient water quality, and the flexibility and efficiency of the rule. The data used to evaluate and discuss these factors come primarily from reports about the agricultural rule that were developed by the Neuse Basin LACs, the Neuse BOC, N.C. DENR, and researchers affiliated with North Carolina Cooperative Extension Service.

BMP acreage and coverage information was calculated using values supplied in the "Neuse Nutrient Sensitive Water Management Strategy Annual Report for Year 2005." The 2005 report contains updated information about the BMPs in place in 2003 as well as in the baseline years of 1991-1995. The types of BMPs and the number BMP acres proposed by the LACs were obtained from a document titled "Summary of Local Nitrogen Reduction Strategies for the Neuse River Basin," which was obtained from N.C. DENR. To address apparent differences in how the LACs reported their BMP goals, we assumed that the local nitrogen reduction strategies built upon BMPs already in place in the baseline years if the number of BMP acres in the local strategy was the same or higher than in the baseline. In cases where the BMP acres in the local strategies were less than those in the baseline, we assumed that the local strategy numbers were additions to the baseline BMPs. Percentage changes in BMP acres were calculated from the reported values.

In order to calculate the BMP coverage values for the baseline and 2003, we divided the total number of acres treated by BMPs in that time period by the total number of cropland acres in the county at that time. For coverage proposed in the local strategies, we divided the number of acres of BMPs proposed for use divided by the number of crop acres in the baseline. The BMP coverage calculations assume that BMPs are not doubled up on the same cropland acres unless the percentage is greater than 100. This is not likely to be perfectly accurate, but does allow for simple comparisons in coverage over time and among different counties and regions.

Nutrient application rates were calculated using values from the "Neuse Nutrient Sensitive Water Management Strategy Annual Report for Year 2005." We first calculated the total amount of nitrogen applied to all reported crops in each county for the baseline and for 2003 by multiplying the crop acreage by the average fertilization rate for each crop type and then summing across all crop types. We then divided the total amount of nitrogen applied by the total number of crop acres in that time period to yield a weighted average nitrogen application rate for the entire county.

The nitrogen loss reductions discussed in the report are simply the values reported by the Neuse BOC to the N.C. EMC in 2005 for crop year 2003. The 2005 report was used because of changes made to NLEW that year that affected the calculated nitrogen losses. After NLEW was updated, the nitrogen loss reductions for 2003 and the baseline were recalculated and reported.

Values describing the amounts of cropland lost in the basin between the baseline and 2003 were also calculated from data provided in the "Neuse Nutrient Sensitive Water Management Strategy Annual Report for Year 2005." These values include land taken out of active crop production for any reason, including cropland that became idle, was converted to grass or trees, or was developed.

The discussion of flexibility in the agricultural rule is based on the requirements described in the rule's language concerning the local strategy and standard BMP compliance options as well as written descriptions of the NLEW. The percentages of cropland acres and numbers of farmers who signed up for the local option of the rule were obtained from the "Summary of Local Nitrogen Reduction Strategies for the Neuse River Basin."

Descriptions of how the LAC's operated and determined values for BMP acreage, nitrogen application rates, and cropland acres were obtained from written reports and from Natalie Jones. These descriptions provide the basis for the cost-effectiveness discussion in this report.

4.2 RESEARCH OBJECTIVE 2 – HOW ARE FARMERS RESPONDING TO THE NEUSE AGRICULTURAL AND NUTRIENT MANAGEMENT RULES?

In order to determine how farmers in the Neuse Basin have responded to the agricultural requirements of the Neuse Strategy, the research team participated in a survey of 315 farmers in three Neuse Basin counties in December 2005. The N.C. DWQ funded the survey and survey professionals in the Center for Urban Affairs and Community Services at North Carolina State University carried it out. The research team developed the survey instrument in conjunction with Professors Thomas Hoban and William Clifford from the Department of Sociology and Anthropology at North Carolina State University. The primary purposes of the survey were to provide N.C. DENR with information about farmers' nutrient management practices; to gauge the respondents' knowledge of the Neuse agricultural rules; and to learn about their attitudes toward the rules, water quality issues in the basin, nutrient management training, and other issues. The survey instrument is attached as Appendix A.

The farmer survey was conducted by telephone, with each interview lasting approximately 15 minutes. The sampling frame consisted of all farmers in Wayne County, Johnston County, and Lenoir County who had signed up for the local strategy option of the agricultural rule. These counties were selected because they are geographically similar and share important agricultural features in terms of the amount of farm acreage and the types of crops that are grown. These similarities are meant to help to control for differences in these types of features that could affect the farmers' adopted practices. Approximately 100 completed interviews were obtained from farmers in each of the three counties.

In both Wayne and Lenoir Counties, the entire sampling frame was used in order to achieve 215 completed interviews. In Johnston County, which has a larger number of farmers, two-thirds of the sampling frame was randomly selected, yielding 100 completed interviews. Because the sampling frame consisted of a list of farmers generated in 1998 and 1999, many of the phone numbers were not usable and there was high level of ineligibility due to attrition from farming and other factors. Using the American Association for Public Opinion Research's response rate calculator for "Response Rate 3," which includes the completed interviews in the numerator and the completed interviews, refusals, non-contacts, and a proportion of the cases of unknown eligibility (i.e., those who were contacted the maximum number of tries without success) in the denominator, this survey had a response rate of 74%. This assumes that 30% of the cases of unknown eligibility were actually eligible to participate in the study. However, this assumption generates a response rate that is likely very conservative given the quality of the information in the sampling frame. Therefore, the cooperation rate may be a better determinant of how representative the survey sample is of the target population in these counties. The cooperation rate was 86%. This value divides the number of completed interviews by the number of completed interviews plus the number of refusals.

The survey data were analyzed using the STATA statistical package. Due to the binary and categorical dependent variables investigated in this study, logistic, ordered logistic, and multinomial logistic regression models were employed. These models overcome problems associated with using the standard linear regression model for noncontinuous dependent variables, including violations of basic model assumptions (Long 1997). In this study, models with dichotomous dependent variables use logistic regression, those with dependent variables that consist of ordered categories use ordered logistic regression, and those with unordered categorical outcome variables or those that do not meet the parallel slopes assumption of the ordered logistic regression model utilize multinomial regression analysis.

In this report, the coefficients generated by STATA for the independent variables in the models are exponentiated to facilitate their interpretation as odds ratios. Odds ratios indicate the change in the odds of an event occurring and can also be interpreted as percentages. An odds ratio of 1.0 indicates even odds, whereas an odds ratio of less than 1.0 indicates decreased odds and one greater than 1.0 indicates increased odds. For example, in this project, model 3 tests the influence of various independent variables on whether or not a farmer plants cover crops. In this model, the odds ratio for farmer age is calculated as 0.95. This means that for each additional year of age, the odds of a farmer planting cover crops decrease by 5%. In other words, for each additional year of age, a farmer is 5% less likely to plant cover crops holding other variables constant. If the odds ratio had been found to be 1.15, it would mean that for each additional year of age, a farmer is 15% more likely to plant cover crops holding other factors constant. It is important to note that for odds ratios, positive effects are greater than 1, whereas negative effects are between 0 and 1. This means that the magnitudes of positive and negative effects are not directly comparable. These effects can be compared by taking the inverse of the negative effect. For example a positive factor change of 2 and a negative factor change of 0.5 are equivalent in magnitude (Long 1997).

5. RESULTS AND DISCUSSION - RESEARCH OBJECTIVE 1

The first objective of this research effort is to evaluate and discuss the success of the Neuse Strategy agricultural rule in achieving its key goals. These goals include reducing nitrogen losses from agricultural lands in the basin by 30%, achieving this reduction in a way that enhances flexibility and cost-effectiveness relative to a standard requirement for BMP implementation, and ultimately reducing nitrogen-related pollution problems in Neuse River.

In order to evaluate the program's success in achieving the 30% nitrogen runoff reduction, this study focuses on the extent of BMP implementation, reductions in nitrogen application rates, and the magnitude of the calculated nitrogen loss reductions on a county-by-county basis, regional basis, and for the entire Neuse Basin. It focuses specifically on impacts in the year 2003, which is when the strategy was required to be fully implemented.

In order to evaluate whether the agricultural rule achieved its goals of enhanced flexibility and cost-effectiveness, the study investigates whether it provided alternatives for complying with the nitrogen reduction goal that were not included in the standard BMP option and whether it pursued a more cost-effective BMP strategy through spatial targeting of BMPs.

The pollution reduction goal in the agricultural rule targets nitrogen losses from agricultural operations rather than specific impacts on ambient water quality in the Neuse River and Neuse Estuary, since it is these impacts that initially drove the creation of the Neuse Strategy, this chapter of the report will also discuss what is known about the water quality impacts of the rule.

5.1 RESULTS: NITROGEN APPLICATION RATES, BEST MANAGEMENT PRACTICE IMPLEMENTATION, AND NITROGEN RUNOFF REDUCTIONS

General results are discussed first for each of the three regions within the Neuse Basin (i.e., the Piedmont, Upper and Middle Coastal Plain, and Lower Coastal Plain regions), and then for the basin as a whole. Results for each county are detailed in the data tables. Acreages subject to management with BMPs are shown in Table 2. More detailed acreages by type of BMP by county are provided in Appendix B. Changes in county cropland from the baseline to 2003 are found in Table 3, and changes in the percentage of cropland treated by BMPs are shown in Table 4. Changes in county average nitrogen application rates for the same period are given in Table 5. Reported nitrogen loss reductions come from the "Neuse Nutrient Sensitive Water Management Strategy Annual Report for Year 2005."

5.1.1 Piedmont Region

The Piedmont Region includes the six western-most counties in the Neuse River Basin: Durham, Franklin, Granville, Orange, Person, and Wake.

Due primarily to the prevalence of existing grass, forest, and riparian buffers, the majority of cropland in the Piedmont Region was treated by a BMP in the baseline years of 1991 to 1995. Assuming that BMPs were not doubled up on the same cropland, the average percentage of cropland covered by a BMP in this region's counties was 95.5 in the baseline. Of the six counties, only Durham proposed to add new BMPs in its local strategy. It proposed to treat approximately 500 additional acres with riparian buffers or nutrient management.

By 2003, all six counties had experienced losses in the overall amount of cropland treated by BMPs, losing an average of 22.3%. These losses occurred despite small additions of nutrient management and cover crops in several of the counties and derive primarily from the significant loss of cropland that occurred in this region from the baseline to 2003. However, the percentage of cropland treated by BMPs actually increased slightly during the implementation period, reaching a regional average of 98% in 2003. This indicates that the ratio of untreated to treated cropland was higher in the cropland that was taken out of production than in the cropland that remained in 2003.

All of the Piedmont counties except Person anticipated cropland losses in their local strategies. Five counties including Person lost more cropland than expected during the implementation period. Franklin County lost less than expected. The losses across all six counties ranged from 1 percent to 29.6% of baseline cropland acres, with an average loss of 19.6%. A total of 25,499 acres were lost across the region.

All six counties reduced their average nitrogen application rates, ranging from 4.9 to 26%, with an average reduction of 15%.

All six counties reported meeting their nitrogen loss reduction targets by 2003, averaging a 39.5% reduction from the baseline. In the Piedmont region, the loss reductions are clearly attributable to cropland attenuation and nitrogen application rate reductions. BMPs installation did not contribute significantly to the region's success.

Table 2. Total Acres of Reported BMPs in the Baseline, Local Strategies, and 2003

County	Location	Baseline (acres)	Local Strategy (acres)	2003 (acres)	Change from Baseline to Local Strategy	Change from Local Strategy to 2003	Change from Baseline to 2003
Durham	Piedmont	12,476	12,974	11,221	4.0%	-13.5%	-10.1%
Franklin	Piedmont	6,443	6,443	6,235	0.0%	-3.2%	-3.2%
Granville	Piedmont	7,582	7,582	5,984	0.0%	-21.1%	-21.1%
Orange	Piedmont	19,382	19,382	15,038	0.0%	-22.4%	-22.4%
Person	Piedmont	17,329	17,329	14,411	0.0%	-16.8%	-16.8%
Wake	Piedmont	39,951	39,951	27,277	0.0%	-31.7%	-31.7%
Regional Total		**103,163**	**103,661**	**80,166**			
Regional Average		**17,194**	**17,277**	**13,361**	**0.5%**	**-22.7%**	**-22.3%**
Greene	Up/Mid Coastal Plain	5,476	6,176	21,293	12.8%	244.8%	288.8%
Johnston	Up/Mid Coastal Plain	10,906	17,816	21,865	63.4%	22.7%	100.5%
Lenoir	Up/Mid Coastal Plain	6,406	59,414	82,663	827.5%	39.1%	1190.4%
Nash	Up/Mid Coastal Plain	0	350	3,142		797.7%	
Pitt	Up/Mid Coastal Plain	8,276	48,661	16,554	488.0%	-66.0%	100.0%
Wayne	Up/Mid Coastal Plain	0	114,988	108,124		-6.0%	
Wilson	Up/Mid Coastal Plain	47,189	55,387	69,564	17.4%	25.6%	47.4%
Regional Total		**78,253**	**302,792**	**323,205**			
Regional Average		**11,179**	**43,256**	**46,172**	**286.9%**	**6.7%**	**313.0%**
Carteret	Lower Coastal Plain	11,772	39,607	39,833	236.5%	0.6%	238.4%
Craven	Lower Coastal Plain	11,772	26,300	41,465	123.4%	57.7%	252.2%
Jones	Lower Coastal Plain	13,096	63,176	64,749	382.4%	2.5%	394.4%
Pamlico	Lower Coastal Plain	0	24,658	17,567		-28.8%	
Regional Total		**36,640**	**153,741**	**163,614**			
Regional Average		**9,160**	**38,435**	**40,904**	**319.6%**	**6.4%**	**346.5%**
NEUSE BASIN TOTAL		**218,056**	**560,194**	**566,985**			
NEUSE BASIN AVERAGE		**12,827**	**32,953**	**33,352**	**156.9%**	**1.2%**	**160.0%**

5.1.2 Upper and Middle Coastal Plain Region

The Upper and Middle Coastal Plain consists of seven counties in the central portion of the Neuse Basin: Greene, Johnston, Lenoir, Nash, Pitt, Wayne, and Wilson.

All seven counties in this region included new BMPs in their local strategies consisting primarily of buffers and nutrient management. Some counties, including Nash and Wayne, started from a reported baseline of zero acres of cropland treated by BMPs. Including these two counties in the calculation, BMPs covered an average of 14% of cropland across the region in the baseline years.

According to their local strategies, on average, the seven counties in this region proposed increasing their BMP coverage by over 32,000 acres from an average of 11,179 acres in the baseline to an average of 43,256 acres by 2003. If all of the BMPs included in the local strategies had been implemented, BMPs would have covered over 44% of the region's cropland in 2003.

By 2003, all of the counties had in fact increased their BMP coverage, and all but Pitt and Wayne exceeded the goals established in their local strategies. BMP coverage reached an average of 51.8% of cropland, or 46,172 acres per county. The new BMPs in this region were primarily a mix of buffers, nutrient management, and cover crops.

All but Lenoir and Wayne Counties experienced losses in active cropland during the implementation period and these two counties experienced increases of cropland of only 1 percent each. In the other five counties, losses averaged 4.9 to 19% of baseline acreage, with a region-wide average of 7.7%. This represents a total loss of 33,557 acres across the region from the baseline to 2003.

The average nitrogen application rate decreased in all seven counties, ranging from 9 to 37.9% reductions, with an average reduction of 20.5%.

All counties in this region reportedly met their nitrogen loss reduction targets, averaging a 41.5% reduction. Relative to the Piedmont, the numbers reported for this region show that BMPs played a much greater role in achieving the nitrogen loss reductions and the nitrogen application rate reduction was also more significant in the Middle Coastal Plain than in the Piedmont. Cropland loss played a proportionately smaller role in reducing nitrogen losses in this region than in the Piedmont and it varied more across the counties within the region.

Table 3. Changes in Active Cropland from the Baseline to 2003

County	Location	Total Cropland in Baseline (acres)	Loss Anticipated in Local Strategy (acres)	Total Cropland in 2003 (acres)	Actual Cropland Loss by 2003 (acres)	Actual Cropland Loss by 2003 (%)
Durham	Piedmont	13,561	989	11,247	2,314	17.1%
Franklin	Piedmont	6,509	651	6,441	68	1.0%
Granville	Piedmont	8,219	614	6,113	2,106	25.6%
Orange	Piedmont	17,808	2,676	13,169	4,639	26.1%
Person	Piedmont	19,499	0	15,968	3,531	18.1%
Wake	Piedmont	43,419	6,514	30,578	12,841	29.6%
Regional Total		**109,015**	**11,444**	**83,516**	**25,499**	
Regional Average		**18,169**	**1,907**	**13,919**	**4,250**	**19.6%**
Greene	Up/Mid Coastal Plain	75,474	0	71,747	3,727	4.9%
Johnston	Up/Mid Coastal Plain	129,762	11,000	118,015	11,747	9.1%
Lenoir	Up/Mid Coastal Plain	99,674	0	100,663	-989	-1.0%
Nash	Up/Mid Coastal Plain	21,135	1,347	17,126	4,009	19.0%
Pitt	Up/Mid Coastal Plain	69,184	3,050	63,785	5,399	7.8%
Wayne	Up/Mid Coastal Plain	139,682	0	141,253	-1,571	-1.1%
Wilson	Up/Mid Coastal Plain	73,719	5,898	62,484	11,235	15.2%
Regional Total		**608,630**	**21,295**	**575,073**	**33,557**	
Regional Average		**86,947**	**3,042**	**82,153**	**4,794**	**7.7%**
Carteret	Lower Coastal Plain	22,307	0	22,260	47	0.2%
Craven	Lower Coastal Plain	59,537	0	52,999	6,538	11.0%
Jones	Lower Coastal Plain	50,000	0	47,664	2,336	4.7%
Pamlico	Lower Coastal Plain	37,406	0	42,145	-4,739	-12.7%
Regional Total		**169,250**	**0**	**165,068**	**4,182**	
Regional Average		**42,313**	**0**	**41,267**	**1,046**	**0.8%**
NEUSE BASIN TOTAL		**886,895**	**32,739**	**823,657**	**63,238**	
NEUSE BASIN AVERAGE		**52,170**	**1,926**	**48,450**	**3,720**	**10.3%**

5.1.3 Lower Coastal Plain Region

The Lower Coastal Plain region of the Neuse Basin is comprised of the four eastern-most counties in the basin: Carteret, Craven, Jones, and Pamlico.

Three of these counties each reported having over 10,000 acres of cropland treated by BMPs in the baseline. Existing BMPs consisted primarily of water control structures and in Jones County, 50-foot riparian buffers. Pamlico County reported having zero acres of treated cropland in the baseline years. All four counties proposed to increase BMP coverage significantly in their local strategies, going from an average of 9,160 treated acres to an average of 38,435 treated acres, or equivalently going from an average coverage of 24.7% to 103.5%. The proposed BMPs consisted predominantly of additional water control structures and nutrient management, with some additional acreage of 50-foot buffers.

By 2003, both Jones and Carteret Counties had achieved their BMP treatment goals almost exactly. Craven County exceeded its goal by 58% and Pamlico County fell short of its planned BMP treatment by 29%. Still, as a whole, the region implemented BMPs treating an additional 126,974 acres of cropland, a 347% increase from the baseline. The BMPs existing in 2003 covered an equivalent of 108.7% of the region's cropland, clearly indicating that at least some of the cropland received treatment by more than one type of BMP.

None of the four counties expected to lose cropland in their local strategies. However, three counties did lose acreage ranging from 47 to 6538 acres, or 0.2 to 11% of baseline cropland. Pamlico County actually experienced an increase in cropland of 4,739 acres, or 12.7%. When averaged together, the four counties experienced cropland loss of 0.8%, or 1,046 acres

All four counties reported average nitrogen application rates in 2003 that were lower than those in the baseline. On average, the counties reduced their application rates by 31.8%, the highest average reduction of the three regions in the Neuse Basin. It is notable that Pamlico County reduced its average nitrogen application rate so significantly that it was able to reduce its total application of nitrogen by almost 30% despite a large increase in active cropland.

The four counties in the Lower Coastal Plain reported an average nitrogen loss reduction of 44.5%, the highest average in the basin. This reduction is attributable primarily to the installation of water control structures and nutrient management as reflected in its reduced nitrogen application rates. Cropland loss played a much less significant role in this region than in the Piedmont or in the Upper and Middle Coastal Plain.

Table 4. Percentage of Cropland Covered by BMPs

County	Location	Baseline (%)	Local Strategy (%)	2003 (%)	Change from Baseline to Local Strategy	Change from Local Strategy to 2003	Change from Baseline to 2003
Durham	Piedmont	92.0	95.7	99.8	3.7	4.1	7.8
Franklin	Piedmont	99.0	99.0	96.8	0.0	-2.2	-2.2
Granville	Piedmont	92.2	92.2	97.9	0.0	5.7	5.7
Orange	Piedmont	108.8	108.8	114.2	0.0	5.4	5.4
Person	Piedmont	88.9	88.9	90.2	0.0	1.3	1.3
Wake	Piedmont	92.0	92.0	89.2	0.0	-2.8	-2.8
Regional Average		**95.5**	**96.1**	**98.0**	**0.6**	**1.9**	**2.5**
Greene	Up/Mid Coastal Plain	7.3	8.2	29.7	0.9	21.5	22.4
Johnston	Up/Mid Coastal Plain	8.4	13.7	18.5	5.3	4.8	10.1
Lenoir	Up/Mid Coastal Plain	6.4	59.6	82.1	53.2	22.5	75.7
Nash	Up/Mid Coastal Plain	0.0	1.7	18.3	1.7	16.6	18.3
Pitt	Up/Mid Coastal Plain	12.0	70.3	26.0	58.3	-44.3	14.0
Wayne	Up/Mid Coastal Plain	0.0	82.3	76.5	82.3	-5.8	76.5
Wilson	Up/Mid Coastal Plain	64.0	75.1	111.3	11.1	36.2	47.3
Regional Average		**14.0**	**44.4**	**51.8**	**30.4**	**7.4**	**37.8**
Carteret	Lower Coastal Plain	52.8	177.6	178.9	124.8	1.3	126.1
Craven	Lower Coastal Plain	19.8	44.2	78.2	24.4	34.0	58.4
Jones	Lower Coastal Plain	26.2	126.4	135.8	100.2	9.4	109.6
Pamlico	Lower Coastal Plain	0.0	65.9	41.7	65.9	-24.2	41.7
Regional Average		**24.7**	**103.5**	**108.7**	**78.8**	**5.1**	**84.0**
NEUSE BASIN AVERAGE		**45.3**	**76.6**	**81.5**	**31.3**	**4.9**	**36.2**

5.1.4 Neuse River Basin

Across the entire Neuse River Basin, the amount of cropland treated by BMPs increased by 160% from the baseline years to 2003, going from a total of 218,056 acres to 566,985 acres. These increases derive exclusively from counties in the Upper and Middle Coastal Plain and the Lower Coastal Plain.

Averaging across the entire basin, the counties significantly increased the amount of cropland receiving treatment from BMPs and actually slightly exceeded the treatment goals they included in their local strategies. The percentage of cropland receiving treatment by a BMP in the basin increased from 45.3% in the baseline to 81.5% in 2003. Treatment in 2003 exceeded the local strategy goals by an average of 1.2%, or approximately 400 acres.

The types of BMPs implemented varied from primarily buffers, cover crops and nutrient management in the middle portion of the basin to primarily water control structures and nutrient management in the lower portion of the basin.

Across the Neuse Basin as a whole, 63,238 acres of active cropland were taken out of production between the baseline and 2003. This is the equivalent of 7.1% of the baseline acreage. The BOC reports that 70.5% of this cropland became idle, 24.7% was developed, and 4.8% was converted to grass and/or trees.

The average nitrogen application rate in the Neuse Basin decreased by 21.2% from the baseline to 2003. This reduction can be attributed both to shifts in the amounts of the different types of crops grown in the basin and to reduced fertilization rates for some crops. In general, there was a widespread reduction in the production of corn across the basin. Corn has a relatively high rate of fertilization, so shifting from corn to other crops contributed to lower nitrogen application rates. Cutbacks in the fertilization rates for much of the remaining corn crop also contributed to nitrogen rate reductions. In addition, many counties experienced increases in soybean production, which typically receives little to no fertilization. Another notable change was the widespread decrease in the planting of tobacco, which has a moderate fertilization rate. The 17 counties in the basin reportedly all met their nitrogen loss reduction goals in 2003, ranging from 29.4 to 60.6% reductions. Overall, the counties reportedly reduced their nitrogen losses by an average of 42%, 12% more than the 30% required by the agricultural rule.

Table 5. Changes in Average Nitrogen Application Rates from the Baseline to 2003

County	Location	Baseline Average N Application Rate (lbs./acre)	2003 Average N Application Rate (lbs./acre)	Change in Average Nitrogen Application Rate Baseline to 2003 (%)	Reduction in Total Nitrogen Application Baseline to 2003 (lbs.)
Durham	Piedmont	71.63	57.45	-19.8%	325,188
Franklin	Piedmont	109.07	85.68	-21.4%	158,061
Granville	Piedmont	98.63	93.82	-4.9%	237,161
Orange	Piedmont	104.02	94.04	-9.6%	613,872
Person	Piedmont	107.82	79.75	-26.0%	829,009
Wake	Piedmont	87.38	80.01	-8.4%	1,347,093
Regional Total					**3,510,384**
Regional Average		**96.43**	**81.79**	**-15.2%**	**585,064**
Greene	Up/Mid Coastal Plain	92.18	69.2	-24.9%	1,992,549
Johnston	Up/Mid Coastal Plain	80.7	54.91	-32.0%	3,991,743
Lenoir	Up/Mid Coastal Plain	76.85	69.96	-9.0%	617,967
Nash	Up/Mid Coastal Plain	80.69	72.1	-10.6%	470,469
Pitt	Up/Mid Coastal Plain	75.32	62.46	-17.1%	1,226,464
Wayne	Up/Mid Coastal Plain	96.93	85.62	-11.7%	1,445,008
Wilson	Up/Mid Coastal Plain	76.48	47.47	-37.9%	2,671,825
Regional Total					**12,416,025**
Regional Average		**82.74**	**65.96**	**-20.3%**	**1,773,718**
Carteret	Lower Coastal Plain	113.53	88.95	-21.7%	552,570
Craven	Lower Coastal Plain	100.48	63.8	-36.5%	2,600,906
Jones	Lower Coastal Plain	112.53	77.58	-31.1%	1,928,840
Pamlico	Lower Coastal Plain	95.53	59.25	-38.0%	1,076,497
Regional Total					**6,158,813**
Regional Average		**105.52**	**72.40**	**-31.4%**	**1,539,703**
NEUSE BASIN TOTAL					**22,085,222**
NEUSE BASIN AVERAGE		**92.93**	**73.06**	**-21.4%**	**1,299,131**

5.2 DISCUSSION: NITROGEN APPLICATION RATES, BEST MANAGEMENT PRACTICE IMPLEMENTATION, AND NITROGEN RUNOFF REDUCTIONS

5.2.1 Sources of Reported Nitrogen Loss Reductions

According to the Neuse BOC, in crop year 2003, the 42% nitrogen loss reduction reported for the basin as a whole can be attributed almost equally to BMP installation (12%), fertilizer management (14%), and cropland conversion to idle land, grass/trees, or development (12%) (Neuse BOC 2004). The remaining 4% loss reduction is attributed to cropping shifts in the basin that apparently substituted crops with lower average nitrogen loss rates for crops with higher average losses.

As described above, each region of the basin contributed differently to these sources of nitrogen reduction. The Piedmont region achieved its loss reductions primarily through cropland loss and reduced nitrogen application rates. Four of the Piedmont region's six counties were among the top five fastest growing counties in the basin from 1990 to 2000: Wake, Franklin, Granville, and Orange (N.C. DWQ "Neuse River" 2002). Each of these counties is expected to continue its high rate of growth through 2020. Three Piedmont counties also ranked among the top five in the basin in terms of raw population increases from 1990 to 2000: Wake, Durham, and Orange. Because of these high rates of population growth, cropland conversion to development is not a surprise in the Piedmont and is likely to continue into the future. Though the Piedmont region did not implement any new BMPs during the implementation period, it apparently lost more untreated than treated cropland. This is reflected in the fact that region had a higher percentage of cropland treated by BMPs in 2003 than in the baseline, despite its net losses of cropland acres over this same period.

The Upper and Middle Coastal Plain counties reportedly achieved their nitrogen loss reductions from a mix of BMPs, fertilizer management, and cropland conversion, but relied much more on new BMPs and fertilizer management than the Piedmont counties. However, as discussed below, some of the dramatic increases reported in BMP acreage may not be very reliable as many of these BMPs may actually have been in place in the baseline years but not initially reported by the counties due to a lack of data.

The Lower Coastal Plain counties achieved the highest average nitrogen loss reductions despite much smaller losses in active cropland than the other two regions. This region achieved its nitrogen loss reductions primarily through nutrient management and the installation of water control structures.

Nutrient management, or at least lower estimates of nitrogen application rates, in all of the counties seems to have made one of the most significant impacts on reported nitrogen loss reductions across the basin. Due to the nutrient management rule, most farmers in the basin have been required to develop a nutrient management plan or to participate in nutrient management training. It is possible that these activities have contributed to the reduced fertilization rates. However, according to Natalie Jones (CREP Manager, N.C. DENR, pers. com. 2006), it is likely that higher fertilizer prices have also played an important role.

Though the magnitude of cropland loss varied across the regions of the basin and across counties within the regions, it is important to note that a significant portion of the losses reported in 2003 may not be permanent. Of the 12% nitrogen loss reduction credited to cropland attenuation by the BOC in 2003, only a third of that loss was to development. The other two-thirds were to idle land, trees, or grass land, any of which could be put back into production in the future. This may be an important issue in upcoming years due to predictions of high corn prices caused by the increasing demand for ethanol (USDA "Ethanol" 2006). Higher corn prices may encourage producers to plant corn on land that is not currently in production, may encourage farmers in the basin to switch from other crops to corn production, or may encourage farmers to increase their fertilization rates on existing corn fields in order to increase productivity. Even though average nitrogen application rates for corn have decreased in the basin since the baseline years, relative to other crops typically grown in the basin, corn still has one of the highest average nitrogen application rates ("Neuse Annual Report" 2005). Thus, any one of these changes could increase nitrogen losses from agricultural lands in the basin, erasing some of the gains reported by the counties.

Another important issue related to farmland conversion in the Neuse Basin is that the land converted from agriculture to development may represent a nitrogen loss reduction for agricultural sources of nutrient runoff for the purposes of the agricultural rule, but this does not mean that this land will no longer contribute nitrogen pollution to the Neuse River. In fact, land that is taken out of production for the purposes of development will simply move to the stormwater category of the Nutrient Sensitive Waters Strategy, assuming that the development occurs in the specific geographic areas covered by the stormwater rule. If the converted land falls outside of the designated areas, any nitrogen runoff it produces will no longer be accounted for by the Neuse Strategy.

5.2.2 Issues with the Available Data

As discussed in chapter two of this report, the data used to calculate the baseline nitrogen loss reductions in each county consisted largely of best professional estimates from county personnel. Based on a field survey conducted in the Neuse Basin by Osmond et al. (2003), estimates for BMP acreage in the baseline years seem particularly prone to error and in many cases are significant underestimates of the BMPs that were already in place.

Baseline estimates for the number of acres affected by controlled drainage are likely to be the most reliable due to the existence of some cost-share records. However, since not all structures are cost-shared, these estimates are likely low. In the case of buffers, many counties had little or no information about how many acres were treated by buffers in the baseline years. Some of these counties did not include any buffer acres in their baseline calculations even though subsequent field surveys show that there were substantial amounts of buffers in place. For example, Johnston County reported zero acres of buffers in its baseline, but the field survey found that approximately 48% of cropland in the county was bordered by riparian buffers (Osmond et al. 2003). The field survey was not able to verify estimates of cover crops in the baseline years since the survey was conducted in 2000 and cropping patterns tend to shift over time.

Due to these issues, Osmond et al. (2003) argue that the field survey data they collected could be used to better account for buffers in the baseline period, but it is not as useful for cover crops or for controlled drainage due to survey issues. Adding buffers to the NLEW calculations for the baseline loads would reduce the county nitrogen losses for the baseline period, giving the counties affected by the recalculation a lower starting point from which to achieve their 30% reductions. However, according to Osmond et al. (2003), including the BMP information in the baseline would not affect the overall percent-nitrogen reductions that have been calculated since. Despite this, including more accurate values for BMPs in the baseline period would reduce the striking increases in BMP acres that have been reported by some of the counties between the baseline and 2003.

5.3 RESULTS AND DISCUSSION: RULE FLEXIBILITY AND EFFICIENCY

By allowing farmers to achieve required nitrogen loss reductions collectively in the local strategy option, North Carolina policy makers intended to increase both the flexibility and cost-effectiveness of the agricultural rule relative to an approach that required all farmers to implement particular BMPs (N.C. DWQ "Agricultural Rule" 2002). According to the N.C. DSWC, "for agriculture, these rules provide flexibility at the local level for implementing site-specific practices rather than a one-size-fits-all requirement." In addition, by allowing farmers to target the most critical areas (i.e., those that have the most impact on water quality) rather than having blanket requirements, this approach was meant to improve cost-effectiveness (N.C. DWQ "Agricultural Rule" 2002). As discussed in chapter three, allowing collaborative action could also have the effect of encouraging farmer participation and compliance with the rule. This section of the report discusses how well the agricultural rule performed in improving flexibility and cost-effectiveness. Issues related to farmer participation and compliance are discussed in chapter six of the report.

5.3.1 Flexibility of the Agricultural Rule

In order to determine if the Neuse agricultural strategy did allow a more flexible response to the nitrogen reduction requirements, three factors are important to consider. First, did the collaborative option allow different levels of action from participating farmers? Second, did the collaborative option allow farmers to better tailor the BMPs they used to their site-specific conditions? Third, did farmers prefer the collaborative local strategy option of the rule to the standard BMP option?

In general, the answer to all three of these questions is yes. Like more traditional agricultural conservation programs, the collaborative option of the agricultural strategy is essentially a voluntary program with some financial inducements for participation provided by state and federal cost-share programs. Only farmers who were willing to implement BMPs did so, as the LACs have no legal authority to require uncooperative farmers to act. Thus, as found in other voluntary agricultural conservation programs, some farmers implemented BMPs and others did not.

The local strategy option also appears to have allowed farmers to tailor the BMPs they did implement more specifically to their own farms. Whereas the standard BMP option of the rule prescribes particular combinations of BMPs and the locations where buffers must be used, the local strategy option does neither of these things. Farmers are able to implement just one type of BMP or different combinations of BMPs and they may choose where to install these practices. Further, the variety of BMPs receiving credit in NLEW is slightly greater than that included in the standard BMP option. In NLEW, both cover crops and filter strips can receive nitrogen reduction credits. Neither of these BMPs are included in the standard BMP option. However, even though NLEW does allow farmers to use more types of BMPs than the standard option, it still imposes an upper limit on flexibility because it credits only a finite set of BMPs with reducing nitrogen losses.

Finally, assuming that farmers prefer flexibility, perceived flexibility in the rule can be evaluated by how many farmers selected to sign up for the collaborative local strategy option rather than implement one of the standard sets of BMPs. According to the counties' local nitrogen reduction strategies, the percentage of cropland enrolled in the local strategy option ranged from 77% in Johnston County to 100% in Carteret and Greene Counties, with an average of 89%. The number of operators enrolled in each county ranged from four in Carteret County to 494 in Johnston County. While 11% of cropland in the basin was not enrolled, clearly the local strategy option was the preferred choice for most operators.

5.3.2 Cost-Effectiveness of the Agricultural Rule

A clear-cut indicator of cost-effectiveness in this study would measure how many pounds of nitrogen were removed from agricultural runoff per dollar spent. Ideally, this value would be reported by the agencies managing the agricultural rule or at least could be calculated directly from available data. Unfortunately, neither of these is the case. Even though the agricultural rule itself states that the LACs' annual reports should include documentation on the BMPs implemented including their costs, these reports do not contain any cost information. In addition, the way the data are reported by the counties prevents accurate calculations of cost-effectiveness from the data that do exist. In their annual reports, the counties report BMPs in terms of the acres of cropland treated by BMPs. However, available cost data for BMP installation in the Neuse Basin is reported in terms of the actual acres of a BMP installed not the number of acres treated (Wossink and Osmond 2001). Given significant heterogeneity in cropland and BMP configurations, there was no accurate way for this study to determine how many acres of BMPs were installed in order to treat the number of cropland acres reported in the county data.

Another way to evaluate whether the rule has increased cost-effectiveness is to investigate whether BMPs have been targeted to the most critical areas within the counties and the basin as a whole. Spatial targeting of BMPs is important because the location of a BMP relative to cropland runoff and the bodies of water that receive the runoff can have a significant impact on the effect of the BMP in reducing downstream water pollution.

When water pollution comes from multiple sources and its concentration is measured downstream, policy makers need to know how much each source contributes to the downstream concentration. The factors that connect pollution concentrations at the sources to concentration downstream are called transfer coefficients. A higher transfer coefficient shows that a particular source has a larger impact on downstream pollution concentrations than a source with a lower transfer coefficient. In cases where the pollutant of concern, like nitrogen, is not conservative, one of the most important factors likely to affect transfer coefficients is the distance from the source to the downstream monitor. This is because as distance increases, the likelihood that the pollutant will be taken up or transformed as it is transported across the landscape increase. Thus, sources closest to the downstream monitor are likely to have higher transfer coefficients than those further away.

Given this, BMPs put in place to intercept nitrogen-laden runoff from sources closer to the downstream monitor are likely to be the most efficient, having the greatest impacts in terms of reducing measured concentrations downstream. When BMPs have equal installation costs across different locations, this enhanced efficiency translates into higher levels of cost-effectiveness. This is precisely what Smith, Schwabe, and Mansfield (1999) found when they used Schwabe's model of the Neuse River Basin to compare the cost-effectiveness of hypothetical control measures in different areas of the Neuse Basin. They found that when measuring nitrogen loadings in equivalent units at New Bern, which is located at the mouth of the Neuse Estuary, BMPs in the western counties of the basin were not as cost-effective as those closer to New Bern. Thus, to investigate whether the agricultural rule has resulted in higher levels of cost-effectiveness, one needs to determine whether the rule has resulted in higher levels of BMP installation in the counties closest to the Neuse Estuary, where the worst pollution problems have occurred, and in areas closer to the Neuse River and its key tributaries within the counties themselves.

Answering the first question is relatively straightforward simply by looking at the nitrogen loss reduction goals allocated to the various counties in the basin. If the strategy was attempting to be more cost-effective than simply requiring all farmers to do the same thing, it would allocate higher nitrogen loss reduction requirements to the counties closer to the estuary and smaller reduction requirements to those further away. In fact, this is roughly what has occurred. The four counties in the Lower Coastal Plain have nitrogen loss reduction targets of greater than 30%. In addition, two of the counties in the Middle and Upper Coastal Plain have targets of greater than 30%, while the other five have targets of exactly 30%. Of the six counties in the Piedmont region, which is the furthest region from the estuary, one has a target of greater than 30% and two have targets of exactly 30%. The other three have targets of less than 30%: Person County's target is 26%; Granville's is 21%; and Orange County, the county furthest away from the estuary, has a target of only 18%.

Determining whether individual counties have pursued higher levels of cost-effectiveness is more difficult given a lack of data. Evidence of LAC efforts to do this would again be in the form of where the proposed and implemented BMPs are located within the county relative to the Neuse River and its tributaries. Unfortunately, even though the agricultural rule states that "Local nitrogen reduction strategies must specify the name and location of participant farming operations, BMPs which will be required as part of the plan, estimated nitrogen reduction, schedule for BMP implementation, and operation and maintenance programs," the published strategies do not include information about the location of BMPs within the counties. Instead, each county's local strategy and annual progress reports are aggregated across the entire county. Without location information, there is no clear evidence that the LACs have or have not attempted to target their BMPs in this way.

One description of the process undertaken by the LACs to determine their local nitrogen reduction strategies raises doubts that location was a major factor influencing these decisions, however:

> *The strategy is a consensus determination by the LAC. It is based on the types and amount of the approved BMPs that they believe can be implemented before the deadline that would collectively produce the required 30 percent reduction from their baseline number. The LACs determined which practices would be most acceptable to participating farmers and to predict [*sic*] the number of acres to which they felt these practices could be applied* (N.C. DWQ "Neuse River" 2002 pg. 70).

This description does not include any mention of the LACs considering the location of BMPs in their planning. Instead, the LACs focused on the practices that were most likely to be acceptable to farmers and implementable by the 2003 deadline.

It is important to note that even if the LACs had wanted to target their BMPs in order to improve cost-effectiveness, they lacked effective tools and clear incentives to do so. For example, transfer coefficients for different areas within the counties were not provided, nor was there a GIS-based priority setting mechanism in place. In addition, the version of NLEW used to account for nitrogen loss reductions under the rule does not include the location of BMPs within counties as a parameter. It focuses instead on nitrogen export estimates from each county as a whole. Thus, even if the LACs had attempted to spatially target their BMPs, these efforts would not have been credited in NLEW outputs. Finally, without enforcement of the rule's requirement that the LACs report implementation costs, the LACs have not been given a strong incentive to minimize these costs. As a result, this study cannot conclude that this approach, as implemented, was any more or less cost-effective than the standard BMP option.

One possible exception to this conclusion relates to BMPs that were installed with cost-share funding from particular state and federal programs such as the N.C. Cost Share Program and CREP. Both of these programs require that cost share dollars be targeted to BMPs with the greatest impacts on water quality and both require evaluation and ranking of cost share applications based on this criterion. Thus, one can assume that the BMPs funded through these programs are targeted to maximize pollution reductions per cost-share dollar spent. In particular, the N.C. Cost Share Program is roughly organized by county, so potential BMPs within each county are compared to each other to determine which ones receive funding. The CREP program also has an explicit goal to help achieve the 30% agricultural nitrogen loading reduction. However, even if these programs do result in BMPs being targeted to the most critical areas, credit for this result cannot clearly be given to the design of the agricultural rule.

5.4 DISCUSSION: CHANGES IN AMBIENT WATER QUALITY

Theoretically, any pollution control policy instrument can be evaluated based on its impacts on different "compliance bases." For example, a policy could be judged by how much it reduces the use of pollution-creating inputs, the amount of pollution discharged, ambient concentrations of pollution, or ecological or economic damages caused by pollution.

Shortle and Horan (2001) argue that, in general, the most appropriate compliance base is one that is correlated with environmental conditions, enforceable, and targetable in space and time. For example, discharges tend to be the preferred base for point source pollution control because point sources are relatively easy to identify and their discharges are generally non-random and can be measured accurately and inexpensively (Shortle and Horan 2001). The question of which compliance base is most appropriate for agricultural nonpoint source pollution control is more difficult, however.

Three compliance bases have received the most attention for this purpose: (1) estimated exports of pollutants from fields to surface and groundwater, (2) inputs or practices correlated with pollution flows, and (3) concentrations of pollutants in receiving streams. The primary compliance base of the Neuse Strategy agricultural rule is an estimated field export of nitrogen that is derived from NLEW. The rule also uses estimates of inputs (nitrogen application rates) and practices (BMPs) to calculate losses and exports. However, given the issues described in this report concerning the quality of these estimates, export measures generated by NLEW may not be highly reliable. In turn, these estimates may not be the best way to gauge the true impacts of the agricultural rule on water quality in the Neuse Basin.

Two issues argue for using ambient pollution concentrations rather than nitrogen exports as the compliance base for measuring the impact of the agricultural rule. First, as argued by Stavins (2001), emission or export-based instruments are not very appropriate when pollutants are not well-mixed in the environment. Second, ambient concentrations tend to more directly measure the problem that the policy is trying to address in the first place. In this case, ambient concentrations of nitrogen are more closely tied to water quality problems in the Neuse River and Estuary than estimated exports from cropland.

Unfortunately, using ambient water quality as the yardstick by which to measure success of the Neuse Strategy is easier said than done. This is because ambient monitoring is prone to several problems that can complicate its use for program evaluation. One important problem is that if the land draining into the monitoring station has multiple sources of nitrogen, it can be very difficult to attribute changes in the ambient concentrations of nitrogen to the different sources. This limits the usefulness of this data for enforcement purposes (McNitt and Kepford 1999). Second, it can be hard to time monitoring events in order to gain an accurate picture of how ambient concentrations are changing since nitrogen loads are likely to vary significantly based on weather conditions and other unpredictable factors. Third, changes in water quality may not occur immediately after changes in farming practices or installation of BMPs. According to Caruso (2000), it is difficult to identify water quality improvements from specific management practices because there is usually a considerable time lag in improvements and because it is difficult to isolate the causative factors contributing to improvements. Finally, in addition to lags between behavior and impacts on ambient water quality, Shortle suggests that ambient monitoring is also limited by its potentially high costs and high error rates.

Despite these significant challenges, it is useful to examine the data that are available about ambient concentrations of nitrogen in the Neuse River Basin to determine how these concentrations have changed since the Nutrient Sensitive Waters strategy was implemented and to investigate how useful these data might be in evaluating the impacts of the agricultural rule.

One relevant study (Stow and Borsuk 2003) investigated flow-adjusted nitrogen concentrations from 1979 to 2000 at three monitoring stations near the mouth of the Neuse Estuary. This study finds a slow steady decline in total Kjeldahl nitrogen (TKN) over most of the study period at all three stations. However, trends in total nitrogen (TN), which consists of TKN and oxides of nitrogen, differed among the stations, with one showing a decline from 1985 to 1994 and then stabilizing through 2000 and two showing relatively stable values from 1979 to 1995 and then a decline from 1995 to 2000. This study suggests that these nitrogen decreases are similar to point source nitrogen discharge reductions reported from 1995 to 2000 and may reflect decreases that occurred as a result of the Neuse wastewater discharge rule. It also suggests that the decline may be the result of flushing by two major hurricanes that moved through the basin in the late 1990s.

A second analysis of nitrogen concentration trends in the basin was performed by the DWQ’s Planning Branch (Rajbhandari 2006). This analysis looks at flow and seasonally-adjusted concentrations of TKN, nitrogen oxides, and TN from 1985 to 2005 at two monitoring stations near the mouth of the Neuse Estuary. At both stations, the analysis finds that total nitrogen and nitrogen oxides decreased over that time period. At the Contentnea station, the study finds that TN decreased by 27% and nitrogen oxides decreased by 44%. At the New Bern station, the study finds that TN declined by 17% and nitrogen oxides by 66%. However, in contrast to the Stow and Borsuk study, this analysis did not find any significant change in TKN at either location.

A third study (Burkholder et al. 2006) investigates changes in nitrogen concentrations and loadings in the Neuse Estuary from 1993 to 2003 using a flow model and concentration data from six sampling stations in the Neuse Estuary. This study finds decreasing concentrations of TN in this time period, but concludes that this trend can be explained largely by a prolonged drought from 2000 to 2002. The study also finds a 28% reduction in TN loading to the estuary during the study period, which could not be explained by climactic events. However, this finding was highly sensitive to the beginning period used in the analysis. For example, the study’s authors state that when the analysis is started in June 1994, no significant trend in TN loading is found. In contrast to the TN trends, this study finds a significant increase in NH_4 concentrations in the estuary and attributes this increase to inadequately controlled nonpoint sources, primarily consolidated animal feeding operations. The study’s authors conclude that their findings about the NH_4 increases and “fragile” TN loading trends do not support public reports of a 30% TN loading reduction to the Neuse. However, the study authors also state that noticeable decreases in TN concentrations in the estuary due to management actions may not be detected for a decade or more. Finally, the authors conclude that the nitrogen-reduction management actions that have taken place in the basin regarding point sources and crop-based agricultural sources have largely been offset by significant human and swine population increases in the past decade.

In combination, these three studies do not provide a clear picture of nitrogen loading and concentration trends in the lower Neuse River and Estuary since the implementation of the Neuse rules. While all three studies report reductions in at least one or two measures of nitrogen, these are not consistent among the studies and in one are eliminated when climatic factors are controlled or the study's starting date is changed slightly. In addition, none of these studies conclude that the nitrogen decreases they find are attributable to nitrogen loss reductions from agricultural lands in the basin. In fact, Burkholder et al. find that new agricultural sources, namely confined animal feeding operations, have likely increased nitrogen loading by greatly increasing NH_4 concentrations in the estuary. These studies do illustrate some of the complications that arise when trying to use ambient concentrations to evaluate nonpoint source pollution control measures, however.

6. RESULTS AND DISCUSSION - RESEARCH OBJECTIVE 2

The second key objective of this research project is to describe how farmers in three Neuse River Basin counties have responded to the Neuse Strategy in terms of their knowledge of the strategy's agricultural requirements, their attitudes concerning the strategy and its impacts, and their reported management behaviors. Descriptive statistics and statistical models are used to provide insight into these issues. Data for this section of the report come from a telephone survey of 315 respondents in Johnston, Lenoir, and Wayne Counties. The respondents were screened to include only those who were operating farms at the time of the survey and who made management decisions about the operation of the farm. The sample includes 100 respondents from Johnston County, 102 from Lenoir County, and 113 from Wayne County.

Five groups of models were tested in this analysis focusing on:

A. adoption of nutrient management practices,
B. knowledge of the Neuse rules,
C. attitudes toward the Neuse rules,
D. development of nutrient management plans and participation in training, and
E. attitudes and experiences regarding farm inspections and penalties.

6.1 GROUP A MODELS: NUTRIENT MANAGEMENT PRACTICE ADOPTION

The six models in group A focus on factors that influence the adoption of various nutrient management practices. These models are described in Table 6. In general, nutrient management practices are meant to reduce the amount of nutrients transported from agricultural fields to surface and ground water. In this study, four practices were investigated: (1) the use of soil tests to determine appropriate fertilization rates, (2) the calibration of fertilizer application equipment to ensure that the correct amounts of fertilizer are being applied, (3) the planting of cover crops that help take excess nitrogen out of the soil, and (4) the development of nutrient management plans to guide farmers' nutrient application decisions.

Table 6. Group A Models – Nutrient Management Practice Adoption

Model	Type	Dependent Variable	Independent Variables
1	Logistic Regression	Use of soil tests	Farm characteristics, farmer characteristics, receipt of cost share funds
2	Logistic Regression	Calibration of fertilizer application equipment	Farm characteristics, farmer characteristics, receipt of cost share funds
3	Logistic Regression	Planting of cover crops	Farm characteristics, farmer characteristics, receipt of cost share funds
4	Logistic Regression	Fertilization of cover crops	Farm characteristics, farmer characteristics, receipt of cost share funds
5	Logistic Regression	Preparation of a nutrient management plan	Farm characteristics, farmer characteristics, receipt of cost share funds
6	Ordered Logistic Regression	Category of nutrient management practice adoption (0-1, 2, 3, or 4 practices in use)	Farm characteristics, farmer characteristics, receipt of cost share funds

6.1.1 Dependent Variables

Dependent variables in the group A models indicate whether the respondent reported using particular practices in their farming operations and the total number of practices in use. Five dichotomous variables measure the use of specific practices and are described in Table 7.

Table 7. Percentage of Farmers Using Nutrient Management Practices

Nutrient Management Practice	Measure	Frequency	Percentage
Soil tests	Did the respondent use soil tests at any frequency	258	81.9 (of 315)
Calibration of fertilizer equipment	Did the respondent ever calibrate their fertilizer application equipment	279	88.6 (of 315)
Cover crops	Did the respondent plant one or more of the following cover crops: wheat, rye, triticale, oats, or barley	193	61.3 (of 315)
Fertilized cover crops	If the respondent planted cover crops, did they apply fertilizer to the cover crops	91	47.2 (of 193)
Nutrient management plans	Did the respondent have a written nutrient management plan for the cropland they cultivate	183	58.1 (of 315)

The sixth dependent variable in this group is based upon the number of nutrient management practices respondents reported using. The distribution of responses is detailed in Table 8. The dependent variable used in the statistical models lumps the respondents using zero or one practice into one group due to low frequencies in these categories. This yields an ordered categorical variable with four levels. The respondent only receives credit for using cover crops if they did not apply fertilizer to them, since cover crops that are fertilized do not serve their function effectively.

Table 8. Number of Nutrient Management Practices Adopted

Category of Practice adoption	Frequency	Percentage
0 practices	14	4.4
1 practice	29	9.2
2 practices	74	23.5
3 practices	147	46.7
4 practices	51	16.2
TOTAL	315	100.0

6.1.2 Independent Variables

Six independent variables are used to describe important characteristics of the respondents and their farms: age, farming experience, income, land tenure, farm size, and education level. These variables described in Table 9 and are included as control and/or potential explanatory variables in all of the models tested in all five groups of models.

Table 9. Descriptive Statistics for Farm and Farmer Characteristic Variables

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
Age (years)	315	55.7	11.74	24	84
Farming Experience (years)	315	28.9	12.71	4	63
Income ($)	281	119,075	95,419	10,000	300,000
Land Tenure (percentage of farm land rented)	315	46.3%	38.9%	0%	100%
Farm Size (acres)	315	564	729	5	4,500
Education level	313	1.8	0.8	1	3

Income was recorded in the interviews as falling into one of seven income ranges. For the analysis, each income range was set to its median value. The lowest category has a value of $10,000 and the highest category was set to $300,000. 34 respondents did not answer this question and thus have been left out of all models that include this variable.

Farm size was measured in acres and includes all rented and owned farmland. The average farm size was 564 acres with a standard deviation of 729 acres. To simplify interpretation, this variable was transformed into hundreds of acres for the tested models.

Education level was measured in three categories:

1. Respondents who had completed high school or had less education (42.2% of the sample),

2. Respondents who had completed some college education or obtained an Associate's degree (34.5% of the sample), and
3. Respondents who had completed college or who have attended school beyond a college degree (23.3% of the sample).

Three additional independent variables related to the receipt of government financial support or cost share funds are included as explanatory factors in several of the models. These are described in Table 10.

Table 10. Receipt of Government Support or Cost Share Funds

Measure	Frequency Answering "Yes"	Percentage
Did the respondent receive government financial support or cost-share money in the last five years for any of the following practices: buffers, filter strips, field borders, cover crops, controlled drainage, or nutrient management.	86	27.3 (of 315)
Did the respondent receive funds specifically for cover crops	25	7.94 (of 315)
Did the respondent receive funds specifically for nutrient management	46	14.6 (of 315)

6.1.3 Model Results and Discussion

Table 11 provides the statistical results, expressed as odds ratios, for the six multivariate models included in group A. These results, as well as the results for all of the tested models in this chapter, show the relationship between each independent variable and the dependent variable while controlling for all of the other model parameters. The relationships found to be statistically significant are shaded in gray. Table 11 also includes the likelihood ratio chi-square results for each model. This test compares the model in question to a null model that contains no independent variables. A significant chi-square value indicates that it is possible to reject the hypothesis that none of the included independent variables affect the dependent variable. Results showing the bivariate relationships between the tested independent and dependent variables for all of the models are available from the office of the North Carolina Water Resources Research Institute.

Table 11. Group A Multivariate Model Results

Independent Variables	Multivariate Odds Ratios (standard error)					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Years of farming experience	0.9894 -(0.0173)	1.0332 (0.0189)	1.0174 (0.0148)	0.9807 (0.0216)	1.0002 (0.0147)	1.0204 (0.0134)
Age of farmer	1.0003 (0.0209)	0.9570 (0.0231)	**0.9485 (0.0167)	1.0026 (0.0248)	0.9758 (0.0170)	**0.9569 (0.0145)
Percentage of farm acres rented	1.4498 (0.7111)	1.6321 (1.0087)	0.6915 (0.2595)	*0.3412 (0.1706)	1.3031 (0.5029)	1.8880 (0.6176)
High school or less education	0.8296 (0.3167)	0.9523 (0.4722)	0.7377 (0.2249)	*0.3897 (0.1579)	*0.5007 (0.1604)	0.8892 (0.2409)
Some college education	omitted	omitted	omitted	omitted	omitted	omitted
College graduate or beyond	1.5716 (0.7879)	0.5239 (0.2871)	*0.4758 (0.1676)	0.7929 (0.3757)	0.8524 (0.3100)	0.8088 (0.2471)
Income level	*1.0066 (0.0027)	*1.0109 (0.0050)	1.0027 (0.0015)	1.0008 (0.0019)	1.0029 (0.0016)	**1.0041 (0.0013)
Farm size (in hundreds of acres)	1.0422 (0.0428)	*1.3169 (0.1757)	1.0073 (0.0217)	**0.9041 (0.0293)	1.0283 (0.0253)	***1.0746 (0.0216)
Receipt of any cost-share funds	1.4485 (0.6085)	1.2749 (0.6719)	omitted	omitted	omitted	*1.6983 (0.4541)
Receipt of cost-share for either cover crops or nut. management			**7.5218 (5.7708)	1.6936 (0.9024)	***29.9576 (30.9352)	
Model X^2 (df)	**22.95 (8)	***48.77 (8)	***36.51 (8)	***33.46 (8)	***64.63 (8)	***84.65 (8)
Observations	280	280	280	166	280	280

*coefficient/model significant at the .05 level
**coefficient/model significant at the .01 level
***coefficient/model significant at the .001 level

As seen in Tables 7 and 8, the use of nutrient management practices by the survey respondents is widespread. Over 95% of respondents reported using at least one of the four practices, and 63% reported using three or more. Soil tests and calibration of fertilizer application equipment are the most common practices, with over 80% of the sample using them. Planting of unfertilized cover crops was the least commonly used practice, with only 32% of respondents indicating they both planted cover crops and did not fertilize them.

As seen in Table 11, several factors were found to relate to the use of nutrient management practices in the survey sample. In model 1, income was found to have a significant, positive impact on the use of soil tests. For every $1,000 increase in income, a farmer is 0.7% more likely to use soil tests.

In model 2, income and farm size were each found to exert a positive influence over whether a farmer calibrates their fertilizer application equipment. For every $1,000 increase in income, a farmer is 1.1% more likely to calibrate. For every 100 acre increase in farm size, a farmer is 31.7% more likely to calibrate their equipment.

Three variables were found to have a significant influence over use of cover crops in model 3: age, whether the respondent had graduated from college, and receipt of cost share funds for cover crops. For every year increase in the respondent's age, he or she is 5.2% less likely to plant cover crops. Relative to respondents with only some college experience, farmers who have graduated from college or have gone beyond college in their education are 52.4% less likely to plant cover crops. Finally, farmers who have received government support or cost-share money in the last five years are 752.2% more likely to plant cover crops than those who have not received this money.

In model 4, of those who plant cover crops, three factors were found to have a negative influence over whether the cover crops are fertilized: land tenure, high school education, and farm size. For every additional 1 percent of a farmer's land that is leased rather than owned, he or she is 65.9% less likely to fertilize their cover crops. Relative to farmers who have some college experience, those who have graduated from high school or have completed less education are 61.0% less likely to fertilize their cover crops. For every 100 acre increase in farm size, a farmer is 9.6% less likely to fertilize their cover crops.

In model 5, two factors were found to be significant: education and receipt of cost share funds for nutrient management. Relative to farmers who have completed some college or who have an Associate's degree, a farmer with only a high school education or less is 50.0% less likely to have a nutrient management plan. Farmers who have received government support or cost-share money for nutrient management in the last five years are 2995.8% more likely to have a nutrient management plan than those who have not received this support.

In model 6, four factors influenced the nutrient management practice adoption category reported: age, income, farm size, and receipt of cost share funds. For every additional year of age, a farmer is 4.3% less likely to fall into a higher category of nutrient management practice adoption. For every $1,000 increase in income, a farmer is 0.4% more likely to fall into a higher category of practice adoption. For every 100 acre increase in farm size, a farmer is 7.5% more likely to fall into a higher category of practice adoption. Farmers who had received government financial support or cost-share money for BMPs in the previous five years were 69.8% more likely to fall into a higher category of nutrient management practice adoption than those who had not received support.

Looking across models 1 through 5, age is found to negatively influence the adoption of cover crops, but to have no effect on the use of other practices or the fertilization of cover crops. This finding is consistent with the literature, where some studies find age to have a negative influence on practice adoption and some find it to have no effect. Older farmers may be less likely to plant cover crops because the practice may be unfamiliar and they may be resistant to changing the way they traditionally do things.

The percentage of cropland that is rented rather than owned was found to influence whether the respondent fertilized their cover crops, but not whether they used any of the four practices. This finding of little influence over adoption is consistent with the literature. Those who rent cropland may rely on farming for a larger portion of their income and may be more concerned with fertilizer expenses. They may also run more professional farming operations and have a better understanding of the purpose of cover crops.

The education variables yielded somewhat unexpected results. One would anticipate that respondents with higher levels of education would adopt more nutrient management practices because they are likely to have an easier time learning about the practices and understanding their benefits. This relationship was found to be true in the case of nutrient management plans: those with only a high school education or less were less likely to develop nutrient management plans than those with some college experience. Nutrient management plans typically contain information about soil types, realistic yield expectations for crops, soil test results and other technical information that is likely to be less familiar to those with lower levels of education. However, respondents with lower levels of education were also found to be less likely to fertilize their cover crops, a practice that one would expect to be more common among respondents with higher levels of understanding about the purpose and function of these crops. Similarly, it is not clear why respondents with the highest levels of education were less likely to plant cover crops at all relative to those with only some college experience.

Income was found to positively influence both the use of soil tests and the calibration of fertilizer equipment. Higher incomes are often associated with higher levels of practice adoption because wealthier farmers have an easier time paying the costs of implementing and maintaining the practices. Higher levels of income may also be associated with more professional farming operations, where more emphasis is placed on the efficient use of fertilizer.

Farm size was found to positively influence the calibration of fertilizer equipment and to negatively influence the fertilization of cover crops. Both of these practices could result in significant cost-savings for larger farms.

Finally, the receipt of government support or cost share funds was found to positively influence the use of cover crops and the development of nutrient management plans. In general, financial support can significantly lower barriers to the adoption of nutrient management practices. In the case of these two practices, which have economic benefits that may not be very tangible to farmers, incentives for adoption may be even more important.

In model 6, several variables were found to have an expected direction of influence over practice adoption. Age had a negative influence, whereas income, farm size, and receipt of cost share all had positive influences. Again, older farmers are likely less inclined to incorporate new practices into their operations since they are used to doing things in a particular way. Farmers with higher incomes are likely to be more able to adopt practices and those with larger farms are likely to gain the most from adopting practices that reduce fertilizer use. Finally, the receipt of cost share funds was found to increase the adoption of practices that otherwise might have less obvious financial benefits to farmers such as cover crops and nutrient management planning. Also, when farmers receive cost share funds, they are likely to be educated on the importance of particular practices and to have assistance in implementing them, which may be particularly needed for the development of technical nutrient management plans.

Responses to an additional survey question help shed light on the influence of the Neuse rules on farmers' use of nutrient management practices. This question asked respondents how likely they would be to use all of the same nutrient management practices if there were no Neuse rules in place: very unlikely, unlikely, somewhat likely, or very likely. The distribution of responses is detailed in Table 12. Of the 315 respondents, less than 14% said they would be very unlikely or unlikely to use the same practices without the rules. However, given that almost 50% of the respondents provided an answer other than "very likely" appears to indicate that the rules are playing some role in encouraging practice adoption for approximately half of the farmers in the sample. In addition, these numbers may underestimate the influence of the rules because respondents may not have wanted to show support for the regulations by acknowledging the impact of the rules on their behavior.

Table 12. Likelihood the Respondent Would Use the Same Nutrient Management Practices if the Neuse Rules had not Passed

Response	Frequency	Percentage
Very unlikely	11	3.5
Unlikely	32	10.2
Somewhat likely	111	35.2
Very likely	161	51.1
TOTAL	315	100.0

6.2 GROUP B MODELS: KNOWLEDGE OF THE NEUSE RULES

The six models in group B identify factors that influence how much farmers know about the Neuse agriculture rules. These models are described in Table 13.

Table 13. Group B Models – Knowledge of the Neuse Rules

Model	Type	Dependent Variable	Independent Variables
7, 8, 9, 10, 11	Logistic Regression	Answered five individual knowledge items correctly	Farm characteristics, farmer characteristics, receipt of cost share funds
12	Ordered Logistic Regression	Category of knowledge (0-2, 3, 4, or 5 knowledge items correct)	Farm characteristics, farmer characteristics, receipt of cost share funds

6.2.1 Dependent Variables

The five dichotomous dependent variables used in models 7 through 11 measure whether respondents answered specific knowledge items about the Neuse rules correctly. The survey questions asked the respondents whether or not the Neuse rules required them to undertake specific activities, which are detailed in Table 14.

Table 14. Number of Respondents Answering Each Knowledge Item Correctly

Knowledge Item (Correct Answer)	**Number of Respondents Answering Correctly (Percentage)**	**Number of Respondents Answering Incorrectly (Percentage)**	**Number of Respondents Answering Don't Know (Percentage)**
Item A (No) "Cut your fertilizer use by 50%."	276 (87.6)	35 (11.1)	4 (1.3)
Item B (Yes if farm is ≥ 50 acres) "Develop a nutrient management plan or participate in nutrient management training."	169 (53.7)	141 (44.8)	5 (1.6)
Item C (No) "Install 100-foot vegetated buffers on all streams.	241 (76.5)	68 (21.6)	6 (1.9)
Item D (Yes) "Work with other farmers in your county to reduce your nitrogen runoff by 30%."	131 (41.6)	181 (57.5)	3 (1.0)
Item E (Yes) "Sign up with your local area committee or implement standard best management practices."	136 (43.2)	177 (56.2)	2 (0.6)

The dependent variable used in model 12 measures how many of the five items were answered correctly. This variable is an ordered categorical variable with four levels. Respondents answering zero, one, or two answers correctly were lumped into one group due to low frequencies in some of the groups. The distribution underlying this variable is detailed in Table 15.

Table 15. Number of Knowledge Items Answered Correctly

Number of questions answered correctly out of five	**Frequency**	**Percentage**
0	2	0.6
1	11	3.5
2	105	33.3
3	87	27.6
4	79	25.1
5	31	9.8
TOTAL	315	100.0

6.2.2 Results and Discussion

The survey respondents answered an average of three of the five knowledge items correctly. Two of the knowledge items address specific requirements of the Neuse agricultural rule and one addresses the requirements of the nutrient management rule. In general, respondents were more likely to answer these rule-related questions incorrectly than the two other knowledge items that concerned specific management practices. In particular, the majority of respondents answered the two questions about the agricultural rule incorrectly. This may indicate that most farmers in the survey sample are not aware of or do not understand its requirements.

Results for the statistical models in group B are provided in Table 16. Statistical models 7 through 11 focus on factors that influence whether respondents answered particular questions about the Neuse rules correctly.

Table 16. Group B Multivariate Model Results

Independent Variables	Multivariate Odds Ratios (standard error)					
	Model 7	**Model 8**	**Model 9**	**Model 10**	**Model 11**	**Model 12**
Age of farmer	0.9788 (0.0269)	1.0002 (0.0161)	1.0041 (0.0190)	1.0108 (0.0166)	0.9856 (0.0166)	1.0016 (0.0138)
Years of farming experience	0.9876 (0.0230)	1.0110 (0.0143)	0.9956 (0.0166)	0.9975 (0.0144)	1.0171 (0.0152)	1.00031 (0.0122)
Farm size (in hundreds of acres)	0.9861 (0.0281)	1.0207 (0.0209)	0.9805 (0.0208)	1.0397 (0.0215)	*1.0553 (0.0234)	*1.0375 (0.0183)
Percentage of farm acres rented	0.9402 (0.5504)	1.5086 (0.5324)	1.4067 (0.5838)	0.9439 (0.3352)	1.4366 (0.5136)	1.6772 (0.5239)
High school or less education	1.1317 (0.5392)	0.5662 (0.1661)	0.6554 (0.2216)	1.0759 (0.3171)	0.6625 (0.1965)	*0.5523 (0.1414)
Some college education	omitted	omitted	omitted	omitted	omitted	omitted
College graduate or beyond	0.6919 (0.3568)	0.5740 (0.1916)	0.9323 (0.3776)	1.7729 (0.5945)	0.9848 (0.3301)	0.8280 (0.2448)
Income level	0.9991 (0.0022)	0.9991 (0.0014)	0.9990 (0.0016)	1.0015 (0.0014)	1.0004 (0.0014)	1.0000 (0.0013)
Receipt of any cost-share funds	0.5982 (0.2543)	1.1810 (0.3370)	0.8750 (0.2842)	*1.7845 (0.5017)	1.3859 (0.3946)	1.4014 (0.3561)
Model X^2 (df)	5.04 (8)	10.83 (8)	4.12 (8)	*16.53 (8)	**24.23 (8)	**23.26 (8)
Observations	276	275	275	277	278	280

*coefficient/model significant at the .05 level
**coefficient/model significant at the .01 level
***coefficient/model significant at the .001 level

Models 7, 8, and 9 did not find any tested factors to have a significant influence over whether respondents answered the questions correctly, nor were these models found to be significantly better than models with no predictors. Model 10 found one variable to be significant. Farmers who reported receiving government support or cost-share funds for BMPs were 78.5% more likely to answer Item D correctly than those who did not receive this support. Model 11 also found one variable to be significant. For every 100 acre increase in farm size, respondents were 5.5% more likely to answer Item E correctly.

Model 12 used ordered logistic regression to test factors influencing which category of correct answers each respondent fell into: zero to two answers correct, three answers correct, four answers correct, or five answers correct. This model found two significant factors: farm size and whether the respondent had only completed high school or less education. For every 100 acre increase in farm size, respondents were 3.8% more likely to fall into a higher category of knowledge. For instance, for every 100 acre increase in farm size, farmers were 3.8% more likely to answer 4 items correctly than 3 items correctly, holding everything else constant. In addition, respondents who had only completed a high school education or less were 44.8% less likely to fall into a higher category of correct responses than those who have completed some college or an Associate's degree.

In general, the results of these models were expected. Education, farm size, and receipt of cost share funds were significant and positively associated with knowledge in at least one of the tested models. Each of these factors is likely to increase a respondent's exposure to the requirements of the Neuse rules and to enhance their understanding of those requirements. These results indicate that future educational efforts should focus more on smaller farms, farmers who are not already participating in cost share programs, and those who may need additional help in understanding the requirements.

The results for model 10 may also indicate that the Neuse rules are encouraging farmers to pursue cost share funding for nutrient management practices. The results clearly show a positive relationship between the receipt of cost share funds and knowledge about the collective 30% nitrogen reduction requirement. It is likely that farmers receiving cost share funds are being educated about the rules at a higher rate than those who do not receive funds. However, it is also possible that those who know more about the rules are pursuing cost share funding for nutrient management practices at a higher rate than those who are less informed.

6.3 GROUP C MODELS: ATTITUDES TOWARD THE NEUSE RULES

Four models, numbered 13 through 16, tested the influence of farm and farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules, and the number of nutrient management practices adopted on attitudes concerning the Neuse rules. These models are described in Table 17.

Table 17. Group C Models – Attitudes Toward the Neuse Rules

Model	Type	Dependent Variable	Independent Variables
13	Logistic Regression	Agreement that the Neuse regulations are reasonable	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules, number of nutrient management practices adopted
14	Logistic Regression	Agreement that regulators are unfairly targeting agriculture in the Neuse River basin	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules, number of nutrient management practices adopted
15	Logistic Regression	Strong agreement that regulators are unfairly targeting agriculture in the Neuse River basin	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules, number of nutrient management practices adopted
16	Logistic Regression	Agreement that the Neuse regulations are improving water quality	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules, number of nutrient management practices adopted

6.3.1 Dependent Variables

Four dichotomous variables measure how strongly the respondents agreed with three statements about the Neuse rules. Tables 18, 19, and 20 show the distribution of survey responses underlying these variables. In the four models in this group, the dependent variables were constructed by dividing the respondents into two groups based on their responses and then contrasting these groups. This was done to overcome statistical problems related to low frequencies for some of the response categories. Models 13, 14, and 16 each group all of the respondents who answered either “agree” or “strongly agree” and compare these respondents to those who answered “neither agree nor disagree,” “disagree,” or “strongly disagree.” Model 15 compares respondents who “strongly agree” to those who provided any other answer. Thus, these models contrast those who either agree with the particular statement versus those who do not (models 13, 14, and 16) or those who strongly agree with the statement versus those who do not (model 15).

Table 18. Agreement with statement: “Current regulations to protect water quality in the Neuse River are reasonable.”

Response	Frequency	Percentage
Strongly Disagree	2	0.6
Disagree	41	13.0
Neither Agree nor Disagree	25	7.9
Agree	239	75.9
Strongly Agree	8	2.5
TOTAL	315	100.0

Table 19. Agreement with statement: “Regulators are unfairly targeting agriculture when other groups that pollute the Neuse River are not being held accountable.”

Response	Frequency	Percentage
Strongly Disagree	0	0.0
Disagree	20	6.4
Neither Agree nor Disagree	13	4.1
Agree	113	35.9
Strongly Agree	169	53.7
TOTAL	315	100.0

Table 20. Agreement with statement: “The regulations targeting farmers in the Neuse River Basin are improving water quality.”

Response	Frequency	Percentage
Strongly Disagree	2	0.6
Disagree	64	20.3
Neither Agree nor Disagree	24	7.6
Agree	207	65.7
Strongly Agree	18	5.7
TOTAL	315	100.0

6.3.2 Independent Variables

Two of the dependent variables already described were included in the group C models as control variables. These include: the number of nutrient management practices adopted and knowledge of the Neuse rules.

6.3.3 Model Results and Discussion

In general, respondents had a high level of agreement with each of the three attitude statements. As seen in Tables 18 and 20 respectively, the majority of farmers in the survey either agreed or strongly agreed that the Neuse rules are reasonable (78.4%) and that they are improving water quality (71.4%). This high level of support suggests that the agricultural requirements are generally acceptable to farmers and are believed to be accomplishing their goals. However, as seen in Table 19, 89.5% of respondents agreed or strongly agreed that agriculture is being unfairly targeted by the rules. This indicates that farmers do not appreciate the fact that the Neuse Strategy includes rules targeting all major sources of nitrogen runoff in the basin, not just agriculture. These results suggest the need for additional education about the strategy.

The statistical models testing the influence of various factors on the respondents’ attitudes about the Neuse rules had mixed results. Results are detailed in Table 21.

Table 21. Group C Multivariate Model Results

Independent Variables	Multivariate Odds Ratios (standard error)			
	Model 13	**Model 14**	**Model 15**	**Model 16**
Age of farmer	0.9668 (0.0188)	0.9636 (0.0249)	0.9863 (0.0164)	1.0192 (0.0180)
Years of farming experience	1.0295 (0.0171)	1.0212 (0.0206)	0.9992 (0.0144)	1.0207 (0.0161)
Farm size (in hundreds of acres)	0.9676 (0.0210)	1.0179 (0.0389)	0.9694 (0.0197)	0.9916 (0.0211)
Percentage of farm acres rented	1.3059 (0.5831)	0.9645 (0.5730)	1.5706 (0.5674)	1.1350 (0.4451)
High school or less education	0.8923 (0.3184)	*0.3018 (0.1555)	0.6073 (0.1812)	0.7593 (0.2482)
Some college education	omitted	omitted	omitted	omitted
College graduate or beyond	1.1123 (0.4647)	0.4574 (0.2754)	0.8071 (0.2718)	0.9940 (0.3702)
Income level	0.9989 (0.0017)	1.0041 (0.0028)	*1.0031 (0.0015)	1.0000 (.0016)
Receipt of any cost-share funds	0.8673 (0.2970)	*0.3988 (0.1733)	*0.5444 (0.1597)	1.0218 (0.1776)
Knowledge of Neuse rules	1.1812 (0.1880)	0.8437 (0.1730)	0.9133 (0.1198)	1.2201 (0.1776)
Number of practices adopted	0.8369 (0.1531)	0.9286 (0.2077)	*1.4539 (0.2223)	0.9856 (0.1610)
Model X^2 (df)	8.90 (10)	17.56 (28010	**26.07 (10)	11.40 (10)
Observations	280	280	280	280

*coefficient/model significant at the .05 level
**coefficient/model significant at the .01 level
***coefficient/model significant at the .001 level

Statistical models 13 and 16 did not yield any significant variables, nor were the models themselves found to be significant. None of the included independent variables were able to predict effectively a respondent's attitudes concerning the reasonableness of the Neuse rules nor their impact on water quality.

Several factors were found to influence whether a respondent agreed that regulators are unfairly targeting agriculture, however. Model 14, which contrasts those agree or strongly agree with those who do not, has two significant variables: whether the respondent had completed only a high school education or less and whether they had received cost share funds in the last five years. Interpreting these variables is problematic, however, because the overall model was not found to be significant at the .05 level. Model 15, which contrasts those who strongly agree with those who do not, also found several significant factors and is itself significant. For every $1,000 increase in income, a farmer is 0.31% more likely to strongly agree with the statement that regulators are unfairly targeting agriculture. Farmers who receive cost share funds were 45.6% less likely to strongly agree with this statement than those who did not receive these funds in the last five years. For every additional nutrient management practice adopted, a farmer is 45.4% more likely to strongly agree with this statement.

The results of model 15 suggest that the receipt of cost share funds reduces feelings of burden and resentment toward the Neuse rules. However, surprisingly, the number of nutrient management practices adopted seems to have the opposite effect. Adopting more practices increases a farmer's feelings of burden. This finding may indicate that those who are adopting multiple nutrient management practices feel that they are being asked to do more than their share.

6.4 GROUP D MODELS: NUTRIENT MANAGEMENT PLANS AND TRAINING

As described in the background section of this report, the Neuse Strategy nutrient management rule applies to persons who apply fertilizers to or manage 50 or more acres of cropland, unless the cropland is covered by a certified animal waste management plan. Those who are covered by the rule have two options to meet its requirements. First, they may complete training and continuing education in nutrient management, or they may develop a nutrient management plan for all property where nutrients are applied. The N.C. Cooperative Extension Service offered nutrient management training to farmers in the three counties covered by this survey in 2001 and 2002.

This survey asked respondents whether they participated in this nutrient management training and also whether or not they have developed a written nutrient management plan for the cropland they cultivate. This analysis breaks farms in the survey sample into two groups: those that are less than 50 acres and those that are 50 acres or more. Though this distinction is not likely to exactly delineate the farms that are covered by the regulations from those that are not, it should be a close approximation.

For the analysis, farms that are 50 acres or larger and have completed one or the other activity are considered to be in compliance with the nutrient management rule. Farms of this size that have not completed either activity are considered noncompliant. Farms that are of this size and have completed both activities are considered over-compliant. Farms that are less than 50 acres in size, and thus are not covered by the nutrient management rule, are considered to be over-compliant if they have completed either or both of the activities.

The three models in group D test the influence of farm and farmer characteristics, receipt of cost share funds, and knowledge of the Neuse rules on whether respondents with farms of different sizes have either developed nutrient management plans, participated in nutrient management training, or both. These models are described in Table 22.

Table 22. Group D Models - Nutrient Management Plans and Training

Model	Type	Dependent Variable	Independent Variables
17	Logistic Regression	Whether a farm ≥ 50 acres in size has a nutrient management plan and/or operator has received training	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules
18	Multinomial Regression	Category of compliance status of farms ≥ 50 acres in size: not in compliance (base category), in compliance, or in over-compliance	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules
19	Logistic Regression	Whether a farm <50 acres in size has a nutrient management plan and/or operator has received training	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules
20	Multinomial Regression	Category of how much farmers rely on their nutrient management plans: frequently (base category), never/sometimes, or always	Farm characteristics, farmer characteristics, receipt of cost share funds for nutrient management, receipt of cost share funds for other practices, knowledge of the Neuse rules, whether the nutrient management plan has been reviewed by a government official

6.4.1 Dependent Variables

The three dependent variables used in models 17 through 19 measure whether respondents with different sized farms have completed nutrient management training and/or developed nutrient management plans. The dependent variable in model 17 is a dichotomous variable that indicates whether farms that are 50 acres in size or larger (i.e., those that are regulated by the nutrient management rule) have completed at least one of these activities. As seen in Table 23, of the 274 farms that are this size, 74.8% have completed a plan or training and 25.2% have done neither. The dependent variable in model 18 indicates which category of compliance the farms regulated by the nutrient management rule fall into: noncompliance, compliance, or over-compliance. The distribution of this variable is detailed in Table 23. The dependent variable for model 19 is dichotomous and indicates whether farms that are less than 50 acres in size (i.e., those that are not regulated) have completed at least one of these activities. As shown in Table 23, of the 41 farms of this size, 56.1% have completed one or more of the activities and 43.9% have completed neither.

Table 23. Nutrient Management Activities Undertaken by Farms of Different Sizes

Number of activities	Number of farms < 50 acres (percentage)	Number of farms ≥ 50 acres (percentage)	Total Frequency (Total Percentage)
0 – neither training nor a plan	18 (43.9)	69 (25.2) [noncompliant]	87 (27.6)
1 – either a plan or training	12 (29.3) [over-compliant]	89 (32.5) [compliant]	101 (32.1)
2 – both a plan and training	11 (26.8) [over-compliant]	116 (42.3) [over-compliant]	127 (40.3)
Total Percentage (Total frequency)	41 (13.0)	274 (87.0)	315 (100.0)

The dependent variable in model 20 measures a respondent's level of reliance on their nutrient management plan when making decisions about fertilizer application. This variable is based on the responses detailed in Table 24, and has three levels: never or sometimes, frequently, and always. The "never" and "sometimes" categories were combined due to their low frequencies.

Table 24. How Much Farmers Rely on their Nutrient Management Plans when Making Nutrient Application Decisions

Response	Frequency	Percentage
Never	5	2.7
Sometimes	21	11.5
Frequently	44	24.0
Always	113	61.8
TOTAL	183	100.0

6.4.2 Independent Variables

Model 20 includes an independent variable that indicates whether the respondent's nutrient management plan has ever been reviewed by a government official. Having a plan reviewed is expected to increase a respondent's dependence on the plan. Of the 183 respondents with nutrient management plans, 153 (83.6%) reported having had their plans reviewed.

6.4.3 Model Results and Discussion

Table 25 provides the statistical results for models 17 through 20. Models 17 through 19 each found one or two factors that influence the compliance status of farms in the survey sample.

Model 17 focuses on factors that influence whether regulated farms are in compliance with the Neuse nutrient management rule or not. It finds two significant variables: age and knowledge of the Neuse rules. With every year increase in age, a farmer is 6.3% less likely to be in compliance with the nutrient management rule. With each additional knowledge question about the Neuse rules he or she answered correctly, a farmer is 196.4% more likely to be in compliance. This result is not surprising, as one would expect that those who have a higher level of awareness about the rules would be more likely to comply with them.

Table 25. Group D Multivariate Model Results

Independent Variables	Multivariate Odds Ratios (standard error)					
	Model 17	Model 18		Model 19	Model 20	
		Compliance	Over-compliance		Never or Sometimes	Always
Age of farmer	**0.9373 (0.0220)	**0.9350 (0.0258)	*0.9418 (0.0273)	1.0496 (0.0506)	0.9970 (0.0444)	1.0192 (0.0291)
Years of farming experience	1.0356 (0.0197)	1.0389 (0.0212)	1.0288 (0.0227)	1.0024 (0.0442)	1.0615 (0.0422)	1.0126 (0.0271)
Farm size (in hundreds of acres)	1.0124 (0.0345)	0.9888 (0.0381)	1.0332 (0.0365)	246.789 (1018.3)	0.9902 (0.0409)	1.0129 (0.0279)
Percentage of farm acres rented	1.8296 (0.9358)	1.4626 (0.5470)	2.6117 (0.5818)	0.7340 (1.0112)	0.3769 (0.8461)	0.3112 (0.6128)
High school or less education	0.5471 (0.2392)	0.6320 (0.4715)	0.4636 (0.4826)	0.9074 (0.9945)	1.6003 (0.6692)	*3.2440 (0.4932)
Some college education	omitted	omitted	omitted	omitted	omitted	omitted
College graduate or beyond	0.6688 (0.3326)	0.8390 (0.5262)	0.4824 (0.5584)	1.5273 (2.7346)	1.1705 (0.7325)	1.9443 (0.5263)
Income level	1.0033 (0.0021)	*1.0044 (0.0022)	1.0020 (0.0023)	*1.0454 (.0237)	1.0023 (0.0029)	0.9976 (0.0022)
Receipt of any cost-share funds	1.3940 (0.6708)	1.1971 (0.5193)	1.6938 (0.5239)	1.0732 (1.4195)	omitted	omitted
Knowledge of Neuse rules	***2.964 (0.6631)	***2.1417 (0.2398)	***4.1388 (0.2453)	0.0375 (0.2430)	0.9828 (0.2700)	0.9680 (0.2011)
Receipt of funds excluding nutrient management					2.0518 (0.6662)	1.3868 (0.5161)
Receipt of funds for nutrient management					1.3315 (0.6651)	0.9136 (0.4920)
Plan has been reviewed					1.2077 (0.7703)	1.4956 (0.5564)
Constant		1.6998 (1.4014)	0.2048 (1.4762)		0.1018 (2.0912)	0.7791 (1.5024)
Model X^2 (df)	***70.24 (9)	***103.44 (18)		†16.18 (9)	24.38 (22)	
Observations	243	243		37	165	

† model significant at the .10 level
*coefficient/model significant at the .05 level
**coefficient/model significant at the .01 level
***coefficient/model significant at the .001 level

Model 18 is a multinomial model that focuses on factors that influence which category of compliance a respondent with a farm of 50 acres or more in size falls into: not in compliance, in compliance, or in over-compliance. The first contrast in the model compares those in compliance to those not in compliance. It identifies three significant variables: age, income, and knowledge of the Neuse rules. For every additional year of age, a regulated farmer is 6.5% less likely to be in compliance than in noncompliance. For every additional $1,000 of income, a regulated farmer is 0.4% more likely to be in compliance than in noncompliance. Finally, for every additional question answered correctly about the Neuse agricultural rules, a regulated farmer is 114.2% more likely to be in compliance than in noncompliance.

The second contrast in model 18 compares respondents who are in over-compliance with those who are not in compliance. It identifies two significant variables: age and knowledge of the Neuse rules. For every additional year of age, a regulated farmer is 5.8% less likely to be in over-compliance than in noncompliance. For every additional question answered correctly about the Neuse agricultural rules, a regulated farmer is 313.9% more likely to be in over-compliance than in noncompliance, holding everything else constant.

Model 19 tests the influence of the included independent variables on whether unregulated farms are in over-compliance. In this model, only income is found to be significant. With each $1,000 increase in income, an unregulated farmer is 4.5% more likely to be in over-compliance than not. It is interesting that age is not predictive of the completion of nutrient management plans or training for smaller farms since it is a strong predictor of compliance status for larger farms. In addition, it is interesting that knowledge of the Neuse rules is not a significant factor in this model. This may indicate that the more informed farmers in this group understand that the Neuse nutrient management rule does not apply to them. Thus, they are not any more or less likely to be in over-compliance than those who do not know about the rule.

Model 20 tests the influence of the included independent variables on how much respondents report relying on their nutrient management plans when making nutrient application decisions. This multinomial model is not found to be significant, but it does identify an interesting relationship between education level and reliance on these plans. Whether the respondent has only completed high school or less relative to completing some college is found to positively impact how much they rely on their nutrient management plan when making nutrient application decisions.

6.5 GROUP E MODELS: ATTITUDES AND EXPERIENCE REGARDING FARM INSPECTIONS AND PENALTIES

The last group of models focuses on farm inspections and penalties. These models are described in Table 26.

Table 26. Group E Models – Attitudes and Experiences Regarding Farm Inspections and Penalties

Model	Type	Dependent Variable	Independent Variables
21	Logistic Regression	Agreement that the government is unlikely to inspect nutrient management practices	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules, number of nutrient management practices adopted, whether the farm is ≥ 50 acres, whether the farm is in compliance, whether the farm has ever been inspected
22	Logistic Regression	Agreement that the farmer expects to be penalized if he/she does not comply with the nutrient management rules	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules, number of nutrient management practices adopted, whether the farm is ≥ 50 acres, whether the farm is in compliance, whether the farm has ever been inspected
23	Logistic Regression	Whether the farm has been inspected since 2000	Farm characteristics, farmer characteristics, receipt of cost share funds, knowledge of the Neuse rules, number of nutrient management practices adopted, whether the farm is ≥ 50 acres, whether the farm is in compliance

6.5.1 Dependent Variables

The dichotomous dependent variables used in models 21 and 22 test agreement with two statements concerning inspections and penalties related to the Neuse agricultural rules. In each model the respondents who agree or strongly agree are compared to those who strongly disagree, disagree, or neither agree nor disagree. As shown in Table 27, 28.9% of respondents strongly agreed or agreed that the government was not likely to inspect their nutrient management practices. Table 28 shows that 77.8% of respondents strongly agreed or agreed that they expected to be penalized if they did not comply with the nutrient management rules.

Table 27. Agreement with statement: "The government is not very likely to inspect my nutrient management practices."

Response	Frequency	Percentage
Strongly Disagree	8	2.5
Disagree	176	55.9
Neither Agree nor Disagree	40	12.7
Agree	89	28.3
Strongly Agree	2	0.6
TOTAL	315	100.0

Table 28. Agreement with statement: “If I do not comply with nutrient management rules, I expect to be penalized.”

Response	Frequency	Percentage
Strongly Disagree	0	0
Disagree	56	17.8
Neither Agree nor Disagree	14	4.4
Agree	213	67.6
Strongly Agree	32	10.2
TOTAL	315	100.0

The dependent variable used in model 23 measures whether a farm was inspected at any time between the years 2000 and 2005. Of the 315 survey respondents, 158 (50.1%) reported having experienced an inspection during this time frame. The other 157 respondents either reported that they had never been inspected (88 respondents), were inspected but before the year 2000 (18 respondents), did not know whether they had ever been inspected (42 respondents), or they refused to answer the question (9 respondents).

6.5.2 Independent Variables

In addition to the independent variables that have been described for previous models, this group of models adds two new variables. The first measures whether the farm has ever been inspected. The majority of respondents (55.9%) reported having experienced an inspection at least once. The second variable is a proxy measure for whether the farm is regulated under the Neuse nutrient management rule. It measures whether the farm is greater than or equal to 50 acres in size. Eighty-seven percent of respondents reported having farms of this size.

6.5.3 Model Results and Discussion

As detailed in Tables 27 and 28, the survey results show that the majority of farmers in the sample believe that they are likely to be inspected and that if they do not comply with the nutrient management rules, they are likely to be penalized. These findings indicate that the regulatory components of the Neuse rules are creating a fear of enforcement among most farmers. This is significant because previous studies have found that a fear of being found in violation of rules can be a powerful motivator of compliance with those rules (e.g., Winter and May 2001; Burby and Paterson 1993; Burby, May and Paterson 1998).

The results of the statistical models for group E are detailed in Table 29. In model 21, only one variable is found to influence whether a respondent agreed that the government was not likely to inspect their nutrient management practices: whether the respondent had ever experienced a farm inspection. Not surprisingly, farmers who had experienced a farm inspection were 57.3% less likely to agree with this statement than those who did not report having experienced an inspection. It is somewhat surprising that other factors such as the receipt of cost share funds and farm size were not found to influence attitudes about the likelihood of inspection, however. These two factors would seem to increase a farmer’s exposure to inspectors and thus their concerns about being inspected.

Table 29. Group E Multivariate Model Results

Independent Variables	Multivariate Odds Ratios (standard error)		
	Model 21	Model 22	Model 23
Age of farmer	1.0093 (0.0222)	0.9559 (0.0228)	1.0301 (0.0183)
Years of farming experience	1.0154 (0.0187)	0.9949 (0.0189)	*0.9693 (0.0150)
Farm size (in hundreds of acres)	1.0009 (0.0255)	0.9630 (0.0230)	0.9738 (0.0210)
Percentage of farm acres rented	0.7915 (0.3563)	0.6401 (0.3201)	*0.4599 (0.1778)
High school or less education	1.3707 (0.5201)	1.5128 (0.5877)	0.7550 (0.2349)
Some college education	omitted	omitted	omitted
College graduate or beyond	1.9892 (0.8198)	1.5482 (0.7119)	0.7569 (0.2663)
Income level	0.9987 (0.0018)	1.0010 (0.0019)	***1.0070 (0.0017)
Receipt of any cost-share funds	1.2515 (0.4573)	1.0041 (0.3845)	*1.8251 (0.5544)
Knowledge of Neuse rules	0.7929 (0.1317)	1.1856 (0.2133)	1.0850 (0.1506)
Number of practices adopted	0.9084 (0.1906)	1.4114 (0.3140)	***1.7401 (0.2854)
Farm is regulated	omitted	omitted	0.9558 (0.3978)
Regulated farm is in “compliance”	0.9243 (0.4027)	0.8084 (0.3907)	omitted
Farm has been inspected	*0.4267 (0.1440)	0.9715 (0.3534)	omitted
Model X^2 (df)	*25.18 (12)	17.14 (12)	***52.74 (11)
Observations	243	243	280

*coefficient/model significant at the .05 level
**coefficient/model significant at the .01 level
***coefficient/model significant at the .001 level

Model 22 did not find any factors to be significant in influencing whether a farmer agreed that they are likely to be penalized if they do not comply. It is interesting that the model did not find the inspection variable to be significant in this model. Apparently those who have been inspected in the past are not any more or less concerned about penalties than those who have not been inspected.

Model 23 finds five factors to be significant in influencing whether a respondent's farm was inspected between 2000 and 2005: the percent of farmland rented, years of farming experience, income, receipt of cost share funds, and the number of nutrient management practices adopted. Experience and the percent of farm acres rented are found to have a negative impact on the likelihood of inspection. For every additional year of farming experience, a farmer is 3.1% less likely to have been inspected. For every additional 1 percent of farmland rented rather than owned, a farmer is 54.0% less likely to have been inspected. Receipt of cost share funds makes a respondent 82.5% more likely to have experienced an inspection. For every additional $1,000 in income, a farmer is 0.7% more likely to have been inspected. Finally, for each additional nutrient management practice adopted by a farmer, he or she is 74.0% more likely to have been inspected.

The positive relationship between receipt of cost share funds and experience of a farm inspection was anticipated since many cost share programs require inspections. Inspecting farms that receive public funding is important to ensure that those who are given financial support for nutrient management practices are actually using the practices and are doing so correctly. The model results also support expectations that personal factors such as age, education, and knowledge of the Neuse rules have no discernable effect on the experience of an inspection. Several other variables yielded surprising results, however. The negative impacts of years of experience and percent of farmland rented on inspections were not anticipated. It may be that farm inspectors have more trust in farmers with more experience and feel less need to inspect their operations. It may also be that inspectors find it easier to inspect consolidated farms than those that are comprised of scattered rented parcels. The positive effect of income was not expected, but may be explained by inspectors feeling that their efforts are less burdensome to farmers with higher incomes.

Another surprise was the strong positive effect of the number of practices adopted on inspection, given that receipt of cost share funds is controlled in these multivariate models. Basically, farmers who use the most nutrient management practices are more likely to have been inspected than those who use fewer practices, whether or not they receive cost share funding and thus are subject to inspection under cost-share programs. Finally, the lack of an effect from whether a farm is regulated under the Neuse nutrient management rule was unexpected. One would expect that being subject to the nutrient management requirements would increase the likelihood of inspection, but these results do not support this. When these two findings are taken together, they raise questions about how inspections are being targeted and whether they are being used to encourage compliance with the Neuse nutrient management rule or whether they are simply being used to check up on farmers already known to be using nutrient management practices.

6.6 DISCUSSION: CHANGES IN AMBIENT WATER QUALITY

Theoretically, any pollution control policy instrument can be evaluated based on its impacts on different "compliance bases." For example, a policy could be judged by how much it reduces the use of pollution-creating inputs, the amount of pollution discharged, ambient concentrations of pollution, or ecological or economic damages caused by pollution.

Shortle and Horan (2001) argue that, in general, the most appropriate compliance base is one that is correlated with environmental conditions, enforceable, and targetable in space and time. For example, discharges tend to be the preferred base for point source pollution control because point sources are relatively easy to identify and their discharges are generally non-random and can be measured accurately and inexpensively (Shortle and Horan 2001). The question of which compliance base is most appropriate for agricultural nonpoint source pollution control is more difficult, however.

Three compliance bases have received the most attention for this purpose: (1) estimated exports of pollutants from fields to surface and groundwater, (2) inputs or practices correlated with pollution flows, and (3) concentrations of pollutants in receiving streams. The primary compliance base of the Neuse Strategy agricultural rule is an estimated field export of nitrogen that is derived from NLEW. The rule also uses estimates of inputs (nitrogen application rates) and practices (BMPs) to calculate losses and exports. However, given the issues described in this report concerning the quality of these estimates, export measures generated by NLEW may not be highly reliable. In turn, these estimates may not be the best way to gauge the true impacts of the agricultural rule on water quality in the Neuse Basin.

Two issues argue for using ambient pollution concentrations rather than nitrogen exports as the compliance base for measuring the impact of the agricultural rule. First, as argued by Stavins (2001), emission or export-based instruments are not very appropriate when pollutants are not well-mixed in the environment. Second, ambient concentrations tend to more directly measure the problem that the policy is trying to address in the first place. In this case, ambient concentrations of nitrogen are more closely tied to water quality problems in the Neuse River and Estuary than estimated exports from cropland.

Unfortunately, using ambient water quality as the yardstick by which to measure success of the Neuse Strategy is easier said than done. This is because ambient monitoring is prone to several problems that can complicate its use for program evaluation. One important problem is that if the land draining into the monitoring station has multiple sources of nitrogen, it can be very difficult to attribute changes in the ambient concentrations of nitrogen to the different sources. This limits the usefulness of this data for enforcement purposes (McNitt and Kepford 1999). Second, it can be hard to time monitoring events in order to gain an accurate picture of how ambient concentrations are changing since nitrogen loads are likely to vary significantly based on weather conditions and other unpredictable factors. Third, changes in water quality may not occur immediately after changes in farming practices or installation of BMPs. According to Caruso (2000), it is difficult to identify water quality improvements from specific management practices because there is usually a considerable time lag in improvements and because it is difficult to isolate the causative factors contributing to improvements. Finally, in addition to lags between behavior and impacts on ambient water quality, Shortle suggests that ambient monitoring is also limited by its potentially high costs and high error rates.

Despite these significant challenges, it is useful to examine the data that are available about ambient concentrations of nitrogen in the Neuse River Basin to determine how these concentrations have changed since the Nutrient Sensitive Waters strategy was implemented and to investigate how useful these data might be in evaluating the impacts of the agricultural rule.

One relevant study (Stow and Borsuk 2003) investigated flow-adjusted nitrogen concentrations from 1979 to 2000 at three monitoring stations near the mouth of the Neuse Estuary. This study finds a slow steady decline in total Kjeldahl nitrogen (TKN) over most of the study period at all three stations. However, trends in total nitrogen (TN), which consists of TKN and oxides of nitrogen, differed among the stations, with one showing a decline from 1985 to 1994 and then stabilizing through 2000 and two showing relatively stable values from 1979 to 1995 and then a decline from 1995 to 2000. This study suggests that these nitrogen decreases are similar to point source nitrogen discharge reductions reported from 1995 to 2000 and may reflect decreases that occurred as a result of the Neuse wastewater discharge rule. It also suggests that the decline may be the result of flushing by two major hurricanes that moved through the basin in the late 1990s.

A second analysis of nitrogen concentration trends in the basin was performed by the DWQ's Planning Branch (Rajbhandari 2006). This analysis looks at flow and seasonally-adjusted concentrations of TKN, nitrogen oxides, and TN from 1985 to 2005 at two monitoring stations near the mouth of the Neuse Estuary. At both stations, the analysis finds that total nitrogen and nitrogen oxides decreased over that time period. At the Contentnea station, the study finds that TN decreased by 27% and nitrogen oxides decreased by 44%. At the New Bern station, the study finds that TN declined by 17% and nitrogen oxides by 66%. However, in contrast to the Stow and Borsuk study, this analysis did not find any significant change in TKN at either location.

A third study (Burkholder et al. 2006) investigates changes in nitrogen concentrations and loadings in the Neuse Estuary from 1993 to 2003 using a flow model and concentration data from six sampling stations in the Neuse Estuary. This study finds decreasing concentrations of TN in this time period, but concludes that this trend can be explained largely by a prolonged drought from 2000 to 2002. The study also finds a 28% reduction in TN loading to the estuary during the study period, which could not be explained by climactic events. However, this finding was highly sensitive to the beginning period used in the analysis. For example, the study's authors state that when the analysis is started in June 1994, no significant trend in TN loading is found. In contrast to the TN trends, this study finds a significant increase in NH_4 concentrations in the estuary and attributes this increase to inadequately controlled nonpoint sources, primarily consolidated animal feeding operations. The study's authors conclude that their findings about the NH_4 increases and "fragile" TN loading trends do not support public reports of a 30% TN loading reduction to the Neuse. However, the study authors also state that noticeable decreases in TN concentrations in the estuary due to management actions may not be detected for a decade or more. Finally, the authors conclude that the nitrogen-reduction management actions that have taken place in the basin regarding point sources and crop-based agricultural sources have largely been offset by significant human and swine population increases in the past decade.

In combination, these three studies do not provide a clear picture of nitrogen loading and concentration trends in the lower Neuse River and Estuary since the implementation of the Neuse rules. While all three studies report reductions in at least one or two measures of nitrogen, these are not consistent among the studies and in one are eliminated when climatic factors are controlled or the study's starting date is changed slightly. In addition, none of these studies conclude that the nitrogen decreases they find are attributable to nitrogen loss reductions from agricultural lands in the basin. In fact, Burkholder et al. find that new agricultural sources, namely confined animal feeding operations, have likely increased nitrogen loading by greatly increasing NH_4 concentrations in the estuary. These studies do illustrate some of the complications that arise when trying to use ambient concentrations to evaluate nonpoint source pollution control measures, however.

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2005 FARMERS' NUTRIENT MANAGEMENT PRACTICES AND COMPLIANCE MOTIVATIONS SURVEY

COUNTY: **PHONE:** **ID NUMBER:** (1-5)

NAME: **RIVER BASIN:** **CARD1** (6)

CONTACT STATUS

	1	2	3	4	5	6	7	8	9	10	11	12	13
TIME													
DATE													
STATUS													

CODES						
C	AM	ANSWERING MACHINE	CL	CAN'T LOCATE	OS	OUT OF SERVICE
O	BS	BUSY SIGNAL	FX	FAX / MODEM / TDD	PC	PARTIALLY COMPLETED
D	BG	BUSINESS/ GOVERNMENT	HI	HOUSEHOLD INELIGIBLE	RF	REFUSED
E	CB	CALL BACK	NA	NO ANSWER	TI	TERMINATED INTERVIEW
S	CI	COMPLETED INTERVIEW	NL	NO LISTING	WN	WRONG NUMBER

I N T R O D U C T I O N

Hello, my name is [NAME] and I'm calling on behalf of Researchers at NC State University. We're conducting a study about nutrient management practices in the Neuse and Tar-Pamlico River Basins. Your answers to this survey will be kept confidential and your name will not appear on any of the project reports. The survey will only take about 15 minutes to complete. Are you willing to participate?

a. First, are you still operating this farm?

YES: [CONTINUE INTERVIEW] *1*
NO: [TERMINATE INTERVIEW] *2*

TERMINATE*: "I'm sorry. We are only talking today with farmers who still operate a farm. Thanks for your time."* **[CODE HI.]**

b. Do you make management decisions regarding the operation of the farm?

YES: [CONTINUE INTERVIEW] *1*
NO: [REQUEST TO SPEAK TO SOMEONE WHO DOES] *2*

c. May I please speak with someone who makes the farm management decisions?

[IF NECESSARY, REPEAT THE INTRODUCTION]

IF NO ONE IS AVAILABE RESCHEDULE INTERVIEW*: I'm sorry. I need to speak to someone who makes management decisions regarding the farm. When would be a good time to call back? Record Call Back Time____________ Thanks for your time.*

FARMING PRACTICE

I have a few questions about your current farm operation and some of your current farming practices. Remember that all of the information you give me will be treated confidentially.

1.	How many total acres were in your farm operation in 2004, including all owned and rented land? Please include all locations and land uses such as cropland, pasture, and idle land.	Number of Acres: ____________________________	*(7-12)*
2.	How many of these acres do you rent or lease from others?	Number of Acres: ____________________________	*(13-18)*
3.	How many years have you been a farm operator?	Number of Years:.. __ __	*(19-20)*
4.	How do you determine your nitrogen application rates? **[LET RESPONDENT VOLUNTEER. CIRCLE ALL MENTIONED]**	Fertilizer dealer recommendations........................1 Historical farm yields...1 State agency recommendations or Realistic yield expectation (RYE) for Nitrogen.................1 Soil tests ....1 Crop tissue analysis...1 Other**[SPECIFY]**______________________ __ __	*(21)* *(22)* *(23)* *(24)* *(25)* *(26-27)*
5.	How do you determine your phosphorus application rates? **[LET RESPONDENT VOLUNTEER. CIRCLE ALL MENTIONED]**	Fertilizer dealer recommendations........................1 Historical farm yields...1 State agency recommendations/Cooperative Extension Service..1 Soil tests ....1 Crop tissue analysis...1 Other**[SPECIFY]**______________________ __ __	*(28)* *(29)* *(30)* *(31)* *(32)* *(33-34)*
6.	Has your soil been tested for nutrient content during the last two years?	Yes.. 1 No... 2	*(35)*
7.	How often do you conduct soil tests? **[READ RESPONSES]**	More than once a year .... 05 Once a year.. 04 Every two years.. 03 Every three years or less often **or**......................... 02 Never .... 01 Other**[SPECIFY]**______________________ __ __	*(36-37)*
8.	How often do you calibrate your fertilizer application equipment? **[READ RESPONSES]**	More than once a year .... 05 Once a year.. 04 Every two years.. 03 Every three years or less often **or**......................... 02 Never .... 01 Other**[SPECIFY]**______________________ __ __	*(38-39)*

9. Do you plant any cover crops?	Yes .... 1 No **[SKIP TO Q10]** 2	*(40)*
a. **[IF YES TO Q9]** On average, how many acres of the following types of cover crops do you plant each year? **[ASK ABOUT EACH TYPE]**	Wheat .... ___________ Rye .... ___________ Triticale .... ___________ Oats .... ___________ Barley .... ___________	*(41-46)* *(47-52)* *(53-58)* *(59-64)* *(65-70)*
	DUP ID CARD2	*(1-5)* *(6)*
Any others?	**[SPECIFY]**_______________ **Acreage**___________ __ __	*(7-14)*
Any others?	**[SPECIFY]**_______________ **Acreage**___________ __ __	*(15-22)*
b. **[IF YES TO Q9]** What is the average nitrogen rate you use on your cover crops? **[READ RESPONSES]**	1 to 10 lbs per acre .... 1 11 to 25 lbs per acre .... 2 26 to 50 lbs per acre .... 3 More than 50 lbs per acre .... 4 None 5	*(23)*
c. **[IF YES TO Q9]** During what time period do you generally plant your cover crops? **[READ RESPONSES]**	October 1-15 .... 01 October 16-31 .... 02 November 1-15 **or** .... 03 Some other time **[SPECIFY]**________________ __ __	*(24-25)*
d. **[IF YES TO Q9]** During what time period do you generally kill off your cover crops? **[READ RESPONSES]**	March 15-30 .... 01 April 1-15 .... 02 April 16-30 **or** .... 03 Some other time **[SPECIFY]**________________ __ __	*(26-27)*

NUTRIENT MANAGEMENT PLAN

I would like to talk with you about nutrient management. Nutrient management involves monitoring and improving soil fertility to meet crop needs while maintaining farm productivity and protecting water quality.

A nutrient management plan is a written document that helps define the nutrient needs of crops. It also identifies the most appropriate amount, form, placement, and timing of nutrient applications to crops.

10. Do you have a written nutrient management plan for the crop land you cultivate?	Yes .... 1 No **[IF NO SKIP TO Q11]** 2	*(28)*
a. **(IF YES)** When did you first prepare a plan?	Record Year: .... __ __ __ __	*(29-32)*

b. **(IF YES)** How much do you rely on the plan when you make decisions about applying fertilizers? **[READ RESPONSES]**	Always....4 Frequently....3 Occasionally **or**....2 Never....1	*(33)*
c. Has a government representative or Extension agent ever reviewed your plan?	Yes**[SKIP TO Q12]**....1 No**[SKIP TO Q12]**....2	*(34)*
11. **[IF NO TO Q10]** What are the main reasons you do not have a nutrient management plan? **[LET RESPONDENT VOLUNTEER. CIRCLE ALL MENTIONED]**	I am not required to have one....1 I do not need one....1 Too difficult....1 Too expensive....1 Water quality is not a problem....1 Nutrients are not a problem....1 Other **[SPECIFY]**________________ ....__ __	*(35)* *(36)* *(37)* *(38)* *(39)* *(40)* *(41-42)*
12. Have you received government financial support or cost-share money for any of the following best management practices in the past five years? **[CIRCLE YES OR NO FOR EACH]**	**Yes** / **No** Buffers....1....2 Filter strips....1....2 Field borders....1....2 Cover crops....1....2 Controlled drainage....1....2 Nutrient management....1....2	*(43)* *(44)* *(45)* *(46)* *(47)* *(48)*
13. Would you say that using nutrient management decreases farm income, increases farm income, or doesn't really change farm income?	Decrease farm income....3 Increase farm income....2 Doesn't really change farm income....1	*(49)*

14. I'd like to read you a list of statements. For each statement I read, please tell me whether you **Strongly Agree**, **Agree**, **Disagree**, or **Strongly Disagree** with the statement.

Read Scale After Each Statement	**Strongly Agree**	**Agree**	**Neither Agree or Disagree**	**Disagree**	**Strongly Disagree**	
a. The rising price of fertilizer is now the most important reason for practicing nutrient management.	5	4	3	2	1	*(50)*
b. Using nutrient management significantly reduces the impact of agriculture on water quality.	5	4	3	2	1	*(51)*
c. Using more nutrient management practices on my farm would require too many changes.	5	4	3	2	1	*(52)*
d. Developing a nutrient management plan is easy for my type of farm.	5	4	3	2	1	*(53)*

NUTRIENT MANAGEMENT TRAINING

Now, I would like to talk with you about nutrient management training.

WAYNE COUNTY SKIP TO Q16

EDGECOMBE COUNTY SKIP TO Q19

15. **(Johnston and Lenoir Counties READ:)** "The Cooperative Extension Service offered nutrient management training to farmers in your county in 2001 and 2002. Did you participate in this training?	Yes **[SKIP TO Q17]** .... 1 No **[SKIP TO Q21]** 2	*(54)*
16. **(Wayne County READ:)** The Cooperative Extension Service offered nutrient management training to farmers in your county in 2001 and 2002. This training consisted of a slide presentation about nutrient management issues and some farmers also participated in one-on-one meetings where Extension agents helped them design their plans. Did you participate in this training?	Yes .... 1 No **[SKIP TO Q21]** 2	*(55)*
a. **(IF YES TO Q16) –** Did you participate in the slide presentation training, in a one-on-one meeting, or both?	Slide presentation training .... 1 One-on-one meeting .... 2 Both 3	*(56)*
17. **(IF YES to 15 or 16)** How much impact did the training have on the way you manage nutrients on your farm? Would you say a lot of impact, moderate impact, a little impact, or no impact?	A lot of impact .... 4 Moderate impact .... 3 A little impact **or** .... 2 No impact 1	*(57)*
18. **(IF YES to 15 or 16)** Overall, how satisfied were you with the training? Would you say very satisfied, somewhat satisfied, not very satisfied, or not at all satisfied?	Very satisfied .... 4 Somewhat satisfied .... 3 Not very satisfied .... 2 Not at all satisfied 1	*(58)*

EDGECOMBE COUNTY ONLY:

Your county is planning to offer nutrient management training in 2006.

19. Do you intend to participate in this training?	Yes....1 No **[IF NO SKIP TO Q21]**....2	(59)
20. **[IF YES TO Q19]** What is the **main** reason you are planning to participate in the training? **[LET RESPONDENT VOLUNTEER. CIRCLE ALL MENTIONED]**	I am required to attend....1	(60)
	An extension agent suggested it....1	(61)
	Another farmer suggested it....1	(62)
	I want to learn more about it....1	(63)
	I am concerned about water quality....1	(64)
	I want to reduce my fertilizer use....1	(65)
	Other [**SPECIFY**]__________ __ __	(66-67)

KNOWLEDGE OF NEUSE/TAR RIVER REGULATIONS

In the late 1990's, North Carolina passed several new regulations that require the amount of nitrogen entering the Neuse River and Tar Rivers to be reduced.

21. As a crop farmer, do the regulations require you to do any of the following? **[READ EACH AND CIRCLE YES OR NO]**

	Yes	No	
a. Cut your fertilizer use by 50 percent.	1	2	(68)
b. Develop a nutrient management plan or participate in nutrient management training.	1	2	(69)
c. Install 100 foot vegetated buffers on all streams.	1	2	(70)
d. Work with other farmers in your county to reduce your nitrogen runoff by 30 percent.	1	2	(71)
e. **(JOHNSTON, LENOIR AND WAYNE ONLY)** Sign up with your local area committee or implement standard best management practices.	1	2	(72)
f. **(EDGECOMBE ONLY)** Sign up with your local area committee.	1	2	(73)

ATTITUDES AND COMPLIANCE MOTIVATIONS

22. We will be discussing water quality in the Neuse River **(EDGECOMBE COUNTY SUBSTITUTE "Tar River")**. On a scale from zero to ten where zero is not at all important and ten is extremely important, how important is Neuse **(Tar)** River water quality to you personally?

[ENTER 0 TO 10] __ __ (74-75)

DUP ID (1-5)

CARD3 (6)

23. I'd like to read you some statements. For each one, please tell me whether you **Strongly Agree**, **Agree**, **Disagree** or **Strongly Disagree** with the statement.

Read Scale After Each Statement		Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree	
a.	Most people will do the right thing for the Neuse **(Tar)** River on their own without more government regulations.	5	4	3	2	1	*(7)*
b.	Agriculture should be regulated for its environmental impacts just like any other industry.	5	4	3	2	1	*(8)*
c.	Current regulations to protect water quality in the Neuse **(Tar)** River are reasonable.	5	4	3	2	1	*(9)*
d.	Regulators are unfairly targeting agriculture when other groups that pollute the Neuse **(Tar)** River are not being held accountable.	5	4	3	2	1	*(10)*
e.	The regulations targeting farmers in the Neuse River Basin **(Tar-Pamlico River Basin)** are improving water quality.	5	4	3	2	1	*(11)*
f.	Agricultural water pollution is not a serious threat to fish and wildlife in the Neuse **(Tar)** River.	5	4	3	2	1	*(12)*

24. If the Neuse **(Tar-Pamlico)** nitrogen regulations had not been passed, would you have been very likely, somewhat likely, unlikely, or very unlikely to use all of the same nutrient management practices you are now using? *(13)*

- Very likely.......4
- Somewhat likely.......3
- Unlikely.......2
- Very unlikely.......1

25. How would you rate the water quality in the Neuse **(Tar)** River? Would you say it is excellent, good, fair, or poor? *(14)*

- Excellent.......4
- Good.......3
- Fair.......2
- Poor.......1

26. Please respond to the following statements by telling me whether you **Strongly Agree, Agree, Disagree,** or **Strongly Disagree**:

Read Scale After Each Statement		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	
a.	Among the farmers in my community, I am one of the first to try new practices.	5	4	3	2	1	*(15)*
b.	Land should be farmed in ways that protect water quality even if this means lower profits.	5	4	3	2	1	*(16)*
c.	It is important that my community recognizes that I am doing the best I can to protect water quality.	5	4	3	2	1	*(17)*
d.	If current nutrient management regulations in the Neuse River Basin **(Tar-Pamlico River Basin)** don't work, stricter regulations will likely follow.	5	4	3	2	1	*(18)*
e.	The government is **not** very likely to inspect my nutrient management practices.	5	4	3	2	1	*(19)*
f.	Having a nutrient management plan is like having insurance against enforcement.	5	4	3	2	1	*(20)*
g.	I have a duty to follow environmental regulations even if I disagree with them.	5	4	3	2	1	*(21)*
h.	If I do **not** comply with nutrient management rules, I expect to be penalized.	5	4	3	2	1	*(22)*

27. In what year was your farm last inspected?	Year Inspected:..................................__ __ __ __	*(23-26)*
DEMOGRAPHICS Finally, I'd like to ask you a few background questions for statistical purposes only.		
28. In what year were you born?	Birth Year:...__ __ __ __	*(27-30)*
29. What is the highest level of education you have completed? **[LET RESPONDENT VOLUNTEER]**	Less than high school graduate ....1 High school graduate...2 Some college/Associate's degree ....3 College graduate, Bachelor's degree.....................4 Some graduate school...5 Professional or graduate degree 6	*(31)*
30. Which of the following best represents your family's approximate <u>2004 total income</u> before taxes? Please include all income sources such as wages, salaries, pension dividends, net farm income, and government payments. **[READ LIST]**	Less than $20,000...01 $20,001 to $40,000...02 $40,001 to $60,000 ....03 $60,001 to $80,000...04 $80,001 to $100,000 ....05 $100,001 to $200,000 ....06 More than $200,000 07	*(32-33)*
31. About what percentage of your family's 2004 total income came from farm income?	Percent of 2004 Family Income .....__ __ __ %	*(34-36)*
32. What racial group do you belong to? **[LET RESPONDENT VOLUNTEER]**	White (Caucasian) ....01 Black (African-American)..................................02 Asian/Oriental...03 Hispanic...04 Native Indian/Eskimo/Aleutian ....05 Multiracial ....06 Other **[SPECIFY]**__________________ .....__ __	*(37-38)*
33. Do you <u>generally</u> vote for Democrats or Republicans?	Democrats..1 Republicans ....2 Neither...3	*(39)*
34. CODE RESPONDENT'S GENDER (**DO NOT ASK UNLESS UNSURE**)	Male...1 Female 2	*(40)*
This completes the interview. Thank you very much for your time and cooperation. Do you have any comments you would like to make? ____ ____ ____ ____		*(41-42)*

Durham County

Table 1: Acres of reported baseline, planned, and implemented BMPs.

Best Management Practices (BMPs)	1. Baseline acreage (acres)	2. Planned acreage included in county "Local Strategy" (acres)	3. Implemented acreage in 2003 (acres)
20' Vegetated buffer (grass)	1356	1356	1125
30' Vegetated buffer (grass)	0	0	0
20' Forested or shrub buffer	0	0	0
50' Riparian buffer *(i)*	11120	11268	9223
Water control structure	0	0	0
Nutrient management *(ii)*	0	350	0
Cover crops *(iii)*	0	0	873
TOTAL	**12,476**	**12,974**	**11,221**

Table 2: Cropland loss

4. Planned cropland loss included in county "Local Strategy" (acres)	989
5. Actual cropland loss experienced by 2003 (acres)	2,314
6. Change from Local Strategy to 2003 (acres)	1,325
7. Percentage change from Local Strategy to 2003	134.0%

Table 3: Cropland acreage and fertilization data

8. Weighted average of N applied to all crops in baseline years (lbs./acre)	71.63
9. Weighted average of N applied to crops in 2003 (lbs./acre)	57.45
10. Total cropland in baseline years (acres)	13,561
11. Total cropland in 2003 (acres)	11,247
12. Change in cropland from Baseline to 2003 (acres)	-2,314
13. Total N applied in Baseline (lbs)	971,352
14. Total N applied in 2003 (lbs.)	646,164
15. Change in total N applied from Baseline to 2003 (lbs.)	-325,188
16. Percentage change in total N applied from Baseline to 2003	-33.5%
17. Percentage change in cropland from Baseline to 2003	-17.1%
18. Percentage change in weighted average N application rate from Baseline to 2003	-19.8%

Table 4: Total BMP acreage

19. Total number of qualifying BMP acres in baseline years (acres)	12,476
20. Percentage of Baseline cropland under qualifying BMPs	92.0%
21. Total number of qualifying BMP acres in county Local Strategy (acres)	12,974
22. Percentage of Baseline cropland planned to be under qualifying BMPs	95.7%
23. Total number of qualifying BMP acres implemented in 2003 (acres)	11,221
24. Percentage of 2003 cropland under qualifying BMPs	99.8%

Table 5: Reported nitrogen load reduction progress

25. Total N load in baseline years (lbs.)	88,274
26. Total N load in 2003 (lbs.)	62,349
27. Change in N load from Baseline to 2003 (lbs.)	-25,925
28. Percentage change in N load from Baseline to 2003	-29.37%

NOTES:

i. Riparian buffers include 30' of trees and 20' of grass.

ii. N-removal efficiency of nutrient management is highly variable, so no average values were available.

iii. Total of rye, triticale, oats, barley, and wheat. N-removal efficiency averages 5-15%, so set to 10%.