AGRICULTURAL NUTRIENT MANAGEMENT IN THE NEUSE RIVER BASIN:
Exploring the Links Between Mandates, Motivations, and Behavior

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of City and Regional Planning.

Chapel Hill
2012

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ABSTRACT

Alyssa Wittenborn: Agricultural Nutrient Management in the Neuse River Basin:
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(Under the direction of David H. Moreau)

Water pollution from agricultural nutrient runoff is a significant environmental problem inadequately addressed by existing voluntary programs. Other types of policy instruments have proven difficult to implement due to challenges in monitoring diffuse pollution. Combining different instruments may be effective, but has not been assessed sufficiently.

This project evaluates a hybrid policy targeting nitrogen runoff in the Neuse River Basin in North Carolina. The Neuse strategy mandates participation in nutrient management training or development of nutrient management plans, but leaves adoption of best management practices voluntary. Data from a telephone survey of 315 producers in the Neuse Basin and a control group of 100 producers in the adjacent Tar-Pamlico Basin, where training had not been offered, are used to test the impacts of training and planning on adoption of realistic yield expectations (RYEs), cover crops, and soil tests. The roles of capacity, adoption motivations, perceived control, and rule awareness are also evaluated.

The study finds that nutrient management training and planning impact adoption of the three practices. Both activities increase use of RYEs and planning increases use of soil tests. Results for cover crops are complex. Training increases adoption, but the relationship is mediated by rule awareness, which has a negative effect and reduces the impact of training. The study finds that a fear of stricter future regulations also negatively impacts adoption of cover crops. These results indicate that the coercive elements of the Neuse strategy are backfiring for this practice.

The study also does not find the Neuse strategy to overcome key problems of voluntary and coercive policy instruments. High rates of noncompliance with the mandates are identified. Additionally, producers who exceed rule requirements show signs of resentment in their reported attitudes, which could undermine future participation.

The results suggest that hybrid policies have promise in the context of agricultural pollution control, but must be designed to reduce incentives for strategic avoidance. They also must consider the different types of individuals in the target population and work to strike an appropriate balance between enforcing requirements for those who will not act voluntarily and reducing resentment among those who will.

ACKNOWLEDGEMENTS

I owe a debt of gratitude to the many people who contributed to the completion of this dissertation. Thank you to Tom Hoban and Bill Clifford at N.C. State University, who made this project possible by allowing me to participate in their farmer survey. Thank you also to my committee members, Phil Berke, Ray Burby, and Yan Song, who have been consistently supportive throughout this process. I would particularly like to thank Dave Moreau, my Chair, for his endless supplies of patience and good humor, and Cathy Zimmer, whose constant encouragement and guidance kept me on track this last year despite life's many interventions. Most of all, I would like to thank my family, who through their supportive gestures, both large and small, have made all the difference.

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CHAPTER 1: Introduction and Background

1.1 Introduction and Problem Statement

Water pollution from diffuse sources, or "nonpoint source" ("NPS") pollution, is an increasingly significant and pervasive environmental problem. NPS pollution derives from a variety of land use activities and can lead to considerable ecological, aesthetic, and economic damage. Nutrient-laden runoff from agricultural lands is particularly problematic. The 2004 U.S. National Water Quality Inventory identified agriculture as one of the major sources and nutrients as one of the major causes of water quality impairments in assessed streams, lakes, and estuaries across the country (U.S. Environmental Protection Agency [EPA], 2009). Peter Silva, former EPA Assistant Administrator for Water, recently stated that nutrient management is one of the two most significant water pollution issues today (Roeder, 2009).

Nutrient pollution in surface waters can cause eutrophication, leading to algae blooms that diminish the penetration of sunlight and reduce levels of dissolved oxygen. Both of these changes can cause serious harm to aquatic plants and animals. Excessive algal growth can also decrease the recreational value of a water body and increase treatment costs for municipal drinking water systems (Ribaudo, Horan, & Smith, 1999). A striking example of this type of pollution can be found in the Gulf of Mexico, where each summer dissolved oxygen levels drop dangerously over an 8,000 square mile expanse of water (Achenbach, 2008). Researchers largely attribute this hypoxic "dead zone" to nitrate pollution flowing down the Mississippi River from Midwestern farming regions (Ribaudo et al., 1999; Achenbach, 2008).

As the environmental impacts of agricultural NPS pollution become increasingly evident, so too do the challenges associated with effectively controlling it. NPS water pollution is not only diffuse, making it impossible to pinpoint sources, it is also stochastic. Pollution loads can vary by season, weather conditions, land use activities, soil type and other factors. NPS water pollution can also travel long distances and there can be significant time lags between discharges and water quality problems (Ribaudo et al., 1999). Due to its physical characteristics, monitoring NPS pollution at its source is challenging and cost-prohibitive (Malik, Larson, & Ribaudo, 1994; Shortle & Horan, 2001). In turn, the inability to both clearly link pollutants and pollution problems with particular sources and accurately measure pollution loads through monitoring confounds the use of most standard environmental policy instruments. This includes not only the traditional command and control ("CAC") policies used for point source water pollution, but also many market-based policy instruments, such as pollution taxes and pollution permit trading schemes (Batie & Ervin, 1999).

Given these difficulties, government response to the NPS pollution problem has consisted primarily of encouraging polluters to undertake voluntary actions to reduce their discharges and offering limited technical and financial assistance for the adoption of particular pollution-reducing best management practices ("BMPs") (McElfish, 2000; Weersink, Livernois, Shogren, & Shortle, 1998; Bosch, Cook, & Fuglie, 1995; Ribaudo & Johansson, 2007). This approach has been the basis of federal farm programs, such as the Conservation Reserve Program, the Environmental Quality Incentives Program, and the more recent Conservation Security Program, which were created to support agricultural conservation efforts. In part, these programs were developed to help counteract the incentives for increased crop production and use of marginal lands created by commodity support programs (National Research Council, 2008). More recently, they have been targeted specifically to critical problems such as nutrient runoff, soil erosion, and wildlife habitat protection. The voluntary approach employed by these and other similar programs assumes that polluters are inherently willing to reduce their pollution, but may need some assistance in overcoming potential barriers to action, such as a lack of information or ability to pay for necessary equipment or land management changes. It is clear from ongoing water quality concerns, however, that the voluntary approach has not been sufficient to address NPS pollution problems.

Due to the limitations faced by individual policy instruments in controlling NPS water pollution, some scholars believe that the solution to the problem lies in implementing innovative policy mixtures (Osborn & Datta, 2006; Shortle & Horan, 2001; Batie & Ervin, 1999; Weersink et al., 1998). Combining components of different policy instruments is meant to capitalize on each instrument's strengths while overcoming its key weaknesses. Little is known about the practical results of such hybrid approaches, however. This dissertation will help fill this knowledge gap by investigating the real-world impact of an agricultural nitrogen runoff control program implemented in the Neuse River Basin of North Carolina. The Neuse Basin strategy incorporates CAC-style mandates for participation in nutrient management activities (i.e., training or planning) along with features of an informal pollution trading approach into an otherwise traditional, voluntary agricultural pollution control program.

This dissertation evaluates the efficacy of this hybrid policy approach specifically by investigating the influence of the Neuse Basin agricultural activity mandates on producers' adoption of nutrient BMPs. Nutrient BMPs can reduce polluted runoff from farms by reducing the amount of fertilizer applied or by capturing excess nutrients from the soil.

This dissertation also investigates the factors that are motivating agricultural producers to use nutrient BMPs in the context of the Neuse Basin strategy. Understanding such motivations is critical for identifying the mechanisms through which a policy influences behavior. When these mechanisms are unclear, policy makers lack the information they need to learn from and improve upon existing approaches. This need is particularly vital in a mixed instruments policy setting, where different aspects of the policy may trigger different motivations for action. Knowing the motivations that lead to behavior change can indicate which aspects are effective and which are not. By investigating these issues, this dissertation will have practical implications for improving the current Neuse Basin strategy and informing other efforts to control agricultural NPS pollution around the country.

1.2 Research Objectives

The principal goal of this dissertation is to evaluate the influence of the Neuse Basin strategy's agricultural mandates on producers' adoption of nutrient BMPs. It seeks both to assess the direct impacts of the mandated activities on practice adoption and to identify the motivational mechanisms through which the activities may influence adoption. In order to achieve this goal, the project pursues answers to three primary research questions:

1. How is the use of nutrient BMPs associated with agricultural producers' adoption motivations and capacity?[1]
2. How are agricultural producers' motivations to use nutrient BMPs associated with their participation in the mandated activities (i.e., nutrient management training and planning)?
3. How is the use of nutrient BMPs associated with participation in the mandated activities, both directly and indirectly as mediated by producers' motivations?

If producers' motivations and measures of capacity are found to be associated with the adoption of nutrient BMPs, two secondary questions will be explored:

1. Do deterrent and normative motivations interact with each other in their relationship with nutrient BMP adoption?
2. Does a producer's capacity moderate the relationship between his or her motivations and practice adoption?

1.3 Background

1.3.1 Limitations of Individual Policy Instruments

Three types of policy instruments are typically used or advocated for use in controlling agricultural NPS water pollution: voluntary programs, CAC approaches, and

[1]Capacity refers to characteristics of the producers that may influence their relative ability to use nutrient BMPs, such as education level, farming experience, and economic status.

market-based instruments. Each approach has particular strengths and weaknesses; none is a panacea for solving agricultural NPS water pollution problems.

Voluntary programs that offer financial and technical assistance for producers to adopt BMPs have been the main-stay of agricultural NPS pollution control efforts to date. This approach assumes that producers are inherently willing to adopt, but may be unable to do so because of informational and financial barriers. There are several reasons why those who generate NPS pollution may not be willing to act voluntarily, however, with or without assistance. One problem is that water is a common-pool resource, and water pollution is characterized by externalities. Polluters are able to gain all of the benefits associated with using their land, while spreading the costs of the pollution they generate over all users of the water resource. However, the reverse is true for actions to control the pollution: polluters bear the costs while the benefits accrue to everyone. This imbalance is exacerbated by the fact that in riverine systems, water pollution flows downstream, physically displacing the benefits and costs of NPS pollution and its control. In order to voluntarily reduce their pollution, a polluter must be willing to absorb the costs of pollution control while reaping few, if any, of the benefits. Johnson and Napier (1998) claim that a reluctance to internalize these costs is the major barrier to adoption of BMPs.

Free-riding can also be a problem in agricultural NPS pollution control because individual producers likely make only a small impact on water quality and that impact cannot easily be traced back to their actions. Lubell and Fulton (2008) state that BMP adoption "entails a challenging problem in cooperation" (p. 673). Numerous producers must adopt BMPs to make a real impact on water quality, so those who cooperate cannot be assured that their efforts will make a difference unless other polluters also agree to act (Lubell & Fulton, 2008). This can be a significant disincentive for action under voluntary programs. Producers also may be hesitant to put themselves at a competitive disadvantage by adopting practices that may increase their costs or expose them to risk (Ribaudo & Caswell, 1999).

In addition to these structural impediments, polluters may hold personal beliefs or attitudes that prevent them from acting voluntarily to reduce pollution. Polluters simply may not agree that NPS pollution is a problem, they may not believe that they are contributing to a pollution problem, or they simply may not care about the problem or its consequences (May, 2004). Further, polluters may not believe that they are able to act or may think that available pollution control measures are ineffective (Coombs, 1980). As a result, the voluntary approach has not resulted in sufficient pollution control activity to alleviate water quality problems (Weersink et al., 1998).

Due to the failures of a strictly voluntary approach, CAC strategies are sometimes used. In the context of agricultural NPS pollution, CAC policies can target producers' activities, such as fertilizer use or adoption of BMPs, or the environmental results of those activities (Ribaudo et al., 1999). When monitoring and enforcement activity is sufficient, CAC approaches can ensure that all targeted pollution sources take action. In this way, the CAC approach can be more effective at controlling pollution than the voluntary approach. However, a reliance on monitoring is clearly problematic when it comes to regulating NPS water pollution. According to Ribaudo and Caswell (1999), state governments most often attempt to regulate agricultural NPS pollution by requiring producers to implement recommended BMPs. By using technology standards as a proxy for emissions, this approach minimizes the need to monitor actual pollution loads. However, the environmental impacts of technology standards are not always predictable or reliable because use of BMPs is not perfectly correlated with water quality. Critics also charge that a strict CAC approach can be counterproductive to pollution control by creating backlash among policy targets (Bardach and Kagan, 1982).

Economists often criticize the CAC approach as being inefficient. “One-size-fits-all” mandates may require firms to use practices or technologies that are not the most cost-effective for their particular operation. They also require all firms to meet the same standards regardless of differences in control costs (Tietenberg, 2000). While regulators can attempt to improve cost-effectiveness of CAC approaches by requiring different actions by different polluters, this requires firm-specific information that regulators generally lack (Gunningham & Sinclair, 1998). It can also make enforcement efforts more difficult (Scholz, 1994); increase government administrative costs, particularly in areas with large numbers of smaller firms; and raise questions of fairness.

Scholars often advocate the use of market-based instruments, such as tradable pollution permits and pollution taxes, as more economically-efficient alternatives to the CAC approach. With tradable permits, regulators set an overall level of allowable emissions and then divide this amount into discrete units that are represented by permits. They distribute the permits by various means to the targeted pollution sources, who can then buy and sell them, creating a permit market. In theory, this approach can be more economically efficient because it achieves a desired level of pollution reduction while allowing firms to decide how much to control their own pollution and by what means

(Pindyck & Rubinfeld, 2000). This results in lower total pollution control costs because firms with low abatement costs can reduce pollution more than those with higher costs.

When applied to NPS pollution, the tradable permit approach suffers several practical limitations. Adequate monitoring and enforcement effort is still needed (Stavins, 2001), which is particularly challenging for trading instruments targeting nonpoint sources (Boyd et al., 2003; Letson, 1992). There can also be additional administrative challenges. Whenever there are differences in the types of pollutants, the location and timing of their release, or uncertainties in the costs and effects of control technologies, regulators must establish what constitutes an "environmental equivalent" in trading (Boyd et al., 2003; Malik et al., 1994). Also, since nonpoint sources tend to be smaller in size and larger in number than point sources, the number of trades can be significant and, according to Tietenberg (nd), regulators need to validate every one of them. When pollutants are not conservative or uniformly mixed, trading can also result in pollution "hot-spots" (Stavins, 2001; Tietenberg, nd). Finally, the economic superiority of this approach is predicated largely upon the existence of variable pollution control costs among potential trading partners (Thurston, Goddard, Szlag, & Lemberg, 2003; Gannon, Osmond, Humenik, Gale, & Spooner, 1996; Schwabe, 2000). When pollution sources have similar abatement costs, which may be the case for agricultural producers, potential cost savings are diminished.

The efficacy of taxes for reducing NPS pollution is also limited. Applying taxes to pollution discharges requires significant monitoring data. Imposing taxes on inputs that lead to pollution, such as fertilizer or pesticides, does not require information about discharges. However, research has found that input taxes tend to be more effective at raising revenue than significantly changing demand for inputs, because this demand is often highly inelastic (Knutson, Penn, & Flinchbaugh, 2004; Whittaker, Faere, Srinivasan, & Scott, 2003).

Due to the significant challenges facing each of these individual policy instruments in addressing agricultural NPS pollution, many scholars advocate combining aspects of different instruments into one policy package (Ribaudo et al., 1999). For example, based on his extensive computer modeling efforts in the Neuse River Basin, Schwabe argues that using incentive-based and CAC approaches together would be more cost-effective for reducing nitrogen pollution than either approach individually (2000).

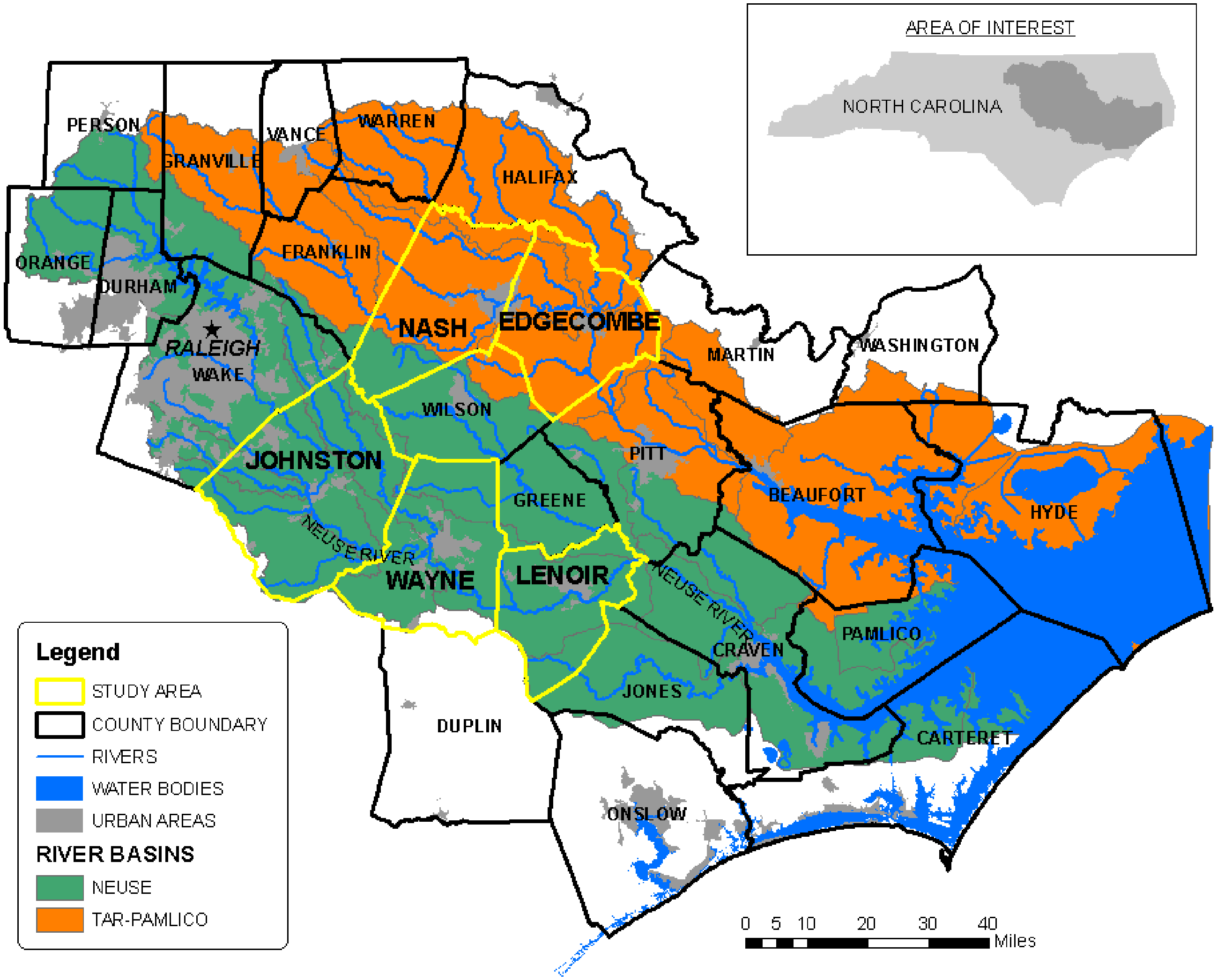
In particular, a number of scholars have argued that using carrot (i.e., voluntary) and stick (i.e., CAC) approaches jointly may be efficacious (Segerson, 1999; Ribaudo & Caswell, 1999; Bosch et al., 1995). In theory, using these approaches in combination could lead to stronger incentives for action than the voluntary approach generates. Depending on the basis of the policy (e.g., input use, practice adoption, etc.), it also could result in less need for pollution monitoring, and possibly more buy-in to the goals of the policy than is typically associated with the traditional CAC approach. Schwabe also argues that adding flexibility to a CAC approach can enhance cost-effectiveness. His Neuse River Basin model shows that giving agricultural producers a choice of three structural BMPs reduces control costs and achieves a higher overall level of pollution abatement compared to mandating use of one specific practice (2001). Because the Neuse Basin strategy includes elements of both voluntary and mandatory approaches, investigating its impacts can help shed light on whether carrot and stick strategies can in fact work synergistically to combat NPS pollution.

1.3.2 North Carolina's Neuse River Basin Program

According to the N.C. Division of Water Quality, 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 identifying nitrogen and phosphorus as the main problems.

The Neuse River Basin, shown in Figure 1.1, is the third largest in North Carolina, encompassing 6,235 square miles in 19 counties (N.C. Division of Water Quality [DWQ], 2009). In 1988, the N.C. Environmental Management Commission 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 regarding nitrogen. In December 1997, the state responded by establishing a goal of a 30 percent nitrogen input reduction from all major sources in the basin and adopting a set of rules in support of this "Neuse River Basin Nutrient Sensitive Waters Management Strategy." The Neuse Basin strategy is comprised of several components targeting both point and nonpoint sources of nutrient pollution. Point sources are targeted by a wastewater discharge rule. Nonpoint sources are covered by rules addressing urban stormwater management, riparian buffer protection, agricultural runoff reduction, and nutrient management. Agricultural sources

Figure 1.1. Map of the Neuse and Tar-Pamlico River Basins in North Carolina



of nutrient pollution are primarily targeted by these last two components: the "Agricultural Nitrogen Reduction Strategy Rule" and the "Nutrient Management Rule."

The Agricultural Nitrogen Reduction Strategy Rule (15A NCAC 2B .0238) took effect on August 1, 1998. The rule affects "all persons engaging in agricultural operations" in the Neuse River Basin and required a mandatory 30 percent 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 producers with two options for reaching the reduction goal.

The first option is to follow the default "Standard Best Management Practice Strategy," in which producers 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 producers. The second option is for producers to participate in a "Local Nitrogen Reduction Strategy" that allows a group of producers to achieve the required reduction collectively. In this option, a Local Advisory Committee that includes local producers and governmental representatives develops collective strategies to meet the local area's reduction goal. According to the DWQ, the Local Advisory Committee approach was developed to allow agricultural agencies and producers to cooperatively develop strategies tailored to local conditions and to be more cost-effective by focusing resources on the most critical areas. Though very informal, this approach is similar to a pollution trading scheme, where differential levels of pollution control can be pursued by different producers in order to achieve the collective target.

The second major Neuse Basin strategy rule affecting agricultural producers is the primary focus of this investigation. 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. Agricultural producers 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.

Hardy, Osmond, and Wossink (2002, p. 1) describe nutrient management as "…the careful monitoring and amending of soil fertility to meet crops' needs, with emphasis on maintaining productivity and profitability and protecting water quality." Nutrient management seeks to properly balance the amount and timing of nutrient applications with crop needs in order to minimize "the level of 'excess' nutrient in the soil at any given time" (Claassen et al., 2004, p. 31). Nutrient management plans are written documents that contain information agricultural producers need to practice sound nutrient management.

Producers who chose to comply with the Nutrient Management Rule by participating in 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. Nutrient management training in the Neuse Basin was offered by N.C. Cooperative Extension Service agents on a county-by-county basis from 2000 to 2002. This training covered numerous topics including: basic hydrology, water quality problems, sources of nutrients, soil systems in the Neuse Basin, fertilizers, agronomic rates, realistic yield expectations, nutrient management plan content and development, soil testing, BMPs that reduce nitrogen, and information specific to different commodities such as corn and cotton (Osmond et al., nd).

Those who chose to comply with the Nutrient Management Rule by developing a nutrient management plan were required to follow the Natural Resource Conservation Service's Conservation Practice Standard for Nutrient Management, Code 590. This standard requires that nutrient management plans contain, among other things: soil survey maps; current and planned crops; soil sample analyses; realistic yield expectations for planned crops; nutrient budgets for planned crops; listing and quantification of all nutrient sources; and guidance for implementation, maintenance, and recordkeeping. The Nutrient Management Rule allows for plans to be written either by the producer or a consultant. It stipulates that plans shall be kept on site with the producer, but upon request by the state, must be produced for inspection within 24 hours. The Rule states that those who choose not to participate in training are subject to enforcement measures if they fail to develop a nutrient management plan or do not apply nutrients in accordance with their approved plan.

Implementation of both Neuse Basin strategy agricultural rules has been supported by the N.C. Agricultural Cost Share Program. 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. Division of

Soil and Water Conservation [DSWC], 2004). It is carried out by the state's 96 Soil and Water Conservation Districts (DSWC, 2004).

The N.C. Agricultural 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 percent of the average cost for each practice, with the producer providing the rest. The producer's contribution can consist of in-kind support. Participation in the program is voluntary and projects are funded based on their potential to improve water quality. To ensure ongoing operation and maintenance of funded BMPs, the Soil and Water Conservation Districts are required to perform spot checks on 5 percent of participating farms each year. They are also required to spot check 5 percent of cost-shared nutrient management plans each year. If found out of compliance, operators must be notified in writing about their need either to reimplement the practice or refund the cost share allocation (DSWC, 2004).

The Neuse Basin strategy represents one form of a "hybrid" policy approach to addressing agricultural NPS pollution. The program assumes a command and control stance in requiring producers to participate in management activities and achieve collective pollution reduction goals. However, the actual adoption of nutrient BMPs remains voluntary. By exposing producers to information about how and why to control nutrient pollution and by providing a threat of enforcement or risk of more stringent future requirements if collective pollution reduction targets are not met, the program is meant to secure higher rates of pollution control activity than a purely voluntary approach would achieve. At the same time, by not requiring producers to implement specific practices or meet individual discharge limits, this approach offers flexibility that could improve cost-effectiveness of pollution control and also minimizes the need for farm-level monitoring of emissions.

In theory, this approach sounds promising and, on paper, it has been successful in achieving the mandated 30 percent nitrogen runoff reduction. However, there are reasons to question how much of the reported runoff reduction can be attributed to changes in producer behavior generated by the Neuse Basin strategy (Wittenborn & Moreau, 2007). Much of the reported nitrogen runoff reduction achieved to date has come from conversion or temporary retirement of farmland and from shifts in the types of crops grown, not from implementation of BMPs or nutrient management. For example, in the Annual Progress Report on the Neuse Agricultural Rule for Crop Year 2008, it is estimated that approximately 40 percent of the total nitrogen reduction from the baseline period came from these changes (Neuse Basin Oversight Committee [BOC], nd). The impermanence of these reductions is being observed in Lenoir County, where recent increases in total crop acreage and corn acreage have led to the county not meeting its 30 percent reduction goal (Kelly Ibrihim, Neuse Tar-Pamlico Basin Coordinator, N.C. DSWC, personal communication 3/11/10). The Neuse BOC estimates that only approximately 12 percent of the reported 2008 nitrogen runoff reduction from cropland in the basin came from implementation of BMPs and only 29 percent came from fertilizer management, which they attribute partially to increases in the cost of fertilizer (Neuse BOC, nd). Further, the reductions attributed to fertilizer management are only estimates because the strategy does not require producers to maintain or submit fertilizer use records (Ibrihim, personal communication, 3/11/10). State officials must estimate fertilizer application rates through indirect means such as gathering information from commercial applicators and selected producers (Ibrihim, personal communication, 3/11/10). Thus, it is unclear from these measures how much of the reported nitrogen reduction actually stems from the Neuse Basin strategy itself. Though use of nutrient BMPs is not perfectly correlated with water quality changes, it is the best metric by which to judge the success of the Neuse Basin strategy in influencing producers' relevant behavior in the absence of verifiable farm-level fertilizer application or farm-specific nitrogen runoff data.

1.4 Expected Contribution

This dissertation will contribute to a clearer picture of how the Neuse Basin strategy is working in the agricultural sector by investigating: the adoption of nutrient BMPs, the relationship between nutrient BMP adoption and participation in the mandated training and planning activities, and the role of adoption motivations in mediating this relationship. The information it generates will have numerous practical implications. First, evaluating the impacts of the Neuse Basin strategy on agricultural producers' use of specific nutrient BMPs will provide useful information to environmental and agricultural officials on how effective activity mandates are in changing producers' behavior. Second, if the mandated training and planning activities are found to be influential over adoption, identifying the specific motivational mechanisms through which these activities influence behavior will help identify which components of the strategy are effective and which may need improvement. Third, because certain types of motivations underlying behavior change are likely to be more durable than others, the findings of this dissertation may help indicate the possible long-term impacts of the Neuse Basin strategy on producer behavior.

This information is needed in North Carolina as the Neuse Basin strategy approach is being replicated in more watersheds. Both the Tar-Pamlico River Basin and the Lake Jordan watershed are now covered by rules requiring agricultural fertilizer applicators to participate in nutrient management training or develop nutrient management plans. Information on the practical impacts of these activity requirements could shed light on whether this approach needs modification in future efforts. In addition, ambient water quality monitoring results have not generally supported the nitrogen runoff reductions reportedly being achieved in the Neuse Basin (Neuse BOC, 2009; Burkholder et al., 2006). If the state determines that more must be done to achieve the 30 percent reduction, this research may help point to changes that could be made to improve performance in the agricultural sector.

The results of this dissertation may help efforts to address agricultural NPS pollution in other parts of the country as well. For example, the federal government is promoting the use of nutrient management plans to help address water quality problems in the Chesapeake Bay (Roeder, 2009). Scholars and government officials are also working to identify more effective ways to address water quality problems from agricultural runoff in the Mississippi River Basin (National Research Council, 2011). Data on experiences in the Neuse Basin should be informative for those endeavors.

The results of this study may also be useful because agricultural NPS water pollution is just one example of a whole class of environmental problems involving common-pool resources, large numbers of small polluters, and challenges in monitoring individual behavior and impacts. Policy-makers working in areas such as mobile source air pollution, stormwater pollution, and household-level energy consumption, face similar difficulties. Any insights about potentially-effective policy approaches identified in this project may be transferable to these other settings.

1.5 Study Overview

The dissertation is divided into seven chapters. This first chapter introduced the problem of agricultural NPS water pollution, presented the study questions, provided background information on the Neuse Basin strategy, and suggested potential contributions of the study's findings. Chapter 2 contains the literature review. It focuses on three key areas: diffusion, farm structure and economics; social psychology; and deterrence. Chapter 3 presents the study's conceptual framework and research hypotheses and describes the research setting and source of data for the project. Chapter 4 discusses the research design and methods. Chapter 5 presents the study's data and discusses descriptive statistics. Chapter 6 presents and evaluates the study's multivariate predictive models, including the testing of mediation effects and interactions. Finally, Chapter 7 contains a review and discussion of the key results, study implications and recommendations.

CHAPTER 2: Literature Review

2.1 Introduction

In order for any NPS pollution control policy to be effective, it must change the behavior of polluters (Ribaudo et al., 1999). To understand how a policy can exert influence over behavior, one must understand the factors that affect both a polluter's willingness to alter pollution-causing practices and their ability to do so. Given the complexity of the agricultural NPS problem and the relative novelty of hybrid policy approaches for addressing it, insight into these factors must be drawn from several different bodies of literature. These include: agricultural sociology and economics literature focused on diffusion of innovations and farm structure; social psychology literature focused on environmentally-responsible behaviors; literature in the areas of political science, public policy, and law that addresses compliance behavior under regulatory programs; and literature that considers the impacts of educational and training programs on adoption behavior. The following review discusses how key theories and empirical findings in each of these areas contribute to an understanding of the factors that may influence whether or not agricultural producers choose to adopt nutrient BMPs in response to the Neuse Basin strategy. It also highlights ongoing theoretical debates and research needs that bear on the project at hand.

2.2 The Traditional Perspective: Diffusion, Farm Structure, and Economics

The most directed and prolific research into the adoption of BMPs is found in the fields of agricultural sociology and economics. Theory and empirical investigations in these areas have focused primarily on the role of variables related to the demographics of the producer, characteristics of the farm operation, and economic factors in adoption behavior. These factors measure various aspects of an agricultural producer's potential capacity to adopt new practices. While studies have found these factors to help explain BMP adoption behavior in various settings, the literature has generally failed to converge on a consistent set of explanatory variables (Prokopy, Floress, Baumgart-Getz, & Klotthor-Weinkauf, 2008; Knowler & Bradshaw, 2007).

2.2.1 Diffusion and Farm Structure

Research focused specifically on the adoption of BMPs began in earnest in the 1970s. It started at a time when concerns over the state of the environment were growing in the U.S. and when research into adoption of more traditional farming technologies was beginning to wane (Fliegel, 1993). The "diffusion of innovations" model, first advanced by Everett M. Rogers and others several decades earlier, served as the theoretical underpinning of much of this new research.

The diffusion of innovations model focuses on explaining the rate at which new ideas or practices are adopted within a given social system. The rate of adoption is measured by the length of time it takes for a certain percentage of the system's members to adopt the innovation under investigation, and is generally found to follow an S-curve (Rogers, 2003). When first developed in the context of agriculture, the diffusion model focused on technological innovations, such as hybrid seed corn and the use of agricultural chemicals (Black & Reeve, 1993). By definition, these innovations were seen as improvements over previous practices and conferred clear productivity benefits to adopters. Thus, agricultural diffusion studies tended to view adoption as a positive act that should be promoted and to focus on identifying factors that either hindered or promoted the process (Fliegel, 1993).

Based on the classic diffusion model, researchers typically explored three groups of factors. One included characteristics of the would-be adopter that might influence his or her relative openness to adopting innovations and ability to do so. Studies typically investigated demographic variables such as an adopter's age, education, and socio-economic status (Fliegel, 1993; Rogers, 2003). Some also considered an adopter's personality characteristics, such as his or her attitudes toward change, perceptions about control over the future, and rationality (Rogers, 2003). The second group of factors involved the adopter's communication behaviors, such as their relative levels of social participation and contact with change agents (Rogers, 2003; Fliegel, 1993). These variables indicate exposure to innovations and contact with people who are likely to promote adoption. The third group of factors included characteristics of the innovation itself that may influence the rate of adoption, such as whether would-be adopters perceive it to be better than previous ideas and easy to understand and use (Rogers, 2003).

In later diffusion studies, researchers also included so-called "farm structure" variables such as farm size, income from farming, and farm ownership. This stemmed from the recognition that not all farms are equally equipped to adopt new practices that can entail costs and expose the adopter to financial risk. Investigators expect farm operations with higher levels of resources to handle these challenges more easily than lower-resource farms. Thus, measures of an operation's resource status may be important considerations.

Based on a significant amount of empirical work conducted over several decades, a number of key diffusion and farm structure variables warrant investigation in this dissertation: education, experience, farm size, income, income from farming, land tenure, age, and innovativeness. The following discussion explains why these factors are conceptually significant and highlights key empirical findings related to the potential influence of each one on the adoption of BMPs. Some of these findings derive from two review articles focused on BMP adoption. The 2007 review by Knowler and Bradshaw includes 31 empirical studies, published from 1984 to 2002, that focus on factors influencing adoption of soil conservation practices. Sixteen of these studies took place in the U.S. and Canada and the rest were carried out in developing countries. The 2008 review by Prokopy et al. investigates the influence of numerous factors on the adoption of a variety of BMPs. It includes 55 U.S. studies published from 1982 to 2007, nine of which overlap those in the Knowler and Bradshaw review. Other findings reviewed here come from studies more specifically focused on the types of practices under consideration in this dissertation or, when relevant, from studies of producers' participation in agricultural water quality programs.

Education. Researchers believe that the amount of formal education obtained by agricultural producers influences the adoption of BMPs in three ways. Those with higher levels of education are better able to: 1.) obtain needed information about new practices (Caswell, Fuglie, Ingram, Jans, & Kascak, 2001; Gould, Saupe, & Klemme, 1989); 2.)

understand that information (Caswell et al., 2001; Thomas, Ledewig, & McIntosh 1990); and 3.) apply it to their own farms due to their possession of superior management skills (Gale et al., 1993; Gould et al., 1989).

Researchers generally find education to have a significant influence over adoption of BMPs about half of the time they investigate it (Knowler & Bradshaw, 2007; Prokopy et al., 2008). Most of the studies finding significance have found the relationship to be positive (Knowler & Bradshaw, 2007, Prokopy et al., 2008). For example, Bosch et al. (1995) found that more educated corn farmers were more likely to adopt nitrogen testing in Nebraska. Caswell et al. (2001) found that education was associated with adoption of information-intensive, modern nutrient BMPs, but not with adoption of nitrogen soil testing in 12 U.S. watersheds. Hoban and Clifford (1999) found education to be positively associated with use of BMPs in a study of farm operators in the Neuse River Basin. Smithers and Furman (2003) found education to positively influence producers' levels of engagement in the Ontario Environmental Farm Plan Programme. A handful of studies, including a few focused on nutrient management, have found education to have a negative impact on adoption (Gould et al., 1989; Prokopy et al., 2008).

Experience. Researchers argue that producers with more years of farming experience are better able to obtain and use information about new agricultural practices (Caswell et al., 2001). The expected direction of influence for experience is not necessarily the same as for education, however. Caswell et al. (2001) argue that experience can have positive or negative impacts on practice adoption because while farmers with a lot of experience may be more efficient at incorporating new practices, they may also be more reluctant to switch away from familiar approaches.

The majority of studies have not found experience to significantly impact adoption of BMPs (Lubell & Fulton, 2008; Prokopy et al., 2008; Knowler & Bradshaw, 2007) or participation in environmental farming programs (Smithers & Furman, 2003; Gale et al., 1993). For example, Bosch et al. (1995) did not find experience to impact either adoption of nitrogen testing or use of nitrogen testing for making fertilizer application decisions in their Nebraska study. In the cases where studies have found it to be significant, the findings were generally mixed or inconclusive as to the direction of influence (Prokopy et al., 2008). For example, Caswell et al. (2001) found experience to have a negative effect on the adoption of modern nutrient BMPs such as soil nitrogen testing, split nitrogen applications and micronutrient use, but no impact on the adoption of traditional nutrient BMPs including the use of organic sources of nutrients.

Farm Size. The size of a producer's farm can indicate adoption capacity. Scholars frequently associate larger farm sizes with a greater availability of resources and higher levels of risk tolerance and decision-making flexibility (Gale et al., 1993). In addition, some farm innovations are not scale neutral and may be more practical for larger farms to adopt (Fliegel, 1993), in part because they can spread adoption costs across more productive acres (Prokopy et al., 2008).

Though empirical evidence of the influence of farm size on BMP adoption is mixed, studies that find it to be significant generally find a positive impact (Knowler & Bradshaw, 2007; Prokopy et al., 2008). These results hold for studies that focus specifically on nutrient BMPs (Prokopy et al., 2008). Caswell et al. (2001) found farm size to positively impact adoption of modern nutrient BMPs, including nitrogen testing. Ribaudo and Johansson (2007) found farm size to positively impact soil testing, but not adoption of nutrient management plans. Gale et al. (1993) found farm size to positively correlate with the use of nutrient management, soil testing, and cover crops. Lubell also found farm size to positively impact producers' participation in the Suwannee River Partnership in Florida, which encourages the implementation of nutrient management plans (2004). Even when significant, the relationship between farm size and adoption may not be linear (Gould et al., 1989; Bosch et al., 1995).

Income. A higher household income can enhance a producer's ability to pay for investments and tolerate risk (Gale et al., 1993; Gould et al., 1989). Researchers generally find income to have a significant impact on adoption and program participation, and this impact is most often positive (Buttel, Larson, & Gillespie, Jr., 1990; Caswell et al., 2001; Gale et al., 1993; Gould et al., 1989; Wilson, 1997; Knowler & Bradshaw, 2007; Prokopy et al., 2008). For example, Ribaudo and Johansson (2007) found income to positively impact adoption of soil nutrient testing and nutrient management plans. However, among the studies reviewed by Prokopy et al. (2008) that focused on nutrient management, income was generally found to have no influence over adoption. In addition, Lubell and Fulton (2008) did not find income to have a significant influence on use of water quality-protecting pest management practices or on adoption of runoff control practices.

Income from Farming. The percentage of a farm operator's income that derives from farming is significant because it can indicate the importance of the operation to the household and the availability of additional financial resources for adoption (Knowler & Bradshaw, 2007). Theoretically, farm operators with higher percentages of their income from farming may adopt more BMPs because farming is a higher priority for them.

Income from farming can also signify the amount of labor available for farm work. Prokopy et al. (2008) hypothesize that the more a producer works off the farm, the less time they will have for farm work and the less likely they will be to adopt time-intensive technologies.

Knowler and Bradshaw (2007) found mixed impacts of farm income on adoption. Other investigators have found a positive relationship. Hoban and Clifford (1999) found that producers in the Neuse River Basin who obtained a larger proportion of their income from farming were more likely to use BMPs. Gale et al. (1993) found that participants in the Rural Clean Water Program (RCWP) obtained a significantly larger proportion of their income from farming than did non-participants.

Land Tenure. Whether a farm operator owns the land they cultivate, rather than rents it, can also influence adoption. Prokopy et al. (2008) hypothesize that this characteristic, called "land tenure," is important because land owners should be better stewards of their land and more willing to adopt technologies with higher fixed costs. Nowak (1991) explains that renting land can also be a barrier to adoption because the producer may have to obtain the owner's approval to adopt new practices or technologies (cited in Ribaudo et al., 1999).

In practice, the relationship between land tenure and adoption has been found to be quite inconsistent (Buttel et al., 1990; Gale et al., 1993). Most studies have not found land tenure to be a significant factor (Buttel et al., 1990). For example, among the nine nutrient management studies in Prokopy et al.'s review (2008), one found a significant positive relationship and the rest were insignificant. While some studies of nutrient BMPs have found significant positive relationships (Knowler & Bradshaw, 2007;

Prokopy et al., 2008), some of the most relevant have found a negative relationship between land ownership and adoption. Gale et al. (1993) found that farmers with a higher proportion of owned land were less likely to report using nutrient management and cover crops. Bosch et al. (1995) found that land owners were less likely to adopt nitrogen testing. Caswell et al. (2001) found that land ownership had a significant, negative impact on the use of legumes in rotation.

Age. A producer's age is relevant because older farmers generally have a shorter time horizon in which to experience potential benefits from new practices (Nowak 1991) and they may be less willing to accept risk (Thomas et al., 1990). Accordingly, older farmers may be more reluctant to adopt new farming practices (Caswell et al., 2001). Though many studies have failed to find a significant relationship between age and adoption (Smithers & Furman, 2003; Prokopy et al., 2008; Knowler & Bradshaw, 2007), others have generally found a negative effect (Caswell et al., 2001; Gould et al., 1989; Knowler & Bradshaw, 2007; Prokopy et al., 2008). Particular to nutrient BMPs, Prokopy et al. (2008) did not identify any studies that found a significant relationship between age and adoption. Gale et al. (1993) found age to have no relationship with the use of cover crops, but to have a negative correlation with the use of nutrient management and soil tests.

Innovativeness. A producer's relative level of "innovativeness" may also bear on their adoption behavior. Innovativeness, or how early one tends to adopt new ideas relative to others (Rogers, 2003), may reflect a relatively high tolerance for risk, a strong belief in the benefit of new technologies or practices, or a favorable attitude toward trying new things. It captures a variety of characteristics that may bias a person toward adopting or rejecting new practices without regard to other factors. Thus, it does not measure a farm operator's capacity to adopt conservation practices per se, but rather their predisposition to do so. Previous research has generally found that more innovative farmers are more likely to adopt (Gale et al., 1993).

2.2.2 Economic Factors

More recent studies of BMP adoption have addressed economic issues more explicitly than the traditional diffusion and farm-structure traditions. In particular, these studies have explored how the receipt of financial support for adoption and perceptions that BMPs are profitable influence adoption behavior.

Whether or not a producer receives cost share funding or other financial support for adoption can be highly consequential for adoption decisions. This support can help pay the costs of purchasing, installing, and maintaining new technologies and practices. It can also help offset any potential losses or increased risk to crop yields as the practice is being implemented (Ribaudo et al., 1999). In these ways, receipt of cost share funding not only enhances a producer's ability to adopt BMPs, but it can allow a producer's other motivations for adoption to manifest by reducing financial barriers.

The literature has often found receipt of financial support or cost share funding for adoption to be a significant and positive factor in encouraging adoption of BMPs (Knowler & Bradshaw, 2007; Prokopy et al., 2008; Napier & Tucker, 2001; Buttel et al., 1990) and participation in agricultural water quality programs (Gale et al., 1993). Gale et al. (1993) found that 38 percent of RCWP participants identified cost share as a reason for their participation. The N.C. Corn Growers study (2002) found a strong anecdotal relationship between the receipt of cost share payments and the implementation of BMPs. Ribaudo and Johansson (2007) found that receipt of financial assistance had a positive impact on adoption of nutrient management plans in their U.S. national survey. This relationship is not immutable, however; some studies have found no significant relationship (Knowler & Bradshaw, 2007; Prokopy et al., 2008; Napier & Tucker, 2001). For example, Ribaudo and Johansson (2007) did not find financial assistance to influence soil nutrient testing. Johnson and Napier (1998) also failed to find a significant relationship between the receipt of financial support and the adoption of BMPs in the Darby Creek watershed in Ohio, including of practices related to nutrient applications and soil testing. A few investigations have even found evidence of a counter-intuitive negative relationship (Prokopy et al., 2008).

Scholars have also considered how agricultural producers' perceptions about a BMP's profitability can influence adoption. The classic micro-economic assumption that people are rational maximizers who act in their own self-interest underlies arguments that agricultural producers will adopt new practices only if they provide personal net benefits – no matter how many social benefits they might provide (Caswell et al., 2001). Since "benefits" are typically operationalized in monetary terms (Hatcher, Jaffry, Thebaud, & Bennett, 2000), this means that a new practice will only be adopted if producers believe that it will maximize profits, which it can do by reducing costs, increasing yields, or doing both relative to the status quo (Casey & Lynne, 1999).[2]

Profitability is addressed in two key ways in the agricultural sociology and economics literature, one implicit and one explicit. The first approach, found in many

[2]In the case of structural BMPs, producers may also consider the value of capital investments in their decision-making.

studies purporting to take an "economic" view of adoption, is to assume that profitability is actually the fundamental driver behind adoption decisions. The variables typically included in diffusion and farm structure models, such as farm size and income, determine whether a practice is likely to be profitable for a particular farm operation and thus whether it will be adopted. In essence, decisions to adopt new practices or technologies are inherently profit-maximizing decisions (Bosch et al., 1995). A decision to adopt a practice or technology indicates that the producer believes it will be profitable for their particular operation. This assumption obviates the need to include an operator's perceptions about profitability as a separate factor in adoption models that already include diffusion and farm structure variables.

The other approach is to treat expectations about profitability explicitly, though in practice this is rarely done. Only six of the 55 studies in Prokopy et al.'s 2008 review and only three of the 31 studies reviewed by Knowler and Bradshaw (2007) included measures related to the expected profitability of the practice in question. Not surprisingly, though, when researchers test profitability as an explanatory factor, they generally find it to have a significant, positive impact on adoption (Napier & Tucker, 2001; Gale et al., 1993). They also have found perceptions about profitability to be particularly important regarding practices that reduce the use of fertilizers or other inputs. Saltiel, Bauder, and Palakovich (1994) found that a farmer's perception that farming practices would result in long-term increases in net farm income was the strongest predictor of adoption of both low-input and management-intensive sustainable farming practices among their sample of Montana operators. Feather and Amacher (1994) found perceived profitability to have a significant, positive influence on the adoption of water quality-protecting farming practices in their eight-state study. Ribaudo and Johansson (2007) conclude from their study of corn farmers in 18 states that the use of soil testing is driven largely by the expectation of enhanced profits. These findings support the need to include explicit measures of perceived profitability in studies of BMP adoption, particularly BMPs that can reduce input costs.

In conclusion, the diffusion, farm structure, and economic perspectives on adoption of BMPs can help inform the model employed in this study. Many of the key variables from these research traditions may be influential in the adoption decisions made by producers in this dissertation's study population. Though empirical evidence of the influence of these variables over BMP adoption is sometimes inconclusive, theory argues for including them in future BMP adoption studies. Several important issues remain unresolved by these approaches, however.

One issue relates to the diffusion model's assumption that adoption of innovations is a voluntary act over which adopters have complete control (Fliegel, 1993). Lynne, Casey, Hodges, & Rahmani (1995) argue that this assumption has become less realistic as the government has focused more on agricultural pollution issues. Yet, the perspectives described above do not account for potential government influences over the adoption process, other than through cost-sharing. This is a key issue in this dissertation, and relevant literature is discussed in Section 2.4 of this review.

Another issue arises for practices that do not provide tangible net benefits to the producer. The classic diffusion of innovations model assumes that innovations always provide such benefits, but this may not be the case for many BMPs. These practices may only provide off-site environmental benefits like enhanced downstream water quality or future productivity benefits like reduced soil erosion that the adopter may not personally experience. If direct benefits do occur, the costs of adoption may exceed them, even though the net social benefits of adoption may be significant. In these cases, by assuming that producers are only motivated by profit, the traditional diffusion, farm structure, and economic perspectives are not well-suited to explain adoption behavior. As a result, it is important to look beyond measures of adoption capacity and beliefs about profits for other factors that may motivate adoption. Even Rogers (2003) argues that diffusion researchers have been ineffective in exploring why innovations are adopted and suggests that future work should focus more on motivations. These considerations must be drawn from other theoretical traditions.

2.3 The Social Psychology Perspective: The Impact of Attitudes, Personal Norms, Social Pressure, and Perceived Abilities on Behavior

The Social Psychology literature, particularly the portion focused on environmentally-relevant behaviors, offers several important insights into factors that could be driving nutrient BMP adoption in the Neuse River Basin. This literature argues that social pressure, personal norms, and attitudes may motivate such behavior. It also offers an expanded perspective on the concept of ability and provides theoretical guidance on how key motivational and capacity-related variables may relate to each other in their impact on adoption behavior.

2.3.1 The Theory of Planned Behavior: Social Pressure and Perceived Behavioral Control

Icek Ajzen developed the theory of planned behavior to predict and explain human behavior in a variety of contexts (Ajzen, 1991). As seen in Figure 2.1, it holds that behavior is a function of two key factors: intention and perceived behavioral control. Intention to perform a behavior captures the motivational factors that influence a behavior by indicating how much effort people are willing and planning to put into performing the behavior (Ajzen, 1991). Perceived behavioral control reflects a person's beliefs about their abilities to perform the behavior and theoretically influences behavior both directly and indirectly by affecting intention. The theory of planned behavior extends previous behavioral theories by focusing on situations where behavior is not under complete volitional control and thus perceived abilities are an important factor (Armitage & Connor, 2001).

In addition to perceived behavioral control, the theory of planned behavior identifies two additional determinants of intention: attitude and subjective norm. Attitude measures the degree to which a person has a favorable or unfavorable appraisal of the behavior (Ajzen, 1991). Subjective norm refers to the perceived social pressure to perform or not perform the behavior. In general, the more favorable a person's attitude toward the behavior, the more social pressure they feel to perform the behavior, and the more control they believe they have over the behavior, the more likely they are to perform it (Ajzen, 1991).

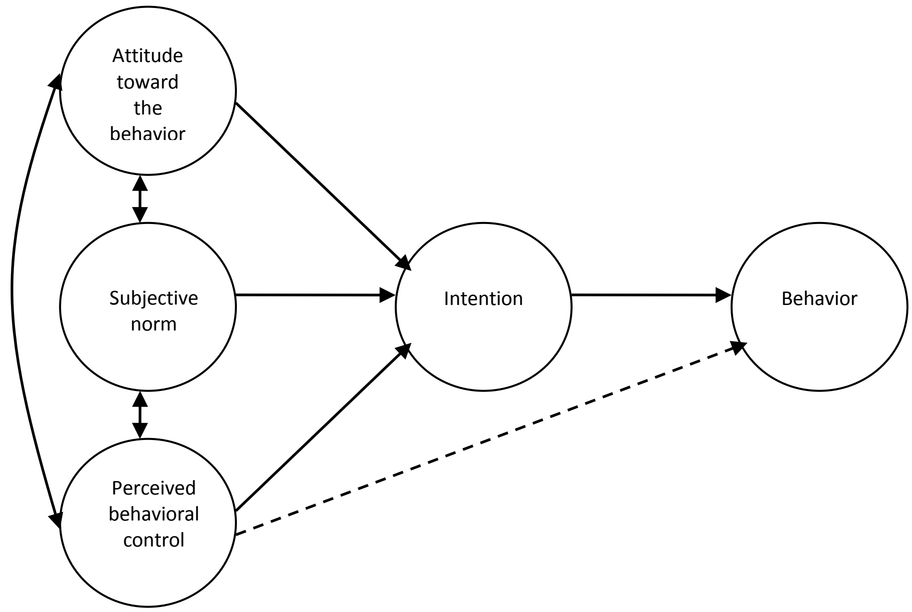


Figure 2.1. The Theory of Planned Behavior.

There is strong empirical support for the theory of planned behavior. Ajzen (1991) reviewed 12 studies employing the theory, and found that the theory explained an average of 51 percent of behavioral variation. Armitage and Connor (2001) conducted a meta-analysis of 161 articles containing 185 empirical tests of the theory. Across all of the behaviors investigated in these studies, the model accounted for 31 percent of the variance in self-reported behavior and 20 percent in observed behaviors (Armitage & Connor, 2001). Kaiser, Hubner, and Bogner (2005) claim that on average, intentions and perceived behavioral control together have been found to predict 25-30 percent of a behavior's variance, but they found even stronger support for the theory's efficacy in their own investigation. In their study of general environmentally-responsible behaviors (e.g., recycling) they found that the theory explained 76 percent of intentions and, in turn, intentions explained 95 percent of behavior. In a study of voluntary adoption of agricultural BMPs in New York, Welch and Marc-Aurele (2001) found attitudes, subjective norm, and perceived behavioral control to have statistically significant influences on behavior.

Evidence of the interaction between perceived behavioral control and intention in influencing behavior is mixed. Many studies have not found a significant interaction (Collins & Chambers, 2005; Ajzen, 1991), but others have (Heath & Gifford, 2002; Armitage & Connor, 2001). Ajzen (1991) argues against including interactions in statistical tests of the model, claiming that linear models are generally found to account well for psychological data even when they are known to come from a multiplicative model.

Empirical evidence also supports the significant roles that each of the theory's key components can play in influencing behavior, including the adoption of BMPs. While attitude measures are discussed in Section 2.3.2 of this review, evidence supporting the need to investigate social pressure and perceived behavioral control in this dissertation is considered here.

2.3.1.1 Social Pressure

Research has found that social pressure can motivate general environmentally-responsible behavior and the adoption of agricultural BMPs. Social pressure exists when an individual believes that certain important others think that they ought to behave in a particular way (Ajzen 1991). It can reflect a concern for social moral norms regarding behavior, popular social attitudes, or reputation. For example, May (2005 "Compliance") measures this concept as the extent to which respondents agree that their reputation with others is an important consideration for how they do business. Social pressure is an extrinsic motivation for behavior, coming from sources external to the person. Depending on the social situation and behavior in question, social pressure can have a positive or negative influence over behavior.

Previous work has found social pressure to have a significant, positive influence over participation in environmental farming programs (Wilson & Hart, 2000; Beedell & Rehman, 1999; Gale et al., 1993) and adoption of BMPs (Lynne et al., 1995; Lynne & Casey, 1998; Fielding, Terry, Masser, Bordia, & Hogg, 2005). Lynne and his colleagues found that social norms influenced adoption of water conservation technologies among Florida strawberry and tomato growers (Lynne et al., 1995; Lynne & Casey, 1998). Winter and May (2001) found that social motivations led to higher levels of compliance with environmental rules among Danish agricultural producers.

2.3.1.2 Perceived Behavioral Control

Research has also found measures of perceived behavioral control to influence environmentally-responsible behaviors. Perceived behavioral control involves a person's subjective perceptions about the "ease or difficulty of performing the behavior" (Ajzen, 1991, p. 188) and "pertain[s] to factors that will either facilitate or interfere with the performance of a behavior" (Heath & Gifford, 2002, p. 2156). Defined in this way, perceived behavioral control can be thought of as a psychological take on the concept of capacity. Control beliefs help explain why a person's intentions do not always predict their behavior; perceived constraints on action can interfere with performance (Armitage

& Connor, 2001). Perceived behavioral control beliefs tend to be influenced by past personal experience and second-hand information about the experiences of others with the behavior (Ajzen, 1991). They reflect both internal and external factors that can influence a person's perceptions of their control over a particular behavior.

Influential internal factors can include information, skills, abilities, and personality characteristics (Ajzen, 1988). These relate to Bandura's concept of "self-efficacy," or how people judge their own ability to perform given behaviors (1986). Bandura (1986) explains why self-efficacy is important: "It is because people see outcomes as contingent on the adequacy of their performances, and care about those outcomes, that they rely on self-judged efficacy in deciding which courses of action to pursue" (p. 392). Self-efficacy beliefs help determine how much effort people put forth in performing the behavior and how persistent they are when they face challenges (Bandura, 1986; Ajzen, 1991). Rogers (2003) argues that agricultural producers with higher levels of self-efficacy are more likely to adopt innovations.

External factors that may influence a person's perceived ability to perform a behavior include opportunities or dependencies on others, which are relevant for behaviors that require cooperation (Ajzen, 1988). They may also include situational or environmental constraints (Bandura, 1986).

Empirical evidence of the influence of perceived behavioral control beliefs over environmentally-responsible behaviors is mixed. Gale et al. (1993) found that ease of use was cited as an important influence over adoption of BMPs among participants in the RCWP and the idea that changing practices is too much trouble was one of the key reasons producers gave for not participating. In a transportation study, Heath and Gifford

(2002) found that beliefs about the difficulty of taking the bus played a significant role in college students' bus usage. Fielding et al. (2005) found a moderately significant, but negative effect of control beliefs on intentions to manage riparian areas. Other studies have found perceived control not to be significant in explaining environmentally-responsible behaviors (Corbett, 2005; Beedell & Rehman, 1999). Though perceived behavioral control beliefs are not found to be influential over behavior in all cases, they are worthy of investigation in this dissertation because of the potential for participation in nutrient management training to influence these beliefs, and thus, indirectly influence adoption of nutrient BMPs.

While there is empirical support for the ability of the theory of planned behavior to help explain environmentally-responsible behaviors and adoption of BMPs, an important deficit exists: the role of personal norms. Though Ajzen's version of the theory does not include personal norms as predictors of behavior, there is evidence that they are significant in cases relevant to this study. Another social psychology theory, the value-belief-norm theory of environmentalism ("VBN theory"), helps to fill this gap by providing a theoretical basis for the influence of personal norms over behavior.

2.3.2 The Value-Belief-Norm Theory: Personal Norms and Attitudes

VBN theory holds that personal moral norms are the primary basis for a person's general predisposition to pro-environmental behavior (Stern, 2000). Personal norms involve beliefs about what one ought to do (Stern, Dietz, & Black, 1985), and are often described as personal moral obligations or duties to perform or refrain from performing particular behaviors (Schwartz & Howard, 1981). A personal norm is an intrinsic motivation, sometimes called an internalized obligation, because it comes from a person's own sense of right and wrong rather than from what others believe or desire. In this way personal norms differ from the social norm component of the theory of planned behavior. For example, a person may feel a desire to earn approval and respect from others for performing a certain behavior even if they lack an intrinsic motivation to do it (Winter & May, 2001).

According to VBN theory, personal moral norms are shaped by a person's beliefs, and beliefs are shaped by a person's values and educational experiences. This theory incorporates S. H. Schwartz's moral norm-activation theory of altruism as a key component (Stern, 2000). Following Schwartz, VBN theory holds that a feeling of personal moral obligation to protect the environment is activated by two factors. First, an individual must have an awareness of environmental problems and their consequences and believe that these problems are threatening to things they personally value (Corbett, 2005). This awareness activates a feeling that action should be taken to reduce the threat (Stern et al., 1985). Second, he or she must feel a sense that they or people like them have a responsibility to resolve the problems (Stern et al., 1985). These two beliefs activate a feeling of personal moral obligation, which, along with other factors, can play an important role in shaping behavior (Stern et al., 1985). VBN theory is particularly relevant to this dissertation because it provides theoretical support for the potential role of nutrient management training to facilitate adoption by altering beliefs and activating personal norms concerning nutrient management behaviors.

According to Kaiser et al. (2005), the VBN model has been shown to account for 19 to 35 percent of behavior variance in previous studies. In their own study of German university students' environmentally-responsible behaviors, they found that VBN explained 30 percent of personal norms and 64 percent of behavior variance. Norlund and Garvill (2002) also found support for VBN theory in their study of behaviors like recycling and energy conservation among Swedes. They found that environmental values and problem awareness activated personal norms which had a strong, positive effect on behavior.

While VBN theory is useful in emphasizing and providing support for the inclusion of personal norms in models of environmentally-responsible behavior, the relationship between beliefs and norms clearly needs further specification. For instance, while VBN theory argues that beliefs activate norms, Kaiser and his colleagues have not found this to be true when investigating personal norms in the context of the theory of planned behavior. Based on a study of environmentally-responsible behaviors in Switzerland, Kaiser and Scheulthle (2003) concluded that moral norms precede attitudes in influencing behavior, rather than the other way around. Kaiser et al. (2005) argue that in the environmental domain, moral norms are an integral part of people's attitude. Blamey (1998) argues that attitudes moderate the influence of personal norms on behavior.

2.3.2.1 Personal Norms

Research has found personal norms to help explain both intentions to engage in environmentally-responsible behaviors and actual performance of those behaviors (Heath & Gifford, 2002; Corbett, 2005; Norlund & Garvill, 2002). Evidence of the positive impact of personal norms on adoption of BMPs also exists. In their review of the agricultural diffusion of innovations literature, Buttel et al. (1990) found that a stewardship obligation toward land tends to have a significant, positive impact on BMP adoption. Gale et al. (1993) report that 20 percent of their survey respondents said that they participated in the RCWP because it was the right thing to do or because of their conservation ethic. The North Carolina Corn Growers (2002) study found that some producers who had highest levels of BMP adoption chose to adopt only because of a motivation to do what they think is right. Lubell and Fulton (2006) found a significant positive correlation between a feeling of duty to protect the land and the number of activities producers participated in, including adoption of BMPs.

2.3.2.2 Attitudes

Ajzen (1988) defines the concept of attitude as a disposition to respond favorably or unfavorably to something like a behavior, person, or event. He argues that attitude is a hypothetical construct that has to be inferred from measurable responses such as expressed beliefs, feelings, or behavioral intentions concerning the attitude object (Ajzen, 1988). VBN theory, Schwartz's norm activation theory, and others help specify the concept by distinguishing among different beliefs that may comprise a person's attitude regarding environmentally-responsible behaviors. Three beliefs emerge as key: 1.) there is an environmental problem with important consequences, 2.) one has a responsibility to try to address the problem, and 3.) the behavior in question will positively impact the problem. If the government is involved in the problem or in promoting particular behaviors, then a person's beliefs concerning government initiatives may also play a role.

This factor is discussed in section 2.4 of this review. Generally, the more favorable a person's attitudes are toward a behavior, the more likely they are to perform it.

Though conceptually distinct, the various components of attitude listed above and the personal norm concept are frequently combined in research application. For example, Peter May employs a concept in his work that he variously labels "duty to comply" (May, 2005 "Compliance"), "normative motivations" (Winter & May, 2001) and "civic duty" (May, 2003). In each case, it involves a combined sense of moral obligation to address a problem along with an agreement with the need for, and approach to, addressing it. Winter and May (2001) state that these concepts are difficult to disentangle in practice.

The following discussion highlights relevant empirical findings concerning these key attitude concepts and the role they may play in explaining adoption behavior.

Awareness of environmental problems and consequences. Scholars have found that awareness of environmental problems and their consequences is positively associated with environmentally-responsible behaviors, including the adoption of BMPs. Gale et al. (1993) found that participants in the RCWP who were aware of NPS water pollution were more likely to use nutrient management and soil tests, though not cover crops. 60 percent of participants cited their concern for water quality and its effects as a reason for participating in the program (Gale et al., 1993). Gould et al. (1989) found the perception of an erosion problem to be positively associated with the adoption of conservation tillage. Lubell and Fulton (2008) found awareness that pesticides had been discovered in local waterways to have a significant and positive influence on adoption of pesticide management and runoff control practices in the Sacramento Valley. Corbett (2005) found that a perception that air pollution was a threat to one's own health explained 28 percent of the variation in intention to reduce personal contributions to air pollution.

Acceptance of personal responsibility. Although VBN theory argues that acceptance of personal responsibility for environmental problems is a critical factor in encouraging environmentally-responsible behavior, few studies appear to test this. However, based on the results of their producer surveys, Gale et al. (1993) conclude that awareness of water quality issues in not enough to spur sufficient participation in NPS control programs, that producers must accept responsibility for these problems too.

Outcome expectations. Though a person's beliefs about the likely impacts of their behavior on the environment are not discussed in VBN theory, they are worthy of consideration. These beliefs are conceptually related and have been found to influence relevant behaviors. Outcome expectations are significant because people are more likely to engage in environmentally-responsible behaviors when they believe that their contribution will make a difference (Kaplan, 2000; Lindenberg & Steg, 2007). Empirical evidence supports this assertion (Collins & Chambers, 2005; Fielding et al., 2005; Beedell & Rehman, 1999). Specific to BMPs, several studies are informative. Gale et al. (1993) found that producers in the RCWP cited the impact of BMPs on water quality as the second most important influence over adoption. Thomas et al. (1990) found that a belief in the benefits of integrated pest management practices had a positive impact on adoption among cotton farmers. Welch and Marc-Aurele (2001) found that producers who believed that BMPs would effectively reduce the impacts of farming on water quality had higher rates of BMP adoption. Feather and Amacher (1994) found that producers who believed that BMPs would affect water quality on their own farms had significantly higher rates of adoption.

Given some confusion apparent in the literature, it is important to distinguish the concept of outcome expectations from the concept of self-efficacy. At least two studies claim to investigate the role of perceived behavioral control on environmentally-responsible behaviors, but actually measure outcome expectations instead (Collins & Chambers, 2005; and Welch & Marc-Aurele, 2001). Albert Bandura (1977) explains the distinction:

> *An outcome expectancy is defined as a person's estimate that a given behavior will lead to certain outcomes. An efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes. Outcome and efficacy expectations are differentiated, because individuals can believe that a particular course of action will produce certain outcomes, but if they entertain serious doubts about whether they can perform the necessary activities such information does not influence their behavior. (p. 193).*

2.3.3 A-B-C Model of Behavior: Interactions Between Motives and Capacity

It is evident that several factors, including economic self-interest, social pressure, personal norms, and environmental attitudes may be involved in motivating agricultural producers' adoption of BMPs. In addition, a number of capacity-related factors may play a role in adoption, including characteristics of the producer and his or her operation (e.g., age, education level, farm size, and income), receipt of financial support, and perceived behavioral control. Research has demonstrated that all of these factors can directly impact adoption behavior. However, there is also evidence that motivations and capacity factors may sometimes interact in their effects on behavior. Though the theory of planned behavior suggests a tentative interaction between intentions and perceived behavioral control, further specification of the relationship between motivations and capacity factors is needed. The A-B-C Model of Behavior (ABC model) put forth by Guagnano, Stern, and Dietz (1995) offers a useful perspective.

The ABC model argues that behavior (B) is the result of both attitudes (A) and contextual factors (C). In the model, "attitudes" include motivational factors such as environmental attitudes, personal norms, and social pressures (Stern, 1999). "Contextual factors" are akin to the diffusion, farm structure, economic, and self-efficacy variables previously discussed and include things like personal attributes, capabilities, situational and economic factors, and policy influences (Stern, 1999). In the ABC model, attitudes and contextual factors both have a direct impact on behavior, but they also interact with each other in their effects. The interaction is such that contextual factors provide boundaries for the influence of attitudes on behavior: when contextual factors are neutral (i.e., neither highly favorable nor unfavorable toward the behavior), attitudes are more determinative of behavior, and when contextual factors are strong in a positive or negative direction, attitudes play a smaller role (Guagnano et al., 1995). Graphically, with contextual factors ranging from highly unfavorable to highly favorable on the X-axis and the influence of attitudes over behavior on the Y-axis, the relationship can be represented by an inverted U-shape (Stern, 2000).

Limited testing of the ABC model supports its basic structure. Guagnano et al. (1995) found that factors related to attitudes and contextual factors both had direct effects on recycling and that they also interacted. They found that when households in Fairfax, VA had curbside bins (i.e., a highly favorable external condition), their attitudes toward recycling played a very small role in determining their behavior. However, when households had to transport their bottles and cans to a drop-off center (i.e., a more neutral external condition), attitudes played a much more significant role.

Two transportation-related studies also appear to support the interaction effect predicted by the model. Heath and Gifford (2002) investigated the impacts of a bus-pass program on bus usage among Canadian college students. They found that before implementation of the program, when taking the bus was more expensive, moral norms and awareness of the problems caused by cars both played a significant and positive role in predicting a student's intention to take the bus. However, after implementation of the program, which had the effect of reducing external constraints to bus use, these factors lost their influence. Collins and Chambers (2005) found that when the costs of public transportation went up, Australian college students' commuter choices were less influenced by beliefs about the environmental consequences of car usage. The results of these two studies appear to contradict each other, but it is possible that they represent the two ends of the inverted U-shaped relationship. In the first study, the bus pass program may have made the contextual conditions highly favorable, reducing the influence of attitudes, and in the second study, the rising cost of public transportation may have made the contextual conditions highly unfavorable, also reducing the influence of attitudes on behavior. The results of these studies suggest that exploration of interactions between attitudes and contextual factors is warranted in future research efforts.

2.4 The Deterrence Perspective

The motivational and capacity-related factors discussed so far in this review are relevant to BMP adoption under any type of water quality management scheme, including cases where adoption is voluntary. When adoption is not strictly voluntary, the drivers of adoption behavior can be more complex. Under management schemes like the Neuse Basin strategy that involve mandates or other coercive elements, consideration of three additional issues is needed. First, new factors related to attitudes and personal norms need to be taken into account. Second, behavioral motivations related to deterrence become relevant. Third, interactions among normative and deterrent motivations need to be explored. In cases where regulations are in force, the behaviors of interest also expand to include compliance with relevant laws.

2.4.1 Considering a Broader Range of Norms and Attitudes

In the case of environmental problems where government regulations exist, personal norms influencing behavior may involve not only a moral duty to protect the environment, but a duty to comply with the law as well. According to Tyler (1990), the normative view of why people obey the law includes two components: personal morality and legitimacy. People who comply for personal moral reasons do so because they agree with the substance of the law. Those who comply for legitimacy reasons may not agree with the law in question, but still comply because they feel that the authority enforcing the law has a right to dictate their behavior. Tyler (1990) tested the influence of these two types of normative beliefs on compliance with speeding, parking, noise, littering, drunk driving, and shoplifting laws in Chicago and found that both legitimacy and personal morality had positive impacts on compliance.

Similar to personal moral norms, a person's sense of duty to comply with the law is related to their attitudes, particularly those concerning the actual or threatened policy initiatives at hand. Blamey (1998) explains that beliefs concerning who is responsible for acting, trust in the organizations involved, perceptions about fairness and practicality of the initiatives are relevant. Similarly, May (2005 "Regulation") and Winter and May (2001) argue that acceptance of a regulatory approach includes a belief that the rules are reasonable, trust in the agencies that promulgate the rules, perceived fairness in enforcement of the rules, and a belief that others are doing their part. In accordance with norm-activation theories like VBN theory, it is possible that positive attitudes toward the policy initiative trigger a sense of duty to comply. However, both Blamey and May argue for a more integrated relationship between attitudes and norms in this context. Blamey (1998) suggests that acceptance of policy initiatives interacts with norms to influence behavior. May (2005 "Regulation") claims that acceptance of the regulatory approach is part of a duty to comply.

In either case, arguments and evidence point to a positive relationship between compliance with the law and both a duty to comply and positive attitudes about the policy initiative. For example, Cohen (1998) argues that compliance is expected to be higher when rules are seen as legitimate and fairly applied. Wasserman (1992) explains that according to the "behavioral school of compliance," those who are regulated are believed to be inherently willing to comply with the law as long as it is not perceived to be arbitrary or irrational. Welch and Marc-Aurele (2001) found in their study of the

Skaneateles Lake Watershed Agricultural Program that attitudes about whether the program was treating producers and other sources of water pollution equitably were significantly related to BMP adoption. Korsching and Nowak (1983) found that the use of BMPs was associated with positive attitudes toward legal regulation (cited in Buttel et al., 1990). May (2003) found that feelings of civic duty had a positive impact on adoption of BMPs among marine facilities regulated by the Clean Water Act.

2.4.2 Investigating the Influence of Deterrence Motivations

Because the Neuse Basin strategy includes regulations, it is important to consider the role that deterrence motivations may be playing in agricultural producers' adoption behavior. Deterrence theory holds that threats of legal action and sanction motivate compliance with rules (Wasserman, 1992). These threats may motivate compliance in various ways or, in some cases, may actually be counterproductive to achieving the goals of the rules.

Many scholars view deterrence as a negative motivation for compliance, assuming that regulated entities are unwilling to comply with the law unless they are coerced into doing so. Negative deterrent motivations stem from a desire to avoid something unwanted and may be based on economic or psychological factors. Those who see deterrence as an issue of rational economic calculation (i.e., "calculated" deterrence) argue that regulated entities determine how to behave by weighing the relative costs and benefits of compliance (Wasserman, 1992). Firms will comply only if it is in their economic interest to do so. If the benefits of compliance (e.g., improvement in water quality) are outweighed by the costs of compliance or are not experienced by the regulated entity directly, then penalties for noncompliance can help tip the calculus in favor of compliance. When penalties for noncompliance exist, regulated entities compare the costs of compliance against the costs of penalties. In theory, they comply if the penalties they would face for noncompliance multiplied by the likelihood of being found in noncompliance exceed the costs of coming into compliance (Cohen, 1998; Wasserman, 1992). Others see deterrence more broadly, arguing that penalties for noncompliance can also be psychological in nature. For example, May (2005 "Regulation") argues that the concept of deterrence includes concerns over feeling ashamed or embarrassed for being found in noncompliance.

The literature describes several possible sources of deterrence. It can derive from legal sanctions against one's own firm or against other firms. These are termed specific and general deterrence respectively (Gunningham, Thornton, & Kagan, 2005; May, 2005 "Regulation"). It can also be explicit, coming from observations of actual sanctions imposed against firms, or implicit, coming from a more vague sense that sanctions are possible (Gunningham et al., 2005). Gunningham et al. (2005) explored the role of "implicit general deterrence" in encouraging compliance with environmental laws in the electroplating and chemical industries. They found that the mere existence of regulations created a deterrent threat. The threat of future regulations can also trigger deterrence motivations. For example, Bosch et al. (1995) suggest that policies can promote adoption of BMPs by "raising the possibility of high adjustment costs caused by future regulation if farmers do not voluntarily adopt such practices now" (p. 15).

Evidence shows several specific deterrent fears to be influential over compliance behavior, particularly those concerning the likelihood of being inspected, penalized, and more stringently regulated in the future. For example, in their study of Danish farmers' compliance with environmental regulations, Winter and May (2001) found that the perceived likelihood of detection had a positive impact on compliance but the likelihood of getting fined did not. Burby and Paterson (1993) found that the frequency of inspection and beliefs about the likelihood of being fined for noncompliance were both significant factors in their study of compliance with the N.C. Urban Sedimentation and Erosion Control Law. Gale et al. (1993) found that many participants in the RCWP cited concerns about possible future pollution regulations as a reason for their participation.

Interestingly, studies of compliance have not generally found the severity of punishment (i.e., the size of financial penalties) to be significant (Tyler, 1990; Burby & Paterson, 1993). This bolsters the argument that deterrence operates more as a fear-based psychological phenomenon than an economic one. Cohen (1998) and Hatcher et al. (2000) also suggest that the "calculated" deterrence perspective is not well-supported. They explain that calculated deterrence does not sufficiently explain the relatively high levels of compliance found among firms even when monitoring is limited and fines are low, and they suggest that other motivations appear to account for compliance.

Some scholars argue that deterrence can actually be counterproductive, having a negative impact on compliance. According to Bardach and Kagan (1982) and Gunningham and Sinclair (1998), when CAC regulations are strictly applied, they can create a negative reaction among those targeted, reducing their willingness to share needed information with regulators and comply with the law. Some argue that this negative reaction stems from a psychological phenomenon termed "reactance," whereby a person who feels that their sense of freedom has been restricted shows an "increased desire for a forbidden alternative or decreased desire for what they feel forced to do" (De Young, 1993, p. 498). Lynne et al. (1995) report observing a backlash to external regulatory control among farmers in Florida who were required to install drip irrigation systems. Bosch et al. (1995) found a more subtle form of this problem in their study in Nebraska. They found that while regulations requiring use of nitrogen testing led to higher levels of adoption than an alternative voluntary approach, the farmers who adopted under the regulations were actually less likely to use the test results to make their nitrogen application decisions than those who adopted voluntarily. Thus, farmers complied with the letter of the law, but the regulations ultimately failed to change the behavior that really mattered. Lynne et al. (1995) suggest that coercive government regulations may also be counterproductive because they can reduce a person's sense of behavioral control. In their study of Florida strawberry producers, they found that measures related to how much control producers believed they had over installing drip irrigation systems and whether they believed that organizations or agencies could require them to install a drip irrigation system, helped explain their adoption of irrigation technologies.

Determining if deterrent motivations are a factor in adoption of nutrient BMPs in the Neuse Basin, and if so, whether they support or undermine adoption behavior is critical to gauging the effectiveness of the Neuse Basin strategy's activity mandates. Though the true threat of enforcement and sanction under the Neuse rules is weak, the mere existence of rules could be creating influential deterrent motivations, similar to the implicit general deterrence found by Gunningham et al. (2005). Or, the activity mandates may be inadequate to generate any kind of deterrent threat, which would raise the question of whether stronger mandates are needed or whether a voluntary approach would be just as effective.

2.4.3. Exploring How Deterrence and Personal Norms Interact

An important debate emerges in the deterrence literature: whether deterrence and normative motivations interact in their influence over compliance behavior, and if so, whether they are synergistic or antagonistic. Some scholars argue that deterrence can play a positive role in compliance by reinforcing personal norms. They identify three mechanisms by which these two types of motivations can work together. First, environmental programs or regulations can serve an "expressive" or "reminder" function, signaling that the behavior in question is socially desirable, and reinforcing environmental norms (Frey, 1999; Gunningham et al., 2005). Second, deterrence can play a "reassurance" function by guaranteeing some degree of equity across regulated entities. Both Frey (1999) and Scholz and Pinney (1995) suggest that a person's environmental moral norms and sense of duty to comply can be negatively impacted if he or she believes that others are cheating. As a result, those who otherwise have strong motivations to comply may fail to do so because they are concerned that others will not do their part. This has been found to be an issue in other collective action situations, such as tax-paying, where free-riding may be a factor (Levi, 1988). In these situations, the existence of a deterrent threat may help ensure would-be cooperators that the situation is fair because others are being compelled to cooperate too. Levi (1988) calls this "quasi-voluntary compliance," and claims that rather than relying on a fear of punishment, this type of compliance "rests on norms but is backed by…coercion." (p. 68).

Gunningham et al. (2005) find support for these two possible positive deterrence-personal norm interactions in their study of compliance with environmental laws in the U.S. electroplating and chemical industries:

> *Interviewees tended to divide the world into two types of people, "good guys" (like them) who obey the law voluntarily, and "bad guys" who do not. Two things followed from this. First, regulation served a* ***reminder function*** *as to what it meant to be a good guy: a predisposition to "do the right thing" was tightened or brought into focus by the introduction of specific regulation. Second, regulation, as noted earlier, served a* ***reassurance function****. Since they believed bad guys would cheat if possible and thereby gain an unfair business advantage, our respondents indicated that they would be far less inclined to voluntary compliance if others were perceived to be "getting away with it."* (p. 310)

May (2003) also finds possible evidence of an interaction between deterrence and normative motivations for compliance. He found that while regulated and unregulated marine facilities did not differ in their feelings of civic duty, civic duty only influenced adoption of BMPs among those who were regulated by the Clean Water Act. Among these facilities, feelings of civic duty had a positive impact on adoption.

A third possible mechanism through which deterrence motivations and personal norms may interact in a positive way is called the "duty heuristic" and is described by Scholz and Pinney in their 1995 study of tax compliance. The authors found that study respondents who reported having a strong sense of duty to pay taxes also tended to have biased beliefs about the costs of noncompliance. Those with a strong duty to comply were more likely to believe that they would be caught if they cheated and they believed that their probability of being caught was higher than it really was. These biased beliefs tended to reinforce compliance. Supporting these findings, May (2005 "Compliance") found that Danish agricultural producers who expressed attitudes consistent with positive personal norms, also had higher deterrence motivations. Tyler (1990) also found a correlation between a person feeling that breaking the law is immoral and the belief that it will lead to arrest.

Other scholars suggest that deterrence and personal norms may interact negatively and that deterrence can actually undermine personal norms and lead policy targets to try to weaken the law. Frey (1999) argues that command and control policies can "crowd out" intrinsic motivations for compliance, such as personal norms. This occurs because external control over behavior reduces a person's sense of autonomy and can shift the sense of responsibility for the problem from the person to the policy intervention (Frey, 1999). According to norm activation theory, having a sense of responsibility for a problem and its solution is key to having a personal norm in favor of that solution (Stern et al., 1985). Thus, by imposing strong external controls, regulations can have the effect of undercutting personal norms. In turn, this can threaten the durability of behavior change because extrinsically-motivated behavior relies on the continued presence and effectiveness of the external controls (De Young, 1993). If those controls, such as the threat of enforcement, are reduced or removed, the behavior is unlikely to endure. Additionally, the overuse of deterrence can lead regulated groups to work to weaken the rules and their enforcement through the use of political pressure (Burby & Paterson, 1993).

Though the arguments on all sides of this issue are compelling, evidence is limited. Given the increasing interest in using regulatory instruments to induce producers to reduce their impacts on water quality, the potential for deterrence motivations to interact with personal norms in either positive or negative ways in their effects on compliance is a critical issue in need of more investigation.

2.5 The Role of Information and Educational Programs

The success of the Neuse Basin strategy rests largely on the assumption that producers' participation in nutrient management training or development of a nutrient management plan will result in concrete behavioral changes that are believed to improve water quality. However, this assumption has not been tested. As such, it is critical to gauge the actual impacts of these activities on adoption of nutrient BMPs. Literature related to the impacts of educational programs and technical assistance on adoption is relevant to this question as nutrient management training, and to a lesser extent, nutrient management planning, are educational tools.

In the context of agricultural water pollution control, a key assumption drives the use of educational programs - that producers tend to be unaware of the environmental effects of their practices or of how they can reduce those effects (Johnson & Napier, 1998; Ribaudo & Caswell, 1999). According to Ribaudo and Caswell (1999), surveys have consistently found agricultural producers to lack an understanding of the relationship between their actions at the farm level and local water quality. For example, the N.C. Corn Growers study (2002) found that the producers sampled generally did not understand how nitrogen moves into water sources, and thus did not understand the role of nitrogen-reducing BMPs. Educational programs seek to inform producers about these types of issues including the impacts of NPS pollution on themselves and others (Ribaudo et al., 1999). Caswell et al. (2001) argue that educational efforts are particularly important in encouraging adoption of practices that are information-intensive or provide off-site benefits.

The relevant literature describes numerous pathways by which educational programs may influence adoption and compliance behavior. In general, educational programs can impact adoption by affecting a producer's relevant abilities or motivations. Educational programs can enhance adoption abilities by teaching producers about how to adopt practices and obtain support for doing so. Educational programs usually describe specific actions that people can take to help resolve the problem at hand (Gardner & Stern, 1996). This allows participants who already possess pro-environmental attitudes and beliefs to act in accordance with those beliefs (De Young, 1993). It also helps those for whom adoption is in their best interest, but are unable to adopt because they are unaware or incapable of doing it (Winter & May, 2002). For example, Nowak (1991) explains that a lack of management skills can prevent some producers from adopting nutrient management. Educational programs that enhance these skills can help overcome this obstacle. Nutrient management training is also likely to alter producers' perceived behavioral control beliefs by providing information about the difficulty of using nutrient BMPs and exposing them to other producers who have first-hand experience with those practices. For those who are able but unwilling to adopt, educational programs can provide information and opportunities for social interaction that may enhance all four types of adoption motivations explored in this dissertation.

Following VBN theory, educational programs can influence behavior by triggering personal norms in favor of behavior change (Stern, 2000). They can do this by providing information about the nature and severity of environmental problems and their consequences in order to change the participants' attitudes and beliefs to be more favorable to action (Gardner & Stern, 1996; De Young, 1993). Educational programs can also try to instill a sense of personal responsibility for solving problems by explaining how particular behaviors can make a difference (Lindenberg & Steg, 2007). Participation in training may also affect personal norms and behavior by raising awareness of the policies and programs related to nutrient management. Winter and May (2002) argue that the influence of information on compliance is mediated by rule awareness – that those who reach a certain threshold of rule awareness will have higher compliance rates than those who do not. They in fact find rule awareness to be the most significant factor influencing compliance among the Danish agricultural producers in their study. One effect of higher levels of rule awareness may be to alter beliefs about the fairness and acceptability of the policy approach, which can influence personal norms and adoption.

Participation in educational programs can also influence adoption by creating opportunities for communication that enhance personal norms and trigger social pressures. According to Frey (1999), research has shown that communication among colleagues and between principles and agents can raise the intrinsic motivation to cooperate. He argues that "Communication is a precondition of reciprocity; through communication one learns about, and acknowledges, the duties and responsibilities of other people." (p. 403). Lubell and Fulton (2008) discuss the importance of "policy networks" in encouraging cooperation for solving water quality problems. They argue that communication among the actors in a policy subsystem can increase adoption by disseminating information about "the existence and effectiveness of different types of BMPs, the existence of water quality issues and policies, and the decisions and viewpoints of other producers" (p. 676).

Participation in educational programs may also influence adoption by altering economic and deterrent motivations. Feather and Amacher (1994) liken educational programs to "informational incentives" because they encourage adoption by revising producers' perceptions about the cost-effectiveness of new farming practices. Similarly, Bosch et al. (1995) suggest that provision of technical information can influence a farmer's perception of the value of practices, thereby improving the efficiency of their decisions about adoption, and increasing their profits. Winter and May (2002) argue that education can help lower compliance costs, which increases a firm's willingness to comply by altering cost-benefit ratios. Educational programs that focus on regulations also can influence deterrence motivations by altering perceptions about the likelihood of detection, severity of penalties, and risks of future regulation. By providing a rationale for required behavior changes, educational programs also have the potential to reduce reactance among those targeted by regulations (Lindenberg & Steg, 2007).

Despite the strong theoretical arguments in favor of educational programs having an influence over motivations and abilities and thus over behavior, empirical support is limited in several key ways. Many of the existing studies focus on the effects of more general exposure to information rather than the impact of participation in targeted training programs. For example, Feather and Amacher (1994) investigated the impact of BMP demonstration projects on adoption of practices on corn farms and found that farms in demonstration project areas were significantly more likely to adopt some practices but not others. Bosch et al. (1995) investigated the impacts of farming in designated educational program areas on adoption of nitrogen testing and use of nitrogen testing information as the primary way to make fertilizer application decisions. They found that farmers in these areas were less likely to adopt nitrogen testing than those in regulated areas, but those who did adopt voluntarily were more likely to use the information to make decisions. Caswell et al. (2001) found that receiving outside information on nutrient application from consultants, fertilizer companies, or extension agents was a significant factor in farmers' adoption of modern nutrient BMPs, but was less important for traditional practices.

Other studies investigate targeted training programs, but not in ways that measure the individual impact of these programs on adoption. For instance, Lubell and Fulton (2008) tested the joint impact of participation in training classes, reading brochures, attending meetings, speaking with representatives, and participating in committees on adoption of pest management practices among orchard growers in the Sacramento Valley. They found that the more of these activities a producer participated in the more likely they were to adopt some of the practices. However, because they lumped training together with other activities, it is not possible to discern the actual impact of training on adoption in their study. Lubell (2004) investigated participation in BMP training sessions as a component of the dependent variable in his study of the Suwannee River Partnership in Florida, a program that aims to reduce fertilizer runoff. Lubell focused on factors leading to participation in training rather than testing the impacts of training on other relevant behaviors, such as adoption of BMPs.

Another limitation in the literature is that most existing studies investigate only the direct effects of information or educational programs on adoption, failing to specify and test the motivations that may mediate this relationship. For example, Johnson and Napier (1998) found that producers in the Darby Creek watershed in Ohio who participated in an educational program to reduce fertilizer application were significantly more likely to adopt conservation practices than those who did not participate. Though it accounted for only three percent of the variance in adoption, participation in the program was the only significant variable identified in their model. However, the authors claim that the fact that their research was unable to determine why some producers in the watershed have chosen to adopt conservation practices and others have not is a major limitation of their project. An investigation of adoption motivations, particularly in the context of the educational program, might have helped answer this question.

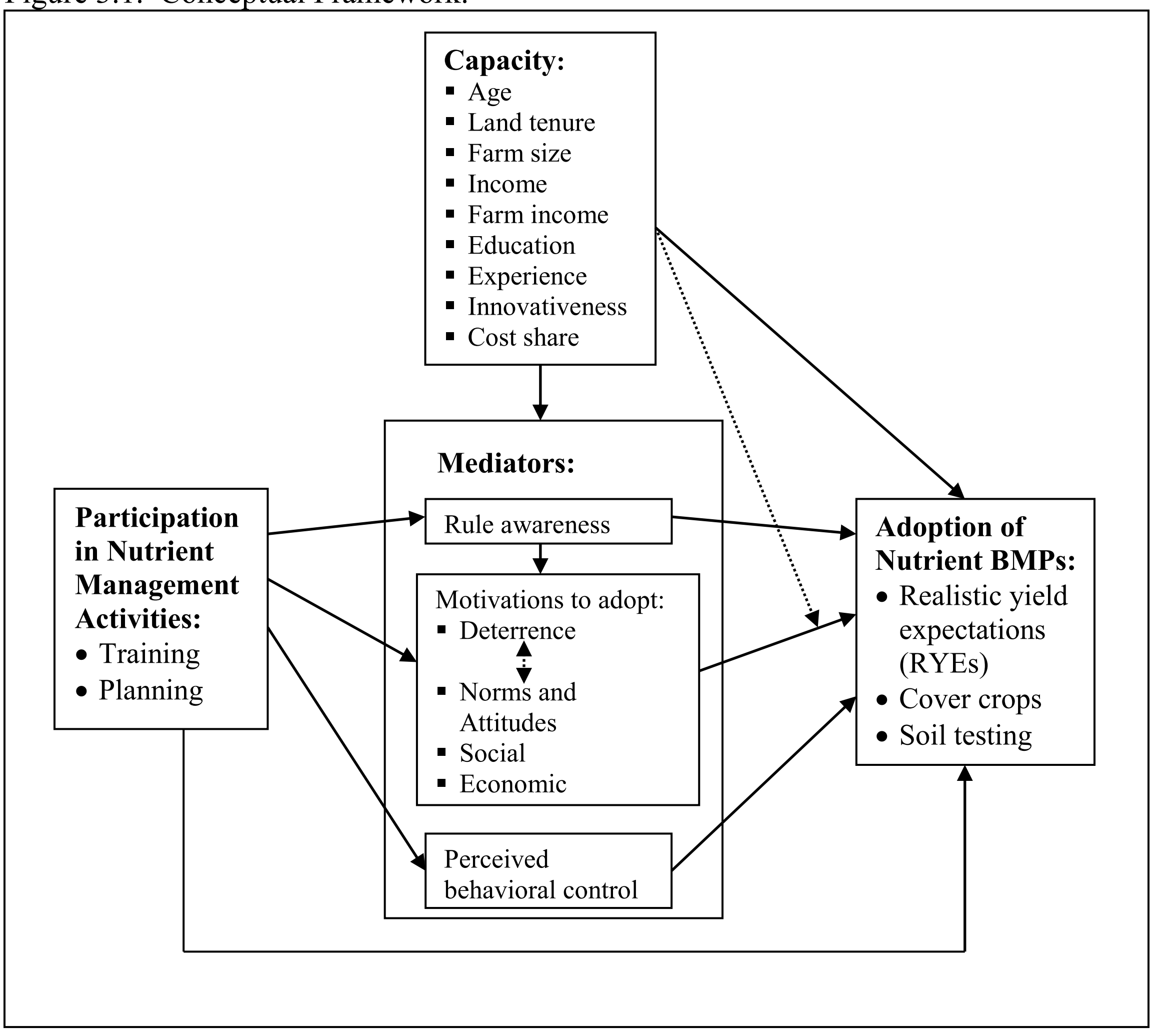
Winter and May (2001) write that "…we cannot identify a causal mechanism for directly connecting information to compliance" (p. 120). Instead, they argue that the influence of information on compliance is indirect. In their subsequent paper, Winter and May (2002) demonstrated these indirect effects in their investigation of the impact of different sources of information (i.e., professional, official, or informal) on rule awareness, duty to comply, and compliance with environmental rules among Danish farmers. They found that the source of information was not a significant factor in compliance, but did make a difference in rule awareness and duty to comply. In turn, they found that rule awareness and duty to comply positively affected compliance, and based on this, they argued that information indirectly affects compliance by influencing these factors. Though this evidence of information operating on behavior through motivations is preliminary and limited, it suggests that this is a ripe topic for future study.

CHAPTER 3: Research Model, Hypotheses, and Setting

3.1 Model Description

As seen in Figure 3.1, the conceptual framework employed by this dissertation starts with the basic structure of the theory of planned behavior and incorporates

Figure 3.1. Conceptual Framework.



additional factors and relationships that other relevant research traditions suggest may be important in the specific context of the Neuse Basin strategy. The dissertation proposes that there are two primary drivers of the use of nutrient BMPs: a person's relevant motivations and his or her capacity. The theory of planned behavior argues that social pressure and personal attitudes are the key motivators of behavior. This framework includes these factors, but also posits that several additional motivations may be relevant to behavior in this research setting. Because NPS water pollution is an environmental issue, personal norms are expected to influence behavior. Economic motivations should also be relevant given the potential for nutrient BMPs to affect production costs. Deterrent fears may also play a role in motivating agricultural producers to adopt nutrient BMPs because of the legal mandates in the Neuse Basin strategy.

The theory of planned behavior includes only one measure of capacity that may influence behavior, perceived behavioral control. This dissertation's framework includes this factor, but also includes measures of capacity that indicate the availability of tangible financial and intellectual resources for performing the behavior: age, land tenure, farm size, income, farm income, education level, farming experience, personal innovativeness, and receipt of cost share funding. These factors are important because producers may face practical constraints when adopting new practices. Both capacity and motivational factors are expected to have a direct influence on whether a producer adopts nutrient BMPs.

In addition to these motivation and capacity factors, this dissertation argues that a person's participation in one or both of the mandated nutrient management activities (i.e., nutrient management training or development of a nutrient management plan) will impact their use of nutrient BMPs. This influence may in part be direct, but it should largely be indirect, operating through the motivational factors, perceptions about adoption difficulty, and awareness of the nutrient management rules. In other words, these factors should mediate the relationship between participation in nutrient management activities and adoption of nutrient BMPs. This dissertation also posits that awareness of the nutrient management rules will, to some extent, mediate the influence of nutrient management activities on a person's adoption motivations.

The conceptual framework also suggests the possibility of interactions among some of the variables, which are indicated by dashed lines in the diagram. Specifically, deterrent fears and personal norms are likely to interact in their influence over practice use. Following the ABC model, adoption capacity and motivations are also likely to interact such that a person's capacity will moderate the influence of motivations on practice use.

3.2 Research Hypotheses

This dissertation will test a number of hypotheses that derive from the conceptual framework. These hypotheses focus on prediction of adoption of nutrient BMPs, prediction of the mediating variables, testing of mediation, and testing of interactions.

Prediction of nutrient BMP adoption:

- Hypothesis 1: Producers with different levels of capacity will have different levels of nutrient BMP adoption, ceteris paribus.

- Hypothesis 2: Producers with different levels of adoption motivations will have different levels of nutrient BMP adoption, ceteris paribus.
- Hypothesis 3: Producers with different perceptions about the difficulty of adopting nutrient BMPs will have different levels of adoption, ceteris paribus.
- Hypothesis 4: Producers with different levels of awareness of the relevant agricultural rules will have different levels of nutrient BMP adoption, ceteris paribus.
- Hypothesis 5: Producers with different levels of participation in the mandated nutrient management activities will have different levels of nutrient BMP adoption, ceteris paribus.

Prediction of mediators:

- Hypothesis 6: Producers with different levels of capacity will have different levels of awareness of the agricultural rules, ceteris paribus.
- Hypothesis 7: Producers with different levels of capacity will have different levels of adoption motivations, ceteris paribus.
- Hypothesis 8: Producers with different levels of capacity will have different perceptions about the difficulty of nutrient management, ceteris paribus.
- Hypothesis 9: Producers with different levels of awareness of the relevant agricultural rules will have different levels of adoption motivations, ceteris paribus.
- Hypothesis 10: Producers with different levels of participation in the mandated nutrient management activities will have different levels of adoption motivations, ceteris paribus.

- Hypothesis 11: Producers with different levels of participation in the mandated nutrient management activities will have different perceptions about the difficulty of nutrient management, ceteris paribus.
- Hypothesis 12: Producers with different levels of participation in the mandated nutrient management activities will have different levels of awareness of the agricultural rules, ceteris paribus.

Testing of mediation:

- Hypothesis 13: The impact of participation in the mandated nutrient management activities on adoption of nutrient BMPs is partially mediated by producers' awareness of the relevant agricultural rules, adoption motivations, and perceptions of adoption difficulty.

Testing of interactions:

- Hypothesis 14: If Hypotheses 1 and 2 hold, then the influence of a producer's motivations on adoption of nutrient BMPs is moderated by his or her adoption capacity.
- Hypothesis 15: If Hypothesis 2 holds for normative and deterrent motivations, then these motivations will interact in their influence on nutrient BMP adoption.

3.3 Research Setting and Data Sources

This dissertation focuses on agricultural producers in three counties in the Neuse River Basin: Wayne, Johnston, and Lenoir and two counties in the Tar-Pamlico River

Basin: Nash and Edgecombe. These counties were selected because they are geographically proximate, all located primarily in the Upper-Middle Coastal plain of the state (See Figure 1.1). They also share important agricultural features in terms of the amount of farm acreage and the types of crops grown. These counties are largely agricultural, with agriculture comprising from 38 to 59 percent of land use (U.S. Department of Agriculture [USDA] Census, 2007). Soybeans rank as the first or second most prevalent crop grown in each of the five counties in terms of acreage (USDA Census, 2007). Corn, wheat, cotton, and tobacco are also top crops in most of the counties (USDA Census, 2007). These similarities are meant to help to control for differences in these types of features that could affect the producers' adopted practices.

Data for this dissertation come from a survey conducted by trained interviewers from the North Carolina State University (NCSU) Center for Urban Affairs and Community Services in December 2005. The N.C. DWQ funded the survey to collect information about agricultural producers' use of nutrient BMPs in the middle Neuse Basin. The survey also sought to gauge producers' knowledge of the Neuse Basin strategy agricultural rules and to learn about their attitudes toward the rules, water quality issues, nutrient management training, and other topics. The author assisted Professors Thomas Hoban and William Clifford from the NCSU Department of Sociology and Anthropology in designing the survey, which was reviewed by a survey consultant at the University of North Carolina at Chapel Hill's Odum Institute. The survey consisted of questions about participation in nutrient management activities and the use of nutrient BMPs, Likert-type items to measure attitudes, and demographic questions. The survey instrument is attached as Appendix A.

Individual agricultural producers serve as the unit of analysis for the dissertation and all data related to these producers come directly from the survey. The survey data analyzed in this dissertation are anonymous, per Institutional Review Board requirements, and thus no additional details on the individual participants can be obtained.

The survey was conducted by telephone, with each interview lasting approximately 15 minutes. The sampling frame in the Neuse Basin consisted of all agricultural producers in Wayne County, Johnston County, and Lenoir County who had signed up for the local strategy option of the Agricultural Nitrogen Reduction Strategy Rule in 1998 and 1999. Approximately 100 completed interviews were obtained from farmers in each of the three counties, for a total of 315 completed surveys.

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 producers, two-thirds of the sampling frame was randomly selected, yielding 100 completed interviews. Because the data in the sampling frame were seven to eight years old when the survey was conducted, 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 percent This assumes that 30 percent of the cases of unknown eligibility were actually eligible to participate in the study. However, this assumption generates a response rate that is likely 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 percent This value divides the number of completed interviews by the number of completed interviews plus the number of refusals.

In addition to the 315 interviews completed in the three Neuse Basin counties, 100 telephone interviews were conducted in Edgecombe and Nash counties in the adjacent Tar-Pamlico River Basin. These interviews were conducted in order to collect data from producers who are operating under rules almost identical to those in the Neuse Basin, but who had not yet had the opportunity to participate in nutrient management training at the time of the survey. This sample was intended to function as a comparison group in order to assess more accurately the impacts of nutrient management training. The sampling frame for the Tar-Pamlico counties also consisted of producers who were signed up by the state under the relevant agricultural rules. In Edgecombe County, the whole sampling frame was used to complete 51 interviews and in Nash County, about two-thirds of the sampling frame was used to complete 49 interviews. Together, these counties had response rate of 71 percent and a cooperation rate of 84 percent. When all five counties are combined into one sample, a response rate of 74 percent and a cooperation rate of 86 percent were achieved.

CHAPTER 4: Study Variables and Research Methods

4.1 Study Variables and Measurement

This study investigates four groups of variables: variables that indicate adoption of nutrient BMPs; variables that quantify different aspects of adoption capacity; variables that indicate participation in nutrient management activities; and variables that measure potential mediators of the relationship between participation in nutrient management activities and adoption of nutrient BMPs. Descriptions of the variables in these four groups follow. Descriptive statistics of the variables are presented and discussed in Chapter 5.

4.1.1 Dependent Variables: Adoption of Nutrient BMPs

In the Neuse River Basin, there are five general types of BMPs approved for reducing nitrogen losses from cropland. Three of these are structural practices (i.e., riparian buffers, filter strips, and water control structures), where efficacy depends on site-specific conditions like drainage, slope, and soil type (Hardy et al., 2002). These practices are only applicable in certain landscapes. The other two BMPs, nutrient management and cover crops, are managerial practices that can be used anywhere, regardless of site-specific conditions. Nutrient management focuses on reducing nutrient pollution at its source by preventing the over-application of fertilizers. Cover crops help absorb excess nitrogen in the soil after fertilizers have been used. Adoption of these two universally-applicable practices is investigated in this dissertation.

In North Carolina, nutrient management targeted at nitrogen should be based on the use of realistic yield expectations ("RYEs"). RYEs estimate soil productivity either by averaging the best three crop yields of five seasons the same crop was grown or by using a statewide database that gives RYEs for different soil types (Hardy et al., 2002). RYEs are multiplied by nitrogen factors, which indicate the efficiency of different crops in converting nitrogen into yield, and by a slope/erosion factor to determine the total nitrogen fertilization rate that should be used. Nutrient management plans for nitrogen in the Neuse Basin are based on RYEs, but RYEs should guide fertilizer application decisions even without the use of a nutrient management plan. Nutrient management training focused extensively on why and how to use RYEs. Because both nutrient management plans and nutrient management training emphasize the importance of using RYEs, one would expect producers who have participated in these activities to use RYEs more than those who have not.

Using RYEs to determine nitrogen application rates helps reduce the amount of excess fertilizer applied to crops. However, this is only one side of the equation. Because most crops take up nitrogen from fertilizer inefficiently, up to half of the nitrogen applied can remain in the soil at the end of the growing season (Hardy et al., 2002). In North Carolina, this excess nitrogen is found primarily in the form of nitrate, which is highly water-soluble and can easily be transported via shallow ground water to nearby water bodies. Winter cereal cover crops (also called "scavenger" or "catch" crops) can help reduce the amount of this excess nitrogen available for transport. These cover crops are small grains (i.e., oats, wheat, rye, triticale, or barley) that are planted in the fall to absorb excess nitrogen from the soil. The crops are not harvested, but are killed in the spring and incorporated into the soil, typically as part of a conservation tillage system. For cover crops to receive nitrogen reduction credits under the Neuse Rules, they cannot be fertilized. Nutrient management training in the Neuse Basin briefly discussed the use of cover crops, but did not emphasize it as much as using RYEs. Thus, it is expected that participation in training should be less strongly related to adoption of cover crops than to adoption of RYEs. It is not expected that having a nutrient management plan will be significantly related to the use of unfertilized cover crops.

A third practice that can improve general fertilizer management, and thus reduce nutrient pollution, is soil testing. In some regions, soil testing is used to determine appropriate nitrogen application rates, but this is not the case in North Carolina, where residual nitrogen in the soil is unpredictable (Hardy et al., 2002). However, in North Carolina, soil test results are used to determine phosphorus and potassium applications in a nutrient management approach. Additionally, soil testing is important for determining soil pH, which can affect the ability of crops to take up nutrients efficiently. Soil testing is required to develop a nutrient management plan, and should be conducted regularly to update the plan. Soil testing was also addressed in nutrient management training. As such, it is expected that participation in one or both of these activities will be positively associated with soil testing.

This dissertation investigates three dichotomous dependent variables that indicate nutrient BMP adoption:

1. *RYEs*. This variable indicates whether respondents listed RYEs or state agency recommendations as one of the ways in which they determine their nitrogen application rates. Survey respondents who listed RYEs or state agency recommendations were coded “1” and those who did not include these on their list were coded “0.”
2. *Cover crops*. This dependent variable indicates whether or not respondents reported planting wheat, rye, triticale, oats, or barley as a cover crop and indicated that they did not apply any fertilizer to these crops.
3. *Soil tests*. This dependent variable indicates whether respondents reported testing their soil for nutrient content in the two years prior to the survey.

4.1.2 Capacity Variables

This study investigates the influence of numerous variables related to a producer’s capacity to adopt nutrient BMPs. These variables are hypothesized to influence adoption directly as well as indirectly by affecting producers’ relevant attitudes and motivations. The first set of capacity variables all relate to a producer’s financial resources and risk tolerance.

- *Farm size (ln)*. Farm size is measured in acres and includes all rented and owned farmland. The natural logarithm of each farm size value was taken to normalize the data. Logged farm size is a continuous variable that is expected to have a positive relationship with adoption. The square of this variable is also included in the study models to capture any potential nonlinearities in the relationship between farm size and adoption.

- *Income*. Total household income was initially recorded as falling into one of seven income ranges: less than $20,000, $20,001 to $40,000, $40,001 to $60,000, $60,001 to $80,000, $80,001 to $100,000, $100,001 to $200,000, and more than $200,000. For the analysis, each income range is set to its middle value. The lowest category has a value of $10,000 and the highest category is set to $300,000. The variable is treated as continuous, and is expected to have a positive relationship with adoption in this study.
- *Cost share for nutrient management*. This is a dichotomous indicator of whether a producer received cost share or other government funding for nutrient management in the five years prior to the survey. It is expected to have a positive relationship with the adoption of RYEs and soil testing.
- *Cost share for cover crops*. This dichotomous indicator measures whether a producer received cost share or other government funding for cover crops in the five years prior to the survey. It is expected to have a positive relationship with adoption of cover crops.

The next two variables relate to a producer's ability to obtain, understand, and apply information about nutrient BMPs.

- *Education.* The amount of education that producers had completed at the time of the survey was measured in three categories: 1.) Respondents who had completed high school or had less education (*high school*), 2.) Respondents who had completed some college education or obtained an Associate's degree (*some college*), or 3.) Respondents who had completed college or attended school beyond a college degree (*college graduate*). These variables are treated as dummies in the analysis with high school serving as the base category. It is expected that if education plays a role in adoption within the study sample, it will be positive.

- *Experience.* This continuous variable measures how many years the producer had been a farm operator at the time of the survey. As discussed in the literature review, farming experience could theoretically increase adoption by improving producers' ability to understand and use new practices or it could decrease adoption because more experienced producers may be resistant to changing their practices. It is unclear what association, if any, this variable will have with adoption in this study.

The remaining four variables relate to other aspects of capacity.

- *Age*. This continuous variable measures how old the producer was at the time of the survey. It is expected that if age is associated with adoption, the relationship will be negative.
- *Farm income*. This continuous variable measures the percentage of a producer's reported total household income derived from farming. It is expected that, if significant, this variable will have a positive relationship with adoption.
- *Rented land*. This continuous variable measures the percentage of a producer's farm acres that they rent rather than own. The likely association between this variable and adoption is not predictable.
- *Innovative*. This variable was constructed from a Likert-type survey item with five response categories. It measures respondents' level of agreement with the statement: "Among the farmers in my community, I am one of the first to try new practices." To

address small cell sizes, prior to analysis, the variable was recoded as dichotomous, comparing those who disagreed or neither agreed nor disagreed with the statement ("0") to those who agreed ("1"). Producers who agreed with this item are expected to have higher rates of nutrient BMP adoption.

4.1.3 Mediating Variables

This dissertation investigates a number of variables as potential mediators of the relationship between participation in nutrient management activities and the adoption nutrient BMPs in the study population. With the exception of rule awareness, all of these variables are constructed from Likert-type attitude items from the producer survey.

The first of these mediating variables is *rule awareness*, which measures how knowledgeable survey respondents were about the Neuse or Tar-Pamlico Rules at the time of the survey. The survey asked five true-false questions about the rules. This variable measures the number of those questions answered correctly, lumping respondents who gave only zero, one, or two correct answers into one group. It is a count variable that ranges from two to five and it is treated as categorical for the purposes of analysis. This variable is anticipated to be directly associated with BMP adoption, and also to mediate the relationships between participation in the nutrient management activities and both producers' adoption motivations and actual adoption behavior. The expected relationship between rule awareness and practice adoption is positive, but its relationship with specific adoption motivations is unknown.

The next set of mediating variables relates to the four different types of adoption motivations investigated in the dissertation. Economic motivation may play a significant role in encouraging the adoption of RYEs because of the potential cost-savings from using fertilizer more judiciously. Economic motivation for adoption is measured by a variable called *income impact*, which was created from responses to this survey item: "Would you say that using nutrient management decreases farm income, increases farm income, or doesn't really change farm income?" Producers who responded "decreases" or "doesn't really change" farm income were grouped together and coded "0" to create a dichotomous variable. Those who stated that nutrient management increases farm income (coded "1") are believed to have stronger economic motivations in favor of adoption and thus are expected to have higher rates of adoption of RYEs and soil testing. It is not expected that income impact will play a significant role in the adoption of cover crops because cover crops should not affect fertilizer costs.

As discussed in the literature review, social pressure may also play an important role in encouraging nutrient BMP adoption in the study population. Social motivation for adoption is measured by respondents' level of agreement with this item: "It is important that my community recognizes that I am doing the best I can to protect water quality." It is expected that producers who agree more strongly with this item will have stronger social motivations and will be more likely to use RYEs, cover crops, and soil testing. However, due to a highly skewed response distribution and small cell sizes, this survey item could not be tested as a stand-alone variable in the analyses. Instead, it was included in the factor analysis of the normative motivation items.

Normative motivations related to protecting water quality and complying with environmental regulations are also expected to play a role in nutrient BMP adoption in the study population. Normative motivations are measured with 11 survey items that focus on moral norms, legitimacy norms, and related attitudes. Details about these items and producers' responses to them are found in Appendix B. These 11 items plus the social motivation item underwent factor analysis to clarify how they relate to each other and to reduce the number of variables included in the study's statistical models. Exploratory factor analysis ("EFA") using principle axis factoring was employed to identify the common factors underlying the 12 survey items. Of the 12 items, two did not load sufficiently on any factors and thus were excluded from further analysis. After analyzing the ten remaining items, solutions with four and five factors were investigated. Both a screeplot and a lack of items loading on the fifth factor suggested that four factors were appropriate.[3] The resulting factor loadings were rotated using Promax to facilitate interpretation.[4] Oblique rotations such as Promax tend to be preferred by psychologists for analysis of behavioral characteristics because they allow for the possibility that the factors may be slightly related to each other (Child, 2006). The rotated factor loadings are provided in Table 4.1.

To double check the EFA results, confirmatory factor analysis ("CFA") was used to test how well the identified factor structure fit the data. The factors that had only two loading items could not be tested because they are unidentified in structural equation modeling. However, the two factors that each had three loading items were evaluated.

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[3]Principal component analysis of the same 10 survey items was consistent with these results. Principal component analysis resulted in four factors with eigenvalues greater than 1 and found the same items to load on each of the factors.

[4]The factor loadings were insensitive to the type of rotation used. Both oblique and orthogonal rotations identified the same items loading on each of the four factors.

Table 4.1. EFA Factor Loadings Using Principal Axis Factoring and Promax Rotation.

Item	Factor 1 Attitude	Factor 2 Norm	Factor 3 External	Factor 4 Denial
Protectwater		0.451		
Regulated		0.417		
Rightthing				0.358
Waterrating				0.311
Reasonable	0.417			
Improvewater	0.512			
Nmimpact	0.414			
Community			0.395	
Duty			0.339	
Unfair			0.435	

Note: Only loading factors greater than 0.3 are shown.

Though these two factors were perfectly identified and thus resulted in fit statistics that were not useful, the results indicated that the items for each factor do measure the same underlying construct. As shown in Table 4.2, for each of these factors, the factor loading estimates and R^2 values are significant at the .01 level or better.

Table 4.2. CFA Factor Loadings and R^2 Estimates.

Variables and Survey Items	Standardized Factor Loading Estimates (standard error)	Two-Tailed P-value	R^2 Estimates	Two-Tailed P-value
Attitude				
Reasonable	0.446 (.079)	0.000	0.198	0.005
Improvewater	0.533 (.087)	0.000	0.284	0.002
Nmimpact	0.566 (.090)	0.000	0.321	0.002
External				
Community	0.602 (.102)	0.000	0.362	0.003
Duty	0.489 (.092)	0.000	0.239	0.008
Unfair	0.640 (.105)	0.000	0.410	0.002

The results of the EFA were used to create four new study variables: *attitude*, *norm*, *external*, and *denial*. The variables were created by averaging across the particular items that loaded on each of the four factors, and are treated as continuous in subsequent analyses.

Three items loaded on *attitude*: "Current regulations to protect water quality in the Neuse River are reasonable" (Reasonable), "The regulations targeting farmers in the Neuse River Basin are improving water quality" (Improvewater), and "Using nutrient management significantly reduces the impact of agriculture on water quality" (Nmimpact). Based on these items, attitude is interpreted as measuring respondents' attitudes concerning the Neuse/Tar-Pamlico water quality regulations and their impact. This variable corresponds well to two of the particular attitude concepts discussed in the literature: attitudes concerning regulations and outcome expectations, and is expected to be positively associated with adoption.

Two items comprise the variable *norm*: "Land should be farmed in ways that protect water quality even if this means lower profits" (Protectwater) and "Agriculture should be regulated for its environmental impacts just like any other industry" (Regulated). Norm measures the extent to which producers in the survey possess an internalized moral obligation or sense of duty to protect the environment and water quality and is expected to be positively related to practice adoption.

The third variable, *external*, contains three items: "It is important that my community recognizes that I am doing the best I can to protect water quality" (Community), "I have a duty to follow environmental regulations even if I disagree with them" (Duty), and "Regulators are unfairly targeting agriculture when other groups that pollute the Neuse River are not being held accountable" (Unfair). External measures a respondent's sense of obligation to act to protect water quality that comes strictly from external sources such as the community and government legitimacy and is actually contrary to their own attitudes about the regulations requiring that action. It is consistent with the concept of social pressure or subjective norm found in the theory of planned behavior and its expected relationship with adoption is unknown.

The final variable, *denial*, is made up of two items: "Most people will do the right thing for the Neuse River on their own without more government regulations" (Rightthing) and "How would you rate the quality in the Neuse River? Would you say it is poor, fair, good, or excellent?" (Waterrating). These items indicate that respondents are in denial that there is a water quality problem and that government regulations are needed to spur action to protect the rivers. Denial reflects beliefs that are expected to impede adoption of BMPs.

Given the Neuse Basin strategy's inclusion of nutrient management activity mandates, deterrence motivations are the most important set of mediating variables investigated in this dissertation. Deterrent motivations are expected to influence adoption in the study population, but given the open debate in the literature on whether regulatory approaches create backlash, it is not clear whether deterrent motivations will have a positive or negative relationship with adoption. Three survey items measure deterrent motivations: "If current nutrient management regulations in the Neuse River Basin don't work, stricter regulations will likely follow," "The government is not very likely to inspect my nutrient management practices" (reversed), and ("If I do not comply with nutrient management rules, I expect to be penalized." These items relate to a fear of stricter regulations, a fear of inspections, and a fear of penalties respectively.

EFA was used to help determine whether the three items all measure the same construct or whether it would be more appropriate to include them as separate motivations. Results pointed to a one-factor solution that had only two of the items loading on it. These results could not be tested with CFA because the model was unidentified. However, because these three deterrence-related fears have been treated separately in previous literature, they are left as stand-alone motivations in subsequent analyses.

Fear of stricter regulations is an ordered categorical variable with three levels: disagree or neither agree nor disagree (coded "2"), agree (coded "4"), and strongly agree (coded "5"). *Fear of inspection* is a dichotomous variable with those who agreed or strongly agreed that they were <u>not</u> likely to be inspected coded "0" and those who did not agree or did not agree or disagree with the item coded "1." *Fear of penalties* is a dichotomous variable with those who disagreed or did not agree or disagree that they were likely to be penalized coded "0" and those who agreed or strongly agreed coded "1."

The final mediating variable investigated in this dissertation is *perceived control*. Perceived control is measured with two survey items: "Using more nutrient management practices on my farm would require too many changes" (reversed) and "Developing a nutrient management plan is easy for my type of farm." Responses to these two items were averaged and the resulting variable is treated as continuous in the analyses. Those who perceive adoption to be less difficult are expected to have higher rates of adoption.

4.1.4 Activity Variables

This study tests the relationships between participation in two different mandated nutrient management activities (i.e., nutrient management training and nutrient management planning) and producers' motivations; rule awareness; perceptions of adoption difficulty; and use of RYEs, cover crops, and soil testing. Agricultural producers in the Neuse Basin who apply fertilizers to or manage 50 or more acres of cropland per year were required to develop a nutrient management plan or participate in nutrient management training by December 2002. Producers in the Tar-Pamlico River Basin were required to complete one of these activities by April 2006. Nutrient management training was offered in the Neuse River Basin counties between 2000 and 2002, but was not offered in the Tar-Pamlico River Basin counties until after completion of this survey. In order to help create comparison groups for those who had completed training in the Neuse Basin, survey respondents in the Tar-Pamlico counties were asked if they intended to participate in training once it was offered. To allow for comparisons among different levels of participation in the nutrient management activities, six dummy variables are used in the data analysis:

1. *Nutrient plan*. This activity variable indicates whether or not the respondent had developed a nutrient management plan only. This indicator was developed based on responses to three survey questions. First the respondent must have reported having a written nutrient management plan for the cropland they cultivate. Second, the respondent must have indicated that their nutrient management plan had been reviewed by a government representative or Extension agent. This helps ensure that only the adoption of officially-sanctioned nutrient management plans is counted.

Third, they must have indicated that they did not participate in nutrient management training in the Neuse River Basin or did not intend to participate in training when it was offered in the Tar-Pamlico Basin.

2. *Train only*. This variable indicates whether or not the respondent participated in one of the nutrient management training workshops offered by the Extension Service. This indicator applies to those respondents who participated in training only, not to those who also developed a nutrient management plan. This variable includes producers in the Neuse Basin only, since training had not been offered in the Tar-Pamlico Basin at the time of the survey.
3. *Both activities*. This variable indicates respondents in the Neuse Basin who had both participated in nutrient management training and developed a nutrient management plan that had been reviewed by a government representative or Extension agent.
4. *Intend to train*. This variable indicates producers in the Tar-Pamlico Basin counties who had not developed a nutrient management plan, but indicated that they intended to participate in nutrient management training when it was offered. The producers in this group are meant to serve as a control group to compare to those who have completed training only in the Neuse Basin.
5. *Intend to do both*. This variable indicates producers in the Tar-Pamlico Basin who had developed nutrient management plans and also stated that they intended to participate in nutrient management training. This group serves as a comparison group for those in the Neuse Basin who had completed both planning and training. It is meant to help isolate the impacts of completing training in addition to developing a plan.

6. *No activities*. This variable indicates producers in the Neuse Basin who had not participated in either activity and producers in the Tar-Pamlico Basin who did not have a nutrient management plan and stated that they did not intend to participate in nutrient management training.

4.2 Statistical Analyses

Data analysis in the dissertation proceeds in four stages. First, summary statistics of the study variables are used to describe the demographic characteristics of study participants as well as their reported activities and attitudes. Second, the demographic characteristics of producers participating in different nutrient management activities are compared. Activity participation among producers with different sized farms is investigated to generate a measure of general levels of compliance with the Neuse and Tar-Pamlico Nutrient Management Rules in the study counties. ANOVA test results are also presented to identify significant demographic differences among producers in the six activity groups. The ANOVA results are intended to help program managers more effectively target future outreach and education efforts.

Third, bivariate relationships between the study variables are tested. Correlations are tested among the capacity variables and among the mediating variables. Relationships between the dependent and independent variables are tested with the same types of regression analyses utilized in the multivariate models, with the type of analysis depending on the measurement scale of the dependent variable. Results of the bivariate regression models are provided in Appendix C.

Fourth, the dissertation evaluates a series of multivariate statistical models to test the study's main hypotheses. Models with continuous dependent variables are tested using OLS regression, whereas those with categorical dependent variables are tested with either logistic, ordered logistic, or multinomial logistic regression analysis. Models with dichotomous dependent variables utilize logistic regression, those with dependent variables that consist of ordered categories use ordered logistic regression, and those that do not meet the parallel slopes assumption of the ordered logistic regression model utilize multinomial regression analysis. These approaches overcome problems associated with using OLS regression for noncontinuous dependent variables, including violations of basic model assumptions (Long, 1997).

In all of the models tested, several dummy variables are included. To test the influence of education, both *college graduate* and *some college* are compared to the base case of *high school*. To test the influence of unknown factors associated with farming in a particular county, dummy variables for the five counties are included. Edgecombe is used as the base case in the main models. For nutrient management activity participation, *intend to train*, *both activities*, *intend to do both*, *nutrient plan*, and *no activities* are compared to the base case of *train only*. Using train only as the base case allows for direct comparisons to be made between those who trained only and those who intended to train only, which lends this aspect of the dissertation a quasi-experimental structure. For each set of dummy variables, any additional statistically significant comparisons are described in the discussion section for each model.

The following model tests Hypotheses 1, 2, 3, 4, and 5. This model uses logistic regression analysis to identify factors that have a significant direct relationship with the adoption of RYEs, cover crops, and soil testing.[5] The specific variables included in each vector are listed in Table 4.3.

$$Ln\ (P_{RYEs}/1\text{-}P_{RYEs}) = B_0 + B_{1\text{-}12}CAPACITY + B_{13\text{-}22}MEDIATORS + B_{23\text{-}26}COUNTIES + B_{27\text{-}31}ACTIVITIES$$

The following model tests Hypotheses 7, 8, 9, 10, and 11, identifying factors that have a significant relationship with the study's potential mediators. Factors associated with fear of penalties, fear of inspection, and income impact are all tested utilizing logistic regression:

$$Ln\ (P_{MEDIATOR}/1 - P_{MEDIATOR}) = B_0 + B_{1\text{-}12}CAPACITY + B_{13}AWARE + B_{23\text{-}26}COUNTIES + B_{27\text{-}31}ACTIVITIES$$

Tests of the factors associated with the potential mediators: attitude, norm, external, denial, and perceived control utilize OLS regression:

$$MEDIATOR = B_0 + B_{1\text{-}12}CAPACITY + B_{13}AWARE + B_{23\text{-}26}COUNTIES + B_{27\text{-}31}ACTIVITIES + e$$

Factors associated with fear of stricter regulations are tested with multinomial logistic regression.[6] This model uses those who responded strongly disagree, disagree, or neither agree nor disagree (coded "2") as the base case.

$$Ln[Pr(4|x)/Pr(2|x)] = B_{0,\ 4|2} + B_{1\text{-}12,\ 4|2}CAPACITY + B_{13,\ 4|2}AWARE + B_{23\text{-}26,\ 4|2}COUNTIES + B_{27\text{-}31,\ 4|2}ACTIVITIES$$

$$Ln[Pr(5|x)/Pr(2|x)] = B_{0,\ 5|2} + B_{1\text{-}12,\ 5|2}CAPACITY + B_{13,\ 5|2}AWARE + B_{23\text{-}26,\ 5|2}COUNTIES + B_{27\text{-}31,\ 5|2}ACTIVITIES$$

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[5]When testing cover crops, the left side of the equation is Ln ($P_{CVRCROP}/1\text{-}P_{CVRCROP}$) and when testing soil testing, it is Ln ($P_{SOILTEST}/1\text{-}P_{SOILTEST}$).

[6]Multinomial logistic regression analysis is used because the model does not meet the parallel slopes assumption of the ordered logistic model.

Table 4.3. Variables Planned for Inclusion in Study Models.

Variables[c]		Model Number[a,b]									
		1	2	3	4	5	6	7	8	9	10
***Capacity*:**	1. Rent	x	x	x	x	x	x	x	x	x	x
	2. Age	x	x	x	x	x	x	x	x	x	x
	3. Farm size (ln)	x	x	x	x	x	x	x	x	x	x
	4. Farm size sq. (ln)	x	x	x	x	x	x	x	x	x	x
	5. Income	x	x	x	x	x	x	x	x	x	x
	6. Farm income	x	x	x	x	x	x	x	x	x	x
	7. Experience	x	x	x	x	x	x	x	x	x	x
	8. Some college	x	x	x	x	x	x	x	x	x	x
	9. College graduate	x	x	x	x	x	x	x	x	x	x
	10. Innovativeness	x	x	x	x	x	x	x	x	x	x
	11. Cost share cover crops	x	x	x	x	x		x	x	x	x
	12. Cost share nutrient mngt.	x	x	x	x	x		x	x	x	x
***Mediators*:**	13. Rule awareness	x	x	x	x	x		x	x	x	x
	14. Income impact	x	x	x							
	15. Attitude	x	x	x							
	16. Norm	x	x	x							
	17. External	x	x	x							
	18. Denial	x	x	x							
	19. Fear of penalties	x	x	x							
	20. Fear of inspection	x	x	x							
	21. Fear of stricter regulation	x	x	x							
	22. Perceived control	x	x	x							
***Counties*:**[d]	23. Johnston	x	x	x	x	x	x	x	x	x	x
	24. Lenoir	x	x	x	x	x	x	x	x	x	x
	25. Nash	x	x	x	x	x	x	x	x	x	x
	26. Wayne	x	x	x	x	x	x	x	x	x	x
***Activities*:**[e]	27. Intend to train	x	x	x	x	x	x	x	x	x	x
	28. Both activities	x	x	x	x	x	x	x	x	x	x
	29. Intend to do both	x	x	x	x	x	x	x	x	x	x
	30. Nutrient plan	x	x	x	x	x	x	x	x	x	x
	31. No activities	x	x	x	x	x	x	x	x	x	x

Notes: [a] Dependent Variables: 1= RYEs, 2 = Cover Crops, 3 = Soil Tests, 4 = Fear of Inspections, 5 = Fear of Stricter Regulations, 6 = Rule Awareness, 7 = External, 8 = Denial, 9 = Perceived Control, 10 = Income Impact. [b] Models for Attitude, Norm, and Fear of Penalties ultimately were not included in the analysis because they were found to be statistically nonsignificant. [c] The variables rent, income impact, norm, attitude, external, denial, and perceived control ultimately were excluded from the tested models due to a lack of statistical significance. [d] County dummy variables are compared to the base: Edgecombe County. [e] Activity group dummy variables are compared to the base: Train.

Hypotheses 6 and 12 are tested with the following model, using ordered logistic regression to identify factors significantly associated with producers' awareness of the nutrient management rules. This variable has four categories, and thus the model estimates three equations:

$Ln\ (P_{AWARE\_2}/1\text{-}P_{AWARE\_3+4+5}) = B_0 + B_{1\text{-}10}CAPACITY + B_{23\text{-}26}COUNTIES + B_{27\text{-}31}ACTIVITIES$

$Ln\ (P_{AWARE\_2+3}/1\text{-}P_{AWARE\_4+5}) = B_0 + B_{1\text{-}10}CAPACITY + B_{23\text{-}26}COUNTIES + B_{27\text{-}31}ACTIVITIES$

$Ln\ (P_{AWARE\_2+3+4}/1\text{-}P_{AWARE\_5}) = B_0 + B_{1\text{-}10}CAPACITY + B_{23\text{-}26}COUNTIES + B_{27\text{-}31}ACTIVITIES$

In order to test for the mediation effects predicted in Hypothesis 13, the dissertation utilizes Mplus statistical software. Tests of mediation effects rely on the products of coefficients approach, which is found to be the most accurate for models with categorical outcomes (MacKinnon, 2008). The effect estimate generated through this approach indicates how much a one unit change in X affects Y through its influence on the mediator of interest. Standard errors and confidence limits for identified mediation effects are obtained using bootstrapping.

Based on the results of the preceding models, additional models will test Hypotheses 14 and 15, which predict interactions among key variables. If any capacity factors and motivational factors are found to have a significant relationship with practice adoption, the following general model will test for interactions among the significant factors:

$Ln\ (P_{RYEs}/1\text{-}P_{RYEs}) = B_0 + CAPACITY + MOTIVATIONS + CAPACITY*MOTIVATION + B_{13}AWARE + B_{23\text{-}26}COUNTIES + B_{27\text{-}31}ACTIVITIES$

Similarly, if any of the deterrence motivations (fear of inspection, fear of stricter regulation, or fear of penalties) and any of the normative motivations (attitude, norm, external, or denial) are found to have significant relationships with practice adoption, the following general model will test for interactions among these factors:

$$Ln\ (P_{RYEs}/1\text{-}P_{RYEs}) = B_0 + B_{1\text{-}12}CAPACITY + B_{13}AWARE + NORMATIVE + DETERRENCE + NORMATIVE*DETERRENCE + B_{23\text{-}26}COUNTIES + B_{27\text{-}31}ACTIVITIES$$

4.3 Threats to the Validity of Inferences

In any study, it is important to anticipate and, to the extent possible, address potential threats to the validity of causal inferences drawn from its results. Shadish, Cook, and Campbell (2002) sort these threats into four categories: statistical conclusion validity, internal validity, construct validity, and external validity. The following discussion highlights the validity threats believed to be most plausible in this dissertation, describes steps taken to address these threats, and, where possible, identifies the likely impact of the threats to the study's conclusions.

Statistical conclusion validity concerns inferences about whether study treatments and outcomes covary and the strength of their relationship (Shadish et al., 2002). Despite the dissertation's sample size of 415, statistical power may be an issue in testing some models. Three steps are taken to help increase power. First, survey respondents were drawn from five counties that share many features that may be relevant to adoption of farming practices including climate, physiographic region, farming economy, and crop types. By limiting the survey to these areas, these features do not need to be controlled in the statistical models. Second, the models include covariates that could influence practice adoption, such as farm and producer characteristics, which should increase power (Shadish et al., 2002). Finally, the survey data were checked for outliers and the impacts of the identified outliers on statistical conclusions were assessed. If any models in the dissertation prove to be underpowered despite these measures, the likely effect will be that they will incorrectly conclude that the relationship between treatment and outcome is insignificant (Shadish et al., 2002).

Internal validity concerns whether any identified covariance between treatments and outcomes reflects a causal relationship (Shadish et al., 2002). Two internal validity threats are potentially important, temporal precedence and selection. Establishing temporal precedence can be difficult in cross-sectional studies where all study variables are measured simultaneously. However, in this study, both the timing of the survey and theory help to diminish the plausibility of this threat. Nutrient management training was offered in the Neuse Basin counties between 2000 and 2002 and producers in the Basin were required to develop their nutrient management plans by December 2002. The survey was conducted in December, 2005, several years after the completion of these activities. As such, the treatments (training and planning) clearly took place prior to the measurement of the attitudes and use of nutrient BMPs. Additionally, as outlined in the literature review, there are strong theories and empirical data supporting the argument that the motivations under study in this dissertation influence environmentally-responsible behaviors, such as adoption of BMPs. Though it is possible that there is some feedback from adoption to attitudes based on producers' experiences with the practices, the predominant influence should be from attitudes to adoption.

Selection is a concern in this dissertation because producers chose the nutrient management activities in which they participated. It is probable that the producers who chose to participate in training were different from those who either chose to develop nutrient management plans, chose to do both, or chose to do nothing. Two approaches will be used to help address this threat. First, the statistical models control for covariates that could be related to selection into the different activities, primarily characteristics of the farm and producer. Second, the study uses control groups (i.e., the intend to train group and the intend to do both group) that should be very similar to the treatment groups on any unknown factors leading to selection into different treatments. The relatively high response rate in the survey of 74 percent diminishes the potential validity threat that those who chose to participate in the survey could be systematically different from those who did not.

Construct validity refers to how higher order constructs related to people, settings, treatments, and observations in a study are measured and how well the measures match the actual constructs (Shadish et al., 2002). Three potential construct validity threats are significant in this study: mono-operation bias, mono-method bias, and treatment diffusion. Mono-operation bias stems from using only one measure, or "operationalization" of a construct. Using only one measure can simultaneously fail to capture all aspects of the construct and include irrelevant constructs (Shadish et al., 2002). For most constructs in the study, such as age or participation in training, one measure is appropriate. For the motivation constructs, multiple measures would have been ideal, but were not possible in all cases due to strict survey length limitations. In mediation analysis, the impact of measurement error is to attenuate the mediated effect estimates (MacKinnon, 2008). Thus, any bias from mono-operation bias should be to underestimate the role of the mediating variables.

Mono-method bias may exist in this study because all of the data come from the survey. Accordingly, what is actually studied in this dissertation is “self-reported” activity participation, attitudes, and adoption behavior, which could differ from more objective measures. Treatment diffusion may also be a factor in this study. Even though producers in the Tar-Pamlico River Basin did not have access to nutrient management training prior to implementation of the survey, it is possible that they were exposed to information from the training informally through contacts with Extension agents and other producers who had participated in the Neuse Basin. Exposure to this information by participants in the study’s control groups could have the effect of reducing the size and significance of any relationship found between participation in training and adoption of nutrient BMPs.

External validity concerns inferences about the extent to which the size and direction of causal relationships between treatments and outcomes are consistent over different people, settings, treatments, and outcomes (Shadish et al., 2002). The goal of the dissertation is to evaluate the impacts of one particular type of agricultural NPS policy on producers’ motivations and adoption of three specific practices. It does not attempt to generalize these results to other types of policies that may be very different in nature or contain different incentives and disincentives for adoption. Findings from this study will directly pertain only to the particular policies and training and planning activities that occurred in the Neuse Basin and to the particular nutrient BMPs investigated. However, investigating three different BMPs that are expected to be influenced to varying degrees by training and planning provides much more information about Neuse Basin strategy's impacts than investigating just one. It is also important to note that the study sample was not a random sample of all producers in these counties, but rather those who had signed up under the Neuse Basin and Tar-Pamlico Basin rules. The average farm size in this sample is larger than that found in the agricultural census. While use of this sampling frame precludes drawing inferences about all producers in the counties, it facilitates a focus on those farm operations most targeted by the agricultural rules in the two basins.

CHAPTER 5: Results and Discussion of Summary Statistics

In order to begin evaluating the impacts of the Neuse Basin strategy's agricultural mandates on producers' behavior, this chapter presents descriptive statistics, data on rates of compliance with the Nutrient Management Rule and information on the characteristics of producers who participated in the different mandated activities.

5.1 Descriptive Statistics

5.1.1 Dependent Variables: Adoption of Nutrient BMPs

Table 5.1. Adoption of Nutrient BMPs.

Practice	Using	Not Using	Total
RYEs	47 11.3%	368 88.7%	415 100%
Cover crops	146 35.2%	269 64.8%	415 100%
Soil tests	341 82.2%	74 17.8%	415 100%

As shown in Table 5.1, use of the three nutrient BMPs was highly variable in the study population. Despite the fact that producers are supposed to use RYEs to determine their nitrogen application rates, only 11.3 percent of the respondents reported using RYEs or government recommendations for this purpose. This suggests that the overall Neuse and Tar-Pamlico programs have not been very successful in encouraging use of this practice. Not surprisingly, the majority of producers (82.2 percent) reported having used soil tests in the two years prior to the survey. This simple practice has been widely promoted among agricultural producers in general, not just in the Neuse and Tar-Pamlico basin programs. Interestingly, a sizeable portion (35.2 percent) of respondents reported using unfertilized cover crops. The basin programs are likely responsible for some of the use of this practice since its benefits to individual producers are less direct and tend to be far off in the future.

5.1.2 Capacity Variables

Table 5.2. Summary Statistics for Continuous Capacity Variables.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Skewness
Age (years)	415	55.8	11.7	24	84	-0.05
Rented land (% of farmland rented)	415	47.2	38.6	0	100	-0.04
Farm size (acres)	415	676	899	5	6,500	2.54
Income ($1,000)	371	117	94	10	300	1.08
Farm income (%)	393	63.3	35.7	0	100	-0.43
Experience (years)	415	29.1	12.6	2	63	0.13

As seen in Table 5.2, the age of producers in the sample averaged 55.8 years. Only 9.4 percent were 40 years old or younger. 34.0 percent of respondents were over 60 years old. If age is found to be predictive of adoption behavior in this study, the fact that so many of the producers are at or near retirement age could have important implications for the use of nutrient BMPs in the future.

The percentage of farmland that is rented rather than owned has an inverted distribution, with peaks at the extreme ends of the scale. 28.4 percent of respondents owned all of the land they cultivated and 11.1 percent rented all of their land. The remaining 60.5 percent had a mix of rented and owned land, with a mean of 47.2 percent rented.

The size of farms in the study sample varied widely. More than one-quarter of the sample (27.5 percent) consists of farms 100 acres or smaller. The majority of farms in the sample (62.4 percent) were 500 acres or smaller. Only 31 of the 415 farms (7.5 percent) were over 2,000 acres in size.

Producers in the sample were fairly evenly distributed among the income categories. 18.9 percent of those who responded earned $40,000 or less and 18.1 percent earned more than $200,000, with the remaining 63 percent falling in the middle.

The percentage of household income that derives from farming had a mean of 63.3 percent. This indicates that for most producers in the sample, farming is their primary profession. Over 31 percent of respondents earned all of their income from farming, whereas only 15 percent earned 10 percent or less of their income from farming.

The number of years of farming experience in the study sample tended to be high, averaging 29.1 years. 15.7 percent of the sample had more than 40 years of farming experience, whereas only 9.9 percent had ten years or less experience.

In the study sample, a plurality of respondents (43.0 percent) had completed high school or less education. However, a large proportion (24.0 percent) had obtained a college degree or attended graduate school.

Producers in the sample who perceived themselves to be innovative by agreeing with the statement: "Among the farmers in my community, I am one of the first to try new practices" slightly outnumbered those who did not. 55.5 percent agreed or strongly agreed that they are among the first to try new practices. 38.5 percent either disagreed or strongly disagreed with the statement. The remaining 6.0 percent did not agree or disagree.

Table 5.3. Distributions of Categorical Capacity Variables.

Variables	Frequency	Percent
Level of education completed		
High school or less	177	43.0%
Some college or Associates degree	136	33.0%
College degree or higher	99	24.0%
Total	412	100%
Innovativeness		
Strongly disagree	3	0.7%
Disagree	157	37.8%
Neither agree nor disagree	25	6.0%
Agree	204	49.2%
Strongly agree	26	6.3%
Total	415	100%
Cost share for cover crops		
Received	40	9.6%
Did not receive	375	90.4%
Total	415	100%
Cost share for nutrient management		
Received	48	11.6%
Did not receive	367	88.4%
Total	415	100%

Table 5.3 shows that relatively few respondents had received cost share or other government funding for cover crops (9.6 percent) or nutrient management (11.6 percent) in the five years prior to the survey. Because this type of funding is not wide-spread despite the intensive efforts in these basins to encourage these practices, it is critical to investigate the role of other motivations for practice adoption in the study sample.

To understand how the study's capacity variables interrelate, pairwise correlation coefficients were obtained. As indicated in Table 5.4, statistically significant correlations

Table 5.4. Pairwise Correlation Coefficients for Capacity Variables.

	Age	**Rented land**	**Farm size**	**Income**	**Farm income**	**Education**	**Cost share for cover crops**
Rented land	-0.300 (415)						
Farm size	-0.232 (415)	0.320 (415)					
Income	-0.113 (371)	0.114 (371)	0.333 (371)				
Farm income	-0.143 (393)	0.296 (393)	0.317 (393)	0.379 (370)			
Education	-0.139 (412)				-0.122 (392)		
Experience	0.701 (415)	-0.099 (415)				-0.228 (412)	
Innovative			0.148 (415)	0.164 (371)	0.14 (393)	0.105 (412)	
Cost share cover crops			0.223 (415)		0.111 (393)		
Cost share nutrient mgt.	-0.159 (415)	0.178 (415)	0.169 (415)		0.114 (393)		0.214 (415)

Notes: 1. Only correlations significant at the .05 level or less are shown.
2. The numbers of observations for each pairwise correlation are in parentheses.

exist among many of the demographic variables. Among the 26 statistically significant correlations, 15 are weak (i.e., less than .200), ten are moderate (i.e., .200 to .399), and only one is strong (i.e., .400 or larger). The correlations reveal that older farmers tend to be more experienced, but also less professional than younger farmers in the sample. Older farmers tend to rent less of their land, have smaller operations, earn less money, earn a smaller proportion of their income from farming, have less education, and be less likely to obtain cost share for nutrient management. The correlations also suggest that those for whom farming is the primary profession (as indicated by high farm incomes) tended to be younger, rent more of their land, have larger farms and higher incomes, perceive themselves to be more innovative, and have cost share funding. However, these producers also had lower levels of education, which may reflect that those with higher levels of education choose alternative primary occupations. It is also notable that producers in the sample who perceived themselves to be innovative tended to have larger farms, more income, more farm income, and more education than those who did not perceive themselves that way. These producers likely have a higher tolerance for the risks of trying new practices.

5.1.3 Mediating Variables

Table 5.5. Summary Statistics for Continuous Mediating Variables.

Variable	Obs.	Mean	Mode	Std. Dev.	Min.	Max.	Skewness
Attitude	415	3.62	4	0.57	2	4.33	-1.15
Norm	415	3.38	4	0.70	2	4	-0.67
External	415	4.21	4	0.47	2.67	5	-0.67
Denial	415	2.99	3	0.83	1.50	4.50	-0.05
Perceived control	415	3.43	4	0.73	1.50	5	-0.42

The four normative motivation variables: attitude, norm, external, and denial, all had a possible maximum value of five and a minimum value of one. A score of five indicates that a respondent agreed strongly with each of the items used to construct the variable. A score of one indicates that a respondent strongly disagreed with each item. A score of three indicates that, on average, a respondent neither agreed nor disagreed with the component items.

The high mean score (3.62) and small standard deviation (0.57) for attitude found in Table 5.5 show that most respondents had positive feelings about the Neuse and Tar-Pamlico rules and their impacts. The mean score of 3.38 for norm indicates that on average, respondents tended to feel some sense of internalized moral obligation to protect water quality and the environment, though the standard deviation of 0.70 shows that some respondents did not. With a mean of 4.21 and a standard deviation of 0.47 for external, the vast majority of respondents reported feeling a sense of community pressure and obligation to follow the regulations despite believing that they are unfair. These results suggest that the first three normative motivations could be encouraging adoption of nutrient BMPs among producers in the study sample. The variable denial has a mean of 2.99 and a mode of 3, indicating that, on average, the respondents were either split on whether they believe there is a water quality problem and that government intervention is needed to spur action or were indifferent.

Perceived control has a mean of 3.43 and a standard deviation of 0.73 indicating that most respondents do not perceive nutrient management activities to be very difficult. This suggests that perceptions about difficulty should not be a barrier for adopting nutrient management practices for most producers.

As seen in Table 5.6, out of five possible correct answers concerning the Neuse and Tar-Pamlico rules, a plurality of respondents (35.4 percent) were only able to answer two questions correctly. 4.3 percent were not able to answer any or only one correctly. This indicates that a considerable portion of the sample has a low level of awareness concerning the rules. However, 32.3 percent were able to answer four or five correctly, indicating a high level of rule awareness among at least one-third of the sample. This may indicate that education about the rules has not reached all producers evenly, or that differences among the producers themselves (e.g., educational level) lead to differences in awareness. The roles that producer characteristics play in rule awareness are tested in the multivariate analyses in Chapter 6.

Table 5.6. Distributions of Categorical Mediating Variables.

Variable	Frequency	Percent
Rule awareness		
0	3	0.7%
1	15	3.6%
2	147	35.4%
3	116	28.0%
4	97	23.4%
5	37	8.9%
Total	415	100%
Income impact		
Decreases	20	4.8%
Doesn't change	238	57.3%
Increases	157	37.8%
Total	415	100%
Fear of stricter regulations		
Strongly disagree	3	0.7%
Disagree	18	4.3%
Neither agree nor disagree	16	3.9%
Agree	317	76.4%
Strongly agree	61	14.7%
Total	415	100%
Fear of inspections		
Strongly disagree	2	0.5%
Disagree	115	27.7%
Neither agree nor disagree	46	11.1%
Agree	242	58.3%
Strongly agree	10	2.4%
Total	415	100%
Fear of penalties		
Strongly disagree	1	0.2%
Disagree	74	17.8%
Neither agree nor disagree	18	4.3%
Agree	287	69.2%
Strongly agree	35	8.4%
Total	415	100%

As shown in Table 5.6, the majority of producers (57.3 percent) did not believe that using nutrient management changes farm income. Among those who did believe there was an impact, more believed that it would increase income (37.8 percent) than decrease income (4.8 percent). This distribution reveals that many producers believe there are financial reasons to use nutrient management practices and very few perceive a financial disincentive to use them.

Table 5.6 also shows that the vast majority of respondents (91.1 percent) expressed concern that stricter regulations would be likely to follow if current regulations did not improve water quality. Majorities also expressed a fear of being penalized if they did not comply with nutrient management rules (77.6 percent) and a fear that their nutrient management practices were likely to be inspected (60.7 percent). These results indicate that deterrent fears are prevalent in the study sample and as such could be influencing adoption behavior.

The fact that more respondents were concerned about stricter future regulations than about penalties or inspections may be evidence that implicit general deterrence (i.e., deterrent fears created by the existence of regulations) is playing a more significant role in the study sample than deterrent fears that come from actual enforcement of laws. This likely reflects the fact that while there has been a significant amount of outreach conducted in both basins about water quality problems and the nutrient management rules there has also been a general lack of enforcement actions against producers in the two basins.

Table 5.7. Pairwise Correlation Coefficients for Mediating Variables.

	Rule awareness	Attitude	Norm	Denial	Fear of penalties	Fear of inspection	Income impact
Rule awareness							
Attitude	0.108 (415)						
Norm							
External							
Denial							
Fear of penalties			0.268 (415)				
Fear of inspection		-0.127 (415)			0.124 (415)		
Fear of stricter regul.	0.117 (415)	0.164 (415)	0.118 (415)		0.196 (415)		
Income impact		0.225 (415)					
Perceived control	0.133 (415)	0.256 (415)		-0.135 (415)	0.104 (415)	0.121 (415)	0.180 (415)

Notes: 1. Only correlations significant at the .05 level or less are shown.
2. The numbers of observations for each pairwise correlation are in parentheses.

As given in Table 5.7, the pairwise correlation coefficients reveal several interesting relationships among the study's mediating variables, though the correlation coefficients tend to be low. Higher levels of rule awareness are associated with more positive attitudes about the rules and their impacts, with beliefs that nutrient management is easy, and with a fear of future regulations. Not surprisingly, having a positive attitude about the nutrient management rules and their impacts is positively associated with beliefs that nutrient management increases farm income and is relatively easy to do. However, attitude has a mixed association with the deterrence motivations. Those with a more positive attitude are more apt to believe that stricter regulations are likely in the future if current ones do not succeed but they are also less fearful of being inspected. It could be that a positive attitude is enhanced if one believes that imminent enforcement actions, like inspection, are unlikely, though no similar relationship was revealed between attitude and fear of penalties. It could also be that the producers in the sample have determined that the existing regulations are better than the likely stricter ones in the future and thus report higher levels of satisfaction with the current regulations.

Perhaps the most interesting correlations revealed in Table 5.7 are those that exist between norm and two of the deterrence motivations. Essentially, producers who felt an intrinsic moral obligation to protect water quality and the environment also tended to be more concerned about penalties and stricter future regulations. This finding supports arguments in the literature that the relationship between moral obligation and deterrent fears can be a positive one. In particular, this finding suggests that the "duty heuristic" described by Sholz and Pinney (1995) is operating among producers in these basins. Producers who have an intrinsic normative obligation to protect water quality also believe that they are more likely to be punished if they do not follow the rules. These two variables were more strongly correlated than any other pair of mediators.

Another interesting relationship found in the correlation matrix is the negative association between denial and perceived control. Producers who did not believe that the nutrient management rules were needed or that water quality was a problem also tended to believe that nutrient management is difficult to do. It seems unlikely that this relationship merely reflects a negative attitude toward the rules because denial was not found to have a significant correlation with attitude. Though this relationship does not necessarily show a causal relationship between the two variables, it seems plausible that producers who do not adopt nutrient management practices because they believe it is too difficult may choose to rationalize their inaction by arguing that the practices are not really necessary.

5.1.4. Activity Variables

Table 5.8. Performance of Mandated Nutrient Management Activities by Basin and Distribution of Final Activity Groups.

Activities	Neuse Basin	Tar-Pamlico Basin	Total and Final Activity Groups
Training only	65 20.6%	NA	65 15.7%
Intend to train only	NA	59 59.0%	59 14.2%
Both activities	107 34.0%	NA	107 25.8%
Intend to do both	NA	20 20.0%	20 4.8%
Nutrient plan only	46 14.6%	6 6.0%	52 12.5%
No activities	97 30.8%	15 15.0%	112 27.0%
Total	315 100%	100 100%	415 100%

Table 5.8 presents the numbers of producers who participated in the mandated nutrient management activities by basin. Two things stand out when looking at participation in the Neuse Basin. First, a significant proportion of the producers (30.8 percent) did not participate in either of the mandated activities, raising questions about the extent to which producers in the Neuse Basin are complying with the Nutrient Management Rule. This issue is explored further in the next section. Second, among those who did participate, more chose to complete both activities (34.0 percent) than either training (20.6 percent) or planning (14.6 percent) only, even though they were only

required to participate in one. These results suggest a very uneven response to the Neuse Nutrient Management Rule. Among the producers who did participate, there did not appear to be a strong preference for one activity over the other; 172 producers (54.6 percent) participated in training and 153 (48.6 percent) developed nutrient management plans.

Activity participation was different in the Tar-Pamlico Basin group. The proportions of respondents who had completed plans only and who intended to do both activities were smaller in the Tar-Pamlico sample, whereas the proportion of respondents who stated that they intended to participate in training was much larger than the proportion of those in the Neuse Basin who actually did complete training. It is likely that not all of the respondents who expressed an intention to train in the survey ultimately did so. This means that the number of producers in the intend to train group is likely somewhat inflated and the no activities group is likely somewhat underrepresented in the Tar-Pamlico sample.

For the subsequent statistical analyses, the nutrient plan only groups in the Neuse Basin and Tar-Pamlico basins are combined as are the no activity groups. This creates the six final activity groups listed in the last column of Table 5.8.

5.2 Compliance with the Nutrient Management Rules

The key assumption in the Neuse Basin strategy is that requiring producers to participate in nutrient management activities, either training or planning, will lead them to adopt voluntarily BMPs that protect water quality. Prior to investigating the impacts of these mandated activities on adoption of BMPs, it is important to determine if the producers who are required by the Nutrient Management Rule to participate in these activities are actually in compliance with the Rule.

The Neuse Basin strategy's Nutrient Management Rule requires farmers who manage or apply fertilizers to 50 or more acres of land to either develop a nutrient management plan or participate in nutrient management training. Using a conservative assumption that producers will manage and/or apply fertilizers to at least half of their farm acres, this study uses a farm size cutoff of 100 acres to analyze compliance rates. Those with farms smaller than 100 acres are considered to be exempt from the Rule and those with farms that were 100 acres or larger are considered to be regulated under the Rule. Table 5.9 shows the proportion of farms in the study sample that fall into different compliance categories, based on producers' self-reported participation in the mandated activities.

At the time of the survey, 25.0 percent of regulated farms were not in compliance with the Neuse Nutrient Management Rule. Producers on these farms had not developed nutrient management plans or participated in nutrient management training. Among those regulated, 36.6 percent had completed either training or a plan, indicating compliance with the Rule. The largest group of regulated producers (38.4 percent) had exceeded rule requirements by completing both training and a plan.

Among the producers who had farms smaller than 100 acres and thus are considered in this study to be unregulated, over half had completed a plan, training, or both. These producers completed these activities even though they were not legally required to do so.

Table 5.9. Compliance with the Nutrient Management Rules.

Number of Activities	Unregulated Farms (< 100 acres)	Regulated Farms (≥ 100 acres)	Total
Neuse River Basin			
0 – No activities	39 47.0%	58 25.0% (not in compliance)	97 30.8%
1 – Either a plan or training	26 31.3% (exceeds compliance)	85 36.6% (in compliance)	111 35.2%
2 – Both a plan and training	18 21.7% (exceeds compliance)	89 38.4% (exceeds compliance)	107 34.0%
Total	83 26.4%	232 73.7%	315 100%
Tar-Pamlico River Basin			
0 – No activities	4 19.1%	11 13.9% (not in compliance)	15 15.0%
1 – Either a plan or intend to train	14 66.7% (exceeds compliance)	51 64.6% (in compliance)	65 65.0%
2 – Both a plan and intend to train	3 14.3% (exceeds compliance)	17 21.5% (exceeds compliance)	20 20.0%
Total	21 21.0%	79 79.0%	100 100%

Producers in the Tar-Pamlico Basin operate under a nutrient management rule nearly identical to the Neuse rule. However, because training had not been offered at the time of the study, compliance was determined based on development of nutrient management plans or reported intentions to complete training when offered. This is likely to overestimate compliance rates, as some of those who reported that they would participate in training may not have done so. As seen in Table 5.9, among regulated farms, 13.9 percent were out of compliance with the Tar-Pamlico Nutrient Management Rule. Producers from these farms had not developed plans and reported that they did not intend to participate in training. The majority of regulated producers (64.6 percent) were in compliance, but only six of the 51 producers in this group had completed plans, the other 45 producers stated that they intended to complete training. 21.5 percent of regulated producers in the Tar-Pamlico Basin exceeded requirements by completing a plan and intending to complete training too.

Among those farms smaller than 100 acres, and considered unregulated, over 80 percent either had already performed or intended to perform one or more of the required activities. Three producers in this group of 17 had already developed plans and also intended to train. The other 14 intended to train only.

These results indicate that producers in both basins have responded inconsistently to the respective nutrient management rules. A substantial portion of producers have failed to comply. However, an even larger percentage of regulated producers have gone above and beyond the requirements of the rules by completing both activities. In addition, more than half of unregulated producers in both basins have met or exceeded the requirements of the rules without being legally required to do so.

To investigate in more depth the characteristics of producers who were likely to complete the different activities, ANOVA analyses were performed to identify demographic differences among producers falling into the different activity groups. This information is important because it can help reveal which types of producers need to be targeted more effectively in future outreach efforts and because it highlights the importance of controlling for such factors in predictive models.

5.3 Differences Among Participants in the Different Activity Groups

One-way ANOVAs were conducted comparing the mean values of key demographic variables across the six different activity groups. Significant ANOVA tests indicate that there are statistically significant differences among the groups, but do not reveal where the differences exist. In order to identify specifically which groups differed from others, post-hoc comparisons were conducted using the Bonferroni method. The results reveal many important differences.

As seen in Table 5.10, the ANOVA results show that while there were no significant differences among the groups in terms of the average level of educational attainment, there were significant differences in mean age, percentage of farmland rented, farm size, income, farm income, experience, and innovativeness. These differences arose primarily when comparing the mean values of producers who had completed no activities with producers in the other groups. Those in the no activities group differed from those in the both activities group on each of the seven factors with significant ANOVA tests. Producers who had completed no activities were on average older, rented less of their farmland, had smaller farms and smaller annual incomes, derived a smaller percentage of their incomes from farming, had more years of farming experience, and considered themselves to be less innovative than producers who had completed both activities. Those in the no activities group were different from producers who intended to train and those who intended to do both activities on three factors: rented land, farm size, and farm income. Those in the no activities group were also older than those who intended to train only and less innovative than those who intended to do

Table 5.10. One-way ANOVAs Comparing Demographic Variables Across Activity Groups.

	Total sample mean (std. dev.)	**1. No activities mean (std. dev.)**	**2. Nutrient plan mean (std. dev.)**	**3. Train only mean (std. dev.)**	**4. Intend to train Mean (std. dev.)**	**5. Both activities mean (std. dev.)**	**6. Intend to do both mean (std. dev.)**	**F**	**df**	**Post hoc**
Age (years)	55.8 (11.7)	61.0 (12.0)	52.5 (11.4)	56.3 (12.6)	54.5 (11.0)	52.4 (9.2)	55.3 (11.9)	***7.97	5, 409	1 > 2,4,5
Rented land (%)	47.2 (38.6)	29.6 (37.4)	43.0 (37.5)	53.0 (37.2)	51.0 (37.6)	58.6 (35.8)	65.5 (35.1)	***8.71	5, 409	1 < 3,4,5,6
Farm size (ln)	5.66 (1.45)	5.03 (1.39)	5.67 (1.32)	5.56 (1.33)	5.95 (1.47)	6.03 (1.35)	6.66 (1.68)	***8.80	5, 409	1 < 4,5,6 3 < 6
Farm size (acres)	676 (899)	354 (503)	583 (658)	565 (793)	879 (1,070)	802 (821)	1,806 (1,840)	x	x	x
Income ($1,000)	117 (94.3)	90 (82.8)	139 (110)	116 (88.4)	115 (92.2)	138 (96.2)	111 (97.3)	**3.26	5, 365	1 < 5
Farm Income (%)	63.3 (35.7)	47.2 (39.7)	69.6 (32.4)	60.3 (34.1)	69.1 (33.1)	72.5 (31.1)	77.5 (26.5)	***7.49	5, 387	1 < 2,4,5,6
Education (level)	1.81 (0.80)	1.76 (0.82)	1.98 (0.79)	1.75 (0.79)	1.69 (0.81)	1.84 (0.77)	2.05 (0.76)	1.27	5, 406	
Experience (years)	29.1 (12.6)	31.4 (13.9)	26.7 (11.1)	31.8 (13.1)	28.1 (12.7)	26.7 (11.2)	29.9 (12.2)	*2.60	5, 409	
Innovative (yes)	0.55 (0.50)	0.41 (0.49)	0.54 (0.50)	0.68 (0.47)	0.49 (0.50)	0.63 (0.49)	0.80 (0.41)	***4.45	5, 409	1 < 3,5,6
Group size (% of total)	415 (100%)	112 (27.0%)	52 (12.5%)	65 (15.7%)	59 (14.2%)	107 (25.8%)	20 (4.8%)	x	x	x

Notes: 1. *p < .05, **p < .01, ***p < .001

2. The numbers preceding each group name in the column headings refer to the numbers used to illustrate the significant differences in the last column titled "Post hoc." Only differences significant at the .05 level or less are reported.

3. x's for Farm size (acres) and Group size indicate that F, df, and post hoc tests were not calculated.

both. Those in the no activities group were most similar to those who had trained only or developed plans only, differing from each of those groups on only two of the seven factors. They rented less farmland and were less innovative than those in the train only group and they were older and had less farm income than those in the nutrient plan group. With the exception of farm size, producers in the other five groups were not significantly different from each other.

Bivariate statistics (found in Appendix C) show that producers in the no activities group also differed from those in the both activities group in their attitudes and adopted practices. Producers who completed no activities felt less external pressure, had lower levels of perceived control, and were less likely to believe they would be inspected. Surprisingly, they were less in denial about the water quality problem and need for regulations and they were more likely to believe that nutrient management increases income than producers who both trained and developed plans. Those who completed no activities were less likely to receive cost share for nutrient management and were less likely to use RYEs and soil tests. Finally, producers in the no activities group also had lower levels of rule awareness, which may partially account for their lack of participation in the mandated activities.

These results suggest that efforts to educate producers about the nutrient management activities and encourage participation may not have reached all producers equally. However, they also suggest that certain producers were simply more resistant to participating. In both cases, future efforts to encourage participation in nutrient management training and development of nutrient management plans should target producers using these findings.

5.4 Summary of Key Findings

The survey data described above show that adoption of the three nutrient BMPs investigated in this study varied widely. Only 11.3 percent of producers in the sample were using RYEs to determine their nitrogen application rates at the time of the survey. This low rate of usage suggests that the nutrient management rules and activities have not had a great deal of impact on adoption of this particular practice. However, most producers used soil tests and a surprisingly large number used cover crops despite this practice having benefits that are mostly off-site and in the future. Whether usage of these practices can be credited to the nutrient management activities will be tested in the next chapter.

The descriptive statistics in this chapter also reveal important insights into the attitudes and beliefs of the producers in the study. A number of findings suggest that the study population should have been receptive to the Neuse and Tar-Pamlico rules and the use of nutrient BMPS. Specifically, producers in the study population generally had favorable attitudes towards the rules, a sense of internalized moral obligation to protect water quality, a feeling of external pressure to follow the rules, and a positive sense of perceived control. In addition, the distributions of the survey items found in Appendix B reveal that producers generally perceived the rules to be reasonable and effective in improving water quality.

However, a number of other beliefs and attitudes may have presented challenges for gaining cooperation with the rules. Most producers in the study perceived the rules to be both unfair and unnecessary. They did not believe that non-agricultural sources of pollution were being held accountable and they believed that farmers would do the right thing without regulations. By failing to agree that agricultural water pollution was a serious threat to fish and wildlife in the Neuse and Tar-Pamlico Rivers, at least one-half of the sample appears to have lacked a sense of personal responsibility for the water quality problems targeted by the rules. In addition less than 40 percent of the producers believed that nutrient management has a positive impact on farm income.

Producers reported having relatively strong deterrent fears, particularly regarding the likelihood of stricter future regulations. Over 90 percent of the survey respondents reported agreeing or strongly agreeing that stricter regulations were likely if current ones were not effective. This may indicate the existence of a high level of general implicit deterrence. Correlations among the mediators reveal that producers who had high deterrent fears also tended to have a stronger intrinsic moral duty to protect water quality and the environment. Not only does this support the contention that norms and deterrence motivations can be positively related, but it appears to be evidence of the duty heuristic described by Sholz and Pinney (1995).

The data show that awareness of the nutrient management rules varied widely among the producers, but tended to correlate with positive attitudes toward them. Of the five questions about the rules presented to producers in the survey, almost 40 percent could answer only two or fewer correctly. On the other hand, more than 32 percent were able to answer four or five correctly. It appears that educational efforts about the rules did not reach all producers equally. Whether this is due to the outreach efforts themselves or to differential levels of responsiveness to those efforts is not clear. For those who did know more about the rules, however, this knowledge was found to correlate with more positive attitudes towards the rules. Rule awareness was also correlated with stronger feelings of perceived control and greater fears of future regulations.

The data in this chapter also show that participation in the nutrient management activities varied widely. Among those who are considered in this study to be regulated by the Neuse Nutrient Management Rule, 25.0 percent had failed to complete either nutrient management training or a nutrient management plan and thus were not in compliance. On the other hand, a plurality of producers had exceeded rule requirements by completing both activities. Comparisons, using ANOVA and bivariate regressions (found in Appendix C), between the producers who completed no activities and those who had completed planning, training, or both, identify numerous statistically significant differences. Strikingly, the group of producers who completed no activities differed from those who completed both on 16 of the 23 study variables. Many of these variables are immutable demographic characteristics of the producers, but many are attitudes that may be susceptible to influence by policies and related education. Determining more effective ways to gain cooperation by the recalcitrant producers could greatly improve the efficacy of the Neuse and Tar-Pamlico strategies.

CHAPTER 6: Results and Discussion of Predictive Models

The purpose of this chapter is to evaluate the study's hypotheses and conceptual framework. It presents key findings from the multivariate statistical models, including the testing of possible mediation pathways and interactions. The chapter begins with a discussion of the issue of missing study data and the steps taken to ensure that missing data do not bias the study's results. It then discusses the multivariate model results.

6.1 Treatment of Missing Data

Prior to performing the multivariate analyses, it was important to evaluate and address the issue of missing survey data. Missing data can be a concern if the respondents who failed to provide data differ in some meaningful way from the rest of the sample. If the respondents missing data are different, then excluding them can bias statistical results. In this study, two of the demographic variables had missing data requiring investigation: income and farm income. Of the 415 survey respondents, 44 respondents (10.6 percent) did not provide information about their total annual incomes. Twenty-two respondents (5.3 percent), declined to state how much of their total annual income came from farming.

To investigate the potential impacts of these missing data on the study results, t-tests were conducted comparing the respondents who reported data and those who did not on all of the other study variables. For income, the t-tests revealed only one significant difference: those who did not report on average scored slightly lower on perceived control (3.2 versus 3.5) than those who did (significant at the .05 level). No other differences were significant at the .05 level for a two-tailed test.

In the t-tests comparing those who reported farm income and those who did not, only two variables were significant: cost share for cover crops and fear of penalties. The t-test results for cost share are invalid because no respondents who received cost share for cover crops failed to report their farm income. For fear of penalties, 78.9 percent of respondents who reported their farm income believed they might be penalized whereas only 54.6 percent of respondents who did not report farm income believed this. Even though respondents were ensured that their participation in the survey was anonymous, the significant relationship between beliefs about penalties and willingness to report farm income may reflect a concern that not answering the question could make them more susceptible to regulatory scrutiny. However, this relationship did not hold for reporting of total income, which limits this concern.

In summary, the t-test results indicate very few significant differences between the producers who reported income and farm income data and those who did not. This suggests that the missing data are unlikely to bias the study results. However, to be sure that dropping the non-responsive producers from the study sample would not bias the results, multiple imputation was conducted.

Multiple imputation is a missing-data replacement procedure comprised of two distinct steps. First, an imputation model is selected and missing data are generated using this model. Second, the desired statistical tests are performed using each imputed data set and the results are combined. This procedure generally is favored over other methods of addressing missing data because it is found to be relatively insensitive to whether the data are missing at random or not and it can estimate the amount of missing information (McKnight, McKnight, Sidani, & Figueredo, 2007). The amount of missing information indicates the influence that missing data have on statistical inferences and can help determine whether it is reasonable to ignore them in analyses. In the statistical software Stata, the influence of missing information is reported as the relative increase in variance ("RVI") for each model tested. RVI measures how much the variance of the parameter estimates increases due to missing data. Greater variance tends to make parameter estimates less reliable and standard errors less accurate (McKnight et al., 2007).

Despite the potential benefits of using multiple imputation to address missing data, a decision to use this technique must weigh the benefits against the procedure's key drawback: the inability to conduct many types of post-estimation analyses. For example, likelihood–ratio tests are not currently applicable to multiple imputation results (StataCorp, 2009). RVI values can help indicate whether the amount of missing information in each model is significant enough to tip the scale in favor of using this approach.

In this dissertation, the imputation model was based on a multivariate normal distribution and included all of the study variables. Twenty imputations were performed, resulting in 20 distinct complete data sets. In this case, each of the study models was tested using each of the 20 imputed data sets and Stata was used to pool the results into one final set of parameter estimates and standard errors for each model. To determine whether the missing income and farm income data were likely to bias results in this study, the RVI values for each model were checked.

Based on these values, using the imputed data did not add a significant amount of information to any of the study models. The average RVI was less than 2 percent in each model, which is considered trivial (McKnight et al., 2007). Due to the low RVI values and the t-test results, the choice was made to preserve the ability to conduct model post-tests by not using the imputed data. As a result, the respondents with missing data for income, farm income, and/or education level[7] were excluded from the multivariate model testing in the dissertation, resulting in a final study sample of 369 producers.

6.2 Multivariate Model Results

Using this final study sample, a series of multivariate statistical models were analyzed to test the research hypotheses from Chapter 3. The results of these models are presented here, along with a discussion of the meaning and relevance of the findings. Model results are divided into three groups: 1.) those that predict adoption of nutrient BMPs, 2.) those that predict the potential mediating variables, and 3.) those that explore associations between participation in the nutrient management activities and additional adoption motivations.

6.2.1 Predicting Adoption of Nutrient BMPs

Three models employ logistic regression analysis to test the relationships between key study variables[8] and use of the three nutrient BMPs: RYEs, cover crops, and soil

[7]Three respondents failed to report their education level.

[8]For the sake of parsimony, several of the variables hypothesized to relate to use of the study's nutrient BMPs were ultimately excluded from these models. Rented land, attitude, norm, external, denial, income impact, and perceived control were each found not to be significant in any of the nutrient BMP models. They were also found to be jointly insignificant in each model

tests. Odds ratios, standard errors, and levels of significance for each predictor are given in Table 6.1. Each model has a significant Chi-square value, indicating that all three models are statistically significant. Other post-estimation procedures and tests also support the use of these three models.[9] Outlying and high leverage observations were identified and investigated.[10] Finally, predicted probabilities were calculated to more adequately characterize the magnitude of the relationships between the statistically-significant predictors and outcome variables.[11] Predicted probability findings are discussed for each model below[12], and detailed results are found in Appendix D.

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and likelihood-ratio tests comparing the full and trimmed models confirmed that the variables could be safely dropped. Differences in BIC between the full and trimmed models for each nutrient BMP ranged from 34 to 44, providing very strong support for using the trimmed models.

[9]Post-estimation tests using Stata, including the linktest, Hosmer-Lemeshow, and Box-Tidwell indicate that the three models are specified correctly and fit the data well. Additionally, none of the three models are found to suffer from multicollinearity.

[10]Influential observations were identified in three ways: standardized residuals, cook's statistic, and least likely predictions/observations. Observations that stood out from the others on all three of these measures were investigated. First, these observations were dropped from the model being tested to see what impact, if any, they had on parameter estimates, significance levels, and measures of model fit. Second, the recorded response data for each observation were examined to identify anything potentially unusual and to detect anything the different outliers might have in common.
Each model had five observations that stood out as potential issues. In each case, when the identified observations were removed from the models, the chi-square model fit statistics improved. In the RYEs and cover crops models, the primary impacts of removing the observations were to increase the level of significance of the already-significant variables. Impacts on the soil testing model were more substantial. In this model, the variables income, farm income, and innovative became significant and cost share for nutrient management lost its significance. In addition, the intend to do both activity group is omitted and the sample size drops to 348.
Upon examining the observations individually, it was apparent that the reason they were found to be outliers is that they each represent uncommon response patterns. Due to the relatively low numbers of respondents in some of the response categories (e.g., those who used RYE, received cost share, and participated in a small activity group) there are a number of very small cell sizes, which result in multivariate outliers. Because there was no overlap in the observations of concern among the three models, all observations were retained. Retaining these observations leads to more conservative results than would otherwise have been found.

6.2.1.1 RYEs Model

As shown in Table 6.1, the RYEs model identifies a number of significant independent variables, including three capacity variables: farm income, education, and cost share for cover crops. Income from farming has a small, positive effect. For a one percent increase in farm income, the odds of using RYEs increase by 1.3 percent. In terms of predicted probabilities, increasing farm income from one standard deviation below the mean to one standard deviation above the mean increases the probability of using RYEs by 8.2 percent. This finding was expected, as producers who derive more of their income from farming are likely to have more time to put into learning and implementing new management practices.

Having graduated from college also has a positive impact on the use of RYEs, relative to those who completed high school or had less education. The odds were 2.5 times greater that respondents who had graduated from college used RYEs and their predicted probability of use was 9.0 percent higher. Education was expected to have a positive relationship with adoption, particularly of RYEs, given the practice's technical complexity.

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[11]Predicted probabilities were calculated using the observed values for each respondent in the data set and then varying the predictor of interest. For dummy predictors, the predicted probability was calculated for values of zero and one and then the difference was taken. For continuous predictors, the probability was predicted at the mean value of the predictor and then at one standard deviation above and one standard deviation below the mean. Then the changes in the predicted probability were calculated. For ordinal variables treated as continuous, probabilities were predicted at each level.

[12]Both odds ratios and changes in predicted probability percentages are presented in the model discussions. The reader should focus on whichever approach is more familiar.

Table 6.1. Multivariate Logistic Regression Results for Nutrient BMP Models.

Variables	Multivariate Odds Ratios (standard error)					
	RYEs		Cover Crops		Soil Tests	
***Capacity*:**						
Age	0.976	(0.026)	0.979	(0.019)	0.995	(0.020)
Farm size (ln)	0.853	(0.133)	******0.168***	**(0.112)**	*****1.556**	**(0.222)**
Farm size^2 (ln)[a]	x	x	******1.229**	**(0.074)**	x	x
Income	0.999	(0.002)	1.000	(0.002)	1.003	(0.002)
Farm income	****1.013**	**(0.007)**	****1.011**	**(0.005)**	0.991	(0.005)
Experience	0.992	(0.024)	1.007	(0.018)	1.001	(0.018)
Some college	1.437	(0.638)	0.832	(0.257)	1.127	(0.442)
College graduate	****2.502**	**(1.146)**	****0.454**	**(0.169)**	1.257	(0.536)
Innovativeness	0.713	(0.266)	0.771	(0.213)	1.490	(0.500)
Cost share crops	***0.244**	**(0.200)**	0.972	(0.416)	2.401	(1.658)
Cost share nutrient	1.427	(0.769)	1.639	(0.721)	***0.292**	**(0.195)**
***Mediators*:**						
Rule awareness[b]	1.188	(0.227)	****0.687**	**(0.104)**	1.315	(0.275)
Fear penalties	****0.393**	**(0.164)**	0.991	(0.317)	1.156	(0.455)
Fear inspection	1.173	(0.457)	1.093	(0.308)	****2.140**	**(0.714)**
Fear stricter regs.[b]	1.206	(0.335)	****0.678**	**(0.132)**	0.723	(0.210)
***Counties*:** [c]						
Johnston	0.319	(0.406)	0.684	(0.494)	0.860	(0.712)
Lenoir	0.931	(1.099)	****0.200**	**(0.147)**	2.013	(1.721)
Nash	1.965	(1.457)	1.006	(0.514)	0.490	(0.324)
Wayne	1.434	(1.682)	0.368	(0.266)	1.753	(1.499)
***Activities*:** [d]						
Intend to train	0.526	(0.599)	***0.246**	**(0.186)**	1.614	(1.373)
Both activities	0.627	(0.349)	****0.421**	**(0.182)**	***3.347**	**(2.161)**
Intend to do both	0.418	(0.548)	***0.190**	**(0.171)**	5.070	(6.777)
Nutrient plan	0.913	(0.582)	***0.366**	**(0.194)**	2.377	(1.762)
No activities	****0.242**	**(0.175)**	***0.453**	**(0.200)**	0.608	(0.296)
Model X^2 (df)	****36.63 (23)**		******98.42 (24)**		******68.33 (23)**	
Observations	**369**		**369**		**369**	

Notes: *p ≤ .10, **p ≤ .05, ***p ≤ .01, ****p ≤ .001

[a] Farm size^2 is included only when significant.

[b] To simplify interpretation, rule awareness and fear of stricter regulations are both included in the models as interval-scale variables rather than sets of dummy variables. Likelihood-ratio tests indicated that this was appropriate.

[c] County dummy variables are compared to the base: Edgecombe County.

[d] Activity group dummy variables are compared to the base: Train.

Cost share for cover crops is found to have a negative impact on adoption of RYEs. Among respondents who had received this funding, the odds of using RYEs were 75.6 percent lower than among those who had not received these funds. Receiving the funds lowered the predicted probability of using RYEs by 9.0 percent. This seemingly counter-intuitive result may be the result of producers making a tradeoff in their efforts. If a producer receives cost share funds to use one type of practice, they may be less inclined to also implement a different practice. This may be particularly true in the case of cover crops and RYEs because they focus on opposite ends of the pollution control spectrum. Cover crops are akin to an "end of the pipe" pollution control technique, whereas RYEs focus on pollution prevention.

One potential mediating variable is also found to be significant in the RYEs model. Fear of penalties has a negative relationship with use of RYEs. Among respondents who believed they were likely to be penalized, the odds of using RYEs were 60.7 percent lower than among those who did not believe this. Believing that penalties were likely lowered the predicted probability of using RYEs by 10.1 percent. This too may be the result of producers making tradeoffs in their responses to the Neuse and Tar-Pamlico rules. Those who are afraid of being penalized may be more apt to adopt physical nutrient BMPs that are highly visible to regulators, such as buffer strips and water control structures, rather than those that are more management-based, like RYEs. This possibility should be explored in future research.

Though no differences are found in the use of RYEs between producers in Edgecombe County and the other four counties in the study, producers in Lenoir, Wayne, and Nash counties are found to have higher rates of adoption relative to those in Johnston

County. Producers in Lenoir County had 2.9 times higher odds of using RYEs than those in Johnston County (significant at the .10 level). Those in Wayne had 4.5 times higher odds (significant at the .05 level) and those in Nash had 6.2 times higher odds (significant at the .10 level). The predicted probabilities of using RYEs in each of these counties relative to Johnston County were 6.7 percent higher in Lenoir, 11.1 percent higher in Wayne, and 15.1 percent higher in Nash. The fact that producers in the Johnston County sample were much less likely to use RYEs than those in three of the other counties, but producers in the remaining four counties did not differ from each other, points to something unique occurring in Johnston County. One possibility is that this county has attributes that make the adoption of other types of nutrient BMPs more attractive than using RYEs. Another possibility is that the county Extension staff who worked with producers and who provided the nutrient management training did not emphasize the use of RYEs to the same extent as agents in the other counties. In fact, records of county-wide BMP use for the Neuse Basin show that Johnston County emphasized nutrient management, which would include RYEs, to a much smaller extent than did Wayne and Lenoir counties in their efforts to meet the required 30 percent nitrogen runoff reduction (Wittenborn and Moreau, 2007). Instead, Johnston County reported placing more emphasis on cover crops.

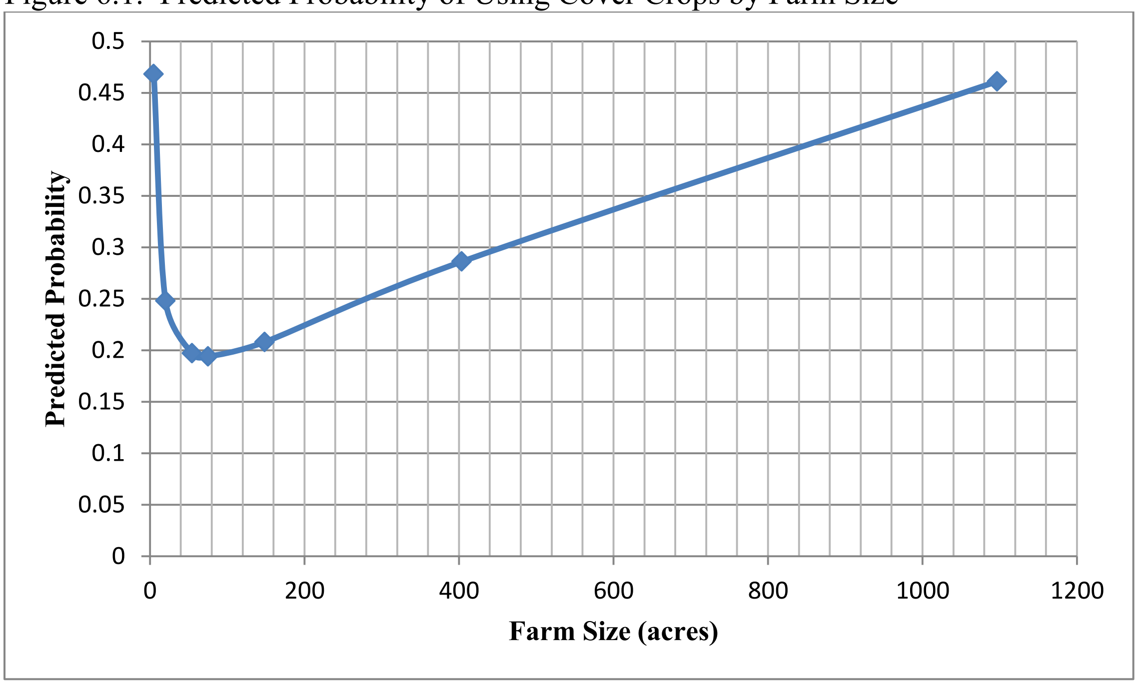
Two activity variables are also found to be statistically significant. Those in the no activities group were less likely to use RYEs than those in the train only and nutrient plan groups. The odds of using RYEs were 75.8 percent lower among respondents who participated in no activities than among those who participated in training. Participating in training increased the predicted probability of using RYEs by 12.1 percent relative to doing nothing. Similarly, those who participated in no activities had 73.5 percent lower odds of using RYEs (significant at the .10 level) than those who had developed plans. Developing a nutrient management plan increased the predicted probability of using RYEs by 11.0 percent relative to doing nothing. Given that the RYEs model controls for many of the ways in which producers in the six activity groups differ from each other, it appears that nutrient management training and development of nutrient management plans can be credited to some extent with encouraging the use of RYEs.

Overall, this model offers a few notable insights into the use of RYEs among the study population. First, as expected, having higher levels of capacity is associated with greater use of the practice. Higher levels of farm income and a college education are both positively associated with use of RYEs. Second, the relationships between receipt of cost share and adoption and between deterrent fears and adoption appear to be complex and may indicate that producers are making tradeoffs in the types of practices they adopt. Those who adopt cover crops may be less likely to use RYEs and those who fear penalties may be forgoing use of management-based practices in exchange for more visible physical practices. Third, differences on the county level are important to control for and likely stem from how much emphasis county-level Extension staff and other local officials place on the use of different practices. Finally, the required nutrient management activities do appear to enhance the use of RYEs relative to not participating in any activities, though the impacts are relatively small.

6.2.1.2 Cover Crops Model

The adoption of cover crops model has seven statistically significant independent variables. Three capacity variables are found to help predict adoption of cover crops: farm size, farm income, and education. Farm size has a significant association with use of cover crops but, as seen in Figure 6.1, the relationship is not linear. For farms smaller than 75 acres, the relationship between farm size and adoption of cover crops is negative and for farms larger than 75 acres, the relationship is positive. Going from a five acre farm to a 75 acre farm decreases the predicted probability of adopting cover crops by

Figure 6.1. Predicted Probability of Using Cover Crops by Farm Size



Note: This graph does not depict the predicted probabilities for farms larger than 1,097 acres. These farms were omitted in order to preserve some of the detail for the smaller-sized farms. Data for the larger farms are found in Appendix D.

27.4 percent. Going from a 75 acre farm to one that is just over 1,000 acres increases the predicted probability of adoption by 26.7 percent. Though not shown on the graph, the predicted probability that the largest farm in the sample (6,500 acres) will adopt cover crops is 89.0 percent, nearly double that of the 1,000 acre farm. While larger farms may have a greater ability to adopt practices, it is not clear why the relationship is negative for farms under 75 acres in size.

Like the RYEs model, higher levels of income from farming are associated with increased use of cover crops. For a one percent increase in a respondent's farm income, the odds of using cover crops increase by 1.1 percent. Moving from one standard deviation below the mean of farm income to one above increases the predicted probability of using cover crops by 13.2 percent. Producers who focus more time on their farms may be more willing to adopt intensive practices and those with professional operations may be more inclined to adopt practices like cover crops that have longer-term benefits such as soil conservation.

Also like the RYEs model, the use of cover crops is found to relate to education. However, the level of education attained has a surprisingly negative association with the use of cover crops. College graduates are less likely to use cover crops than producers who have either completed high school or less education or completed only some college. Relative to those who had completed high school or less education, those who had graduated from college had 54.6 percent lower odds of using cover crops. Relative to those who had completed only some college, the odds were 45.4 percent lower (significant at .10 level). The predicted probability of using cover crops was 12.9 percent lower among respondents who had completed college or more education compared to those who had completed high school or less education. The predicted probability was 9.7 percent lower for college graduates than for those who had completed just some college. Given that education has a positive association with the use of RYEs, it is possible that producers in the study sample are choosing between using RYEs or cover crops and those with higher levels of education are tending to select RYEs, the more technically complicated practice.

Two potentially mediating variables are also significant: rule awareness and fear of stricter future regulations. Respondents with higher levels of rule awareness are less likely to use cover crops. For a one unit increase in rule awareness, the odds of using cover crops decreased by 31.3 percent and the predicted probability decreased by approximately six percent. Moving from the lowest level of awareness to the highest level decreased the predicted use of cover crops by 18.1 percent. This negative relationship is interesting and suggests that producers who are the most savvy about the rules are choosing not to use cover crops. It could be that those who know the rules best understand that the rules do not require implementation of any particular practices. Thus, if these producers are going to use a practice, they are unlikely to choose one that does not have immediate, direct benefits to their financial bottom line.

Use of cover crops also decreases with an increasing belief that stricter regulations are likely if current nutrient management regulations do not work. Increasing this belief by one unit decreases the odds of using cover crops by 32.2 percent. The probability of using cover crops was 20.3 percent lower among those who strongly agree than among those who disagree that stricter regulations are likely. Producers who are concerned that requirements may change in the future may simply be disinclined to adopt a labor-intensive practice that lacks clear financial benefits. They may decide to take a wait and see approach.

Several significant differences are identified in the use of cover crops among producers in the different study counties. Producers in Edgecombe, Johnston, and Nash counties are more likely to use cover crops than those in Lenoir County. Those in Johnston are also more likely to use cover crops than those in Wayne County. Respondents from Johnston County had nearly 3.4 times higher odds (significant at the .01 level) of using cover crops than those in Lenoir and 1.9 times higher odds of using cover crops (sign. at .10 level) than those in Wayne County. Producers in Edgecombe and Nash had approximately five times higher odds than those in Lenoir (both significant at the .05 level). In terms of predicted probabilities, producers in Johnston County had a 19.6 percent higher probability of using cover crops than those in Lenoir and 10.8 percent higher probability than those in Wayne County. Producers in both Edgecombe and Nash counties had approximately a 27 percent higher predicted probability of using cover crops than those in Lenoir County. As discussed in the RYEs model results, county officials in Johnston County emphasized cover crops as a way to meet their mandated 30 percent nitrogen runoff reduction to a much greater extent than did officials in Lenoir and Wayne counties. It appears that Nash and Edgecombe counties also promoted cover crops more than Lenoir.

Participation in nutrient management training is also found to have a statistically significant relationship with adoption of cover crops. Producers who completed nutrient management training only are found to be more likely to use cover crops than producers in any of the other five activity groups. Most importantly, relative to those who participated in training only, those who intended to participate in training only had 75.4 percent lower odds of using cover crops and their predicted probability was 23.2 percent lower. As the intend to train only group serves as a quasi-experimental control for the train only group, this difference offers important evidence of the impact of training on adoption of cover crops. Among the remaining four groups, those who intended to complete both activities had 81.0 percent lower odds of using cover crops than those who had completed training only and their predicted probability was 26.7 percent lower. Respondents who had completed nutrient management plans only had 63.4 percent lower odds of using cover crops, with a 17.3 percent lower predicted probability. Those who had completed no activities had 54.7 percent lower odds of using cover crops and a 13.8 percent lower predicted probability. Finally, those who had completed both activities had 57.9 percent lower odds of using cover crops than those who had completed training only, with a 15.0 percent lower predicted probability. This last comparison is interesting because it suggests that adding a nutrient management plan to training actually lowers the odds of adopting cover crops relative to training only. It appears that while training increases the odds of using cover crops, adopting a nutrient management plan may actually diminish them.

Overall, the cover crops model appears to be a strong model, but many of the relationships it identifies seem counter-intuitive and are difficult to explain. In particular, higher levels of rule awareness and concern about stricter regulations in the future are both associated with lower levels of adoption. These findings suggest that the existence of the Nutrient Management Rule and the Agricultural Nitrogen Reduction Strategy Rule in the two basins may actually have a negative impact on the use of cover crops. Producers who know a lot about the rules may not be adopting cover crops because they are not actually required to do so. Those who are fearful that stricter regulations will be implemented in the future may not be adopting cover crops because they are concerned that future regulations will require them to use different practices. These two variables may be significant in the cover crops model, but not in the RYEs or soil testing models, because cover crops do not offer immediate potential financial benefits compared to practices that can reduce fertilizer costs. Perhaps the potential financial benefits of using RYEs and soil testing help overcome these concerns.

On the other hand, this model offers strong evidence that participating in nutrient management training has a positive impact on use of cover crops. Most notably, participating only in training increases the predicted probability of using cover crops by nearly 23 percent relative to the intend to train control group. The model also suggests that development of nutrient management plans may be counterproductive to encouraging use of cover crops.

6.2.1.3 Soil Test Model

The soil test model finds five significant explanatory variables: farm size, cost share for nutrient management, fear of inspections, counties, and nutrient management activities. Larger farm sizes are associated with greater use of soil tests. For a one unit increase in the natural log of farm size, the odds of using soil tests are 55.6 percent higher. Changing farm size from one standard deviation below the mean to one standard deviation above it increases the predicted probability of using soil tests by 13.7 percent. This positive relationship was expected as larger farms stand to gain the most benefit from applying the proper amounts of lime and other nutrients. Any cost savings they achieve are multiplied over more acres.

Surprisingly, the odds of using soil tests were found to be 70.8 percent lower among respondents who received cost share for nutrient management than among those who had not received this funding and their predicted probability of using soil tests was 16.2 percent lower. This counter-intuitive result appears to arise from the presence of influential observations in this model and thus should be discounted (See footnote 9).

Similar to the RYEs and cover crops models, the soil testing model finds one deterrence motivation to be significant. In this case, respondents who believed that the government was likely to inspect their nutrient management practices were more likely to use soil tests than those who did not believe this. The odds of using soil tests were 2.1 times higher among those who believed they were likely to be inspected and their predicted probability was 8.8 percent higher. The positive association between fear of inspections and soil testing indicates that this deterrent fear is encouraging adoption, which was expected.

Though use of soil testing is not significantly different in Edgecombe County than the other four counties, other disparities are found. Producers in Johnston and Nash counties were less likely to use soil tests than those in Lenoir. Those in Johnston had 57.3 percent lower odds (significant at the .10 level) of using soil tests than producers in Lenoir, and those in Nash had 75.7 percent lower odds (significant at the .10 level). The predicted probabilities of using soil tests were 9.0 percent lower in Johnston than Lenoir and 16.9 percent lower in Nash than Lenoir. In addition, producers in Wayne County were more likely to use soil tests than those in Nash County. Their odds of using soil tests were 3.6 times greater (significant at the .10 level) and their predicted probability was 15.7 percent higher. These results are further evidence of the stronger emphasis placed on nutrient management in Lenoir and Wayne counties.

Use of soil tests is also found to relate to participation in the mandated nutrient management activities. The odds were 3.3 times greater that producers who had completed both training and planning used soil tests in the two years prior to the survey, relative to those who had completed training only. Their predicted probability was 11.6 percent higher. Statistically significant differences are also found when comparing the use of soil tests between those who had completed no activities and those who had completed both, developed a nutrient plan only, and intended to do both activities. Producers who had completed a nutrient plan only had 3.9 times greater odds (significant at the .05 level; 16.4 percent higher predicted probability) of using soil tests relative to those who completed no activities. Those who had completed both activities had 5.5 times greater odds (significant at the .01 level; 18.9 percent higher predicted probability) and those who intended to complete both activities had 8.3 times greater odds (significant at the .10 level; 21.1 percent higher predicted probability) of using soil tests relative to the no activities group.

These results indicate that having a nutrient management plan increased the likelihood that a producer tested their soil in the two years prior to the survey. Those who participated in training and had a nutrient management plan were more likely to use soil tests than those who completed training only. Producers in each of the three groups that had completed plans (i.e., nutrient plan, both activities, and intend to do both) were more likely to test their soil than those who had not completed any activities.

In conclusion, the soil test model offers additional support for the roles that capacity variables, deterrence motivations, and nutrient management activities each play in the adoption of nutrient BMPs. In the case of soil testing, farm size makes a positive impact on use. This is likely because increases in fertilizer application efficiency get multiplied over larger areas, resulting in greater cost savings. Deterrence motivations also played a role. Producers who feared being inspected were more likely to test their soil. Soil testing is an easy, inexpensive practice that likely gives producers a sense of security because it provides them with a written report they can show to inspectors. Development of a nutrient management plan also increased the likelihood that a producer would test their soil. This makes sense as nutrient management plans include soil tests as a component of the planning process.

The findings in the soil test model differ from the other two nutrient BMP models in several ways. First, unlike the RYEs and cover crop models, neither farm income nor education played a role in the use of soil tests. The insignificance of farm income appears to be an artifact of influential observations in the soil testing model (See footnote 9). Education is likely not influential because soil testing is not a complicated practice. This quality may also explain why rule awareness and two of the deterrence motivation variables are not significant for soil testing. Soil testing is so easy and inexpensive that most producers would do it with or without the rules. Finally, unlike the use of RYEs and cover crops, participation in nutrient management training does not appear to play a role in the use of soil tests. Again, this practice is widespread and familiar to producers. Training did not strongly emphasize soil testing and training is not needed to understand how to do it.

6.2.1.4 Summary of Key Results for the Nutrient BMP Models

The three nutrient BMP models test the first five study hypotheses, and offer mixed results. Across the three practices, Hypothesis 1 is supported: capacity is found to relate to adoption of the nutrient BMPs. However, not all of the variables are found to be significant. Farm size and farm income are each found in some cases to have a positive influence over adoption and education has a mixed influence. Age, income, experience, and innovativeness are not found to influence adoption of any of the three practices. Hypothesis 2 is supported for the deterrence motivations, but not for economic or normative motivations. Each of the three deterrence motivations is found to be significant in one of the models, though in the RYEs and cover crops models, deterrence is actually found to have a negative relationship with adoption. No evidence is found to support Hypothesis 3: perceived control is not found to be significant in any of the models. Hypothesis 4 holds for cover crops only. Rule awareness is found to relate to adoption of cover crops, though in an unexpected negative direction. Rule awareness was not found to influence use of RYEs or soil tests. Finally, Hypothesis 5 is supported. Participation in the mandated nutrient management activities does influence the use of all three nutrient BMPs. Participation in nutrient management training appears to increase adoption of RYEs and cover crops, whereas developing a nutrient management plan increases use of RYEs and soil tests.

6.2.2 Predicting Potential Mediators

For a variable to be considered as a possible mediator in this study, it must meet two initial tests. First, it must be found to influence the adoption of at least one of the nutrient BMPs. Second, it must be influenced by either the activity variables or rule awareness. Of all the adoption motivation variables (i.e., attitude, norm, denial, external, income impact, fear of penalties, fear of inspections, and fear of stricter regulations) and the two variables that are additional considerations for adoption (i.e., perceived control and rule awareness), four pass the first test. Rule awareness and the three deterrence motivations: fear of penalties, fear of inspection, and fear of stricter regulations were each found to be significant in one of the nutrient BMP models. To determine if these four variables meet the second test, each was treated as an independent variable in a second set of models with the nutrient management activities, capacity variables, county variables, and rule awareness serving as predictors.[13,14]

Table 6.2 provides the results of the multivariate statistical models that evaluate these relationships for fear of inspections, fear of stricter regulations, and rule awareness. The model for fear of penalties was not statistically significant and is not presented. The remaining models are all significant at the .01 or .001 levels and test Hypotheses 6, 7, 9, 10, and 12.

6.2.2.1 Fear of Inspection Model

The first mediator model investigates factors related to a producer's belief that their nutrient management practices were likely to be inspected. Six significant variables are identified. Increases in farm size lead to weaker fears of inspection. For a one unit

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[13]Rule awareness is not tested as an independent variable in the rule awareness model.

[14]Because the direction of causation between participation in the mandated activities and these four variables is not clear, statistically significant relationships among these variables are interpreted as associations. Where possible, the model results are used to shed light on the likely direction of influence.

increase in the natural log of farm size, producers had 17.1 percent lower odds of believing they would be inspected. Moving from one standard deviation below to one standard deviation above the mean of farm size decreases the predicted probability of fearing inspections by 10.7 percent. Both farm income and education are found to have positive impacts on fear of inspection. For a one percent increase in farm income, the odds of fearing inspection increase by 1.3 percent. Moving from one standard deviation below the mean of farm income to one above, the predicted probability of fearing inspection increases by 18.8 percent. Having completed some college also increases the odds that a producer will fear inspection. Those who had completed some college had 1.8 times higher odds of fearing inspection than those who had graduated from high school or completed less education and their predicted probability was 11.5 percent higher. Those who had graduated from college did not differ from producers in the other two education categories. Finally, producers who perceived themselves as innovative had 40.8 percent lower odds of fearing inspections compared to those who did not perceive themselves this way and their predicted probability was 10.5 percent lower. These results demonstrate that capacity variables do influence fear of inspection, but it is not clear why these particular variables are associated with fear of inspection in the ways determined in the model.

Rule awareness is found to have a positive relationship with fear of inspections. Producers in the highest category of rule awareness were more likely to fear inspections than those in each of the three lower categories. Relative to those in the lowest category of awareness, those in the highest had 2.6 times higher odds of believing that their nutrient management practices were likely to be inspected. Moving from the lowest

Table 6.2. Multivariate Regression Results for Mediator Models.

Variables	Multivariate Odds Ratios[c] (standard error)							
	Fear Inspection		**Fear Stricter Regulations[d]**				**Rule Awareness**	
			Multinomial Logit, Base: Disagree					
	Logit		Agree		Strongly Agree		Ordered Logit	
Capacity:								
Age	0.986	(0.016)	0.959	(0.028)	0.972	(0.034)	0.997	(0.014)
Farm size (ln)	*0.829	(0.089)	1.177	(0.209)	0.983	(0.214)	**0.356	(0.165)
Farm size² (ln)[a]	x	x	x	x	x	x	**1.107	(0.047)
Income	1.002	(0.001)	**0.994	(0.002)	0.998	(0.003)	1.001	(0.001)
Farm income	***1.013	(0.004)	0.991	(0.008)	0.993	(0.009)	1.002	(0.004)
Experience	1.00	(0.015)	1.027	(0.026)	1.022	(0.032)	1.018	(0.013)
Some college	**1.770	(0.514)	1.332	(0.675)	2.352	(1.414)	***2.020	(0.482)
College graduate	1.201	(0.377)	1.568	(0.900)	2.147	(1.477)	**1.900	(0.510)
Innovativeness	**0.592	(0.147)	0.801	(0.350)	0.934	(0.491)	1.007	(0.210)
Cost share crops	0.886	(0.355)	1.497	(1.096)	2.005	(1.710)	x	x
Cost share nutri.	0.684	(0.279)	0.583	(0.377)	0.283	(0.230)	x	x
Mediators:								
Rule awareness	x	x	1.174	(0.275)	*1.708	(0.469)	x	x
Rule awareness 3[b]	0.623	(0.185)	x		x		x	x
Rule awareness 4	0.659	(0.216)	x		x		x	x
Rule awareness 5	*2.579	(1.373)	x		x		x	x
Counties:								
Johnston	0.598	(0.415)	**13.316	(13.494)	5.1E+07	9.3E+10	0.656	(0.407)
Lenoir	0.429	(0.297)	***15.713	(15.443)	4.0E+07	7.3E+10	1.052	(0.645)
Nash	0.670	(0.333)	*4.153	(3.447)	2.760	(3.189)	0.755	(0.308)
Wayne	0.425	(0.295)	***12.334	(11.895)	5.9E+07	1.1E+11	1.505	(0.923)
Activities:								
Intend to train	0.965	(0.689)	3.321	(4.056)	7.1E+06	1.3E+10	0.536	(0.342)
Both activities	1.245	(0.481)	0.426	(0.369)	0.305	(0.283)	*1.778	(0.570)
Intend to do both	1.465	(1.262)	4.224	(6.364)	1.311	(3185)	0.404	(0.296)
Nutrient plan	1.990	(0.982)	0.261	(0.234)	**0.089	(0.094)	0.546	(0.213)
No activities	0.549	(0.211)	1.064	(0.996)	0.316	(0.329)	****0.289	(0.097)
Model X^2 (df)	****55.54 (22)		***66.88 (40)				****88.48 (18)	
Observations	369		369				369	
Ologit cut 1, 2, 3	x		x				-2.48, -1.08, 0.74	

Notes: *p ≤ .10, **p ≤ .05, ***p ≤ .01, ****p ≤ .001

[a] Farm size² is omitted when not significant.

[b] Likelihood ratio tests indicated that rule awareness could be included as an interval-scale variable in the fear of stricter regulations model but not the fear of inspections model. In this model it is included as a set of dummy variables, omitting the lowest level of rule awareness (2).

[c] Relative risk ratios are provided for the fear stricter regulations model rather than odds ratios.

[d] Some relative risk ratios for counties and activities are inflated due to small cell sizes in the model.

category to the highest category of awareness increased the predicted probability of fearing inspection by 16.3 percent. The positive relationship between these two variables is not surprising, and they could be mutually reinforcing. Knowing more about the rules may increase a producer's deterrence fears and having stronger deterrence fears may encourage producers to learn more about the rules.

Fear of inspections is also found to be related to participation in the mandated nutrient management activities. Relative to the producers who completed no activities, those who completed both activities had 2.3 times higher odds of fearing inspection (significant at the .05 level) and those who developed plans had 3.6 times higher odds (significant at the .01 level). Compared to completing no activities, developing a nutrient management plan increased the predicted probability of fearing inspections by 26.4 percent and performing both activities increased the predicted probability by 17.7 percent. The fact that producers with nutrient management plans are more fearful of inspection is likely because five percent of all plans that have been supported by the N.C. Agricultural Cost Share Program are subject to inspection each year.

6.2.2.2 Fear of Stricter Future Regulations Model

The second mediator model tests relationships between study variables and fear of stricter future regulations. This model uses multinomial logistic regression analysis because the dependent variable is ordered, but the model did not meet the parallel slopes assumption of the ordered logistic model. This model provides two sets of coefficients for each independent variable. One set compares those who agreed that stricter regulations were likely in the future with those who did not agree (i.e., those who disagreed, disagreed strongly, or neither agreed nor disagreed). The second set compares those who strongly agreed with those who did not agree. This model identifies three significant variables for the first contrast and two for the second. Relative risk ratios, which are equivalent to odds ratios for the multinomial model, are presented in Table 6.2.

For the first contrast, income, counties, and nutrient management activities are statistically significant. Income has a negative effect. For a $1,000 increase in income, the relative risk of agreeing rather than not agreeing that stricter regulations are likely decreases by 0.6 percent.

Figure 6.2. Predicted Probability of Agreeing that Stricter Regulations are Likely by Income

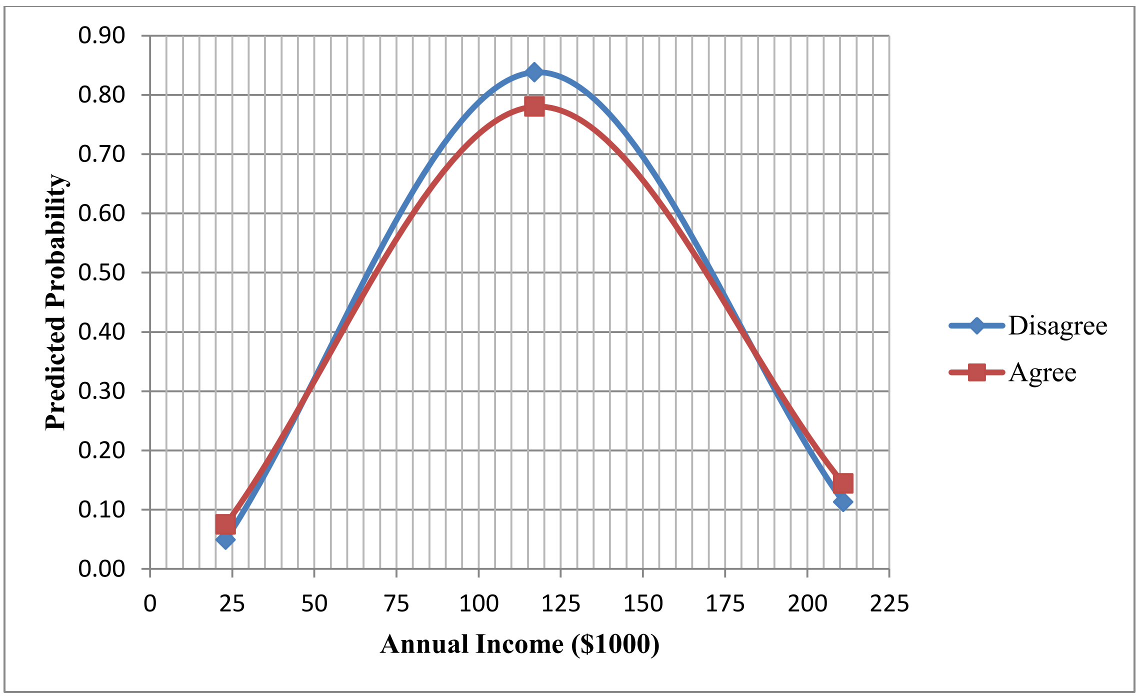
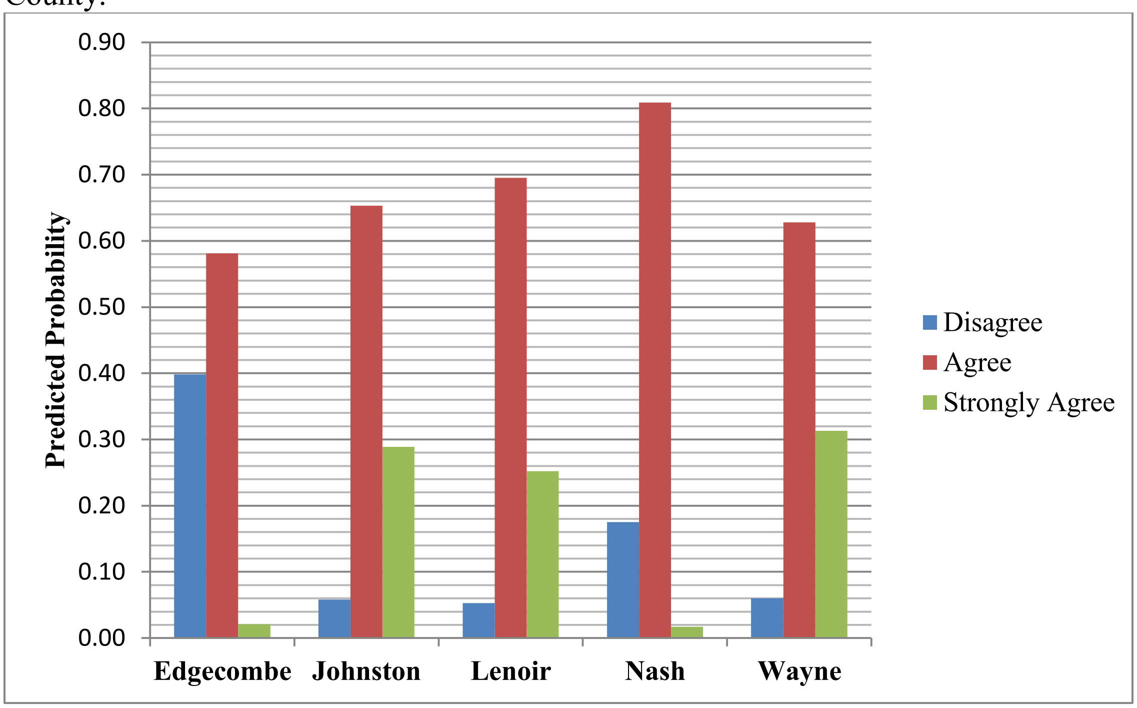


Figure 6.2 shows the relationships between income and predicted probabilities by the level of agreement that stricter regulations are likely. This graph shows that producers who earn the mean income ($117,000) are more likely to disagree that stricter

regulations are likely than to agree. However, those who earn one standard deviation below the mean ($23,000) or one standard deviation above the mean ($211,000) are more likely to agree. Specifically, producers who earn $117,000 have a 5.8 percent lower predicted probability of agreeing than disagreeing. Those who earn $23,000 have a 2.6 percent higher predicted probability of agreeing than disagreeing and those who earn $211,000 have a 3.1 percent higher predicted probability of agreeing than disagreeing.

The influence of the counties on fear of stricter regulations is illustrated in Figure 6.3. This graph shows that producers in Edgecombe County have much higher predicted probability of disagreeing and a lower predicted probability of agreeing that stricter

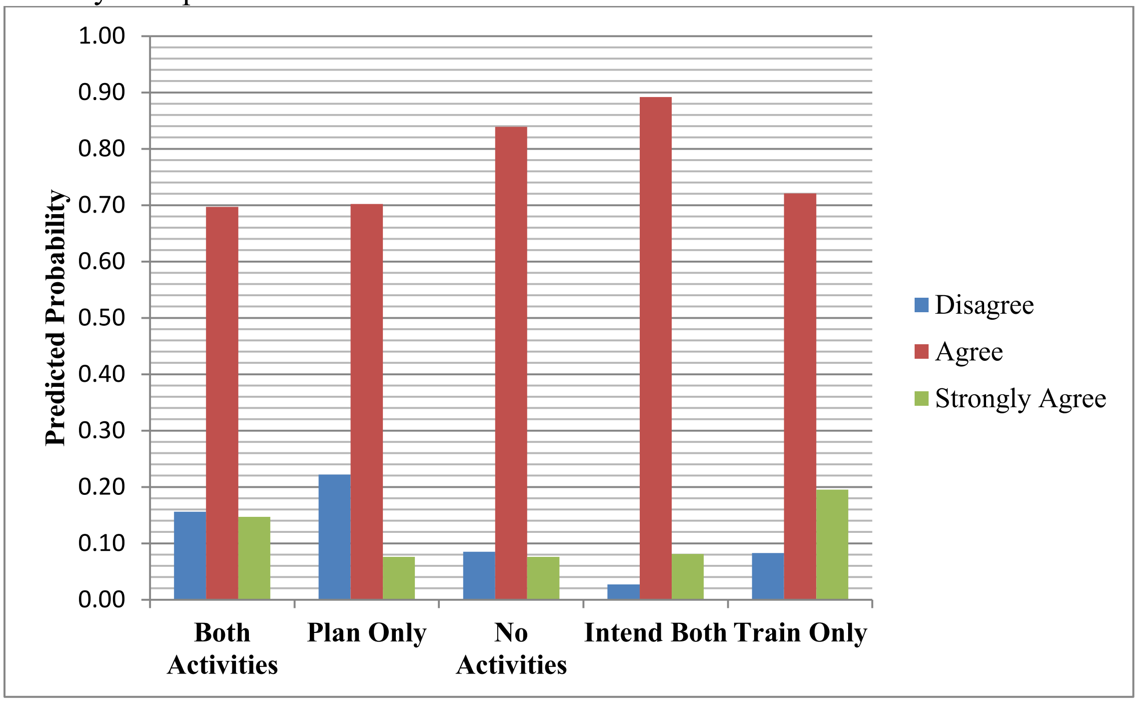
Figure 6.3. Predicted Probability of Agreeing that Stricter Regulations are Likely by County.



regulations are likely in the future than those in the other four counties. Their predicted probability of disagreeing is 22.3 percent higher than producers in Nash, and approximately 34 percent higher than producers in Lenoir, Wayne, and Johnston counties. Their predicted probability of agreeing is 22.8 percent lower than the producers in Nash, 11.4 percent lower than producers in Lenoir, 7.2 percent lower than those in Johnston, and 4.7 percent lower than producers in Wayne County. This graph also shows that producers in the two Tar-Pamlico Basin counties, Edgecombe and Nash have much lower predicted probabilities of strongly agreeing that stricter regulations are likely than those in the three Neuse Basin counties, though these contrasts were not found to be statistically significant in the model. In terms of relative risk, producers in Johnston, Lenoir, Nash, and Wayne counties have relative risks of agreeing rather than not agreeing that are 4.2 to 15.7 times higher than producers in Edgecombe County.

Significant differences also exist when comparing producers who developed plans or completed both activities to producers who intended to train, intended to do both activities, or completed no activities. Generally, those who developed plans or completed both activities were less fearful of stricter regulations than producers in these other groups. In contrast to those who completed both activities, those who intended to train had a 2.1 times higher relative risk (significant at the .10 level) of agreeing that stricter regulations were likely than disagreeing. Those who intended to do both activities had a 2.3 times higher relative risk of agreeing than disagreeing compared to producers who had already completed both activities (significant at the .10 level). Compared to producers who had developed nutrient management plans, those who intended to train had a 2.5 times higher relative risk of agreeing than disagreeing that stricter regulations were likely (significant at the .01 level). Producers who intended to do both activities had a 2.8 times higher relative risk of agreeing than disagreeing compared to producers who developed plans (significant at the .05 level). Finally, producers who completed no activities had a 1.4 times higher relative risk (significant at the .05 level).

Figure 6.4. Predicted Probability of Agreeing that Stricter Regulations are Likely by Activity Group



Note: The intend to train group is not included because its predicted probabilities were distorted due to inflated coefficients in the model.

Figure 6.4 illustrates the differences in predicted probabilities for the activity groups. Relative to producers who completed both activities, those who intended to do both had a 12.9 percent lower predicted probability of disagreeing and those who completed no activities had a 7.1 percent lower predicted probability. Relative to producers who developed nutrient plans, producers who intended to do both had a 19.5 percent lower predicted probability of disagreeing and those who performed no activities had a 13.7 percent lower predicted probability of disagreeing. Relative to those who completed both activities, those who intended to do both activities had a 19.5 percent higher predicted probability of agreeing and those who completed no activities had a 14.2 percent higher predicted probability of agreeing. Compared to producers who developed plans, those who intended to do both activities had a 19.0 percent higher predicted probability of agreeing that stricter regulations were likely and those who completed no activities had a 13.7 percent higher predicted probability of agreeing.

All of these differences suggest two possibilities. First, producers who are concerned about stricter future regulations may be more likely to seek out training, perhaps as a way to learn more about the likelihood of future regulations and how to prepare for them. Second, developing nutrient management plans may allay concerns about future regulations. Having a plan may provide producers with a sense of security that they are less likely to be targeted by additional future requirements because they have already taken some action. In addition, the difference between the both activities group and its control (i.e., the intend to do both activities group) is evidence that when performed in combination with having a nutrient management plan, participating in training reduces fears of stricter regulations.

For the second model contrast between those who strongly agree that stricter regulations are likely and those who disagree, rule awareness and activities are statistically significant. Fear of stricter regulations has a positive relationship with rule awareness. For a one unit increase in rule awareness, the relative risk of strongly agreeing compared to not agreeing that future regulations are likely increases by a factor of 1.7.

Figure 6.5. Predicted Probability of Agreeing that Stricter Regulations are Likely by Rule Awareness.

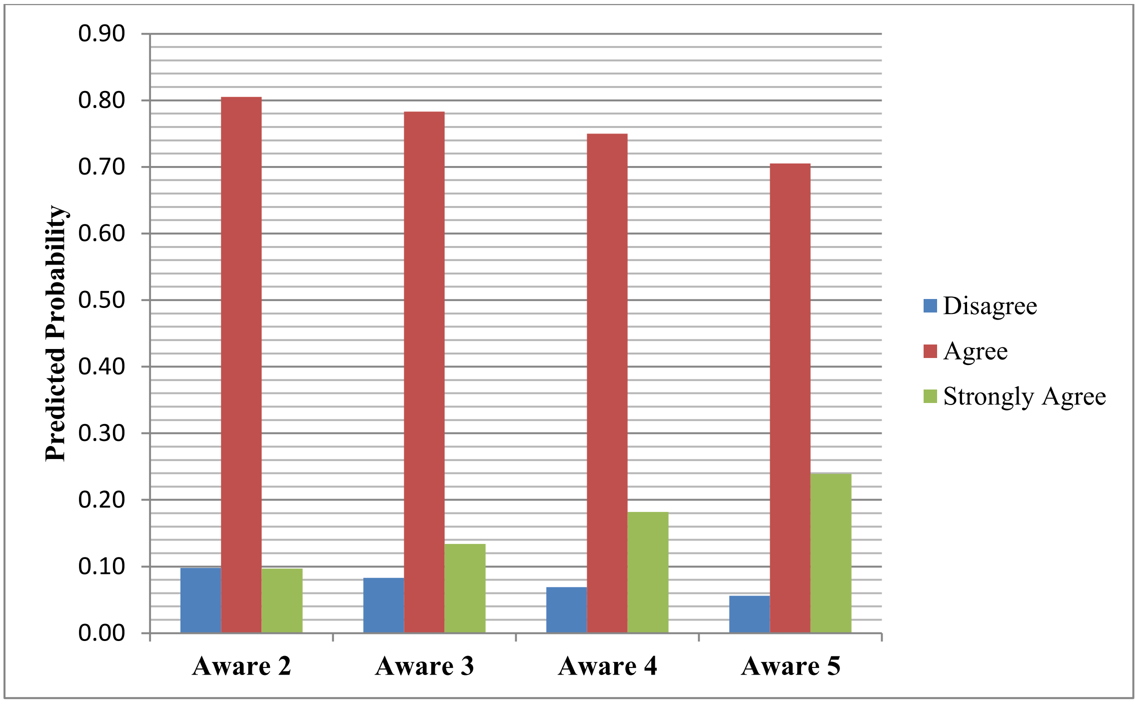


Figure 6.5 shows how the predicted probabilities of the different agreement groups vary by level of rule awareness. The predicted probability that a producer would disagree did not vary much with the different levels of rule awareness. However, there were more sizeable differences in rule awareness for those who strongly agreed that stricter regulations were likely. For example, producers who strongly agreed had a 14.2 percent higher predicted probability of being in the highest category of rule awareness (5) than the lowest level (2). The graph shows that for those who strongly agreed, the predicted probabilities increase with each unit increase in rule awareness. In contrast, for those who either disagreed or agreed, the predicted probabilities decrease with increasing awareness.

Again, this positive relationship is expected. Producers who are concerned about future regulations will likely seek out information about the current rules. Alternatively, those who are well-informed about the rules may appreciate that they are not particularly stringent and may need to be strengthened in the future.

The second statistically significant variable for the contrast between producers who strongly agree and those who disagree is nutrient management activities. For this contrast, developing a nutrient management plan is associated with a weaker fear of stricter future regulations when compared to participating in training. In relation to producers who train only, the relative risk of strongly agreeing rather than not agreeing for producers who have developed plans is 91.1 percent lower. As seen in Figure 6.4, for producers who developed plans, the predicted probability of disagreeing was 13.9 percent higher than for those who trained only. The predicted probability of strongly agreeing that stricter regulations were likely was 11.9 percent lower for those who planned than for those who trained.

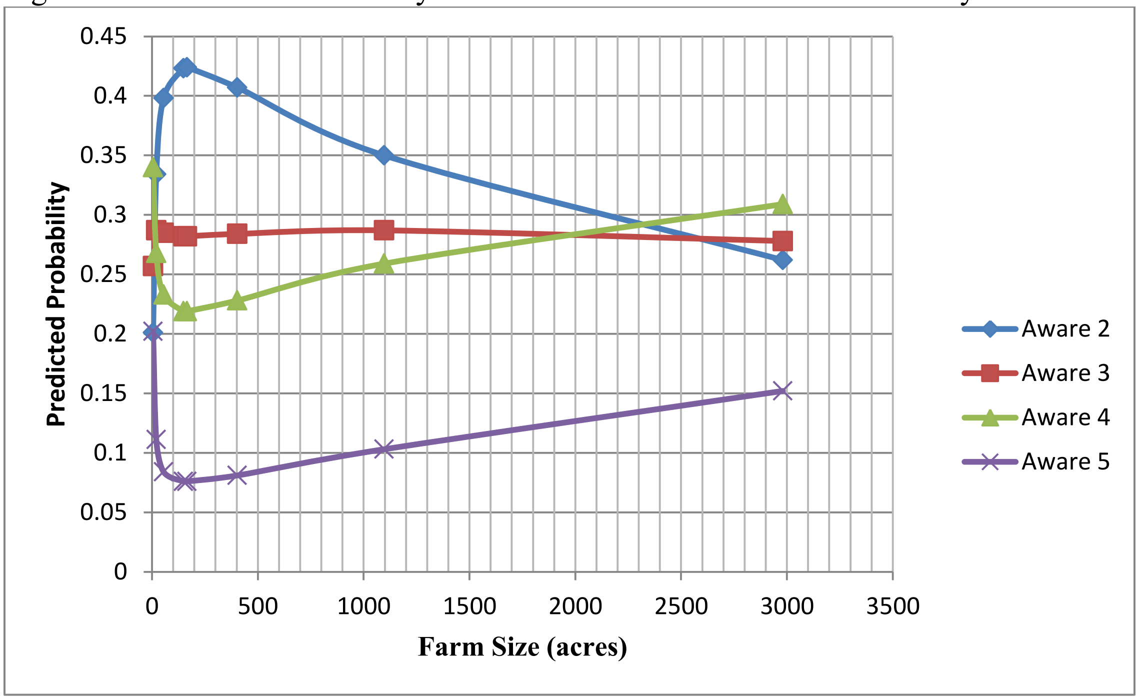
This finding adds to those for the first contrast by suggesting the possibility that training itself may also increase concerns about future regulations. However, because those who trained do not differ from those who intended to train or completed no activities, this possibility is not certain.

6.2.2.3 Rule Awareness Model

Ordered logistic regression analysis was used to identify factors having statistically significant relationships with awareness of the Neuse and Tar-Pamlico Nutrient Management and Agricultural Nitrogen Reduction Strategy Rules. Four significant variables are identified: farm size, education, counties and activities.

Both of the statistically significant capacity factors, farm size and education, have positive impacts on rule awareness. However, the effect of farm size is not linear. For farms smaller than 165 acres, the overall relationship between size and awareness is negative and for those over this threshold, it is positive.

Figure 6.6. Predicted Probability of Different Levels of Rule Awareness by Farm Size



Note: This graph does not depict the predicted probabilities for farms larger than 2,981 acres. These farms were omitted in order to preserve some of the detail for the smaller-sized farms. Data for these farms are found in Appendix D.

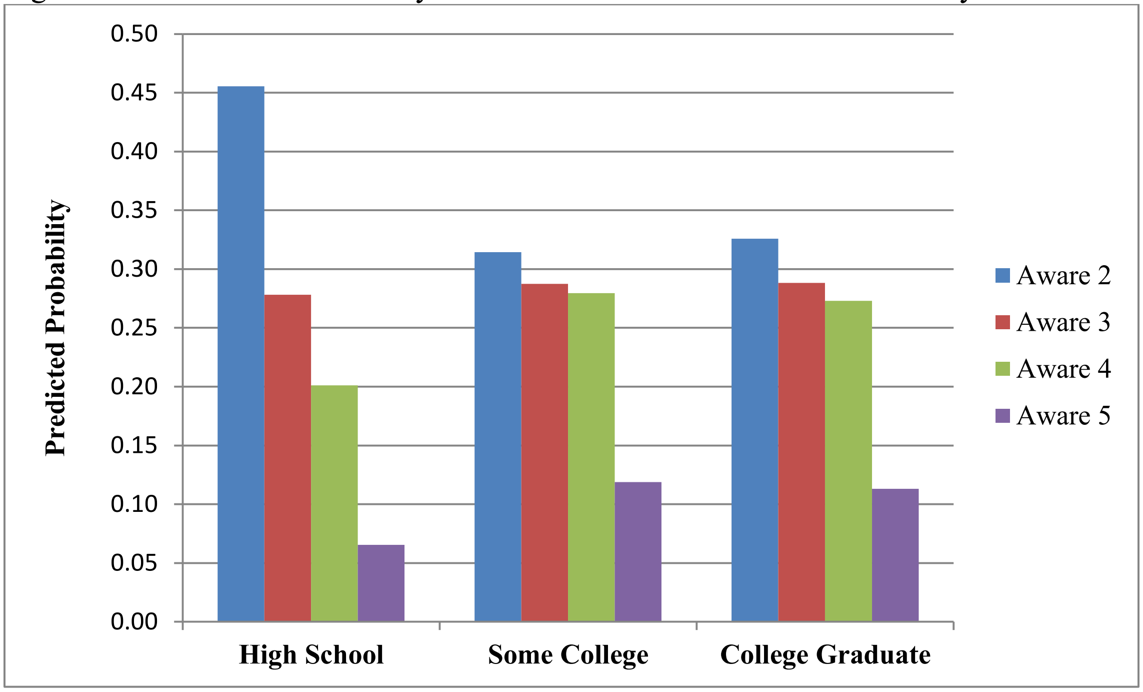
Figure 6.6 shows that this relationship holds for producers in categories 4 and 5 of rule awareness. However, for those in category 2, it is the opposite: the predicted probability of being in the lowest category of rule awareness increases up to 165 acres and then decreases. The predicted probability of being in category 3 does not vary much with farm size. Focusing just on the lowest and highest categories of rule awareness, moving from the smallest farm size of five acres up to 165 acres, increases the predicted probability of being in category 2 by 22.3 percent and decreases the predicted probability of being in category 5 by 12.6 percent. Moving from 165 acres up to the largest farm size of 6,500 acres decreases the predicted probability of being in category 2 by 24.1 percent and increases the predicted probability of being in category 5 by 14.5 percent.

This positive relationship likely exists in part because it is easier and potentially more effective for Extension agents and other officials to target large farms in outreach efforts. Large farms are easier to identify and their actions can have more impact.

Education is also found to be statistically significant. Both attending some college and graduating from college are also associated with higher levels of rule awareness. The odds of those who attended some college having greater rule awareness were 2.0 times greater than those who attended high school only or had less education. The odds of having a higher level of awareness were 1.9 times greater for college graduates than for those who attended high school only or had less education.

Figure 6.7 shows the predicted probabilities for this relationship. Producers who have completed high school or less education have higher predicted probabilities of being in category 2 of rule awareness than producers who have completed some college or have graduated from college. Their predicted probability is 14.1 percent higher than those who have completed some college and 12.9 percent higher than those who have graduated from college. All three education groups have roughly the same predicted

Figure 6.7. Predicted Probability of Different Levels of Rule Awareness by Education.



probability of being in category 3 of awareness. Those who have completed high school or less education have lower predicted probabilities of being in categories 4 or 5 than the other two education groups. Their predicted probability is 7.8 percent lower than producers who have completed some college for category 4 and 5.4 percent lower for category 5. Compared to producers who had graduated from college, those who completed high school or less education have predicted probabilities that are 7.2 percent lower for category 4 and 4.8 percent lower for category 5. Producers in the two higher education groups have very similar predicted probabilities for each category of awareness. Higher levels of education may enhance the ability of producers to obtain and understand information about the rules.

Only one significant difference in rule awareness is identified among the five counties. Producers in Wayne County had 2.3 times greater odds of being in a higher category of rule awareness than producers in Johnston County (significant at the .01 level).

Figure 6.8. Predicted Probability of Different Levels of Rule Awareness by County.

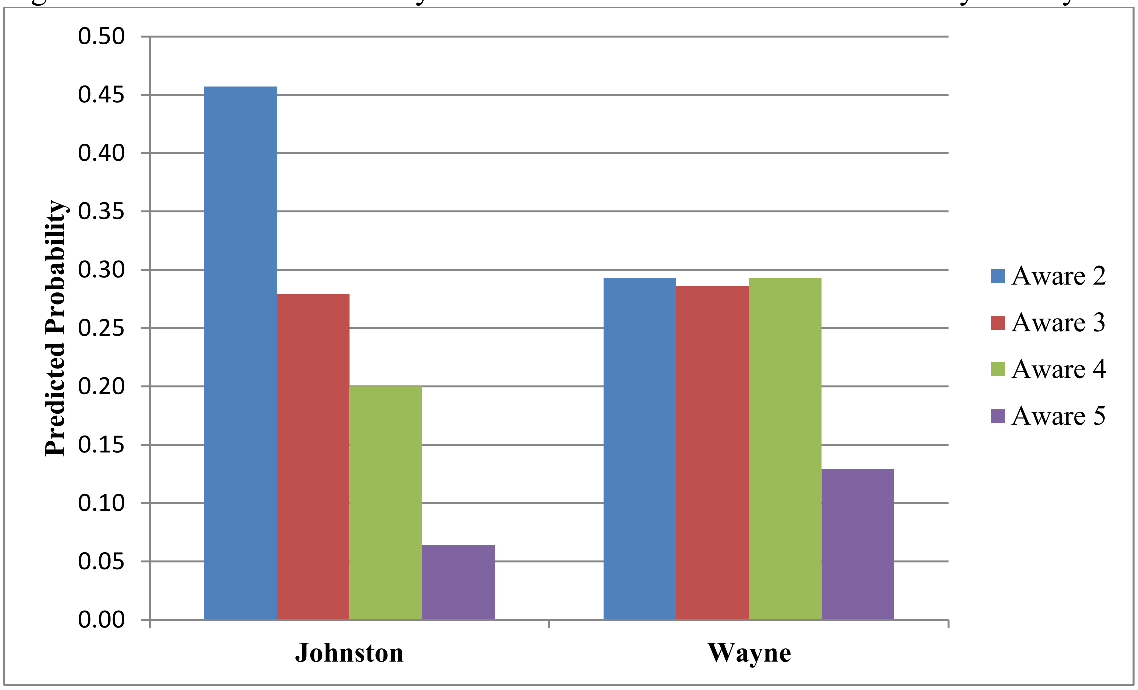


Figure 6.8 shows that compared to producers in Johnston County, those in Wayne County have a lower predicted probability of being in category 2 of rule awareness and higher probabilities of being in categories 4 or 5. Their predicted probability of being in category 2 is 16.4 percent lower. Their probability of being in category 4 is 9.3 percent higher and for category 5 it is 6.5 percent higher. Outreach efforts in Wayne County were known to be particularly intensive (Osmond et al., nd).

Last, rule awareness is found to be significantly associated with participation in the mandated nutrient management activities. Producers who trained, developed plans, or did both had greater odds of being in a higher category of awareness than those who performed no activities. Compared to those who trained, the odds of being in a higher category of awareness were 71.1 percent lower for those who completed no activities. Compared to those who completed no activities, the odds were 1.9 times greater for those who developed plans (significant at the .10 level), and 6.1 times greater for those who performed both activities (significant at the .001 level).

Figure 6.9. Predicted Probability of Different Levels of Rule Awareness by Activity Group.

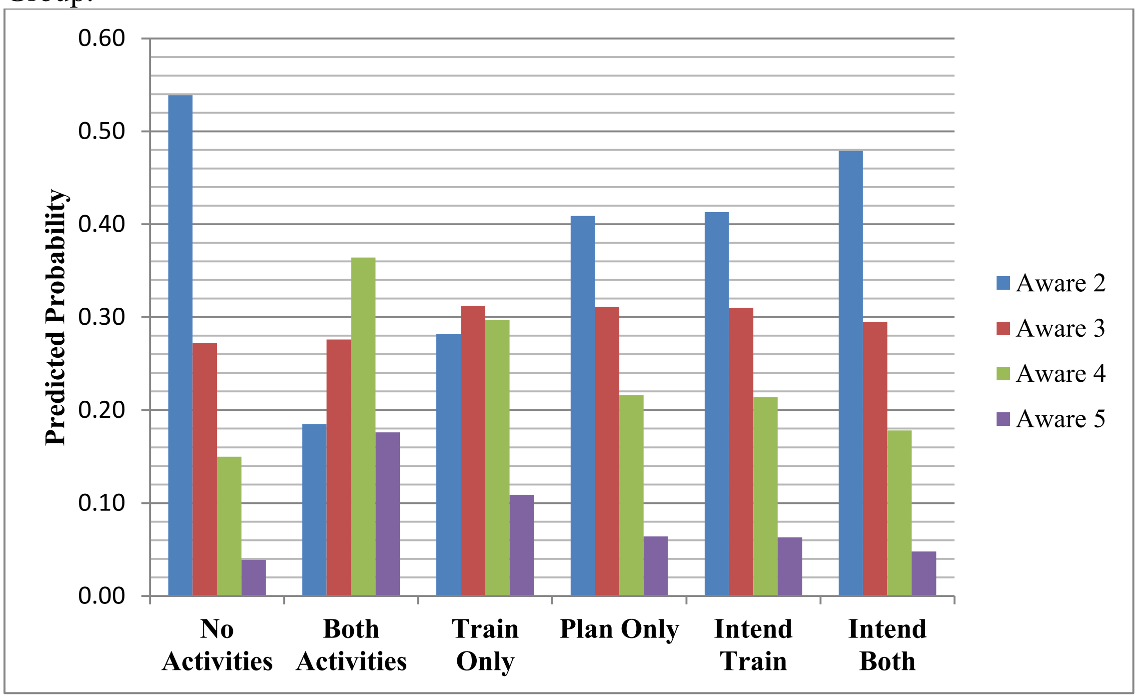


Figure 6.9 shows the associated predicted probabilities. Producers who completed no activities had: a 13.0 percent higher predicted probability of being in category 2 of rule awareness than those who developed plans only, a 25.7 percent higher predicted probability of being in category 2 than those who trained only, and a 35.4 percent higher predicted probability than those who completed both activities. For category 5 of rule awareness, those who completed no activities had: a 2.5 percent lower

predicted probability compared to those who developed plans, a 7.0 percent lower predicted probability than those who trained only, and a 13.7 percent lower predicted probability than those who completed both activities.

In addition, those who completed both activities also had higher odds of being in a category of greater rule awareness than producers in any of the other groups. Their odds were 1.8 times higher than those who trained only, 3.3 times higher than those who intended to train (significant at the.10 level), 4.4 times higher than those who intended to complete both activities (significant at the .05 level), and 3.3 times higher than those who developed plans only (significant at the.001 level). For category 5 of rule awareness, those who completed both activities had a predicted probability that was 6.7 percent higher than for those who trained, 11.2 percent higher than for those who developed plans, 11.3 percent higher than for producers who intended to train, 12.8 percent higher than for producers who intended to do both, and 13.7 percent higher than for those who completed no activities.

While the fact that producers who participated in the mandated activities had a higher level of rule awareness than those who performed no activities is interesting, it does not reveal whether the activities increased awareness, whether the producers who were more aware of the rules were more likely to participate in the activities, or both. It would make sense that producers who know more about the rules would participate in the activities at higher rates since the rules require most producers to do so. However, the fact that producers who completed both activities had higher levels of awareness than those who developed plans only, intended to train only, and who intended to complete both implies that training is partly responsible.

6.2.2.4 Summary of Key Results for the Mediator Models

These three models yield several important insights. First, they reveal that fear of inspections, fear of stricter regulations, and rule awareness all have the potential to serve as mediators in this study. These three variables pass the second test for mediation, as all three are found to be related to participation in the mandated nutrient management activities. In addition, fear of inspections and fear of stricter regulations are also found to relate to rule awareness. These findings support Hypotheses 9, 10, and 12.

Second, in answer to Hypotheses 6 and 7, these models provide evidence that capacity factors do indeed influence rule awareness and the two tested adoption motivations. Though the explanations behind these influences are not always obvious, farm size, income, farm income, education, and innovativeness are all found to play a role.

Third, these models identify one key similarity and several interesting differences between the two deterrence motivations tested. On one hand, both motivations are found to be positively associated with rule awareness. Producers who know more about the rules tend to have higher levels of these deterrence fears. On the other hand, the motivations are not associated with the same capacity factors, counties, or mandated activities. While several capacity variables appear to influence fear of inspection, only income was found to influence fear of stricter regulations. In addition, while Edgecombe County clearly differed from the others in terms of fear of stricter regulations, no county differences were found for fear of inspection. Finally, while producers who have developed nutrient management plans tend to have stronger fears of inspection, they also tend to have weaker fears of stricter regulations. Training does not appear to influence fear of inspection, but a fear of stricter regulations may be encouraging participation in training and training itself may be increasing this fear.

Fourth, the rule awareness model shows that participation in nutrient management training and development of nutrient management plans are both associated with higher levels of rule awareness. It makes sense that producers who know more about the rules would participate in these activities at higher rates than producers who know little about them. This is largely because the rules themselves mandate performance of these activities by most producers. However, there is also some evidence that participating in training further increases awareness of the rules. Statistical testing of the mediation effects of rule awareness will help shed light on causal ordering of this relationship. Mediation testing results are presented and discussed in Section 6.3.

6.2.3 Exploring the Relationships between Nutrient Management Activities and Additional Adoption Motivations

The final models explore the relationships between the remaining adoption motivations: attitude, norm, denial, external, income impact, and perceived control, and variables related to capacity, rule awareness, counties, and nutrient management activities. The adoption motivations and considerations addressed in this section of the dissertation were determined not to be mediators in this study. However, they may be important factors for adoption of other types of BMPs and, thus, are useful to investigate. These models test hypotheses 7, 8, 9, 10, and 11.

Table 6.3 presents the multivariate results for the external, denial, perceived control, and income impact models.[15] Models for attitude and norm were not significant and are not presented. The models for external, denial, and perceived control use multiple regression analysis. All three are found to be significant at the .01 level, though the adjusted R^2 values are low. The models only account for 5.9 to 6.4 percent of the variation in the three motivations. Income impact is tested using logistic regression analysis. This model is significant at the .05 level. Brief discussions of the model results, emphasizing findings related to the nutrient management activities, follow.

6.2.3.1 External Model

The first model focuses on the producers' sense of external pressure to protect water quality and follow the regulations. This pressure stems from concerns about community perceptions and feelings of duty to follow regulations in spite of producers' beliefs that the regulations are unfair. Four significant factors are identified. Income and education are found to have positive associations with this attitude. A $1,000 increase in income increases external pressure by 0.001 units. For producers who have completed some college, the predicted value of external pressure is 0.148 units higher than for those who completed high school or less education. Receiving cost share for nutrient management is associated with weaker feelings of external pressure. Producers who receive cost share for nutrient management are predicted to have values of external

[15]Relationships between these adoption motivations and participation in the nutrient management activities, receipt of cost share, and rule awareness are interpreted as associations due to a lack of clarity about the causal ordering. Where possible, the model results are used to shed light on the likely direction of influence.

Table 6.3. Multiple Regression and Logistic Regression Results for Additional Adoption Motivation Models.

Variables	Multiple Regression Coefficients (standard error)						Logistic Regression Odds Ratios (standard error)	
	External		Denial		Perceived Control		Income Impact	
Capacity:								
Age	-0.005	(0.003)	0.004	(0.006)	***-0.009**	**(0.005)**	0.986	(0.016)
Farm size (ln)	-0.030	(0.021)	****0.086**	**(0.037)**	-0.026	(0.032)	1.142	(0.118)
Income	***0.001**	**(0.000)**	0.000	(0.000)	***0.001**	**(0.000)**	1.000	(0.001)
Farm income	0.000	(0.001)	0.001	(0.001)	-0.001	(0.001)	1.003	(0.004)
Experience	0.003	(0.003)	-0.003	(0.005)	****0.010**	**(0.004)**	1.010	(0.015)
Some college	****0.148**	**(0.059)**	-0.111	(0.102)	-0.004	(0.088)	0.869	(0.239)
College graduate	0.085	(0.065)	***-0.203**	**(0.112)**	0.019	(0.096)	0.832	(0.256)
Innovativeness	-0.016	(0.051)	****0.174**	**(0.088)**	0.033	(0.076)	*****2.141**	**(0.518)**
Cost share crops	-0.059	(0.083)	***0.275**	**(0.144)**	-0.023	(0.124)	1.208	(0.468)
Cost share nutri.	****-0.179**	**(0.084)**	****-0.294**	**(0.146)**	****0.246**	**(0.125)**	0.863	(0.345)
Mediators:								
Rule awareness	-0.020	(0.027)	-0.012	(0.047)	x		1.026	(0.131)
Rule awareness 3[a]	x		x		*****0.257**	**(0.091)**	x	
Rule awareness 4	x		x		0.157	(0.101)	x	
Rule awareness 5	x		x		0.007	(0.140)	x	
Counties:								
Johnston	-0.221	(0.145)	****-0.543**	**(0.250)**	****0.537**	**(0.214)**	****6.120**	**(4.641)**
Lenoir	-0.153	(0.143)	***-0.424**	**(0.247)**	*****0.553**	**(0.212)**	****4.925**	**(3.701)**
Nash	-0.095	(0.100)	0.063	(0.173)	****0.305**	**(0.148)**	****2.847**	**(1.386)**
Wayne	-0.223	(0.143)	-0.284	(0.247)	****0.511**	**(0.212)**	****6.334**	**(4.761)**
Activities:								
Intend to train	*****-0.397**	**(0.150)**	-0.313	(0.259)	0.363	(0.222)	2.769	(2.071)
Both activities	0.047	(0.081)	0.208	(0.141)	0.181	(0.121)	****0.419**	**(0.160)**
Intend to do both	-0.073	(0.174)	-0.328	(0.301)	****0.548**	**(0.258)**	3.495	(2.935)
Nutrient plan	0.057	(0.099)	***0.308**	**(0.170)**	***0.280**	**(0.146)**	1.212	(0.543)
No activities	****-0.163**	**(0.083)**	0.104	(0.143)	0.126	(0.123)	1.251	(0.470)
Constant	******4.774**	**(0.276)**	******2.561**	**(0.476)**	******3.019**	**(0.401)**	**x**	
Prob>F	**0.003**		**0.002**		**0.002**		**0.017**	
R^2	**0.111**		**0.114**		**0.120**		**x**	
Adjusted R^2	**0.059**		**0.063**		**0.064**		**x**	
Model X^2 (df)	**x**		**x**		**x**		****35.73**	**(20)**
Observations	**369**		**369**		**369**		**369**	

Notes: *p ≤ .10, **p ≤ .05, ***p ≤ .01, ****p ≤ .001

[a] Likelihood ratio tests indicated that rule awareness could be included as an interval-scale variable in the external and denial models, but not the perceived control model. In this model it is included as a set of dummy variables, with category 2 omitted.

pressure that are 0.179 units lower than those who do not receive this funding. The mandated nutrient management activities are also associated with external pressure.

Holding everything else constant, training, developing a nutrient management plan, or completing both activities are all associated with stronger feelings of external pressure relative to intending to train and completing no activities. Compared to producers who train only, those who intend to train are predicted to have values of external pressure that average 0.397 units lower and those who perform no activities have external pressure values that average 0.163 units lower. Relative to producers who develop nutrient management plans only, those who intend to train are predicted to have values of external pressure that average 0.454 units lower (significant at the .01 level) and those who complete no activities have values that average 0.220 units lower (significant at the .05 level). Producers who intend to train also have values of external pressure that average .443 units lower (significant at the .01 level) than those who complete both activities. Those who complete no activities have values averaging 0.210 units lower (significant at the .01 level) than those who do both activities.

Intending to train is also associated with weaker feelings of external pressure compared to completing no activities. Those who intend to train are predicted to have values of external pressure that average 0.234 units lower (significant at the .10 level) than those who perform no activities. This finding supports the possibility that participation in the mandated activities, and particularly training, is leading to a stronger sense of external pressure rather than the other way around. If external pressure was encouraging participation in training, one would expect those who intend to train to feel more external pressure than those who intend to complete no activities. Instead, those who intend to train are predicted to have lower levels of external pressure than those who perform no activities, and those who complete training are predicted to have higher levels of external pressure than those who perform no activities.

6.2.3.2 Denial Model

The second model tests the relationships between the study variables and feelings of denial concerning the water quality problem and the need for regulations in the Neuse and Tar-Pamlico River Basins. Seven statistically significant variables are identified. Both farm size and innovativeness have positive relationships with denial, whereas graduating from college has a negative relationship. For a one unit increase in the natural log of farm size, producers' feelings of denial are predicted to increase by an average of 0.086 units. Producers who perceive themselves to be innovative are predicted to have feelings of denial that average 0.174 units higher than those who do not perceive themselves this way. Producers who graduate from college are predicted to have feelings of denial that average 0.203 units lower than those who graduate from high school or have less education.

Interestingly, receiving cost share for cover crops is positively related to feelings of denial, whereas receiving cost share for nutrient management has a negative association with denial. Relative to producers who do not receive these types of funding, those who receive cost share for cover crops are found to have feelings of denial that average 0.275 units higher and those who receive cost share for nutrient management are found to have feelings of denial that average 0.294 units lower.

Several county dummy variables are also significant. Farming in the two Tar-Pamlico counties, Nash and Edgecombe, is associated with higher levels of denial compared to farming in Johnston or Lenoir counties in the Neuse Basin. Producers in Nash County are predicted to have feelings of denial that average 0.487 units higher (significant at the .05 level) than those in Lenoir County and those in Edgecombe are predicted to have feelings of denial that average 0.424 units higher than producers in Lenoir. Relative to producers in Johnston County, producers in Nash County are predicted to have feelings of denial that average 0.606 units higher (significant at the .01 level) and those in Edgecombe County are predicted to average 0.543 units higher. Also, producers in Wayne County are predicted to have higher levels of denial than producers in Johnston County by an average of 0.259 units (significant at the .05 level).

Participation in the nutrient management activities is also related to feelings of denial. Relative to producers who develop plans only, those who intend to train, those who do train, and those who intend to do both activities, are all predicted to have weaker feelings of denial. Relative to planning only, those who intend to train are predicted to have feelings of denial that average 0.622 units lower (significant at the .05 level) and those who intend to complete both activities are predicted to average 0.637 units lower (significant at the .05 level) on denial. Those who complete plans only are predicted to average 0.308 units higher on denial than those who train only. In addition, those who intend to do both activities are predicted to have feelings of denial that average 0.536 units lower (significant at the .10 level) than producers who complete both activities. Finally, producers who intend to train are predicted to have feelings of denial that average 0.417 units lower (significant at the .10 level) than those who complete no activities.

At first glance, these results appear to suggest that developing a nutrient management plan increases feelings of denial. However, if this were true, one would expect that there would be no difference between producers who intended to do both activities and those who developed plans or performed both activities since producers in all three of these groups had already developed plans at the time of the survey. Instead, producers who intended to do both had weaker feelings of denial than the other two groups. One would also expect those who had developed plans to have stronger feelings of denial than those who performed no activities, which was not found to be the case. Instead, what these results imply is that producers who have weaker feelings of denial choose to participate in training. This makes sense as producers who believe there is a water quality problem and do not believe that farmers will address the problem on their own likely seek out training to learn what they can do to help.

6.2.3.3 Perceived Control Model

The third model focuses on factors associated with perceived control, or how easy one perceives nutrient management to be. This model also identifies seven significant variables. Increasing age diminishes perceived control, but increasing experience enhances it. For a one year increase in age, perceived control is predicted to decrease by 0.009 units and for a one year increase in experience, it is predicted to increase by 0.010 units. Increasing income and receiving cost share for nutrient management are both associated with higher levels of perceived control. For a $1,000 increase in income, perceived control is predicted to increase by 0.001 units. Those who receive cost share for nutrient management are predicted to have a sense of perceived control that averages 0.246 units higher than those who do not receive this funding.

Interestingly, having a moderate level of rule awareness (score of 3) is associated with greater feelings of perceived control relative to those in the lowest category of awareness (score of 2) and those in the highest (score of 5). Producers in category 3 are predicted to have feelings of perceived control that are 0.257 units higher than those in category 2 and 0.250 units higher than those in category 5 (significant at the .10 level). It is not clear why this would be the case. Farming in Edgecombe County is associated with lower levels of perceived control than farming in any other county. Producers in Johnston, Lenoir, Nash, and Wayne are not significantly different from each other, but are predicted to have feelings of perceived control that are 0.537, 0.553, 0.305, and 0.511 units higher than those in Edgecombe County respectively.

Finally, developing a nutrient management plan is associated with increased feelings of perceived control. Having a plan, either alone or in conjunction with intending to train, is associated with higher levels of perceived control relative to training only. Compared to producers who complete training only, those who have plans are predicted to have feelings of perceived control that average 0.280 units higher and those who intend to do both activities average 0.548 units higher. Those who intend to do both are also found to have stronger feelings of perceived control compared to those who complete no activities. They are predicted to have a sense of perceived control that is 0.422 units higher (significant at the .10 level). Not surprisingly, going through the process of developing a nutrient management plan appears to ease producers' concerns about the difficulties of performing nutrient management and developing plans.

6.2.3.4 Income Impact Model

The fourth model focuses on factors related to respondents' beliefs about whether nutrient management increases income. Three significant variables are identified: innovativeness, counties, and nutrient management activities. Producers who perceived themselves as innovative had 2.1 times higher odds of believing that nutrient management increases income than those who did not perceive themselves as innovative, and their predicted probability was 16.5 percent higher. The positive association between these attitudes may simply reflect a general bias in favor of new practices. Producers who farmed in Johnston, Lenoir, Nash and Wayne counties all had higher odds of believing that nutrient management increases income compared to those in Edgecombe County. Their odds were 6.1, 4.9, 2.8, and 6.3 times higher and their predicted probabilities were 31.3, 26.7, 15.8, and 32.1 percent higher respectively.

In addition, those who completed both nutrient management training and a nutrient management plan had lower odds of believing that nutrient management increases income compared to producers in all of the other activity groups. Relative to producers who completed both activities, producers in the plan only group had 2.9 times higher odds (significant at the .01 level). Those in the train only group had 1.3 times higher odds (significant at the .05 level) than those in the both group, or alternatively those who completed both activities had 58.1 percent lower odds than those who trained only. Relative to producers who completed both activities, producers in the intend to train group had 6.6 times higher odds (significant at the .05 level), those in the intend to do both group had 8.3 times higher odds (significant at the .05 level), and finally, those in the no activities group had 3.0 times higher odds of believing that nutrient management increases income (significant at the .01 level). In terms of predicted probabilities, participating in both activities lowered the predicted probability of believing nutrient management increases income by 20.3 percent relative to developing a plan only, 16.1 percent relative to training only, 38.3 percent relative to those who intended to train only, 43.1 percent relative to those who intended to do both, and 20.9 percent relative to those who performed no activities. The large difference between producers who complete both activities and those who intend to complete both activities is striking because it indicates that adding training to nutrient management planning increases doubts about the profitability of nutrient management.

It seems unlikely that producers who already believe nutrient management is unprofitable would choose to participate in nutrient management training and/or planning. Instead, it appears more likely that doubts about profitability derive from participation in the activities. It is not apparent whether these doubts are attributable to information producers receive while participating in the activities or to practical experiences on their own farms. However, this belief could be an important potential impediment to securing participation in future nutrient management activities, particularly if these producers share their feelings with others.

6.2.3.5 Summary of Key Results for the Additional Adoption Motivation Models

The four models discussed in this section reveal numerous important relationships between key study variables and the attitudes: external, denial, perceived control, and income impact. First, in support of Hypotheses 7 and 8, these models show that capacity factors are important. With the exception of farm income, all of the capacity variables are significant in at least one model. Three of the attitudes are also related to receipt of cost share. Cost share for nutrient management is associated with weaker feelings of external pressure and denial, and a stronger sense of perceived control. Interestingly, cost share for cover crops is associated with higher levels of denial. Hypothesis 9 is not supported by the external, denial, or income impact models: rule awareness is not found to be significant for these three adoption motivations. However, rule awareness is found to relate to feelings of perceived control.

Counties are also important predictive factors. Producers in the two Tar-Pamlico counties, Edgecombe and Nash, tended to be more in denial about water quality problems and the need for regulations compared to those in Johnston and Lenoir counties in the Neuse Basin. In addition, producers in Edgecombe County felt that nutrient management was more difficult and less likely to increase income than producers in any of the other four counties. These differences indicate that more general outreach efforts concerning the need for regulations and how to manage nutrients have been more effective in the Neuse Basin counties than in the Tar-Pamlico counties, particularly Edgecombe.

In support of Hypotheses 10 and 11, these models identify significant relationships between participation in the mandated nutrient management activities and the four attitudes. Training and planning, individually and in combination, appear to enhance feelings of external pressure. Having a lower level of denial, and thus believing that water quality is a problem and that producers will not address it without regulations, seems to encourage participation in training. Developing a nutrient management plan is associated with higher levels of perceived control. Finally, producers who complete both activities are the most pessimistic about nutrient management having a positive impact on income relative to all of the other activity groups.

6.3. Mediation Pathways

Study Hypothesis 13 predicts that the impact of participation in the mandated nutrient management activities on adoption of the three nutrient BMPs will be partially mediated by producers' awareness of the relevant agricultural rules, sense of perceived control, and motivations for adoption. For any of these variables to act as a possible mediator, it must be related to both adoption of one of the nutrient BMPs and to participation in the nutrient management activities. Perceived control was not found to have a significant relationship with adoption and therefore cannot serve as a mediator in this study. However, based on the model results discussed in Section 6.2, three possible mediation pathways exist:

1. Nutrient management activities → fear of stricter regulations → adoption of cover crops,
2. Nutrient management activities → fear of inspection → adoption of soil testing, and
3. Nutrient management activities → rule awareness → adoption of cover crops.

Unfortunately, the categorical nature of the variables in this study led to numerous challenges in testing mediation effects with Mplus. Potential pathway 1 could not be tested because the fear of stricter regulations variable has three unordered categories when it serves as a dependent variable. Potential pathway 2 could be tested with a minor modification to the rule awareness variable in the fear of inspections model. However, according to the statistics provided by Mplus, the model fit was very poor. As a result, testing specific mediation effects was not warranted.

The third possible mediation pathway, from activities to rule awareness to adoption of cover crops could be tested and proved to have very strong model fit statistics.[16] This mediation model identified three statistically significant activity contrasts that ultimately influence adoption of cover crops in part by acting on rule awareness. The mediation model results are presented below after a brief conceptual discussion.[17]

6.3.1 Background on Mediation

When a variable mediates the relationship between two other variables, it accounts for some or all of the total influence that the initial predictor exerts on the outcome. For pathway 3 in this dissertation, this means that while participating in the nutrient management activities may have a direct influence on adoption of cover crops, it

[16]Chi-square test of model fit p-value = 0.487; CFI = 1.000; TLI = 1.135, RMSEA = 0.000

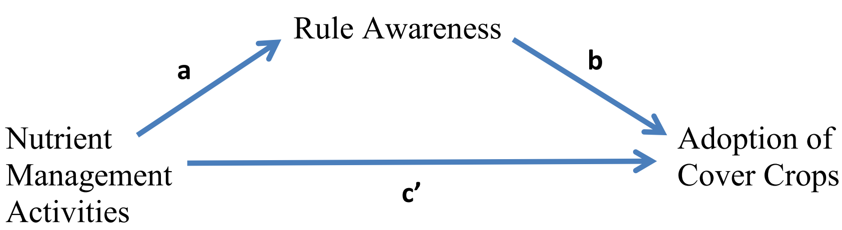
[17]Bootstrapping was used to test the mediation effects and create confidence intervals. In Mplus, this required the use of probit regression analysis. As a result, the mediation testing results are not directly comparable to the logistic regression model results previously presented. Though the probit models identify the same significant variables, the coefficients are interpreted in terms of z-scores instead of odds ratios.

also affects adoption indirectly by influencing rule awareness. The following diagrams illustrate the concepts of total effect, direct effect, and indirect/mediating effect.

Total Effect:

The total effect (c) of the predictor (nutrient management activities) on the outcome (adoption of cover crops) is the coefficient obtained by modeling the relationship without controlling for the mediator (rule awareness).

Direct and Indirect Effects:



The direct effect (c') is the coefficient obtained for the predictor (nutrient management activities) when the mediator (rule awareness) is controlled in the adoption model. The value for path (a) is the coefficient obtained by modeling the influence of the predictor on the mediator and path (b) is the coefficient obtained from modeling the influence of the mediator on the outcome variable, while controlling for the initial predictor (nutrient management activities). The indirect, or mediation, effect (ab) is calculated by multiplying the coefficient for path (a) by the coefficient for path (b). This effect is interpreted as the change in the outcome variable caused by a one unit change in the predictor as relayed through the mediator.

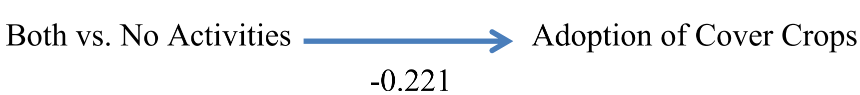
Mathematically, the total effect of the predictor on the outcome variable equals the direct effect plus the indirect effect (c = c' + ab). A measure of the magnitude of mediation is obtained by comparing the mediation effect (ab) to the direct effects (c'). This ratio, ab/c', shows how large the mediation effect is in relation to the direct effect.

6.3.2 Mediation Testing Results

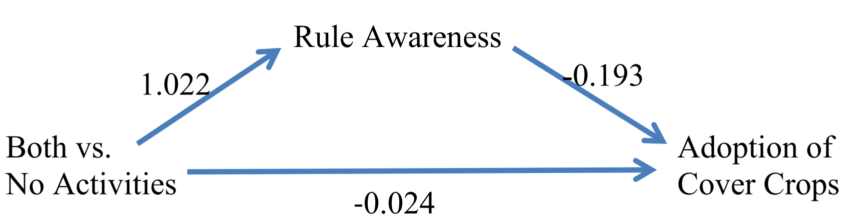
The following diagrams and descriptions provide the mediation testing results for pathway 3. Three activity contrasts are found to be statistically significant: both activities relative to no activities, training only relative to no activities, and both activities relative to planning only.

<u>Contrast 1: Both Activities Compared to No Activities</u>

Total Effect:



Direct Effects:



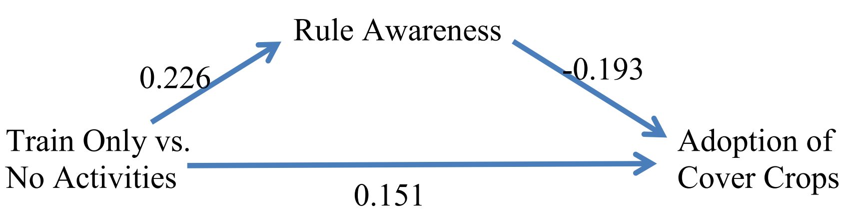
Mediation Effect:

The mediation effect for this contrast is -0.197 (1.022 * -0.193). This effect is significant at the .05 level and the 95 percent confidence interval is -0.418 to -0.030. The ratio of the mediated to direct effect is 8.208 (-0.197/-0.024). The mediated effect is 8.208 times as large as the direct effect.

<u>Contrast 2: Train Only Compared to No Activities</u>

Total Effect:

Direct Effects:

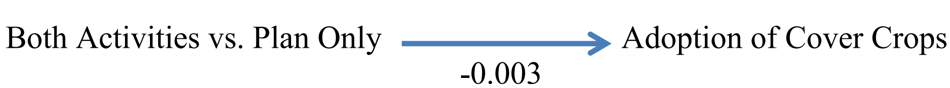


Mediation Effect:

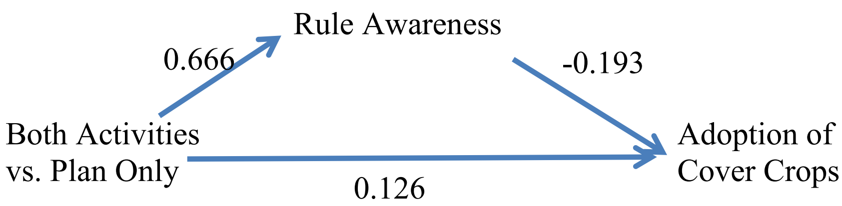
The mediation effect for this contrast is -0.044 (0.226 * -0.193). This effect is significant at the .10 level and the 95 percent confidence interval is -0.107 to -0.005. The ratio of the mediated effect to the direct effect is -0.291 (-0.044/0.151). The mediated effect is approximately 30 percent as large as the direct effect.

<u>Contrast 3: Both Activities Compared to Plan Only</u>

Total Effect:



Direct Effects:



Mediation Effect:

The mediated effect is -0.128 (0.666 * -0.193). This effect is significant at the .10 level and the 95 percent confidence interval is -0.314 to -0.013. The ratio of the mediated effect to the direct effect is -1.016 (-0.128/0.126). The mediated effect is roughly equivalent to the direct effect.

6.3.3 Meaning and Significance of Mediation Testing Results

Contrast 1 compares producers who performed both activities to those who performed no activities. Tests of this contrast reveal that the total effect of both activities on adoption of cover crops is negative. Relative to completing no activities, completing both activities lowers producers' z-scores by 0.221. The direct effect is also negative. When controlling for rule awareness, completing both activities lowers a producer's z-score by 0.024. Interestingly, paths (a) and (b) have opposite signs. The effect of completing both activities relative to no activities on rule awareness is positive. It raises the z-score by 1.022. The impact of rule awareness on adoption of cover crops is negative, however. It lowers the z-score by 0.193. Because the (a) and (b) paths have opposite signs, the indirect effect, or mediation effect, is negative. For this contrast, the mediation effect lowers the z-score by 0.197. The ratio of the mediation effect to the direct effect shows that the mediation effect is over eight times as large as the direct effect. Thus, the majority of the influence that participating in both activities relative to no activities exerts on adoption of cover crops actually comes from its influence on rule awareness.

Unlike the first contrast, producers who participate in training only are more likely to adopt cover crops than those who complete no activities. The total effect of participating in training relative to completing no activities is to raise the z-score by 0.107. Breaking the total effect into its components reveals a case of inconsistent mediation, where the direct effect and indirect effect have opposite signs. The direct effect is positive. When rule awareness is controlled in the model, the direct effect of training versus no activities on adoption of cover crops is to raise the z-score by 0.151. The mediation effect is negative. It lowers the z-score by 0.044. Therefore, in this contrast, the mediation effect suppresses the direct effect of training on adoption. However, because the size of the mediator effect is only about 30 percent as large as the direct effect, the total effect remains positive.

The final contrast compares those who completed both activities to those who completed plans only. In this case, the total effect of completing both activities on adoption of cover crops is negative, though very small. Relative to developing a plan only, completing both activities lowers the z-score by 0.003. Interestingly, when the total effect is broken down into the direct and mediation effects, it is revealed that this small coefficient derives from another case of inconsistent mediation. The direct effect of completing both activities rather than a plan only is to increase the z-score by 0.126.

However, the mediation effect lowers the z-score by 0.128. The direct effect and mediation effect not only have opposite signs, but are almost equivalent in magnitude (the ratio between the two is -1.016). As a result, the two effects essentially cancel each other, leaving a total effect that is close to zero.

These results lead to several important conclusions. First, rule awareness does, in fact, mediate the influence of activity participation on the adoption of cover crops. The mediation effect for rule awareness is statistically significant for three different activity contrasts. Second, the tests reveal that the mediation effect is complex. In the first contrast, mediation reinforces the direct effect, leading to an overall stronger total effect. In the second and third contrasts, it actually weakens the total effect. For the second contrast, the negative mediation effect suppresses the positive direct effect, but does not overwhelm it. For the third contrast, the mediation effect totally counteracts the direct effect, leaving a total effect size of nearly zero. Not only are these results interesting, but they highlight the importance of accounting for mediators in behavioral models when possible.

Third, substantively, these results reinforce the findings of the direct effects rule awareness and cover crops models presented in Section 6.2. These results show that the activities do have a significant impact on rule awareness. In particular, participating in training raises rule awareness. Those who train have higher z-scores than those who do nothing and those who develop plans and train have higher z-scores than those who plan only. The results also provide additional evidence that having a higher level of rule awareness leads to lower rates of cover crop use. This result is somewhat puzzling, but likely results from producers learning that not only do the rules not require use of cover crops, but they may change in the future if the 30 percent nitrogen runoff reductions are not met. These two facts may discourage producers from expending time and money to adopt a practice that does not have clear, immediate benefits to their business in the way that practices focused on reducing fertilizer use might. Finally, the mediation tests, and particularly the fit statistics for the pathway 3 mediation model, provide strong support for the appropriateness of this causal pathway in the dissertation's conceptual framework. On the other hand, the poor fit statistics of the mediation model for pathway 2 suggest that the causal pathway of activities to fear of inspection to adoption of soil testing is not well-supported in the framework.

6.4 Interactions

Study Hypothesis 14 states that if both capacity factors and adoption motivations are found to influence the adoption of the three nutrient BMPs in this study, then there will be statistically significant interactions among these factors. In essence, it was expected that the influence of a producer's motivations to adopt nutrient BMPs would be moderated by his or her adoption capacity.

The nutrient BMP models show that both capacity factors and adoption motivations are significant predictors of adoption in this study. Therefore, to test Hypothesis 14, interaction models were evaluated. For the RYEs model, interactions were tested between fear of penalties and the capacity factors: farm income, education, and receipt of cost share for cover crops. For the cover crops model, interactions were tested between fear of stricter regulations and the capacity factors: farm size, farm income, and education. For the soil testing model, interactions were tested between fear of inspections and the capacity factors: farm size and receipt of cost share for nutrient management. None of these interactions were found to be statistically significant. Thus, Hypothesis 14 is not supported in this study.

The testing of Hypothesis 15 was not warranted based on the results of the nutrient BMP models. Hypothesis 15 predicted that normative and deterrent motivations would interact in their influence on adoption of the nutrient BMPs. However, no normative motivations were found to be statistically significant in the adoption models.

6.5 Conclusion

This chapter presented and discussed the multivariate statistical results for the nutrient BMP models, mediator models, and additional adoption motivation models. It also provided results from the models that tested possible mediation pathways and interactions. A review of the key findings from these models, along with a discussion of their significance for the literature and for water quality policy, is presented in the next chapter.

CHAPTER 7: Conclusions and Recommendations

This dissertation set out to answer three primary research questions in an attempt to evaluate the efficacy of the Neuse River Basin strategy in securing water quality-enhancing behavioral changes from agricultural producers. The research focused specifically on the role of mandates for participation in nutrient management activities, training and/or planning, in bringing about the voluntary adoption of three nutrient best management practices (BMPs): Realistic yield expectations (RYEs), cover crops, and soil tests. This chapter will summarize the key findings of the project in the context of the research questions presented in Chapter 1 and the specific research hypotheses posed in Chapter 3. It will also discuss the theoretical and practical implications of the findings, identify the key limitations of the project, and present recommendations for future regulatory and research efforts.

7.1 Summary of Key Results

7.1.1 Research Question 1

The first research question asks how the use of nutrient BMPs is associated with agricultural producers' adoption motivations and capacity. Adoption of all three nutrient BMPs is found to relate to these two types of variables, though the specific variables found to be significant varied for each one. Two capacity factors, farm income and education, are found to increase adoption of RYEs, whereas receiving cost share for cover crops decreases it. Farm income also increases adoption of cover crops, but education is found to have a negative effect. Farm size is found to have a nonlinear relationship with adoption of cover crops. For farms smaller than 75 acres, the effect is negative and for those over 75 acres it is positive. Only one capacity factor is found to influence use of soil tests; farm size is found to have a positive impact.

Of the eight adoption motivation variables (i.e., attitude, norm, external, denial, fear of penalties, fear of inspections, fear of stricter regulations, and income impact) and the two variables that are considerations for adoption (i.e., rule awareness and perceived behavioral control), only four are found to be significantly related to adoption of the three nutrient BMPs in this study. Each of the three deterrent motivations is found to relate to one nutrient BMP. Fear of penalties has a negative relationship with adoption of RYEs and fear of stricter regulations has a negative relationship with use of cover crops. Fear of inspections has a positive association with soil testing. Rule awareness is also found to play a negative role in adoption of cover crops, but no role for RYEs or soil tests.

Based on these results, three of the first four research hypotheses are found to be supported for at least some variables. The dissertation's research hypotheses are restated in Table 7.1. For Hypothesis 1, four of the ten capacity variables are found to be influential in at least one nutrient BMP model: farm size, farm income, education, and receipt of cost share for cover crops. Receipt of cost share for nutrient management is found to have a negative influence on soil testing, but this result is an artifact of outliers in the model. The remaining variables: land tenure, age, income, experience and innovativeness, are not found to be statistically significant in any of the adoption models.

Table 7.1. Research Hypotheses.

Hypotheses 1-13
1. Producers with different levels of capacity will have different levels of nutrient BMP adoption, ceteris paribus.
2. Producers with different levels of adoption motivations will have different levels of nutrient BMP adoption, ceteris paribus.
3. Producers with different perceptions about the difficulty of adopting nutrient BMPs will have different levels of adoption, ceteris paribus.
4. Producers with different levels of awareness of the relevant agricultural rules will have different levels of nutrient BMP adoption, ceteris paribus.
5. Producers with different levels of participation in the mandated nutrient management activities will have different levels of nutrient BMP adoption, ceteris paribus.
6. Producers with different levels of capacity will have different levels of awareness of the agricultural rules, ceteris paribus.
7. Producers with different levels of capacity will have different levels of adoption motivations, ceteris paribus.
8. Producers with different levels of capacity will have different perceptions about the difficulty of nutrient management, ceteris paribus.
9. Producers with different levels of awareness of the relevant agricultural rules will have different levels of adoption motivations, ceteris paribus.
10. Producers with different levels of participation in the mandated nutrient management activities will have different levels of adoption motivations, ceteris paribus.
11. Producers with different levels of participation in the mandated nutrient management activities will have different perceptions about the difficulty of nutrient management, ceteris paribus.
12. Producers with different levels of participation in the mandated nutrient management activities will have different levels of awareness of the
13. The impact of participation in the mandated nutrient management activities on adoption of nutrient BMPs is partially mediated by producers' awareness of the relevant agricultural rules, adoption motivations, and perceptions of adoption difficulty.

For Hypothesis 2, all three deterrence motivations are found to play a role in adoption, but none of the four normative motivation variables or the economic motivation variable is found to be significant. Hypothesis 3 is not supported by this research. Perceived control is not found to influence adoption of any of the practices. Hypothesis 4 is supported for one practice. Rule awareness is found to influence adoption of cover crops, though the effect is unexpectedly negative.

7.1.2 Research Question 2

The second research question asks how agricultural producers' motivations to use nutrient BMPs are associated with their participation in the mandated activities (i.e., nutrient management training and planning). The multivariate models for attitude, norm, and fear of penalties were not statistically significant. In effect, the activity variables and other included variables were not able to explain these motivations any better than a model with no predictors. However, the activities are found to be significant in the models for: fear of inspection, fear of stricter regulations, external, denial, and income impact. These findings support Hypothesis 10.

Participation in the mandated activities is found to influence two deterrent motivations: fear of inspections and fear of stricter regulations. Developing nutrient management plans is found to have a positive influence over fear of inspection. Producers who completed plans only or completed both plans and training are found to have a stronger fear of inspection than those who completed no activities. Training by itself is not associated with fear of inspection. However, relative to developing nutrient management plans, training is associated with a stronger fear of stricter regulations when contrasting producers who strongly agree that stricter regulations are likely with those who do not agree. For the contrast between producers who agree stricter regulations are likely and those who disagree, comparisons between producers who completed both activities and those in the relevant control group (i.e., those who had plans and intended to complete training) show that adding training to the development of a nutrient management plan decreases the fear of stricter regulations. Other comparisons suggest that having a plan reduces the fear of stricter regulations, while having a fear of stricter regulations may actually encourage participation in training.

Training, planning, and both activities are also found to be positively related to feelings of external pressure. Producers in all three of these groups are predicted to feel more external pressure than those who intended to complete training or completed no activities. The contrast between producers who completed training and producers in the control group (i.e., intend to train), while holding other variables constant, is strong evidence that participating in training increases this pressure. Participation in the activities also relates to feelings of denial concerning water quality problems and the need for regulations. The findings are nuanced, but imply that producers who have weaker feelings of denial choose to participate in training. Finally, completing both activities is found to be negatively associated with a belief that nutrient management increases income when compared to all other groups, including its control group.

Hypotheses 11 and 12 are also supported by the study’s findings. Developing a nutrient management plan only is found to be positively associated with feelings of perceived control when compared to producers who train only or complete no activities. Participating in training, developing a plan, or completing both activities are all found to have a positive association with rule awareness, compared to producers who completed no activities. Further, those who completed both activities are found to have higher levels of awareness than producers in any other activity group.

Hypotheses 6-9 specify additional relationships between different study variables that relate to the second research question. All four of these hypotheses are supported to some degree by the research findings. In testing Hypothesis 6, two capacity variables, farm size and education, are found to increase rule awareness. For Hypothesis 7, farm size, income, farm income, education, innovativeness, and receipt of cost share are all found to influence at least one adoption motivation. Farm size and innovativeness have negative impacts on fear of inspection, whereas farm income and education have positive effects. Income negatively influences fear of stricter regulations. Income and education enhance external pressure, whereas cost share for nutrient management decreases it. Farm size, innovativeness, and cost share for cover crops increase feelings of denial, whereas education and cost share for nutrient management reduce them. Finally, innovativeness is found to be positively associated with the belief that nutrient management increases farm income. Three capacity variables, age, land tenure, and experience, are not found to help explain any of the producers' adoption motivations.

Hypothesis 8 is supported. Four capacity variables are found to influence perceived control. Income, experience, and cost share for nutrient management all increase feelings of perceived control. Age is found to reduce them. Hypothesis 9 is also supported. Rule awareness is found to help predict two adoption motivations and perceived control. The relationships between rule awareness and fear of inspections and fear of stricter regulations are positive. Interestingly, producers with moderate levels of rule awareness are found to have higher levels of perceived control than those with lower or higher levels of awareness.

Neither Hypotheses 14, which predicts interactions among capacity and adoption motivation variables, nor Hypothesis 15, which predicts interactions among normative and deterrence motivations are supported in this study.

7.1.3 Research Question 3

The third research question asks how the use of nutrient BMPs is associated with participation in the mandated activities, both directly and indirectly as mediated by producers' motivations. In support of Hypothesis 5, the mandated nutrient management activities are found to have a significant direct influence over adoption of the three nutrient BMPs. When holding everything else constant, both developing a nutrient management plan and completing nutrient management training are found to encourage the adoption of RYEs, relative to completing no activities. The overall rate of adoption of RYEs in the study sample is low, however, suggesting that these activities do not have a large impact. Producers who participated in nutrient management training are found to be more likely to use cover crops compared to producers in any other activity group, suggesting that training increases adoption. However, this finding also implies that adding a plan to nutrient management training decreases adoption of cover crops because producers who completed both activities were less likely to have cover crops than those who trained only. Development of nutrient management plans is found to increase use of soil tests, but training has no apparent effect.

Based on the mediation testing described in Section 6.3, Hypothesis 13 is also supported for one study variable. Rule awareness is found to be a statistically significant mediator of the relationship between participation in the activities and adoption of cover crops. Neither perceived control nor any of the other adoption motivations were found to act as mediators in this study, though at least one other potential mediation pathway was not able to be tested for significance due to the structure of the data.

7.2 Theoretical Implications

These research findings contribute to the key areas of literature reviewed in Chapter 2: diffusion, farm structure, and economics; social psychology focused on environmental behaviors; compliance behavior under regulatory programs, and the role of information and educational programs. The study results corroborate some assertions in the literature and raise questions about others.

7.2.1 Literature Focused on Diffusion, Farm Structure, and Economics

The models in this study tested the influence of a number of variables from the diffusion of innovations and farm structure traditions on the adoption of the three nutrient BMPs. In many ways, the findings in this study echo the predominant influences identified in the literature. Farm size, farm income, and education are found to have a positive impact on adoption of at least one practice. However, education is also found to have an unexpected negative relationship with adoption of cover crops. This result appears to be the result of more educated producers choosing to adopt RYEs instead of cover crops. Several of the diffusion and farm structure variables typically included in adoption studies are found to have no influence here: land tenure, age, experience, and income. The first three of these variables often are found to have no influence, so these results are not surprising. Income frequently is found to have a positive impact on adoption, but it may not here because the nutrient BMPs are not capital-intensive practices. Testing innovativeness in these models was rather novel, and though it was not found to influence adoption, its significant relationships with some of the adoption motivations suggest that it should be explored further in future work.

This study also tested the influence of three variables related to the economics of adoption: cost share for nutrient management, cost share for cover crops, and perceived profitability of nutrient management (income impact). The general lack of effects found for cost share is surprising, but not out of line with other empirical work. The negative effect of cost share for cover crops on adoption of RYEs suggests that producers in the study sample are making tradeoffs when deciding which practices to adopt. Producers who adopt cover crops are less inclined to also adopt RYEs. The lack of impact of cost share for cover crops on adoption of cover crops is puzzling and may be due to the timing of the survey in relation to when the cost share support was received. Producers were asked if they had received cost share in the previous five years. Those who received funding earlier in that time-frame may have discontinued their use of cover crops by the time of the survey. The findings for income impact are also unanticipated. This variable is not found to affect adoption of any of the practices. It is possible that the lack of an effect is due to the survey item being too general. The item asked about the impacts of "nutrient management" on income rather than the three nutrient BMPs investigated in the study. A more specific item focused on each practice, or ideally a set of items, would be preferable in future studies.

7.2.2 Social Psychology Literature Focused on Environmental Behaviors

This study contributes to the social psychology literature on pro-environmental behaviors by testing the relationships between adoption of nutrient BMPs and various norms and attitudes. This study included 11 survey items focused on different types of attitudes and norms found in the literature. These items underwent factor analysis to reduce their number and also help determine how they relate to each other. Of the four factors identified, two correspond to the concepts of attitudes (attitude) and intrinsic moral norms (norm). One (external) includes the concepts of social norms and legitimacy norms along with a negative attitude about the rules, and roughly relates to the concept of social norms found in the literature. The fourth factor relates in part to the concept of personal responsibility. It measures producers' level of denial concerning the water quality problem and need for regulations.

None of the factors are found to have a significant impact on adoption behavior in this study. Attitude and norm are also not found to relate to participation in the nutrient management activities. The lack of influence of participation on intrinsic moral norms is perhaps evidence contrary to the Value-Belief-Norm theory's assertion that education influences beliefs, which then trigger such norms. This finding is more in line with the arguments of the Advocacy Coalition Framework, which holds that deep core beliefs (i.e., moral norms) are very resistant to change because they are part of one's basic personal philosophy (Sabatier & Jenkins-Smith, 1993). The lack of an effect on attitude is more surprising. The items loading on this factor seem susceptible to change in the course of the activities, particularly training. Perhaps producers had well-formed attitudes about the reasonableness of the rules and their efficacy in improving water quality prior to participation in the activities that were supported during participation.

The factors external and denial are found to be significantly related to participation in the nutrient management activities. Training and planning are found to increase a sense of external pressure. Evidence of the effect of training is particularly strong as those who train are predicted to have higher levels of external pressure than the control group. This supports the idea that bringing producers together can increase social norms. Study results also suggest that a respondent's level of denial played a role in their decision to participate in the activities. Specifically, producers with lower levels of denial chose to participate in nutrient management training, possibly as a way to learn more about how to address the water quality problem.

Two other findings are relevant to the social psychology literature. First, the study failed to support the influence of perceived behavioral control over adoption of nutrient BMPs, as suggested by the theory of planned behavior. This surprising finding may also be the result of having survey items at a different level of specificity. The perceived control items should have focused on each practice individually. The study did find that developing a nutrient management plan has a statistically significant positive relationship with the perceived control variable, however. Second, the study did not find evidence of an interaction between capacity and adoption motivations in their influence over behavior, as suggested by the A-B-C Model of Behavior. It may be that the study lacked sufficient power to identify interactions given that the effect sizes of the variables tested were not very large.

7.2.3 Literature Addressing Compliance Behavior Under Regulatory Programs

This study investigated several issues raised by the literature focused on compliance behavior. It evaluated the influence of attitudes towards regulations and possession of a sense of duty to follow environmental regulations (legitimacy norm) on adoption behavior. It tested the influence of deterrence motivations on adoption, and it set out to test for interactions among deterrence motivations and personal norms.

Producers' attitudes toward the Neuse and Tar-Pamlico regulations and their legitimacy norms were part of the factor analysis discussed above, loading on the attitude and external variables respectively. As components of these variables, these concepts were not found to drive adoption in this study.

This study did find evidence that deterrence motivations influence adoption of the three nutrient BMPs, however. The three deterrence motivations: fear of inspections, fear of penalties, and fear of stricter regulations are each found to be statistically significant for one BMP. One relationship is positive. Fear of inspections is found to increase use of soil tests. This is likely because soil testing is easy and inexpensive and may give producers a sense of security because they can show their soil test results to inspectors. The other two relationships are negative. Fear of penalties is found to decrease adoption of RYEs and fear of stricter regulations is found to decrease adoption of cover crops. Though these negative relationships could be evidence of regulatory backlash, this seems unlikely because producers are not mandated to adopt the practices.

Instead, the negative relationships seem to involve strategic behavior on the part of the producers.

In the RYEs model, it is plausible that the negative impact of fear of penalties on adoption stems from producers choosing to adopt practices that are more visible than RYEs in an effort to show that they are responding to the rules. The idea that producers are making tradeoffs among the practices they adopt is supported by two other findings: that cost share for cover crops has a negative impact on adoption of RYEs, which suggests that producers who adopt cover crops are less likely to also adopt RYEs, and that more educated producers seem to choose RYEs over cover crops and less educated producers seem to choose cover crops over RYEs. Strategic behavior in the context of cover crops adoption is discussed extensively in Section 7.3.

The compliance literature also suggests that deterrence motivations and normative motivations might interact in their influence on behavior. This study intended to test this assertion, but was unable to do so because none of the normative motivations are found to be influential in the adoption models. However, statistically significant, positive correlations are identified between two of the deterrence motivations, fear of penalties and fear of stricter regulations, and moral norms. These positive relationships appear to be evidence that the duty heuristic described by Scholz and Pinney (1995) is operating in the study population. In the duty heuristic, individuals who possess a sense of moral duty to follow a law believe they are more likely to get caught breaking the law than they really are. This biased perception helps reinforce compliance. The positive correlations may also be evidence that the regulations are playing a "reminder" function in the study population, signaling to producers that protecting water quality is the right thing to do, and thus enhancing moral norms.

7.2.4 Literature Concerning the Role of Information and Educational Programs

Finally, the study contributes to literature on the role of information and educational programs in two important ways. First, as discussed above, it shows that educational activities, like nutrient management training and planning, can have positive direct impacts on voluntary adoption of some BMPs. Second, it offers strong evidence that awareness of regulations can influence adoption of BMPs, and, in particular, can mediate the relationship between participation in educational activities and adoption. This reinforces Winter and May's preliminary finding of a mediating role for rule awareness in their study of Danish agricultural producers' compliance with environmental regulations (2002). The significance of these results is discussed in the next section.

7.3 Practical Implications

The overall objective of this study was to evaluate the impacts of the Neuse Basin strategy specifically as an example of a hybrid policy approach that contains both voluntary and coercive elements. Given the growing interest in combining different types of policy instruments together in order to capitalize on their strengths and overcome weaknesses, information about how this hybrid approach has worked should be informative. This study identifies five key findings that have practical implications for efforts to address nutrient pollution from agriculture in the Neuse River Basin and elsewhere. Most of these findings should also be informative in other policy settings.

The first key finding is that combining carrot and stick policy instruments into a hybrid policy approach can be effective in influencing the voluntary adoption of certain nutrient BMPs. The Neuse strategy is found to affect adoption both through the nutrient management activities it mandates and the deterrence motivations it helps create. The impacts on adoption, however, are not all desirable.

The findings for adoption of cover crops show that the coercive elements of the Neuse strategy are backfiring, at least for promoting use of this particular practice. Though participating in nutrient management training is found to have a significant positive impact on adoption of cover crops, two other important variables tied to the coercive aspects of the strategy are found to have a negative impact: fear of stricter regulations and rule awareness.

Fears about possible stricter future regulations are widespread in the study population and likely stem from the implicit threat of such changes if the agricultural community fails to meet its 30 percent nitrogen runoff reduction mandate. Though some scholars argue that this type of deterrence can promote desired behavior changes (Bosch et al., 1995), in this context, it has the opposite effect. The negative influence of fear of stricter regulations on adoption of cover crops is likely due to strategic behavior on the part of producers. A producer who is trying to decide if he or she is going to voluntarily adopt a BMP in the face of possible, more stringent regulations in the future, is likely hesitant to adopt cover crops. This is because, relative to RYEs and soil tests, cover crops do not have the same potential to reduce farm operating costs by reducing the use of expensive fertilizers. Under regulatory uncertainty, producers are more likely to either adopt a practice that has immediate direct benefits or to do nothing until they know what will be required of them in the future. This uncertainty, then, is apparently influencing behavior in a way that is counterproductive to the goals of the rules.

This interpretation is supported by the finding that the adoption of cover crops is also reduced by rule awareness. Producers who know the most about the nutrient management and agricultural nitrogen reduction strategy rules understand that they are not required to adopt BMPs. As a result, these producers are actively avoiding the adoption of a practice that lacks immediate direct benefits. These findings suggest that some producers are focused more on complying with the letter of the law than with its spirit, and in this way the inclusion of mandates in the Neuse strategy is not unequivocally beneficial.

The third key finding in this study has implications for the long-term success of the Neuse strategy in promoting use of nutrient BMPs, and likely other types of practices as well. Though evidence is found that the existing regulations are generally well-received, concerns about a lack of equity in the larger Neuse and Tar-Pamlico strategies could eventually undermine this support. 88.4 percent of producers agreed or strongly agreed that "regulators are unfairly targeting agriculture when other groups that pollute the Neuse (or Tar) River are not being held accountable." Theory suggests that these types of concerns can erode intrinsic motivations to comply (Frey, 1999).

At the time of the survey, a positive association existed between intrinsic, normative motivations for complying with the rules and two deterrence motivations. These relationships suggest that the two types of motivations have the potential to work synergistically. However, over the long-run, the perception of a lack of equity across different sources of pollution could eventually undermine producers' willingness to take voluntary action under the strategies. The high levels of noncompliance within the agricultural community with the Nutrient Management Rule could have the same result.

A fourth key finding from this study has implications for policy design that are likely relevant in a wide variety of settings. The highly disparate response to the Neuse strategy shows that individuals can react to the same set of policies in very different ways and that policies need to be designed with this in mind. In the Neuse Basin, 25.0 percent of the regulated producers failed to comply with the activity mandate. They did not participate in training or develop a nutrient management plan. On the other end of the spectrum, 38.4 percent of regulated producers completed both activities, going above and beyond the legal requirements. Further, 25.0 percent of producers who did not complete either activity also did not adopt any of the three nutrient BMPs, whereas only 2.8 percent of producers who completed both activities failed to adopt any of the practices. Producers in these two groups clearly differ in their relative responsiveness to the both the mandates and the voluntary components of the strategy. They are significantly different from each other in numerous other ways as well, both in their demographic characteristics and attitudes.

It is generally accepted that voluntary policy approaches do not always secure sufficient levels of desired behavioral changes. On the other hand, overly coercive policies may create backlash. One of the potential benefits of designing a hybrid policy with both carrot and stick elements is that it could have the potential to help address these problems, assuming an appropriate balance is struck. With its unenforced activity mandates and reliance on voluntary adoption of BMPs, the Neuse strategy does not appear to achieve the right balance. Both problems still exist. A sizeable group of producers did not comply with the mandates at all. An even larger group of producers went above and beyond the requirements and subsequently reported more negative attitudes about the need for the regulations and weaker beliefs that nutrient management is profitable. These attitudes may be evidence of growing resentment under the rules. These findings not only show that regulators in North Carolina need to address the high levels of non-compliance with the mandates, but also that policies generally need to be designed with these two types of producers in mind.

Feldman and Perez (2011) argue that regulators should use “differentiated regulation” where they try to match policies to the different types of people they intend to influence. Clearly, policy makers cannot assume a monolithic response to the instruments they select. However, it is clear from the Neuse strategy experience that it is not enough simply to pull together different instruments and expect them to gain the cooperation of different types of people. Policy makers need to think carefully about how different instruments will work in combination and, particularly, whether they will gain the cooperation of those most resistant without undermining the cooperation of those who otherwise would be enthusiastic.

The final key implication of this research focuses on the role of outreach in producer behavior. This study makes two important contributions. First, it finds that too much awareness of regulations can lead to strategic behaviors that may meet the technical requirements of the law but work in opposition to its goals. As discussed above, higher levels of rule awareness are found to have a negative impact on adoption of cover crops.

In fact, rule awareness is found to be a statistically significant mediator of the relationship between participation in the nutrient management activities and adoption of cover crops. Due to its negative effects, for two of the activity contrasts, rule awareness completely eliminates the positive impact the activities otherwise would have had on adoption. In combination with the finding that producers with moderate levels of rule awareness have the strongest sense of perceived behavioral control regarding nutrient management, these results suggest that a modest level of outreach and education about regulations is probably enough.

Second, by including county indicator variables in the multivariate models, this study finds that priorities set at the local level have an important impact on the types of practices that producers adopt. For example, officials in Johnston County emphasized use of cover crops as the primary way for the County to meet its nitrogen runoff reduction targets. As a result, producers in this county are found to have higher rates of cover crop use and lower rates of RYEs adoption than those in the other Neuse Basin counties. In addition, respondents from Edgecombe County are found to have higher levels of denial, weaker fears of stricter regulations, weaker feelings of perceived control, and are less likely to believe that nutrient management increases income than producers in the other counties. This suggests that their local outreach efforts were generally less effective.

7.4 Policy Recommendations

Based on the findings of this dissertation, several recommendations can be made for future policy efforts. These recommendations primarily involve the use of regulatory strategies to induce nutrient management behaviors. Though there is growing support for more bottom-up collaborative approaches to managing common-pool resource issues (see Ostrom, 1990), and such approaches could help prevent the strategic behavior and backlash problems evident in the Neuse Basin, features of the agricultural NPS water pollution problem addressed in this dissertation hinder the natural evolution of such efforts. In particular, Ostrom argues that having a strong financial dependence on the common pool resource of interest motivates users to work together to resolve problems (1990). Though using less fertilizer can save money, the livelihoods of the producers in this study are not impacted significantly by the actual pollution they generate. Further, the asymmetrical nature of water pollution in riverine systems means that downstream users of the water resource are impacted more intensely than those who are polluting it. Thus, the producers in this study are unlikely to take action to reduce the pollution they generate without external incentives. The policy recommendations made here are meant to help create incentives for such behavior that are otherwise weak or missing.

First, it is clear from this study that the Neuse and Tar-Pamlico rules targeting agriculture have suffered from a lack of enforcement. Though it may be too late to enforce the activity mandates in these basins, at least not without conducting another round of nutrient management training workshops, the state of North Carolina should use its authority to enforce the activity participation mandates currently being implemented in other watersheds.

Second, policy makers targeting agricultural nutrient pollution in North Carolina and elsewhere should consider reporting requirements as a component of future regulatory efforts. Having records of actual fertilizer use would not only give policy makers a much clearer measure of impacts than simply focusing on use of nutrient BMPs, it might also help agricultural producers identify potential inefficiencies in their practices. In areas like eastern North Carolina, where soil tests are not appropriate for determining nitrogen application rates, requiring producers to maintain records of yields for a specified amount of time would also be helpful. Such information would allow producers to use data from their own farms to determine their RYEs rather than relying on state estimates. Anecdotally, some producers believe the state RYEs are too conservative, underestimating probable yields (Adelski, nd). Whether this perception is accurate or not, it likely reduces their use.

In lieu of fertilizer-use reporting requirements, policy makers could choose to emphasize the adoption of physical BMPs rather than management-based practices. Though these practices may not be as economically efficient in some cases, at least some of the associated losses should be compensated for by the greater ease of tracking adoption and maintenance. Focusing on physical practices may also reduce cooperating producers' fears about penalties and inspections that could have the potential to cause reactance.

Policy makers in other settings should also consider the use of training sessions as they were found to have some efficacy in this study. Participation in nutrient management training is found to enhance adoption of RYEs and cover crops as well as feelings of external pressure. In addition to simply educating participants about the policy and its rationale, bringing individuals together to discuss the actions they plan to take in response to specific policies could help build a social norm in favor of action. It could also help minimize feelings of inequity, helping producers feel more confident that others will do their part. Lubell found that such expectations of reciprocity helped drive farmer participation in a nutrient management-focused water quality program in Florida (2004). Training should emphasize the ways in which all sources of pollution are being targeted for action in order to reduce concerns about free-riding that may undermine cooperation.

Fifth, policy makers should consider using a staged approach to regulation. The first stage could be voluntary, where producers are encouraged to select from a menu of approved practices that are supported to some extent by cost share. At a certain specified date in the not-too-distant future, the second stage would go into effect and require those who failed to adopt in the first stage to undertake more onerous actions. This approach might simultaneously give first-stage adopters the sense of participating in a voluntary program while also reassuring them that free-riders will be brought into the fold in a more demanding way in the second stage. Having the second stage be more burdensome could help prevent the problem of strategic avoidance that is apparent in the Neuse Basin. However, like other efforts that contain coercive elements, this approach would require a sufficient enforcement threat to ensure that the second stage actually catches the laggards.

Finally, in an approach like the Neuse strategy, it would be helpful to break down the targeted management units into smaller sizes, preferably ones that correspond with watershed boundaries. Though implementing the strategy on a county-by-county basis is straightforward and can take advantage of existing county-based agency staff, targeting smaller areas could have important benefits. Foremost, it could allow for water quality monitoring where the results would be easier to trace back to farm-level or at least community-level actions. It would also likely raise social pressures to take action and reduce the temptation to free-ride.

7.5 Key Limitations and Future Research

The results of this project are limited by several factors. Many of these are discussed in Section 4.3 and are not repeated here. Additional limitations exist, however. One concern is that some adoption motivations were measured at a much more general level of specificity than the outcome variables they were predicted to influence. This may have resulted in a mismatch between some independent and dependent variables. It is plausible that this is responsible for some of the surprising study results, for instance, the finding that perceptions about the profitability of nutrient management do not influence adoption.

A strength of this study was the use of quasi-experimental control groups in the Tar-Pamlico Basin. Having groups of producers who had not had the opportunity to participate in nutrient management training at the time of the survey allowed for the effects of training to be isolated in several cases. However, the control groups were established based upon survey respondents reporting their intentions to train, which likely resulted in the presence of individuals in the control groups who should not have been there. Data on whether these producers actually did participate in training would have allowed for non-participators to be screened out. Unfortunately, this information was not obtainable.

Another limitation was the inability to test all of the possible mediation pathways identified in the study due to the categorical nature of many of the study variables. Using indices or factors that can be treated as continuous rather than categorical variables would simplify future mediation testing considerably.

Given the results of this study, several areas seem potentially fruitful for future research. One area would be to evaluate the efficacy of staged policy approaches. For example, new rules went into effect in January 15, 2011 regulating nutrients in the Falls Lake watershed in North Carolina (15A NCAC 02B .0280). The rules use a staged approach were agricultural producers are collectively required to meet particular runoff reductions by 2020 and further reductions by 2035 through a strategy very similar to the Neuse Agricultural Nitrogen Reduction Strategy Rule. If the first stage targets are not met, the second stage will also include an individual mandate to install vegetated stream buffers by 2026. What impact, if any, this more tangible, but very distant, future regulatory threat has on producers' near-term voluntary actions would be useful to investigate.

Even though many of the adoption motivations included in this study proved not to be significant in this context, additional research should explore their role in other settings, and possibly in other agricultural settings using improved measures. Particular attention should be paid to deterrence motivations and rule awareness as they were found to be significant here and to play unexpected roles in adoption behavior.

Generally, more evaluations should be conducted of the implementation of hybrid environmental policies where they exist. Empirical investigations of such efforts can help identify potential synergies and pitfalls that are not anticipated by theory, and can help improve future knowledge and practice.

APPENDIX A: Survey Instrument

2005 FARMERS' NUTRIENT MANAGEMENT PRACTICES AND COMPLIANCE MOTIVATIONS SURVEY

INTRODUCTION

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 management decisions?
[IF NECESSARY, REPEAT THE INTRODUCTION]

IF NO ONE IS AVAILABLE 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 time____________ Thanks for your time.*

FARMING PRACTICE QUESTIONS 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.	Number of Acres:______________________
2. How many of these acres do you rent or lease from others?	Number of Acres:______________________
3. How many years have you been a farm operator?	Number of Years:______________________
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]**____________________... __
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]**____________________ __
6. Has your soil been tested for nutrient content during the last two years?	Yes...1 No 2
7. How often do you conduct soil tests? **[READ RESPONSES]**	More than once a year ....5 Once a year ....4 Every two years ....3 Every three years or less often **or** ....2 Never ....1 Other**[SPECIFY]**____________________ __
8. How often do you calibrate your fertilizer application equipment? **[READ RESPONSES]**	More than once a year ....5 Once a year ....4 Every two years ....3 Every three years or less often **or** ....2 Never ....1 Other**[SPECIFY]**____________________ __
9. Do you plant any cover crops?	Yes...1 No **[SKIP TO Q10]** 2

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 .... ___________ Any others?**[SPECIFY]_____________ .....__ __** Any others?**[SPECIFY]__________________ ....**
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
c. **[IF YES TO Q9]** During what time period do you generally plant your cover crops? **[READ RESPONSES]**	October 1-15...1 October 16-31...2 November 1-15 **or** ....3 Some other time**[SPECIFY]________________ __**
d. **[IF YES TO Q9]** During what time period do you generally kill off your cover crops? **[READ RESPONSES]**	March 15-30 ....1 April 1-15 ....2 April 16-30 **or**...3 Some other time**[SPECIFY]________________ __**

NUTRIENT MANAGEMENT PLAN QUESTIONS

I would also 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
a. **(IF YES)** When did you first prepare a plan?	Record Year:_______________________
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
c. Has a government representative or Extension agent ever reviewed your plan?	Yes**[SKIP TO Q12]** ....1 No**[SKIP TO Q12]** 2
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]_________________**.......__ __

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
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

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
b Using nutrient management significantly reduces the impact of agriculture on water quality.	5	4	3	2	1
c. Using more nutrient management practices on my farm would require too many changes.	5	4	3	2	1
d Developing a nutrient management plan is easy for my type of farm.	5	4	3	2	1

NUTRIENT MANAGEMENT TRAINING QUESTIONS

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

WAYNE COUNTY SKIP TO Q16

EDGECOMBE COUNTY SKIP TO Q19

15 **(FOR 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
16 **(FOR 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

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
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
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

FOR RESPONDENTS IN 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
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 An extension agent suggested it .... 1 Another farmer suggested it .... 1 I want to learn more about it .... 1 I am concerned about water quality .... 1 I want to reduce my fertilizer use .... 1 Other **[SPECIFY]**_________________ ....__ __

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
a. Cut your fertilizer use by 50 percent.	1 ....
b. Develop a nutrient management plan or participate in nutrient management training.	1 ....
c. Install 100 foot vegetated buffers on all streams.	1 ....
d. **(JOHNSTON, LENOIR AND WAYNE RESPONDENTS ONLY)** Sign up with your local area committee or implement standard best management practices.	1 ....
e. **(EDGECOMBE ONLY)** Sign up with your local area committee.	1 ....
f. Submit quarterly reports on fertilizer use.	1 ....
g. Work with other farmers in your county to reduce your nitrogen runoff by 30 percent.	1 ....

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? _____________
23. I'd like to read you some more 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**
b. Agriculture should be regulated for its environmental impacts just like any other industry.	**5**	**4**	**3**	**2**	**1**
c. Current regulations to protect water quality in the Neuse **(Tar)** River are reasonable.	**5**	**4**	**3**	**2**	**1**
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**
e. The regulations targeting farmers in the Neuse River Basin **(Tar-Pamlico River Basin)** are improving water quality.	**5**	**4**	**3**	**2**	**1**
f. Agricultural water pollution is not a serious threat to fish and wildlife in the Neuse **(Tar)** River.	**5**	**4**	**3**	**2**	**1**

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?	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?	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 or 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**
b. Land should be farmed in ways that protect water quality even if this means lower profits.	**5**	**4**	**3**	**2**	**1**
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**

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**
e. The government is <u>not</u> very likely to inspect my nutrient management practices.	**5**	**4**	**3**	**2**	**1**
f. Having a nutrient management plan is like having insurance against enforcement.	**5**	**4**	**3**	**2**	**1**
g. I have a duty to follow environmental regulations even if I disagree with them.	**5**	**4**	**3**	**2**	**1**
h. If I do <u>not</u> comply with nutrient management rules, I expect to be penalized.	**5**	**4**	**3**	**2**	**1**
27. In what year was your farm last inspected?	Year Inspected:______________________				

DEMOGRAPHIC QUESTIONS

Finally, I'd like to ask you a few background questions for statistical purposes only.

28 In what year were you born?	Birth year:_________________
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
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
33 About what percent of your family's 2004 total income came from farm income?	Percent of 2004 Family Income ....__ __ __
34 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]**________________________ __ __
35 Do you <u>generally</u> vote for Democrats or Republicans?	Democrats .... 1 Republicans... 2 Neither.. 3
36 CODE RESPONDENT'S GENDER (**DO NOT ASK UNLESS UNSURE**)	Male .... 1 Female 2

This completes the interview. Thank you very much for your time and cooperation. Do you have any comments you would like to make?

APPENDIX B: Distribution of Responses to Select Survey Items

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total
It is important that my community recognizes that I am doing the best I can to protect water quality. (community)	0 0.0%	5 1.2%	4 1.0%	299 72.0%	107 25.8%	415 100%
I have a duty to follow environmental regulations even if I disagree with them. (duty)	0 0	7 1.7%	5 1.2%	328 79.0%	75 18.1%	415 100%
Agriculture should be regulated for its environmental impacts just like any other industry. (regulated)	15 3.6%	117 28.2%	17 4.1%	250 60.2%	16 3.9%	415 100%
Current regulations to protect water quality in the Neuse (Tar) River are reasonable. (reasonable)	4 1.0%	58 14.0%	34 8.2%	310 74.7%	9 2.2%	415 100%
Regulators are unfairly targeting agriculture when other groups that pollute the Neuse (Tar) River are not being held accountable. (REVERSED) (unfair)	0 0.0%	31 7.5%	17 4.1%	149 35.9%	218 52.5%	415 100%
The regulations targeting farmers in the Neuse River Basin (Tar-Pamlico River Basin) are improving water quality. (improvewater)	3 0.7%	88 21.2%	33 8.0%	271 65.3%	20 4.8%	415 100%
Land should be farmed in ways that protect water quality even if this means lower profits. (protectwater)	8 1.9%	79 19.0%	40 9.6%	272 65.5%	16 3.9%	415 100%
Most people will do the right thing for the Neuse (Tar) River on their own without more government regulations. (rightthing)	8 1.9%	117 28.2%	14 3.4%	232 55.9%	44 10.6%	415 100%
Using nutrient management significantly reduces the impact of agriculture on water quality. (nmimpact)	1 0.2%	62 14.9%	35 8.4%	261 62.9%	56 13.5%	415 100%
Agricultural water pollution is not a serious threat to fish and wildlife in the Neuse (Tar) River. (REVERSED) (pollution)	19 4.6%	182 43.9%	41 9.9%	164 39.5%	9 2.2%	415 100%

Item	Poor	Fair	Good	Excellent	Total
How would you rate the water quality in the Neuse (Tar) River? Would you say it is excellent, good, fair, or poor? (waterrating)	61 14.7%	209 50.4%	135 32.5%	10 2.4%	415 100%

APPENDIX C: Bivariate Regression Results

Table C.1. Bivariate Logistic Regression Results for Nutrient BMPs.

Variables	Bivariate Odds Ratios (standard error)					
	RYE		Cover Crops		Soiltest	
Age	****0.970**	**(0.013)**	***0.984**	**(0.009)**	*****0.969**	**(0.011)**
Rented Land	1.0041	(0.004)	******1.009**	**(0.003)**	*****1.009**	**(0.003)**
Farm size (ln)	0.998	(0.106)	******1.715**	**(0.145)**	******1.634**	**(0.154)**
Income	1.001	(0.002)	*****1.003**	**(0.001)**	******1.007**	**(0.002)**
Farm income	***1.008**	**(0.005)**	******1.016**	**(0.003)**	*****1.011**	**(0.004)**
Experience	****0.975**	**(0.012)**	1.004	(0.008)	0.987	(0.010)
Some college	1.247	(0.473)	0.841	(0.198)	1.497	(0.449)
College graduate	***1.940**	**(0.734)**	*****0.478**	**(0.134)**	1.531	(0.513)
Innovativeness	0.821	(0.254)	1.192	(0.247)	****1.944**	**(0.505)**
Rule awareness	***1.303**	**(0.197)**	****0.811**	**(0.086)**	******1.629**	**(0.241)**
Cost share crops	0.386	(0.287)	****1.976**	**(0.661)**	***2.880**	**(1.770)**
Cost share nutri.	1.682	(0.711)	***1.825**	**(0.565)**	1.592	(0.727)
Attitude	1.142	(0.323)	1.059	(0.193)	1.030	(0.232)
Norm	1.000	(0.220)	***0.761**	**(0.110)**	0.868	(0.162)
External	1.012	(0.336)	1.047	(0.231)	1.301	(0.349)
Denial	0.975	(0.183)	1.166	(0.146)	1.292	(0.202)
Fear penalties	***0.574**	**(0.194)**	0.925	(0.227)	1.246	(0.370)
Fear inspection	1.604	(0.539)	1.161	(0.246)	*****2.230**	**(0.579)**
Fear stricter regs.	1.075	(0.242)	****0.714**	**(0.102)**	0.990	(0.180)
Income impact	1.378	(0.431)	1.293	(0.272)	1.000	(0.264)
Perceived control	1.134	(0.246)	0.853	(0.120)	***1.334**	**(0.232)**
Johnston	0.618	(0.429)	0.641	(0.222)	***0.453**	**(0.211)**
Lenoir	1.716	(1.029)	*****0.329**	**(0.119)**	0.923	(0.456)
Nash	1.958	(1.296)	0.663	(0.268)	0.620	(0.335)
Wayne	2.226	(1.293)	****0.414**	**(0.144)**	0.964	(0.471)
Intend to train	0.838	(0.452)	1.261	(0.461)	1.225	(0.570)
Both activities	1.094	(0.492)	0.811	(0.265)	*****4.208**	**(2.198)**
Intend to do both	0.691	(0.572)	1.309	(0.676)	2.250	(1.816)
Nutrient plan	1.302	(0.668)	0.649	(0.258)	***3**	**(1.817)**
No activities	****0.230**	**(0.144)**	0.727	(0.237)	****0.468**	**(0.172)**
Nutrient plan (no)	*****5.651**	**(3.546)**	0.892	(0.328)	******6.411**	**(3.570)**
Both activities (no)	*****4.747**	**(2.738)**	1.115	(0.322)	******8.993**	**(4.179)**
College graduate (some college)	**1.555**	**(0.601)**	*0.568	(0.167)	**1.023**	**(0.376)**

*p ≤ .10, **p ≤ .05, ***p ≤ .01, ****p ≤ .001

Table C.2. Bivariate Regression Results for Mediators.

	Bivariate Odds Ratios (standard error)							
	Fear Inspection		**Fear Stricter Regulations**				**Rule Awareness**	
			Multinomial Logit[a] (base Disagree)					
Variables	**Logit**		**Agree**		**Strongly Agree**		**Ordered Logit**	
Age	****0.971**	**(0.009)**	0.988	(0.015)	0.993	(0.018)	****0.984**	**(0.008)**
Rented Land	1.003	(0.003)	1.001	(0.005)	1.006	(0.005)	*****1.009**	**(0.002)**
Farm size (ln)	***1.152**	**(0.080)**	0.982	(0.118)	0.973	(0.140)	****1.184**	**(0.072)**
Income	****1.003**	**(0.001)**	****0.995**	**(0.002)**	0.998	(0.002)	****1.003**	**(0.001)**
Farm income	*****1.012**	**(0.003)**	***0.988**	**(0.006)**	0.991	(0.007)	****1.007**	**(0.003)**
Experience	**0.985**	**(0.008)**	1.004	(0.014)	1.014	(0.017)	0.997	(0.007)
Some college	***1.593**	**(0.377)**	1.340	(0.557)	1.964	(0.967)	*****1.941**	**(0.404)**
College graduate	1.212	(0.310)	1.095	(0.474)	1.364	(0.720)	**1.476**	**(0.345)**
Innovativeness	0.861	(0.174)	0.713	(0.255)	0.877	(0.375)	***1.429**	**(0.258)**
Rule awareness	**1.210**	**(0.125)**	1.108	(0.204)	***1.687**	**(0.362)**	x	x
Cost share crops	1.224	(0.426)	0.862	(0.486)	0.900	(0.614)	x	x
Cost share nutri.	1.205	(0.386)	0.872	(0.445)	0.571	(0.383)	x	x
Johnston	**0.523**	**(0.195)**	2.286	(1.267)	**3.886**	**(2.820)**	0.820	(0.262)
Lenoir	**0.519**	**(0.193)**	1.871	(0.981)	2.311	(1.655)	1.512	(0.479)
Nash	0.652	(0.281)	2.211	(1.441)	1.200	(1.144)	0.811	(0.301)
Wayne	0.551	(0.203)	1.895	(0.993)	***4.089**	**(2.832)**	***2.116**	**(0.655)**
Intend to train	1.593	(0.597)	0.326	(0.275)	***0.157**	**(0.145)**	0.590	(0.193)
Both activities	1.625	(0.529)	0.326	(0.260)	0.259	(0.217)	****2.263**	**(0.652)**
Intend to do both	**3.027**	**(1.854)**	0.826	(1.036)	0.000	(0.000)	0.732	(0.345)
Nutrient plan	***2.523**	**(1.043)**	***0.184**	**(0.149)**	****0.065**	**(0.061)**	0.723	(0.247)
No activities	***0.527**	**(0.166)**	0.454	(0.364)	***0.118**	**(0.104)**	*****0.268**	**(0.079)**
Nutrient plan (no)	*****4.783**	**(1.823)**	**0.404**	**(0.206)**	0.556	(0.406)	****2.699**	**(0.868)**
Both activities (no)	*****3.081**	**(0.871)**	0.718	(0.348)	2.200	(1.334)	*****8.450**	**(2.288)**
College graduate (some college)	0.761	(0.209)	0.817	(0.395)	0.694	(0.392)	0.760	(0.184)

Notes: *p ≤ .10, **p ≤ .05, ***p ≤ .01, ****p ≤ .001

[a]Relative Risk Ratios presented instead of Odds Ratios

Table C.3. Bivariate Regression and Logistic Regression Results for Additional Motivations.

Variables	**Bivariate Regression Coefficients (standard error)**						**Bivariate Odds Ratios (standard error)**	
	External		**Denial**		**Perceived Control**		**Income impact**	
Age	***-0.003**	**(0.002)**	-0.002	(0.003)	***-0.005**	**(0.003)**	0.994	(0.009)
Rented Land	0.001	(0.001)	0.001	(0.001)	0.000	(0.001)	1.001	(0.003)
Farm size (ln)	0.007	(0.016)	******0.100**	**(0.028)**	0.007	(0.025)	1.098	(0.077)
Income	****0.001**	**(0.000)**	****0.001**	**(0.000)**	****0.001**	**(0.000)**	1.001	(0.001)
Farm income	0.001	(0.001)	*****0.003**	**(0.001)**	0.001	(0.001)	1.004	(0.003)
Experience	-0.001	(0.002)	0.001	(0.003)	0.000	(0.003)	1.003	(0.008)
Some college	*****0.158**	**(0.053)**	-0.117	(0.094)	***0.155**	**(0.083)**	1.074	(0.252)
College graduate	***0.102**	**(0.058)**	***-0.177**	**(0.104)**	0.114	(0.091)	1.048	(0.271)
Innovativeness	0.042	(0.046)	****0.189**	**(0.081)**	0.096	(0.072)	******2.056**	**(0.431)**
Rule awareness	0.018	(0.023)	0.028	(0.041)	*****0.097**	**(0.036)**	0.957	(0.098)
Cost share crops	-0.095	(0.078)	****0.283**	**(0.137)**	0.007	(0.121)	1.241	(0.418)
Cost share nutri.	-0.057	(0.072)	-0.076	(0.127)	******0.407**	**(0.110)**	0.984	(0.312)
Johnston	0.054	(0.080)	****-0.333**	**(0.141)**	****0.313**	**(0.124)**	1.738	(0.640)
Lenoir	0.075	(0.080)	-0.118	(0.140)	*****0.343**	**(0.124)**	1.097	(0.410)
Nash	-0.068	(0.094)	0.086	(0.164)	****0.292**	**(0.145)**	****2.304**	**(0.967)**
Wayne	0.039	(0.079)	-0.018	(0.138)	*****0.331**	**(0.122)**	1.530	(0.555)
Intend to train	*****-0.218**	**(0.082)**	0.126	(0.149)	-0.036	(0.129)	0.738	(0.271)
Both activities	0.040	(0.072)	0.172	(0.130)	****0.273**	**(0.113)**	****0.462**	**(0.153)**
Intend to do both	0.137	(0.117)	0.142	(0.211)	0.260	(0.183)	1.517	(0.780)
Nutrient plan	0.081	(0.085)	0.198	(0.154)	****0.3**	**(0.133)**	0.985	(0.369)
No activities	***-0.118**	**(0.071)**	-0.028	(0.129)	0.002	(0.112)	0.774	(0.245)
Nutrient plan (no)	*****0.199**	**(0.077)**	0.226	(0.139)	****0.298**	**(0.120)**	1.273	(0.433)
Both activities (no)	****0.159**	**(0.062)**	***0.200**	**(0.112)**	*****0.272**	**(0.097)**	***0.597**	**(0.174)**
College graduate (some college)	-0.056	(0.061)	-0.061	(0.109)	-0.041	(0.096)	0.976	(0.265)

*p ≤ .10, **p ≤ .05, ***p ≤ .01, ****p ≤ .001

Table C.4. Bivariate Regression and Logistic Regression Results for Motivations with Non-significant Multivariate Models

Variables	Bivariate Regression Coefficients (standard error)				Bivariate Odds Ratios (standard error)	
	Attitude		Norm		Fear Penalties	
Age	0.003	(0.002)	0.002	(0.003)	***0.970	(0.010)
Rented Land	*0.001	(0.001)	-0.001	(0.001)	1.003	(0.003)
Farm size (ln)	0.014	(0.019)	****-0.096	(0.023)	0.950	(0.078)
Income	0.000	(0.000)	0.000	(0.000)	1.001	(0.001)
Farm income	0.001	(0.001)	**-0.002	(0.001)	0.997	(0.004)
Experience	*0.004	(0.002)	-0.001	(0.003)	0.986	(0.009)
Some college	0.042	(0.064)	0.012	(0.080)	1.148	(0.314)
College graduate	-0.023	(0.071)	0.099	(0.089)	1.089	(0.326)
Innovativeness	**0.114	(0.056)	-0.074	(0.069)	0.823	(0.196)
Rule awareness	**0.062	(0.028)	-0.004	(0.035)	1.160	(0.141)
Cost share crops	-0.119	(0.094)	-0.134	(0.117)	0.853	(0.329)
Cost share nutrient	0.136	(0.087)	-0.021	(0.108)	0.968	(0.354)
Johnston	*0.184	(0.097)	0.159	(0.121)	0.871	(0.360)
Lenoir	0.137	(0.097)	0.123	(0.120)	0.660	(0.267)
Nash	-0.040	(0.113)	0.182	(0.140)	0.848	(0.403)
Wayne	0.121	(0.095)	**0.284	(0.118)	1.667	(0.724)
Intend to train	-0.133	(0.102)	0.131	(0.126)	1.091	(0.497)
Both activities	0.081	(0.089)	0.156	(0.111)	0.865	(0.335)
Intend to do both	-0.086	(0.145)	-0.167	(0.180)	0.583	(0.337)
Nutrient plan	-0.091	(0.105)	0.035	(0.131)	0.932	(0.428)
No activities	-0.023	(0.088)	0.132	(0.110)	0.750	(0.284)
Nutrient plan (no)	-0.068	(0.095)	-0.097	(0.118)	1.242	(0.501)
Both activities (no)	0.103	(0.076)	0.024	(0.095)	1.153	(0.367)
College graduate (some college)	-0.065	(0.075)	0.087	(0.093)	0.949	(0.303)

*p ≤ .10, **p ≤ .05, ***p ≤ .01, ****p ≤ .001

APPENDIX D: Predicted Probabilities for Categorical Multivariate Models

Table D.1. Predicted Probabilities for RYEs, Cover Crops, Soil Test, Income Impact, and Fear of Inspections Models.

	Predicted Probabilities				
Variables	**RYEs**	**Cover Crops**	**Soil Test**	**Income Impact**	**Fear of Inspection**
Farm size (acres)					
5		.468			
55		.197			
67 (mean – 1std.dev.)			.777		.662
75		.194			
148		.208			
287 (mean)			.857		.610
403		.286			
1097		.461			
1224 (mean + 1std.dev.)			.914		.555
2981		.720			
6503		.890			
Farm Income					
28% (mean - 1std.dev.)	.076	.267			.518
63% (mean)	.111	.329			.615
99% (mean + 1std.dev.)	.158	.399			.706
Education					
High School	.085	.379			.563
Some College		.347			.678
College Graduate	.175	.250			
Innovativeness					
0				.292	.670
1				.457	.565
Cost share crops					
0	.128				
1	.038				
Cost share nutrient					
0			.843		
1			.681		
Rule awareness					
2		.406			.646
3		.340			.547
4		.280			.559
5		.225			.809

Table D.1. Continued

Variables	Predicted Probabilities				
	RYEs	Cover Crops	Soil Test	Income Impact	Fear of Inspection
Fear of penalties					
0	.199				
1	.098				
Fear of inspection					
0			.785		
1			.873		
Fear of stricter reg.'s					
2		.476			
4		.336			
5		.273			
Counties					
Edgecombe		.471		.148	
Johnston	.044	.400	.798	.461	
Lenoir	.111	.204	.888	.415	
Nash	.195	.473	.719	.306	
Wayne	.155	.292	.876	.469	
Activities					
Train Only	.176	.486	.810	.376	
Intend to train		.254		.598	
Both Activities		.336	.926	.215	.665
Intend Both		.219	.948	.646	
Plan Only	.165	.313	.901	.418	.752
No Activities	.055	.348	.737	.424	.488

Note: Predicted probabilities shown only for statistically significant variables.

Table D.2. Predicted Probabilities for Rule Awareness Model.

Variables	Predicted Probabilities			
	Aware 2	Aware 3	Aware 4	Aware 5
Farm size (acres)				
5	0.201	0.257	0.34	0.202
20	0.334	0.287	0.268	0.111
55	0.398	0.285	0.233	0.084
148	0.423	0.282	0.219	0.076
165	0.424	0.282	0.219	0.076
403	0.407	0.284	0.228	0.081
1097	0.35	0.287	0.259	0.103
2981	0.262	0.278	0.309	0.152
6503	0.183	0.248	0.348	0.221
Education				
High School	0.455	0.278	0.201	0.065
Some College	0.314	0.287	0.279	0.119
College	0.326	0.288	0.273	0.113
Counties				
Edgecombe	0.371	0.29	0.248	0.092
Johnston	0.457	0.279	0.2	0.064
Lenoir	0.36	0.29	0.253	0.096
Nash	0.428	0.284	0.215	0.072
Wayne	0.293	0.286	0.293	0.129
Activities				
Train only	0.282	0.312	0.297	0.109
Intend to train	0.413	0.31	0.214	0.063
Both activities	0.185	0.276	0.364	0.176
Intend to do both	0.479	0.295	0.178	0.048
Nutrient plan	0.409	0.311	0.216	0.064
No activities	0.539	0.272	0.15	0.039

Table D.3. Predicted Probabilities for Fear of Stricter Regulations Model

Variables	Predicted Probabilities		
	Disagree	Agree	Strongly Agree
Income			
23	0.049	0.075	0.116
117	0.838	0.78	0.708
211	0.113	0.144	0.18
Rule awareness			
2	0.098	0.805	0.097
3	0.083	0.783	0.134
4	0.069	0.75	0.182
5	0.056	0.705	0.239
Counties			
Edgecombe	0.398	0.581	0.021
Johnston	0.058	0.653	0.289
Lenoir	0.053	0.695	0.252
Nash	0.175	0.809	0.017
Wayne	0.06	0.628	0.313
Activities			
Train Only	0.083	0.721	0.195
Both Activities	0.156	0.697	0.147
Intend Both	0.027	0.892	0.081
Plan Only	0.222	0.702	0.076
No Activities	0.085	0.839	0.076

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