Final Report
Neuse Crop Management Project

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Deanna L. Osmond
Soil Science Department, NC State University

In Association with
Mike Linker (Crop Science Department)
Andy Herring and Bob Pleasants (Wayne County NCCES)
Jeremy Barnes and Bill Lord (Franklin County NCCES)
Greg Jennings (Department of Biological and Agricultural Engineering)
and
Mindy Lohman, Jeff White, and Carrie Waffer (Soil Science Department)

TABLE OF CONTENTS

Executive Summary 1
Chapter 1: Introduction 5
Chapter 2: Project Objectives 9
Chapter 3: Management Strategy 1 — Best Management Practice Implementation 11
Nutrient Management Planning 11
Nutrient Management Plans 12
Nutrient Management Demonstrations 14
BMP Implementation 14
Tracking Nitrogen Reductions (NLEW) 14
USDA-NRCS 590 Nutrient Management Standard, PLAT, and the Neuse River Basin 15
HADSS – Herbicide Application Decision Support System 16
Herbicide Issues 16
Herbicide Project Activities 16
Demonstration Farms 18
Franklin/Wake County Demonstration Farm 19
Wayne County Demonstration Farms 20
Lenoir County Demonstration Farm 21
Craven County Demonstration Watershed 22
Chapter 4: Management Strategy 2 — Partnerships and Communication 23
Advisory Board 23
Web Site 24
NeuseLetter 24
Field Days 24
Popular Press 24
Presentations 24
Chapter 5: Management Strategy 3 — Nutrient Management Training 27
Chapter 6: Management Strategy 4 — Evaluation 29
Focus Group Session 29
Fertilizer and Cropping Survey 29
Fertilizer Application Rate Survey 29
Cost-Benefit Analyses 29
Water Quality Monitoring 30
Project Evaluations 30
Midterm Evaluation 30
Final Evaluation 30
Chapter 7: Conclusions 33
Chapter 8: References 37
Chapter 9: Acknowledgments 39
Appendix A: NLEW and PLAT Descriptions 40
Appendix B: Neuse Education Team Website 41
Appendix C: MidTerm Evaluation 42
Appendix D: Final Evaluation 47
Appendix E: Fact Sheets and Other Publications 70
Appendix F: Nutrient Management Data 72
Appendix G: Franklin County Demonstration Area Activities 73
Appendix H: Evaluation of the Realistic Yield Expectations of Soil Map Units in the North Carolina Piedmont and Coastal Plain 78
Appendix I: News Articles, Television and Radio 85
Appendix J: Neuse Crop Management Project Website 87
Appendix K: Nutrient Management Training Content 90
Appendix L: Neuse River Focus Group Session 91
Appendix M: Shrub Buffer Project Report 94

Executive Summary

The Neuse River Basin drains 1.2 million acres in central and eastern North Carolina (NC), including rapidly growing metropolitan areas, productive farmland, and extensive forests. The Neuse River Estuary has experienced harmful algae blooms and fish kills over the past two decades, resulting in state regulations that mandate a 30% reduction in annual nitrogen loading from all sources by 2003. Agricultural land uses throughout the river basin are estimated to contribute more than half of the total nitrogen load to the estuary, meaning that farmers are responsible for implementing best management practices that reduce nitrogen export by over 1 million pounds annually. At the same time, pesticides used in the region are under intense scrutiny by the US Environmental Protection Agency as it implements the Food Quality Protection Act.

The Neuse Crop Management Project was initiated in 1998 with the goal of increasing the use of production practices that improve the economic, agronomic, and environmental performance of corn/cotton/wheat/soybean farmers in the Neuse River Basin. The project established an unprecedented partnership among farmers, crop consultants, agribusinesses, grower organizations and NC State University research and extension to reduce unnecessary nitrogen and herbicide use and losses, thereby protecting water resources in the Neuse River Basin.

The Neuse Crop Management Project, along with the many other agencies and producers working in the Neuse River Basin, has accomplished its goal of enabling farmers to improve water quality, effectively deal with public and regulatory concerns, and sustain economic viability. Specific accomplishments of the comprehensive education and research efforts include:

- more than 105,000 acres of nutrient management plans;
- a 23% reduction in the amount of fertilizer nitrogen applied per acre of cropland; and
- a greater than 40% reduction in soil-applied preemergence herbicides;

Nutrient management training materials were developed and distributed to NC Cooperative Extension Service county agents, who then educated farmers about nutrients in the environment, how best management practices reduce nutrients, nutrient management planning and eight crop commodity modules. In 2001 and 2002, nutrient management training was offered throughout the Neuse River Basin to 1,240 farmers and turf managers.

Nutrient management planning was a major effort in the project to meet the goal of increasing the use of economic and environmentally sound production practices. Project staff worked directly with cooperating farmers from 1999 to 2002 to write and implement nutrient management plans. By 2002, nutrient plans had been developed for over 105,000 acres of cropland. To meet the challenge of developing nutrient management plans for thousand of acres, project personnel developed two innovative approaches. A simplified computerized nitrogen fertilizer spreadsheet was developed for commercial fertilizer plans. In addition, group nutrient management planning sessions were introduced. The farmers brought field information and project personnel worked with the farmers to write nutrient management plans.

The Neuse Crop Management Project installed complete systems of best management practices on several farms using funding provided by the NC Clean Water Management Trust Fund. Additional practices beyond nutrient management planning included grassed waterways, field borders, sod-based rotations, and flashboard risers (controlled drainage).

On-farm demonstrations were established in four areas within the Neuse River Basin to demonstrate and evaluate effective best management practices for each physiographic region in the

basin. In addition, the project team developed a series of small demonstrations in eight counties throughout the river basin to promote local adoption of nutrient management planning. These plots demonstrated that nutrient rates recommended by state agencies and NC State University did not reduce yield goals. Twelve field days were held at the demonstration farms to provide opportunities for commodity suppliers, farmers and agency personnel to view project activities at demonstration sites.

Two cost-benefit analyses were conducted during the life of this project. One analysis was for the best management practices, such as controlled drainage, cover crops and buffers, and the other was for nutrient management. The nutrient management cost-benefit study found that many farmers could save $20-40 per acre of cropland by using nutrient management. The best management practice cost-benefit analysis found that the benefit of the best management practices was highly dependent on the practice and the physiographic region.

To help producers make better herbicide use choices, and thus reduce preemergent soil-applied herbicides, the project selected to use a computer-based decision support system called HADSS (Herbicide Application Decision Support System) that allows farmers, commodity specialists, or crop consultants to determine the most cost-effective, environmentally sensitive, and effective herbicide. By making decisions on a field-by-field basis (termed site-specific), more precise selection of herbicides, application rates, timing, and placement of weed control measures are possible, and can minimize the application of unnecessary or inappropriate herbicide treatments. During the project, however, the weed control situation changed dramatically when Roundup Ready technology was introduced to NC farmers. Growers quickly embraced the Roundup Ready system for cotton and soybeans. In 2002 over 90% of the soybean acreage and upwards of 60% of the cotton acreage are in Roundup Ready varieties. Using acreage data on corn and shifts into Roundup Ready varieties, one can conservatively estimate a 40% decrease in the use of soil-applied preemergence herbicides. The rapid acceptance and increase in soybean and cotton acreage of Roundup Ready crops has dramatically accelerated the reduction in soil-applied preemergence herbicides.

The project was extremely cost effective. In 2002, nutrient management plans were written on 105,099 acres. The commercial rate for nutrient management planning is $8.00 per acre. Had the commercial rate been charged, the project would have spent the majority of the funding received from the Center for Agricultural Partnerships on only nutrient management planning. As a result of the cost effectiveness of the project, many other educational and promotional activities occurred, including the HADSS work. The project also supported critically important needs that were not sufficiently funded through the state budget:

- Development of training materials for the mandated nutrient management education program
- Computerization of the best management practice accounting and tracking tool – Nitrogen Loss Estimation Worksheet (NLEW)
- Computerization of the new tool – Phosphorus Loss Assessment Tool (PLAT) – needed to meet new USDA-Natural Resources Conservation Services nutrient management standards
- Development of the commercial fertilizer computerized spreadsheet used in developing nitrogen fertilizer plans

The Neuse Crop Management project demonstrated that nitrogen management is an effective and cost-efficient means for controlling nonpoint source nitrogen from agricultural sources. Before the project, many producers used their soil tests for lime, not phosphorus, and they applied nitrogen at standard rates. Two-thirds of the participating growers reported that they decreased their nitrogen application rates as a result of project recommendations. Some examples of estimated nitrogen rate

reductions due to the project are 15 to 20% on cotton, 14 to 28% on corn, 15 to 24% on tobacco, and 4 to 20% on wheat. One farmer stated, “The project helped us think through what we were doing and not just apply fertilizer according to tradition, which is how a lot of us farmers work.”

The project’s success was based on a unique set of circumstances: the existence of the Neuse Education Team and the many other agencies and organizations working in the Neuse River Basin; the extensive consultation and feasibility study at the beginning of the project which led to the creation of strong working relationships that made the project successful on a very significant scale; the ability to obtain funding from multiple sources; a highly competent staff; the multidisciplinary, multiagency, and multipartner nature of the project structure; the willingness of the farmers to be part of the solution; having project technicians that allowed intensive, one-on-one work with growers; an egalitarian structure that allowed staff to make decisions and do their work relatively independently; and the regulatory pressures for nitrogen reduction.

One of the advisory board members, who is also a farmer, summarized the project, "This project provides an opportunity for farmers to provide leadership in implementing solutions to solve regional problems" — *Charles Alexander, Pamlico County producer*. Based on the successes of the Neuse Crop Management Project, the project helped the agricultural community exceed its goal of a 30% nitrogen reduction in the Neuse River Basin. With the agricultural sector documenting a 34% nitrogen reduction in 2002, Mr. Alexander’s words have come true: the farmers provided leadership in implementing the solutions along with many competent and hard working agribusiness personnel and state and federal agency employees.

Chapter 1: Introduction

The Neuse Crop Management Project focused on input reductions of nitrogen and preemergent herbicides on agricultural cropland in the Neuse River Basin. This project was a direct response to state regulations and a federal Total Maximum Daily Load (TMDL) standard requiring a 30% reduction in nitrogen from all sources, including the agricultural community (NC Department of Environment and Natural Resources, 1997). Although the amount of herbicide detected in water resources in North Carolina is low, reducing unnecessary herbicide applications seemed prudent. The project was designed to involve multiple stakeholders, including agribusiness interests, state and federal agency personnel, university extension professionals, commodity organizations, and most especially, the farmers themselves.

Neuse River Basin: Problems and Regulations

The Neuse River in central and eastern North Carolina flows over 200 miles from its headwaters in the Piedmont near Durham through the Coastal Plain and into the Pamlico Sound east of New Bern (Figure 1.1). The Neuse River Basin is a unique and sensitive environment, featuring high water tables, abundant wildlife, and over one million acres of highly productive cropland in close proximity to streams and drainage ditches. The river was classified by the North Carolina Environmental Management Commission as Nutrient Sensitive Waters in 1988 because of excessive algal production and fish kills in the Neuse River Estuary. This classification resulted in mandatory controls on nutrient point source discharges and financial incentive programs to reduce nonpoint sources of nutrients from agriculture.

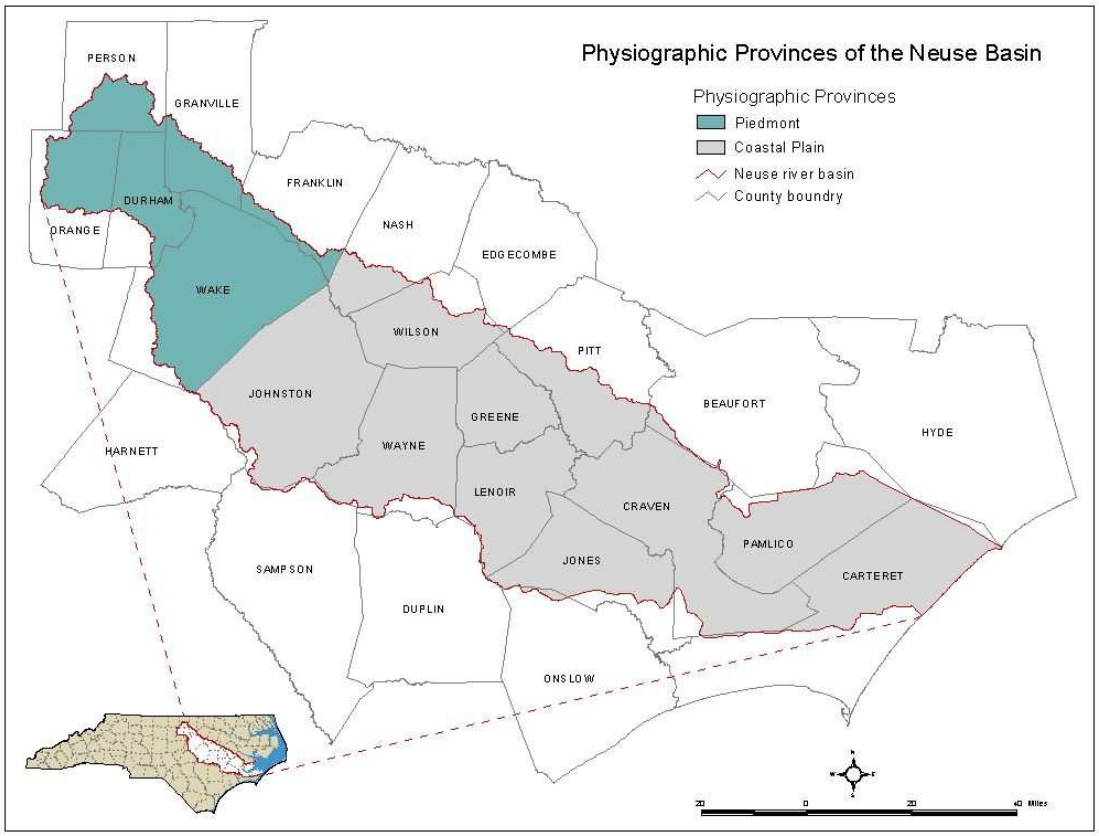

Figure 1.1 Neuse River Basin and Physiographic Regions within the Basin

After several major fish kills in the 1990s, new regulations, known as the "Neuse Rules" were implemented in 1998 with the goal of reducing annual nitrogen loading in the estuary from all sources by 30% by 2003. Approximately half of the Neuse River's nitrogen pollution has been attributed to agricultural operations, including cropland, pasture, and confined animal operations.

Under the "Neuse Rules" agricultural farmers were required to either implement standard best management practices or participate in a county-level area plan. The four choices in standard best management practices were (1) a 50-foot forested riparian buffer, (2)nutrient management and a 30-foot vegetative buffer, (3) nutrient management and a 20-foot forested buffer, or (4) nutrient management and controlled drainage. Under the county-level management plan, farmers in the county were required to collectively achieve a 30% nitrogen reduction by implementing sufficient types and amounts of best management practices. These best management practices consisted of nutrient management, controlled drainage, buffers of different types and widths, and cover crops. To account for the county-level nitrogen reductions, a best management practice tracking and accounting tool, which had not yet been developed, was legislated. The tool developed for this accounting process was the Nitrogen Loss Estimation Worksheet (NLEW), details of which are found in Appendix A (Osmond et al., 2000a & b).

Using Education to Help Solve the Problem in the Neuse

Understanding that the five year, 30% nitrogen-reduction goal was very ambitious, the North Carolina General Assembly initiated the Neuse Education Team in 1996 by providing special funding to address environmental education needs in the river basin. The Neuse Education Team is part of the NC Cooperative Extension Service at NC State University. This unique team comprises four Area Extension Agents and four campus-based Extension Specialists. The objective of the Neuse Education Team is to increase local understanding of how specific technologies can be used to protect water quality and to promote local adoption of effective nutrient-reducing best management practices. Additional information about the team and its activities can be found at http://www.neuse.ncsu.edu/ (Appendix B).

Since 1997, the Neuse Education Team has worked with farmers and agricultural support organizations to develop specific educational programs to meet local needs. It became immediately clear that significant resources would be necessary to implement comprehensive local programs to improve water quality. In 1997, the Center for Agricultural Partnerships began an effort to determine what was necessary to help farmers meet the environmental challenges they faced and to assess whether this effort could be successful. Meeting with growers, crop consultants, Cooperative Extension staff, dealers, and grower associations, the Center for Agricultural Partnerships sought to determine the best course of action to help farmers make necessary and effective changes in their production practices.

In the summer of 1997, a meeting with more than 40 people representing growers, commodity organizations, private sector, and NC State University was held in Kinston, North Carolina. The intent of the meeting was to identify the project's target areas: nutrient and weed management. Building on the Neuse Team's agricultural strategy for best management practice education and implementation for producers in the Neuse River Basin, the Center for Agricultural Partnerships hosted a dozen representatives from the Kinston group, in addition to the Neuse Education Team, to develop a more comprehensive project strategy that also included greater representation from the entire agricultural community and weed management strategies. The Center for Agricultural Partnerships, along with Neuse Team members, worked throughout the next year to develop a work plan and an approach that would bring together everyone who had a role to play and a stake in reducing the impacts from agriculture in the Neuse River Basin.

In the fall of 1998, the Center for Agricultural Partnerships initiated the Neuse Crop Management Project with support form the Pew Charitable Trust and the US Environmental Protection Agency (Table 1.1). The goal was to help farmers identify and implement economically sound farming practices to sustain productivity while meeting environmental obligations. The project established an unprecedented partnership among farmers, crop consultants, agribusinesses, grower organizations, and NC State University research and extension to reduce unnecessary nitrogen and herbicide use and losses, thereby protecting water resources in the Neuse River Basin. The collaboration continued throughout the project from the development of the work plan at the beginning of the project during an all-day session in Goldsboro through annual project meetings, midterm assessments, and final evaluations.

Designed to fill a critical funding role in improving water quality in the Neuse River Basin, the project was able to take advantage of other important efforts in the Neuse that dealt with different but very complementary facets of the solution. The NC Clean Water Management Trust Fund, which provided a grant of $329,520, supported additional aspects of the Neuse Crop Management Project: best management practice implementation, equipment purchases, and water quality monitoring on the demonstration farms. The North Carolina Department of Environment and Natural Resources provided funding totaling $210,000 to support a producer best management practice survey in the basin. As part of the larger US Environmental Protection Agency 319 project, an initial baseline survey of fertilizer rates was conducted. In addition, the project could not have been successful without countless hours of donated time provided by cooperating farmers, agribusiness representatives, and concerned citizens throughout the Neuse River Basin.

A member of the Neuse Education Team, Deanna Osmond, based at NC State University, provided the overall management of the Neuse Crop Management Project. Other team members (David Hardy, Bill Lord, Mike Regans, and Steve Hodges), as well as a county-level Extension Agent (Bob Pleasants), provided management of the demonstration farms and work with area farmers. Neuse Education Team salaries and operating expenses are supported through funding provided by the North Carolina General Assembly since 1996. The team produces the quarterly NeuseLetter with a feature column on the Neuse Crop Management Project (Appendix E).

Mike Linker, a member of the Crop Science Department at NC State University, along with a post-doctoral student, provided leadership for the herbicide portion of the project. Additional funding provided by the UNC Water Resources Research Institute and by NC State University supported several Soil Science Department graduate students, whose research is critically important to information developed by this project.

The project's first year was marked by severe drought and natural disaster. During the 1999 growing season, an intense drought stunted plant growth and precluded nitrogen response in crops. Then in September more than 20 inches of rain from Hurricane Fran fell on the region in a matter of days, causing extensive flooding and damage, only to be followed by another hurricane a few weeks later. As a result the project was extended for an additional year to ensure that data from three full growing seasons would be available. Because of extensive consultation and involvement of the key people and organizations necessary for success and a focus on the implementation of environmentally sound practices, the Neuse Crop Management Project was uniquely able to complement other efforts to craft significant and lasting changes in the basin.

The project's success, as determined by the final evaluation (see Appendix D), was based on the following unique set of circumstances: the ability to obtain complementary funding; a highly competent staff; the multidisciplinary, multiagency, and multipartner nature of the project

structure; the willingness of the farmers to be part of the solution; and the regulatory nature of the problem being addressed.

The Neuse Crop Management Project was one part of a much greater research effort in the Neuse River Basin. This very large effort to reduce agricultural nitrogen loads by 30% could not have been met without the extraordinary efforts of many agencies, groups, and individuals. These groups include the Neuse River Basin Oversight Committee, the NC Department of Environment and Natural Resources (Division of Water Quality, and Division of Soil and Water Conservation), NC Farm Bureau Federation, the Neuse River Foundation, Soil and Water Conservation Districts, the Neuse Technicians (funded under the Division of Soil and Water Conservation), county Cooperative Extension Agents in the basin, USDA-Natural Resources Conservation Service, and most especially the producers themselves.

Table 1.1 Funding for the Neuse Crop Management Project

Funding Organization	Funded Item	Funding
Pew Charitable Trust & US Environmental Protection Agency through the Center for Agricultural Partnerships	Project coordinator and technicians	$867,000
	Nutrient management training	
	Software production (NLEW & PLAT)	
	Economic analysis of best management practices	
	Nutrient management planning and implementation	
	Communications	
	Project evaluation	
	Field days	
	Project logistics and material	
NC Clean Water Management Trust Fund	BMP implementation (controlled drainage & sediment-reducing practices)	$329,520
	Water quality monitoring	
	Equipment	
UNC Water Resources Research Institute	Graduate stipend	$60,000
	Water quality monitoring	
	Travel	
NC Cooperative Extension Service – NC State University	Project personnel – 3 Neuse Education Team members and a county agent provided management of the demonstration farms and local direction of farmer education programs. The NeuseLetter was produced by the team.	$800,000
US Environmental Protection Agency 319 – NC Department of Environment and Natural Resources	Sample selection	$210,000
	Sampling maps	
	Data collection	
	Data analysis	

Chapter 2: Project Objectives

The goal of the Neuse Crop Management Project was to significantly increase the use of production practices that improve economic and environmental performance in the Neuse River Basin. The successful accomplishment of this goal enabled farmers to adopt agronomically and economically sound practices to protect water quality and effectively deal with public and regulatory concerns. The project focused on herbicide and fertilizer practices for corn, cotton, wheat, and soybeans, which account for 84% of planted farmland acres in the Neuse River Basin. Targeted and efficient use of nutrients and herbicides is critical to both cost-effective crop production and water quality protection in the Neuse River.

The specific project objectives focused on implementing best management practices.

> Objective 1. Implement nutrient management and weed integrated pest management practices on 100,000 acres of cropland in the Neuse River Basin.
>
> Objective 2. Implement weed integrated pest management to achieve a 10-30% reduction in the use of soil-applied preemergence herbicides on the project acreage (primarily alachlor, acetochlor, metolachlor, pendimethalin, vernolate, simazine, cyanazine, trifluralin, and atrazine).
>
> Objective 3. Implement nutrient management practices to achieve 10-20% reductions in the use of nitrogen on the project acreage.

Project outcomes, as measured against project objectives, were met for all three objectives.

> Objective 1. More than 100,000 acres of nutrient management and weed pest management practices were implemented (Table 3.1)
>
> Objective 2. As a result of crop shifts from corn to cotton (25% reduction in corn) and the dramatic increase in the use of Roundup Ready soybeans and cotton (to over 75% of these crops), the use of preemergence herbicides was reduced. Based on the increase in Roundup Ready soybeans or cotton and the decrease in corn acreage, one can conservatively estimate a 40% decrease in the use of soil-applied herbicides.
>
> Objective 3. Based on information using the Nitrogen Loss Estimation Worksheet (Appendix A), overall application rates of nitrogen fertilizer were reduced by 23% (Table 3.2).

Chapter 3: Management Strategy 1 — Best Management Practice Implementation

To accomplish the objectives listed in Chapter 2, the project advisory board team (see Chapter 4) developed four management strategies as follows:

> Management Strategy 1: Demonstration and Implementation. The project team used nutrient management planning, the Herbicide Application Decision Support System, and a series of demonstration farms to encourage widespread adoption of best management practice systems by farmers.
>
> Management Strategy 2: Partnerships and Communication. The project team developed basinwide partnerships and communication strategies to promote the adoption of best management practices throughout the Neuse River Basin.
>
> Management Strategy 3: Nutrient Management Training. The project team developed resource materials and conducted extensive training programs to improve the understanding among farmers and agribusiness professionals of nutrient management, water quality protection, and best management practice impacts.
>
> Management Strategy 4: Evaluation. Evaluations to determine the effectiveness of project efforts toward the adoption of nutrient, herbicide, and other best management practices were made throughout the life of the project.

The project team identified those nitrogen-reducing best management practices appropriate to the physiographic region to address producer needs and developed targeted programs to encourage producer adoption. Much of the project success was due to local technical support provided by project technicians and the development of demonstration farms distributed throughout the river basin.

Nutrient Management Planning

Nutrient management is the careful monitoring and amending of soil fertility to meet the needs of crops with an emphasis on improving agricultural profitability and minimizing impacts on water quality. Although the effectiveness and implementation of other best management practices, such as riparian buffers and controlled drainage, depend on specific site characteristics (drainage, soil, slope), nutrient management is universal and has potential for success regardless of the landscape setting. Fact sheets describing nutrient management planning are listed in Appendix E. Updated information on nutrient management is provided at http://www.soil.ncsu.edu/nmp/.

Nutrient management planning was a major effort in the project to increase the use of economic and environmentally sound production practices. This section describes project staff efforts to write and implement nutrient management plans throughout the Neuse River Basin. It also describes two tools developed for the project: (1) NLEW, which was mandated through the “Neuse Rules” and used to track reductions in nitrogen loss and the implementation of best management practices, and (2) a simplified computerized spreadsheet to aid in nutrient management planning. Lastly, efforts of project staff to address changes in the USDA-Natural Resources Conservation Service 590 Standard for Nutrient Management by developing the Phosphorus Loss Assessment Tool (PLAT) are described. Details of the NLEW and PLAT software packages are described in Appendix A.

Nutrient Management Plans

To reduce nitrogen, the project focused on nitrogen-based nutrient management plans specific to crop needs and soil type. A nitrogen-based nutrient management plan uses the concept of Realistic Yield Expectation to derive the appropriate rate of nitrogen fertilizer. In North Carolina, every soil series and agronomic crop has been assigned a Realistic Yield Expectation for use in writing nutrient management plans that are certifiable under North Carolina standards. The Realistic Yield Expectation is multiplied by a factor specific to each crop and soil combination to derive the appropriate nitrogen fertilization rate.

From 1999 to 2002, project staff worked directly with cooperating farmers to write and implement nutrient management plans. By 2002, nutrient plans had been developed for over 100,000 acres of cropland. Table 3.1 lists county results for cropland acres with implemented nutrient management plans in 2002. In Wayne County alone, over 69,000 acres received nutrient management plans. (See the section on the Wayne County Demonstration Farms for further details on how they accomplished this amount of nutrient management planning.) Primarily project technicians wrote these plans, along with a crop consultant (at one location) funded by the Center for Agricultural Partnerships' portion of the project.

Table 3.1 Cropland Acres with Implemented Nutrient Management Plans (NMP) by County in 2002

County	Acres of NMP written by Neuse Crop Management Project (2002 only)
Carteret	0
Craven*	19,502
Durham	0
Franklin	250
Granville	0
Greene	106.1
Johnston	1,038.2
Jones	0
Lenoir	3007.1
Nash	6,000
Orange	0
Pamlico	0
Person	0
Pitt	0
Wake	2,295
Wayne	72,900.2
Wilson	0
Total	105,098.6

**Plans for this project and a companion project written by Billy McLawhorn*

Using the fields of selected cooperators, project staff determined that nutrient management planning decreased nitrogen use by 10 to 30 pounds per acre, depending on crop, soil, and producer management. This reduction translates to an overall rate reduction of basin nitrogen fertilization on all crops from 87 pounds per acre to 67 pounds per acre, a 23% decrease (Table 3.2). This fertilizer rate reduction coupled with a net decrease in fertilized cropland resulted in a total reduction in the amount of fertilizer nitrogen applied from 76.6 million pounds to 55.9 million pounds, a 27% decrease (Table 3.2). Although the project's nutrient management focus was corn, wheat, soybeans,

and cotton, under the "Neuse Rules," nutrient management plans had to be written for all crops. (These data were collected by the Neuse River Basin Oversight Committee through 2001 and are included in their 2002 report.)

Table 3.2 Changes in Nitrogen Fertilization Rates by Crop for All Counties

Crop	Baseline	2001	Base N	2001 N	Base N	2001 N	Change N lbs	Change N lbs/ac
	(acre)	(acre)	(lb/acre)	(lb/acre)	(lb)	(lb)	(%)	(%)
Corn for grain	177808	102431	160	138	28415464	14131178	-50	-14
Corn for silage	3985	2175	150	128	597395	278810	-53	-14
Soybeans for beans	262696	269197	19	4	4910781	1173420	-76	-77
Cotton	127670	220112	84	71	10768118	15551156	44	-16
Wheat for grain	123036	77385	112	107	13815012	8287573	-40	-5
Tobacco	89642	61159	86	82	7715284	5004770	-35	-5
Bermuda grass	20942	35767	215	182	4497193	6515657	45	-15
Fescue	26632	26988	47	50	1261609	1339940	6	5
Rye	488	154.1	100	100	48720	15381	-68	0
Oats for grain	12374	4983	116	110	1438956	545699	-62	-6
Barley for grain	2358	893	95	91	224523	81589	-64	-4
Sorghum for grain	2290	890	129	110	296429	97707	-67	-15
Peanuts	85	270	10	1	884	344	-61	-88
Soybean-waste	20633	19089	106	120	2194465	2293330	5	13
Sweet potatoes	5666	6867	81	78	457865	533468	17	-4
ALL CROPS	876305	828360	87	67	76642698	55850021	-27	-23

Even though nitrogen was the basis for the plans, soil sample data were used, resulting in a complete nutrient management plan. Generally, farmers could reduce their nitrogen application rates by approximately 15%. In one area, the nutrient management planning process, along with aggressive cotton petiole monitoring, convinced some farmers, who were using poultry litter and fertilizer that they did not have to apply additional commercial fertilizer. This decreased nitrogen applications by as much as 100 lb/acre. Many of the fields sampled required no additional phosphorus and often no potassium. This was reflected in plans with a zero phosphorus and potassium recommendation.

Economic analyses of the outcomes of nutrient management planning indicated that farmers typically could save $20 to $40 per acre by implementing nutrient management (http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-43/fertmgt07-30-021.pdf) (Appendixes E and G). Savings were associated not only with reducing nitrogen, but also by using only as much phosphorus and potassium as soil tests prescribed.

Nutrient Management Demonstrations

The project team developed a series of small demonstrations in eight counties throughout the river basin to promote local adoption of nutrient management planning. Producers were concerned that the use of Realistic Yield Expectations for determining nitrogen fertilization rates would limit yield goals. These plots demonstrated that Realistic Yield Expectations did not limit crop productivity. Locations, crops, and data are included in Appendix F.

BMP Implementation

In conjunction with the Neuse Crop Management Project, the best management practices in Table 3.2 were installed using funding from the NC Clean Water Management Trust Fund. The Wake County Soil and Water Conservation District did much of the work installing the grassed waterways, field borders, critical area plantings, sod-based rotations, wildlife areas, and diversions. Likewise, the Lenoir and Wayne County Soil and Water Conservation Districts were instrumental in the implementation of the flashboard risers (controlled drainage). Personnel from these districts worked with the landowners and sized the structures. The structures in Craven County were implemented by personnel funded through the Center for Agricultural Partnerships portion of the project.

Table 3.3 Acres of Best Management Practices Installed by County

Best Management Practices	County	Acres
Grassed waterways	Franklin/Wake	7.84
Field border	Franklin/Wake	15.01
Diversion	Franklin/Wake	0.77
Critical area	Franklin/Wake	0.24
Sod-based rotations	Franklin/Wake	267.71
Wildlife	Franklin/Wake	2.61
Controlled drainage	Craven, Wayne, Lenoir	3,129

Tracking Nitrogen Reductions (NLEW)

Under the “Neuse Rules,” a tracking and accounting tool had to be developed (Appendix A). The tool developed, NLEW, was used to track nutrient management implementation and nitrogen reductions. The conceptual development of NLEW by an interagency committee occurred over a two year period (Osmond et al., 2001a & b). The tool was developed to work at two scales: field level and aggregate. Once the conceptualization was complete, the tool had to be computerized. The computerization was funded by the Center for Agricultural Partnerships and the US Environmental Protection Agency 319 funds.

Since the field-scale version had to account for the over 120,000 fields in the Neuse River Basin with an average field size of less than 10 acres, the aggregate version of NLEW was used to track agricultural nitrogen reductions. Input data for the accounting tool are soil type, crop, field size (acres), nitrogen fertilizer rate (lb/acre), Realistic Yield Expectation for the crop (if known), cover crop type (if grown), use of additional best management practices, such as controlled drainage or buffers (if implemented), and the area that the best management practices affect. The percent total nitrogen reductions due to best management practice implementation (including nutrient management) are compiled in Table 3.4. The percent nitrogen reduction is from the baseline period of 1991-1995. These estimates were compiled by the NC Department of Environment and Natural Resources for a report to the NC Environmental Management Commission in October 2002.

Table 3.4 Estimated Percent Nitrogen Reduction Due To Best Management Practice Implementation

County	Estimated % Nitrogen Loss Reduction
Carteret	45.4
Craven	46.4
Durham	26.4
Franklin	23.7
Granville	23.4
Greene	37.0
Johnston	47.6
Jones	33.9
Lenoir	14.3
Nash	30.2
Orange	19.4
Pamlico	38.5
Person	31.9
Pitt	22.9
Wake	44.7
Wayne	25.1
Wilson	41.6
Total	34.4

USDA-NRCS 590 Nutrient Management Standard, PLAT, and the Neuse River Basin

The Neuse Crop Management Project played an important role as changes were made to the nutrient management standard that the farmers had to implement. The nutrient management standard in the “Neuse Rules” refers to the USDA-Natural Resources Conservation Service 590 nutrient management standard, and as such, must meet these criteria. In 1999, USDA-Natural Resources Conservation Service changed its nutrient management standard 590 to include phosphorus (P) as a limiting nutrient for agricultural nutrient applications. Each state was responsible for developing a procedure to assess phosphorus status during nutrient management planning if animal waste is involved or the field is within an impaired watershed. A North Carolina Phosphorus Committee was formed to address the changes in the USDA-Natural Resources Conservation Service nutrient management policy and standard 590. Each state had three options to set a P-standard: soil test, soil-threshold, and P-Loss Index.

The NC Phosphorus Committee strongly endorsed the P-Loss Index concept. To avoid confusion with the agronomically based NC Department of Agriculture and Consumer Services "P-Index" reported on soil-testing forms, North Carolina will use the term "P Loss Assessment Tool (PLAT)" as the basis for nutrient management planning (Appendix A). Once this new standard was in place, nutrient management was required to meet the new USDA-Natural Resources Conservation Service criteria. Thus it was imperative that this project help develop the necessary tool – PLAT – to ensure that the nutrient management plans written for the Neuse River Basin are certifiable. The Neuse Crop Management Project was proactive in assuring that farmers in the Neuse River Basin would not be penalized by this change in the nutrient management standard USDA-Natural Resources Conservation Service.

HADSS – Herbicide Application Decision Support System

Herbicide Issues

Weeds are essentially a problem in every field every year. So farmers must devise a weed control plan for all crops. Weeds are formidable competitors and well adapted to production systems. For example, many weed species are prolific seed farmers, and seeds can lay dormant for many years (up to 17) and still germinate. Weeds not controlled during the growing season can increase mechanical loss at harvest as well as reduce yield and quality. There are several nonchemical approaches to weed control: rotation, cultivation, cover crops, increased crop density (both within and between rows), and manipulation of planting dates. All of these are practiced to some extent by farmers. Although these approaches lessen weed pressure, none eliminate weeds, so farmers need additional means of direct control. Alternatives to herbicides (e.g., biological control or induced resistance) are not available as they are for insects and plant pathogens. This situation results in herbicides being a fundamental part of controlling weeds.

In the last decade the number of herbicides available for weed control has increased dramatically. For example, in the *1998 Agricultural Chemicals Manual* (NC Cooperative Extension Service), 176 single and herbicide combinations were recommended for cotton weed control. For soybeans it was 136. In 1990, for cotton, there were only 32 single herbicide and herbicide combinations available. Not only is there a bewildering array of choices, but also selecting among the choices makes decisions even more complex. Few herbicides could control a wide array of weeds (before Roundup Ready), requiring farmers to apply multiple herbicides. This situation was ripe for misapplications and unnecessary treatments. Additionally, farmers were coming out of what may be termed a “preemergence and preplant incorporated” era of weed control - a time when postemergence herbicides were few and weed control depended on herbicides applied before or just after the crop was planted. The problem with this system was that herbicides were applied before the weed situation was known and the herbicides being used were most often associated with ground and surface water contamination. The challenge was clear: change the system to allow herbicide treatment according to need and provide farmers with a simple way to sort through the array of herbicides available so they will be more amenable to a treat-as-needed system. Regulatory scrutiny of many of the herbicide choices for farmers under the Food Quality Protection Act added an additional and critical imperative to devise and implement practices that minimize herbicide use.

Herbicide Project Activities

To meet the need for a simple way to make complex decisions faculty at NC State University developed a computer-based decision support system called HADSS (Herbicide Application Decision Support System). This system is the result of many years of weed experimentation and software development. The program allows farmers, commodity specialists, or crop consultants to determine the most cost-effective, environmentally sensitive, and effective herbicide. Users enter relevant, field-specific information regarding weed populations, yield expectations, economic variables, and field conditions. HADSS estimates yield loss that may occur if no control methods are used; eliminates herbicide treatments that are inappropriate for the specified conditions; and calculates expected yield loss after treatment and expected net return for each available herbicide treatment. Treatments are initially sorted by expected net return, but they can be sorted in various ways (cost, efficacy against the total weed complex or a particular weed species, etc.). The web version of this program is at http://cropserv3.cropsci.ncsu.edu/webhadss/.

By making decisions on a field-by-field basis (termed site-specific), more precise selection of herbicides, application rates, timing, and placement of weed control measures are possible, and can

minimize the application of unnecessary or inappropriate herbicide treatments. Project staff members have been working with farmers, consultants, commodity suppliers, and Extension Agents to introduce them to HADSS. Additional information on this system can be found at http://www.hadss.com/.

The weed control situation changed dramatically when Roundup Ready technology was introduced to NC farmers. Growers quickly embraced the Roundup Ready system for cotton and soybeans. In 2002 over 90% of the soybean acreage and upward of 60% of the cotton acreage are planted in Roundup Ready varieties. This compares to the national acreage trend of 71% biotech cotton and 75% biotech soybean (USDA National Agricultural Statistics Service June 2002 report). The speed of adoption surprised both industry and university personnel. Because this new method controlled a wide array of weeds (but not all), many farmers (and professionals advising them) assumed that they could rely on this technology entirely. However, this was not a valid assumption. Many common weeds were tolerant (e.g., morning glories) and were promoted in the system. Other less common weeds became prevalent (e.g., dayflower). Although Roundup Ready provided good control in many situations, NC State University field surveys indicate that almost all weed situations call for a combination of herbicides and that in approximately 15% of the cases Roundup Ready is not the most appropriate choice. (The expectation is that this percentage will increase.) This observation is backed by empirical evidence. A local (Wayne County) herbicide dealer reports that 40% of his soybean customers are now adding another herbicide to Roundup Ready to control tolerant weeds. In a preliminary analysis of cotton fields (all Roundup Ready) monitored by a private agricultural consultant, 26% of the time Roundup Ready was not the most appropriate herbicide choice and 11% of the time another herbicide needed to be added to Roundup Ready for complete control. This phenomenon, called weed shift, is the beginning of returning the herbicide selection process to the pre-Roundup Ready situation.

When farmers quickly achieved confidence in Roundup Ready technology, they began to doubt the value of monitoring weeds and making site-specific decisions. This attitude was backed too often by agricultural consultants, Extension Agents, and NC State University faculty. This situation changed the focus of the HADSS objective. Initially, the focus was for farmers to gain confidence in using a computer-based recommendation system and to develop field-by-field management plans. After Roundup Ready, the focus changed to convincing farmers that one herbicide did not control all weeds (in many cases it did, and HADSS made the appropriate recommendation) and that HADSS could be depended on to give them reliable recommendations. Clearly, this was a more difficult challenge.

HADSS trials were run to increase the user confidence in the tool. Users needed the opportunity to see that HADSS makes good decisions and appropriate recommendations. Results of producer decisions and HADSS decisions were compared. During the season, 39 fields (384 acres) representing corn, cotton, and soybeans were scouted for farmers in Wayne, Lenoir, Craven, and Pitt counties. Recommendations from HADSS were compared with standard producer decisions. The Roundup Ready technology represented 100% of cotton and soybean acreage scouted, whereas conventional varieties represented only 5 fields planted to corn. Producer selection and HADSS recommendations were the same in 72% of these fields. If fields representing corn were removed from these data (a typical situation), similar recommendations occurred in 79% of cases. In 91% (31 of 34 fields) of the fields where Roundup Ready technology was used, HADSS recommended Roundup alone (27 fields) or with a tank-mix chemical (4 fields) as the first recommendation.

One challenge of this project was to provide tools to ensure that increases in are minimized. We continued to promote HADSS through early season educational efforts, specifically weed and herbicide management workshops for agricultural chemical dealers. Forty-five dealers from

Royster Clark and Dixie Fertilizer companies were introduced to HADSS and educated on herbicide resistance, weed shifts, and weed identification. All private agricultural consultants in the Neuse River Basin were trained on the use of HADSS.

When this project was initially developed, herbicide decision making was one of the most difficult tasks of a producer. Much has changed in the last four years due to the aforementioned introduction and rapid widespread adoption of Roundup Ready crops as well as changes in cropping patterns. Over the past few years, there has been a 25% reduction in corn acreage; crop on which many of the soil-applied preemergence herbicides are used. In addition, there has been a 6% increase in the soybean and cotton acreage. These changes in crop production alone have considerably reduced the amount of soil-applied preemergence herbicides used in the Neuse River Basin considerably.

On cotton acreage, where herbicide use has been extensive and where HADSS can be of most use, reduction of herbicide use in project acreage averaged 0.77 lb/acre, a 13% decrease in the volume of herbicides used. The ease of use, acceptable weed control, and commitment through purchase of technology with each bag of Roundup Ready seeds encourages farmers to use Roundup as their primary herbicide. As a consequence, there has been a dramatic decrease in the use of soil-applied preemergence herbicides. Using acreage data on corn and shifts into Roundup Ready varieties, one can conservatively estimate a 40% decrease in the use of soil-applied herbicides. The rapid acceptance and increase in soybean and cotton acreage of Roundup Ready crops has dramatically accelerated the reduction in soil-applied preemergence herbicides. Even though HADSS use has also reduced herbicide use in project acreage, it is important to acknowledge that the use of Roundup Ready technology has been the main factor in the reduction. In fact, to the extent that farmers in the project region adopt Roundup Ready technology, they are less likely to rely on HADSS since their herbicide decisions appear to have been already made.

The dramatic change in herbicide use forced project staff and participants to reevaluate the weed pest management strategy that was a fundamental part of this project. In doing so, several factors indicate that the changes in herbicide use from Roundup Ready technology may not necessarily be permanent. Weed shifts because of reliance on Roundup can easily change the demand for Roundup Ready soybeans or cotton. Additionally, a shift in cropping patterns as a result of commodity price changes could favor corn production, leading to increased use of soil-applied herbicides. Strong evidence already suggests that weed shifts will inevitably occur in Roundup Ready cropping systems, making Roundup either not effective or less effective. In those situations, farmers will again need effective tools for making weed management decisions. In addition, farmers and dealers will always need the ability to identify weed problems and to determine whether it is economically justified to apply an herbicide. Finally, farmers and dealers must be reminded of the need for scouting and its importance in making decisions. Feedback from participants in this project has been invaluable to members of the HADSS development team as they consider both ways to tailor the program to better fit the needs of decision makers and ways to encourage decision making that is based on careful assessment of the situation in each field (G. G. Wilkerson, personal communication).

Demonstration Farms

Demonstration farms have proven to be valuable teaching tools for transferring agricultural information. To this purpose, on-farm demonstrations were established throughout the Neuse River Basin to demonstrate and evaluate effective best management practices for each physiographic region in the basin. The physiographic regions in the Neuse Basin are the Piedmont and the Lower, Middle, and Upper Coastal Plain. The Piedmont is characterized by rolling topography, small agricultural fields, and cattle. Appropriate best management practices are forested riparian buffers, nutrient management and cover crops. The Upper and Middle Coastal Plain topographically

transition from rolling hills to flat areas. This is a highly productive agricultural region where there is a mixture of best management practices, depending on the slope of the land and the degree of ditching. The Lower Coastal Plain is a very flat region that without drainage (ditches) would not be able to sustain agricultural production. The two most useful best management practices in the Lower Costal Plain are nutrient management and controlled drainage. Details on the demonstration farms are provided on the web at http://www.neuse.ncsu.edu/ncmp/demo_farms.html.

Franklin/Wake County Demonstration Farm

On the Piedmont Demonstration Farm in Franklin and Wake counties, the focus was on intensive wheat nitrogen management in the Rocky Branch Watershed. The core demonstration area included six cooperators. Detailed nutrient management plans were developed for each field to account for variability by soil type. Spot checks of wheat yields were made at 15 locations in the project area. The yield checks demonstrated that farmers were overestimating their expected yields, often by almost 50% (Appendix G). In addition, wheat was intensively managed through scouting for cereal leaf beetles and tiller counting, and wheat fertility tests were conducted for two years.

This location is also being used to explore soil sampling strategies that give the best results: whole field, grid, or soil map units. Geographic Information Systems (GIS) technology was used to map soils and wheat yield data to determine whether the Realistic Yield Expectations for the soils typically found in this region matched measure yields. Data have been collected only for one year, and therefore it is too early to state the results. For more information on the project, refer to Appendix H.

Several field days were used to inform agency personnel, farmers, and the news media about project activities, including nutrient management and best management practices. Radio stations and local newspapers publicized information about the project.

In a follow-up to this project, nutrient management with flue-cured tobacco and cotton were demonstrated in a neighboring county. An article in the Southeast Farm Press, which has a circulation of approximately 53,000 in nine different states, highlighted the work with tobacco. Franklin County project details can be found in Appendix G.

Because the field size is small, the topography is rolling, and the streams are highly buffered, sediment rather than nitrogen is of greater concern. Best management practices, consisting of six sediment-reducing practices, were installed and strip-till tobacco was demonstrated (funded by the NC Clean Water Management Trust Fund). The strip-till practice reduced soil loss by 50% or more, depending on the soil type (Appendix G).

Wayne County Demonstration Farms

The focus of the Upper Coastal Plain Demonstration Farms in Wayne County was on nutrient management and controlled drainage for corn, soybeans, cotton, wheat, and tobacco. Intensive soil sampling was completed on over 2,000 acres of cropland on five different farms as a result of the project. Detailed nutrient management plans were implemented for each farm. Cotton petiole nitrate monitoring was used on scores of fields during the project, assuring farmers that their lowered nitrogen fertilizer rates were sufficient.

To meet the challenge of developing thousands of acres of nutrient management plans, project personnel developed two innovative approaches. A simplified computerized nitrogen fertilizer spreadsheet was developed for commercial fertilizer plans. This tool uses significantly less time than the state nutrient management software, although it contains all the components necessary for the plan to be certified under USDA-Natural Resources Conservation Service requirements. In addition, project personnel worked with the agribusiness community to contact farmers regarding nutrient management planning. Agricultural suppliers would invite their customers to a nutrient management planning session. The farmers would be asked to bring field information, such as soil tests, tract numbers, and any orthoquods, to a meeting. At the meeting, project personnel helped the farmers determine their predominant soil type for each field using USDA-Natural Resources Conservation Service Soil Surveys. The Project Technician then took this information and used the nitrogen fertilizer spreadsheet to develop nutrient management plans. The final outcome of the project was that over 69,000 acres of nutrient management plans were developed for farmers in Wayne, Lenoir, Johnston, Greene, and Wilson counties.

Several demonstration tests were conducted as part of the Neuse Crop Management Project. Both corn and cotton nitrogen rate tests were conducted, as well as a foliar potassium test for cotton. Four water control structures were installed to maintain higher water tables and promote denitrification on 400 acres of cropland. A warm season grass buffer was planted on 7,000 feet of ditch bank. In addition, over five miles of ditch banks were maintained with the weed sweep to control large woody vegetation.

Weeds and insects in cotton and soybeans were scouted for the duration of the project. During the first year, HADSS was used experimentally on 450 acres to determine appropriate practices for managing weeds. Water quality monitoring has occurred for the past several years. The Little River has been monitored, as well as two sites at the Center for Environmental Farming Systems in Wayne County, to determine whether there are any changes in stream nitrogen concentrations. This monitoring was funded through the NC Clean Water Management Trust Fund.

Lenoir County Demonstration Farm

On the Middle Coastal Plain Demonstration Farm in Lenoir County, nitrogen application rates were determined using digitized soil maps and their related Realistic Yield Expectations. Yields were measured, and the results demonstrated that the new nutrient management plans had no effect on yields.

To enhance shrub buffers already existing on part of the farm, weed wiping was initiated to control large woody vegetation. Graduate student research projects on this site focused on buffer ecology and width influences on denitrification in shallow groundwater. Over 60 monitoring wells were installed within these shrub buffers to measure nitrogen-reducing values at buffer widths. Redox probes were also installed to ensure that reductions in groundwater nitrate were caused by denitrification instead of by dilution. Vegetative and bird inventories are being collected to determine the habitat quality of these shrub buffers.

Two controlled drainage structures affecting 351 acres were installed at this location. An additional nine structures, draining 1500 acres, were installed on farms throughout Lenoir County.

A kiosk with detailed information was constructed at this demonstration farm, and it has been used extensively as a teaching lab. Two field days were attended by more than 150 people. Nutrient management, buffers, controlled drainage, corn variety trials, and HADSS applications were demonstrated. In addition, the site was used by the NC Department of Agriculture and Consumer Services to educate its Regional Agronomists about the “Neuse Rules” and the best management practices utilized, especially nutrient management. Several agency tours used the location to inform county- and city-level elected officials about the efforts being made by the agricultural community to reduce nitrogen emissions. Lastly, for two years in a row, summer interns from the Center for Environmental Farming Systems visited the site to learn about agricultural best management practices.

Lenoir County Craven County

Craven County Demonstration Watershed

The Mosley Creek Watershed in Craven County was selected because it is situated in the Lower Coastal Plain and because it represents a natural subwatershed boundary. The fields are heavily ditched to ensure adequate drainage. Eight farmers farm in this subwatershed, and all of them participated in the project.

Field boundaries were georeferenced so that digital soil maps could be used to determine Realistic Yield Expectations. Nutrient management plans were written for all farms in this watershed as well as other fields in nearby watersheds. Some of these plans were written by the original technician. As the result of a problem rehiring a technician to finish the job, Billy McLawhorn, an area crop consultant, wrote the nutrient management plans for this project. He wrote additional plans for a companion watershed – Core Creek – that is also funded by the NC Clean Water Management Trust Fund. The two projects covered the majority of the agricultural area in Craven County.

Twelve nutrient management demonstrations were implemented in Craven County. Corn variety demonstrations were used to help farmers select the highest yielding varieties for local farms. Three tours have been given in this subwatershed. Two of the tours were associated with annual Neuse Conferences held in New Bern, and the other was associated with the Center for Agricultural Partnerships. HADSS was used by four farmers on a total of 184 acres. HADSS locations consisted of 10 cotton fields, 5 soybean fields, and 5 corn fields.

A total of nine controlled drainage structures were installed throughout the watershed. These structures drain a total of 628 acres. Sixteen miles of ditch bank in Core Creek Watershed were weed wiped to establish filter strips. Water samples have been collected monthly from Mosley Creek. The initial water quality monitoring design, which was more ambitious, had to be curtailed because of technical difficulties.

Chapter 4: Management Strategy 2 — Partnerships and Communication

The project staff recognized that partnerships were essential to meet project objectives. The following organizations agreed to participate on the Neuse Crop Management Project advisory board: Corn Growers Association of North Carolina, Cotton Incorporated, Dixie, National Cotton Council, North Carolina Cooperative Extension Service, North Carolina Department of Agriculture and Consumer Services, North Carolina Department of Environment and Natural Resources, NC Farm Bureau Federation, North Carolina Plant Food Association, North Carolina Small Grain Growers Association, North Carolina Soybean Growers Association, Royster Clark Inc., and Southern States Cooperative.

The project staff used extensive outreach to promote best management practices that reduce nitrogen and pesticide losses. Media interest in the project increased as the demonstration sites were developed. Project awareness was promoted through the NeuseLetter (a quarterly newsletter of the Neuse Education Team), local newspapers, radio, television, and project literature. The extensive media campaign provided a multiplier effect for increasing project contacts.

Advisory Board

A 35-person advisory board was established to set objectives and provide input on the work plan for the Neuse Crop Management Project. This board consisted of representatives from commodity organizations, agribusiness, state and federal agencies, NC Farm Bureau Federation, consultants, and farmers. The board was updated and consulted yearly. In addition, the board provided a midterm project review to ensure that the project was meeting its objectives. Members of the initial project advisory board are listed here. Several of these people have moved and were not on the advisory board by the project's end.

Charles Alexander, NC Small Grain Growers Association
Steve Bevington/Tom Jones, NC Clean Water Management Trust Fund
Anne Coan, NC Farm Bureau Federation
Jacob Crandall, USDA-Natural Resources Conservation Service
Roger Crickenberger, NC State University
Paul Dugger, National Cotton Council
Larry Elworth, Center for Agricultural Partnerships
David Hardy, Craven County Cooperative Extension Service
Jim Haskins, AgriBusiness Communications Group
Steve Hodges, NC State University
Richard (Rick) A. Holder, Dixie-Harvey Fertilizer & Gas
Carlton Ipock, Royster Clark
Greg Jennings, NC State University
Gene Kamprath, NC State University
Mike Linker, NC State University
Bill Lord, Franklin County Cooperative Extension Service
Susan Mackey, Center for Agricultural Partnerships
Andy Moye, Producer
Becky McClanahan, National Cotton Council
Billy McLawhorn, McLawhorn Agricultural Consulting Services
Deanna Osmond, NC State University
Jim Parrott, Parrott Farms
Ron Perry, Southern States

Bob Pleasants, Wayne County Cooperative Extension Service
Mike Regans, Greene – County Cooperative Extension Service
Richard Reich, NC Department of Agriculture and Consumer Services
Doug Roberts, Southern States
Howard Singletary, NC Plant/Food Association
Tommy Valco, Cotton Inc.
Jim Wilder, NC Soybean Growers Association
David Williams, Division of Soil and Water
Mitch Woodward, NC Cooperative Extension Service
Joyce Woodhouse, NC Corn Growers Association
Lin Xu, Division of Water Quality, NC Department of Environment and Natural Resources

Web Site

A web site was developed both as an informational site and as a historical record. The Neuse Crop Management Project web site (Appendix J) contains detailed information about the project as well as all four demonstration farms. The site can be accessed at http://www.neuse.Ncsu.edu/ncmp.

NeuseLetter

The Neuse Education Team produces a quarterly newsletter, the NeuseLetter (Appendix E). The newsletter generally has three articles: an article on educational programs, an urban feature, and a column on the Neuse Crop Management Project, which deals with the agricultural sector. Articles have included such topics as nutrient management planning, controlled drainage, highlights from the demonstration farms, and best management practice tours. The newsletter is mailed to over 4000 subscribers in addition to be being posted on the web at http://www.neuse.ncsu.edu. The NeuseLetter mailing list includes many local and state government officials, agribusiness professionals, news media outlets, and concerned citizens.

Field Days

Project staff organized 12 field days to provide opportunities for commodity suppliers, farmers, and agency personnel to view project activities at demonstration sites. These field days also provided additional news coverage of the project.

Popular Press

In the spring of 1999, the project was announced at a press conference in Wayne County that generated coverage on the three major television stations in the Raleigh metropolitan area. Twenty-three articles covering nutrient management and best management practice efforts of the project have been printed in regional multistate farm journals, including the Southeast Farm Press and the Agronomic, Economic, and Environmental Digest, and newsletters. Some of these articles, written by the coordinator, promoted best management practices through local newspapers (Appendix I). Ten of these articles appeared in these local news sources. Southern Farm Press presented several articles on the project. In addition, commodity newsletters were used to explain the agricultural rules and best management practice selection. The project received coverage two different times on television and twice on radio reports.

Presentations

Project information was presented at meetings in North Carolina at the NC Plant Food Association, North Carolina Small Grain and Corn Producers (3 years), Southeast Farm Press Cotton Conference, and the UNC Water Resources Research Institute Conference. On a more of a local level, the project was presented to county commissioners in Wayne County, members of the Wake County Agribusiness Council, participants in the Neuse Council of Governments, members of the

Vanceboro Rotary Club, farmers at three meetings in Craven County, and farmers in the Wayne County Young Farmers organization.

Information on nutrient management or the "Neuse Rules" was presented at numerous meetings. A few are listed: Blacklands Farm Tour (2002), Syngenta Wheat Field Day (2001), NC Small Grains Field Day (2002), and two livestock producer meetings (2001, 2002).

Presentations were also given at both national and international meetings: the 10th Annual Nonpoint Source Monitoring Conference (Osmond et al., 2002a); the American Society of Agronomy in 2001 (http://www.neuse.ncsu.edu/reg_ag_N_basin_scale.html) and 2000 (Osmond et al., 2000c; Zanner et al., 2000); the American Water Resources Association conference (Jennings et al., 2002); the International Conference on Agricultural Effects on Ground and Surface Waters (Osmond et al., 2001a); the 2nd International Nitrogen Conference on Science and Policy (Osmond et al., 2001b); and a conference on buffers that was attended by over 200 people from throughout the United States.

Chapter 5: Management Strategy 3 — Nutrient Management Training

Project staff developed a comprehensive nutrient management training program targeted to farmers and agribusiness professionals. The intent of the training is to increase awareness about how nutrients move into water resources and ways to reduce nutrient losses.

One of the requirements of the "Neuse Rules" was for the NC Cooperative Extension Service to develop and provide nutrient management training for anyone who fertilized 50 acres or more. Alternatively, farmers could have a certified nutrient management plan. To accomplish this training, two Neuse Education Team members prepared the training materials. This was, however, a collaborative effort. First, all interested parties were invited to a "needs-to-know" work group. The training was outlined during this session. Training materials were then developed, after which county agents (the people who actually train the farmers) critiqued the training materials. Changes were made before the training materials were released (Hodges et al., 2000). The materials consist of a training notebook containing the curriculum, slide sets, CDs with PowerPoint presentations, and paper copies of presentation materials (Appendix K). These notebooks were distributed to 35 trainers working for NC Cooperative Extension Service and partnering agencies throughout the river basin. Training topics include the water quality problem, how nutrients move, how best management practices reduce nutrients, nutrient management planning, and eight crop commodity modules.

Training was piloted in five locations in 2000: Person, Orange, Durham, Wayne, and Lenoir counties. Over 100 farmers received certificates of training that year. In 2001 and 2002, nutrient management training was offered throughout the Neuse River Basin to 1,240 farmers and turf managers (Table 5.1).

Table 5.1 Nutrient Management Training Participants by County in 2001-2002

County	Training Participants
Craven	105
Greene	73
Johnston	277
Lenoir	81
Nash/Franklin	69
Orange	45
Pamlico	31
Person	75
Pitt	26
Wake	200
Wayne	135
Wilson	123
Total	1240

Evaluations of the nutrient management training suggest that the farmers find the training useful, particularly the water quality portion.

Early in the Neuse Crop Management Project, project staff held six one-day training sessions, three of which were sponsored by the NC Plant Food Association, for general agribusiness audiences, including crop consultants. The other three sessions were specifically for the three major agricultural product distributors (Southern States, Dixie, and Royster Clark). The intent of this

training was to help agribusiness better understand nutrient management, off-site nitrogen movement, and the impact of best management practices - in other words, to get them ahead of the training we would do later for farmers. Topics for this training included a description of a certified nutrient management plan and who can write the plan, the difference between a nitrogen-only plan and a total plan, a description of NC soil management groups and how they are used to determine nitrogen application rates, and other best management practices used to reduce nitrogen losses.

A state interagency nutrient management computer program is being used for nutrient management planning. Agency personnel that included USDA-Natural Resources Conservation Service, NC Cooperative Extension Service, and NC Division of Soil and Water Conservation were trained to use the nutrient management software. Additional training was held for Neuse Crop Management Project technicians, Neuse technicians (hired by the NC Department of Environment and Natural Resources), USDA-Natural Resources Conservation Service staff and other agency personnel to write certifiable nutrient management plans. In addition, we also held a computer training session with NLEW to give Neuse technicians hired by the NC Department of Environment and Natural Resources hands-on practice with the software. This training allowed Neuse technicians to track BMP implementation (including nutrient management) and account for nitrogen losses associated with these best management practices. It would have been impossible to present the basinwide nitrogen reduction information in Chapter 3 without the development of this tool.

Chapter 6: Management Strategy 4 — Evaluation

Evaluations were conducted during the Neuse Crop Management Project to establish baselines, to collect basic data, to ensure that the project was focused and on target, and to assess project results.

Focus Group Session

A focus group session of agribusiness and dealer representatives took place in Goldsboro in February 2001. The intent of the focus groups was to help direct basinwide education programs. A better knowledge of how farmers make decisions related to products and services offered by agricultural industries could help project scientists tailor training and education programs to meet those needs. Also of interest was information concerning how the companies have been changing or organizing themselves to meet consumer demand. The focus group found that more farmers are relying on agribusinesses to provide services in addition to products and that farmers depend on people they trust for advice regarding which products to buy. A detailed report of the focus group session is in Appendix L.

Fertilizer and Cropping Survey

A survey to determine fertilizer practices and best management practice implementation was conducted in 1999 with funding from pass-through US Environmental Protection Agency 319 funds. Information on base crops, acreages, nutrients applied, and best management practices was collected and analyzed for approximately 6,000 individual crop fields. These data were passed on to the county level groups to be used in their NLEW calculations.

Fertilizer Application Rate Survey

Early in the project, and in association with another grant, 30 farmers in the basin were surveyed regarding their nitrogen fertilizer rates with weighted averages calculated: corn (158 lb N/acre), cotton (88 lb N/acre), pasture/hay (194 lb N/acre), tobacco (83 lb N/acre), and wheat (122 lb N/acre). These application rates were similar to the rates our cooperating farmers were using and provided another way to check on rates.

Cost-Benefit Analyses

Cost-benefit analyses provide important direction in determining the financial feasibility of that which is being analyzed. Few projects have ever provided cost-benefit analyses of agricultural best management practices. Two cost-benefit analyses were conducted during the life of this project: one analysis was for the best management practices, such as controlled drainage, cover crops and buffers, and the other was for nutrient management.

The nutrient management cost-benefit analysis was produced using information from our cooperators. The cost-benefit ratio for nutrient management was highly variable, depending on soil test levels and farmers' practices, but in general, it appears that many farmers can save $20-40 per acre by using nutrient management. Detailed analysis was conducted on five farms in the Piedmont and an equal number of farms in the Coastal Plain. The Piedmont information can be found in Appendix E.

The cost-benefit analysis for the other best management practices used in this project was unique. The benefit of the best management practices was highly dependent on the specific best management practice and the physiographic region. For instance, wooded riparian buffers were found to be more cost effective in the Piedmont than in other regions, whereas controlled drainage was only cost effective in the Lower Coastal Plain.

Seven different articles present the cost-benefit information: four fact sheets, two documents, and a journal article (Wossink and Osmond, 2002). The fact sheets and documents can be found at http://www.neuse.ncsu.edu/aginfo.html.

Water Quality Monitoring

Detailed water quality monitoring, funded through the NC Clean Water Management Trust Fund and UNC Water Resources Research Institute took place at one of the farms (Lenoir County) on a shrub buffer system. Preliminary data indicates that nitrogen reductions by these buffer systems range from 60% to 95%, thus validating the usefulness of these buffer systems. Farmers would find shrub buffers much more acceptable than tree buffers, so this is an important finding. Final results will be available in June 2003. The project focused on producing results at the field level. Evaluation of the project's efforts was based on how well the practices have been made available and on the economic and environmental impacts on the region's farmers and their farms. Detailed descriptions of monitoring data and research reports are provided in Appendix M.

Project Evaluations

Project evaluations were conducted at midterm and at the end of the project to identify specific project successes and weaknesses.

Midterm Evaluation

The midterm evaluation was conducted by members of the advisory board. They visited project personnel and toured all four demonstration farms. They identified few problems and encouraged project staff to continue the work. The following are just a few comments from the midterm evaluation. Details of the evaluation are in Appendix C.

- Nutrient management implementation was successful where farmers received local technical assistance on data analysis and plan development.
- The HADSS program worked well for determining which herbicides to use, but where Roundup Ready soybeans and cotton were grown, the program was considered too data intensive.
- Nutrient management training targeted to agribusinesses, including fertilizer salespeople and consultants, successfully increased the local implementation of best management practices.
- The project was meeting its objectives and should continue for the remainder of the term.

Final Evaluation

Project conclusions from the final evaluation are summarized here. The purpose of the report was to provide a “sociological snapshot” of the project by giving the diverse stakeholders the opportunity to voice their opinions about the project’s implementation and impact. For the full evaluation that includes lessons learned and recommendations, see Appendix D.

Thirty-two stakeholders were interviewed: 12 growers and 20 nongrowers. A random sample of three growers in each county was chosen for the interviews, plus one key grower who had worked intensively with the project. The 20 nongrowers represented six different sectors: the funding agency, the project principals, the technical (field) staff, agency contacts, agribusiness contacts, and NC State University faculty. In-person interviews were conducted to generate the information that follows.

Both the growers’ and the nongrowers’ assessments of the Neuse Crop Management Project and its impact were positive. The project reportedly met and exceeded its objectives, and its strengths outweighed its deficits. Its multisector, multidisciplinary approach was reported to be effective and the project staff consistently was rated as highly competent by both growers and nongrowers.

There was good collaboration among the diverse stakeholders, which generated useful information, increased the agencies' knowledge of each other's technical capacities, and strengthened the links between agencies. The three problems consistently identified by the nongrowers were the inherent problem of staff turnover in a short-term project, the need for better communication among project staff, and the lack of progress in the weed management component that was mainly due to the growers' widespread use of Roundup Ready seed.

It is important to note that, when the "Neuse Rules" were written, the general feeling among growers was that they had been unjustly accused of using excessive nitrogen and thus of being major contributors to pollution in the Neuse River. Their view was that the accusation was "all politics," designed to make farmers the culprits, and that urban sprawl was as much or more responsible for nitrogen loading in the Neuse River. As virtually every grower pointed out, the fact that they had to control production costs meant that they could not afford to "throw around nitrogen." At the beginning of the project, the basic position among growers was that their fertilization rates were appropriate, based on their long-term experience with the land they farmed and on technical assistance from suppliers, the NC Department of Agriculture and Consumer Services, and the NC Cooperative Extension Service.

Another important factor to recognize is that growers currently face difficult economic circumstances. According to growers, part of controlling production costs was using only as much nitrogen as they needed. From the nongrowers' perspective, the current agricultural economy was likely to have a conservative influence on their behavior and the perceived risks of a change such as implementing different nutrient management practices, even if the change potentially decreased costs and maintained yields. Given this context, the project did a good job of increasing growers' awareness and use of the options to improve their nutrient management.

Interviews with growers led to the conclusion that "appropriate" nitrogen rates are subjective. Growers reported that their decisions for applying nitrogen were based on their experience with the land, soil samples, rainfall, and technical recommendations from NC State University, suppliers, and NC Cooperative Extension Service. All the growers said that they adapted recommendations from the latter three sources based on their experience. Also, several reported that the state's Realistic Yield Expectations were too low and that they could exceed them, which influenced their fertilization rates. This fact affected their view of their nutrient management plans, in which the Realistic Yield Expectations were an important factor. At least one grower also reported that his Wagram soils were different than elsewhere so his input rates were idiosyncratic also. The growers' general feeling was that "you can't fertilize by the book, you have to fertilize by the field" and that "sometimes someone who's in the field every day knows better than the guys who come from Raleigh."

The big growers who worked intensively with the project and had significant acreage under nutrient management plans had more confidence in their plans. This may have been the result of more contact with the project or of their greater interest in better management, but even a big grower stated that he didn't follow his nutrient management plans "like the Bible." The interviews showed that growers understand the need for good economic and environmental performance. But at this point each grower is using his or her plan "in accordance with my experience of what's worked well for me in the past."

Chapter 7: Conclusions

The agricultural community in the Neuse River Basin in North Carolina faces intense pressure to comply with environmental regulations while experiencing difficult economic conditions. The Neuse Education Team has been successful in helping farmers meet their obligations by improving their understanding of best management practices and promoting economically sound farm management through the Neuse Crop Management Project. Project conclusions are listed here.

1. The project exceeded its numerical objectives:
   - Over 100,000 acres under nutrient management plans
   - 40% reduction in preemergent herbicides
   - 23% reduction in nitrogen applied per acre of cropland

2. The project's success, as determined by the final evaluation (see Appendix D), was based on a unique set of circumstances: the existence of the Neuse Education Team and the many other agencies and organizations working in the Neuse River Basin; the extensive consultation and feasibility study at the beginning of the project, which led to the creation of strong working relationships that made the project successful on a very significant scale; the ability to obtain funding from multiple sources; a highly competent staff; the multidisciplinary, multiagency, and multipartner nature of the project structure; the willingness of the farmers to be part of the solution; and the regulatory pressures for nitrogen reduction.

3. The project's major strengths were the preproject investment of time to build a solid foundation for multisector, multidisciplinary work; collaboration among diverse stakeholders; excellent staff; project technicians that allowed intensive, one-on-one work with growers; and an egalitarian structure that allowed staff to make decisions and do their work relatively independently.

4. The project was extremely cost effective. In 2002, nutrient management plans were written for over 105,000 acres. The commercial rate for nutrient management planning is $8.00/acre. Had the commercial rate been charged, the project would have spent the majority of the funding received from the Center for Agricultural Partnerships on only nutrient management planning. As a result of the cost effectiveness of the project, many other educational and promotional activities occurred, including the HADSS work.

5. The project met critically important needs that were not sufficiently funded through the state budget:

- Training materials for the mandated nutrient management education program
- Computerization of the best management practice accounting and tracking tool – NLEW
- Computerization of the new tool – PLAT – needed to meet new USDA-Natural Resources Conservation Service nutrient management standards
- Development of the commercial fertilizer computerized spreadsheet used in developing nitrogen fertilizer plans

6. Interagency cooperation was facilitated by funding for the intensive local demonstration projects located throughout the river basin.

7. Nitrogen management is an effective and cost-efficient means for controlling nonpoint source nitrogen from agricultural sources. Before the project, many producers used their soil tests for lime but not phosphorus, and they applied nitrogen at standard nitrogen rates. Two-thirds of the

growers reported that they decreased their nitrogen application rates as a result of project recommendations. Most already had decreased their nitrogen rates on tobacco to some extent, to produce the lower-nitrate crop currently in demand. Some growers felt that the project did not significantly change their nitrogen rates because they were not overapplying it. Some examples of estimated rate reductions due to the project are 15 to 20% on cotton, 14 to 28% on corn, 15 to 24% on tobacco, and 4 to 20% on wheat. One farmer stated, "The project helped us think through what we were doing and not just apply fertilizer according to tradition, which is how a lot of us farmers work."

8. Growers appreciated the project's extensive soil sampling because it improved their knowledge of an important production factor and was a key factor in designing their nutrient management plans. The size of the project's sampling blocks - two- or five-acres - provided better information to the growers than the ten-acre blocks they generally sampled. The soil sampling gave growers a better basis for determining nutrient application rates, including lime.

9. More focused, intensive work with growers is necessary to get a significant amount of their acreage under nutrient management plans.

10. The "big" growers who worked intensively with the project were more positive about their nutrient management plans. According to a consultant who worked with the project, this is because growers who have more contact with the project and more acreage under nutrient management plans see the benefits of improved nutrient management more clearly.

11. Almost no information exists on the costs and benefits of controlling nonpoint source nitrogen from agricultural sources. A cost-benefit analysis of the best management practices used to control nitrogen, excluding nutrient management, demonstrated that some practices were not cost effective (cover crops), whereas other practices, such as buffers (in certain areas) were highly cost effective. A separate cost-benefit analysis of only nutrient management showed that farmers can typically save up to $50 per acre by using realistic yield expectations to determine fertilizer nitrogen applications (Appendix E).

12. The major incentives to growers for using their nutrient management plans were to improve water quality and to control production costs. In the words of one grower, "[nutrient management plans are] good for the river and for my pocketbook." They also pointed out that they live where they work and drink the groundwater, so they have a vested interest in controlling pollution.

13. Field demonstrations showed that nitrogen management recommendations currently provided by the NC Department of Agriculture and Consumer Services are usually sufficient to meet crop yields.

14. The project should have been designed to have only one focus – in this case, reducing nitrogen because of the legislation that affects this pollutant in the Neuse River Basin.

15. The weed management component did not meet participants' expectations. This was partly because the widespread use of Roundup Ready seed made Roundup the growers' chemical of choice, and partly because growers would not invest time in the extensive scouting that the Herbicide Application Decision Support System (HADSS) required. One important outcome of the HADSS component of the project, however, has been participant feedback. The feedback has been invaluable to members of the HADSS development team as they consider ways to

tailor the program to better fit the needs of decision makers and ways to encourage decision making that is based on careful assessment of the situation in each field.

16. Five years would be a more appropriate time frame for increasing the growers' awareness and use of the options to improve nutrient management and would facilitate retaining staff.

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Chapter 9: Acknowledgments

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- The Neuse Crop Management Project technicians (Andy Herring and Jeremy Barnes)
- NC Cooperative Extension Service personnel (David Hardy (now with NCDA&CS), Bill Lord, Bob Pleasants, Greg Jennings, Steve Hodges, and all the agents in the Neuse River Basin who have provided Nutrient Management Training)
- The Neuse Basin Oversight Committee (especially Lin Xu (Division of Water Quality), Marion Smith (Neuse River Foundation), and Ann Coan (NC Farm Bureau Federation))
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- Tom Jones (NC Clean Water Management Trust Fund)
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- Tom Hill (Wake County Soil and Water District)
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- NC State University Communication Services
- The NLEW and PLAT Committees
- NC State University College of Agricultural and Life Sciences
- The NC Agricultural Foundation

Most especially we thank all the producers who allowed us to work on their farms.

Appendix A: NLEW and PLAT Descriptions

North Carolina Agricultural Nutrient Assessment Tool (NCANAT), Version 2.0: Users Manual (excerpt)

(Containing NLEW and PLAT)

D.L. Osmond and S.C. Hodges
NC State University
Department of Soil Science
Raleigh, NC

September 2002

Introduction

The North Carolina Nutrient Assessment Tool, Version 2.0, contains two field-scale assessment tools: Nitrogen Loss Estimation Worksheet (NLEW) and Phosphorus Loss Assessment Tool (PLAT). This appendix presents a brief introduction to the tools. A detailed users manual, that includes more information about the systems, can be found with the software.

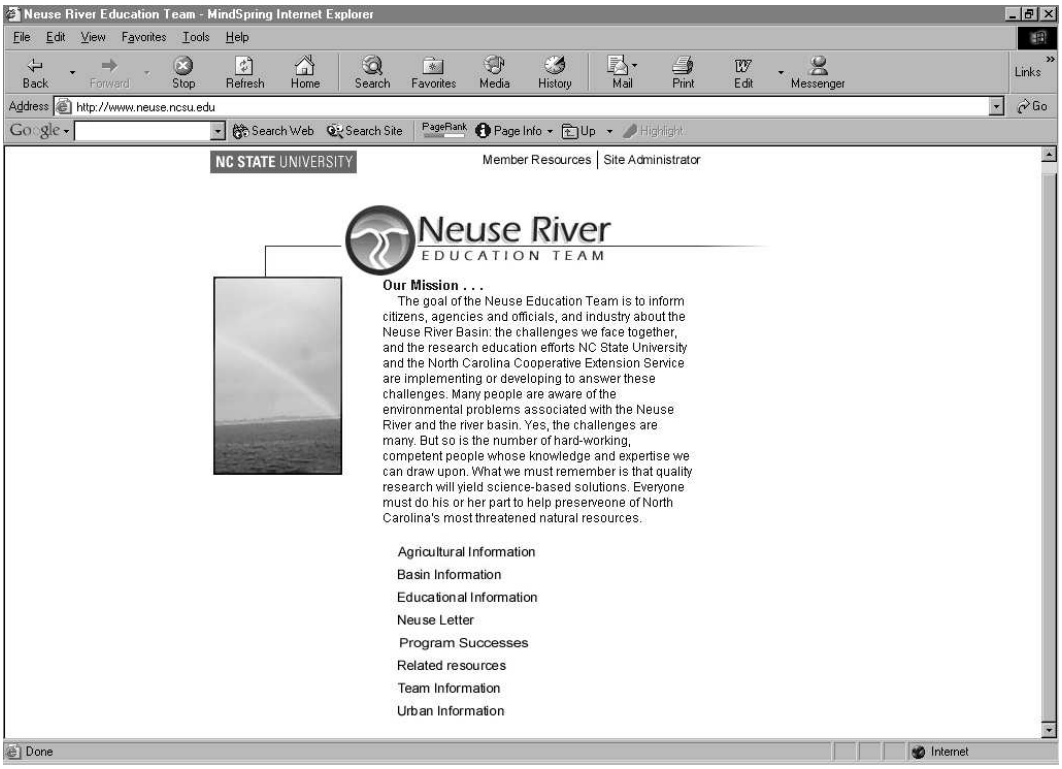
NLEW was developed in response to the ""Neuse Rules"". In August 1998, the ""Neuse Rules"" became law. These rules represented a series of regulations that control point and nonpoint source discharges of nitrogen into the Neuse River. As a result of the Local Option that was added to the agricultural best management practice (BMP) rules, producers can join a local strategy rather than implementing mandatory Best management practices. The local strategy allows a county to determine where the approved Best management practices can be installed to obtain the 30% nitrogen reduction. In addition, the Local Option provides a few more alternatives to the list of Best management practices, such as unfertilized cereal cover crops and no-till corn in the Piedmont, than the standard best management practices. In exchange for this flexibility, however, the rules mandated accountability. The accounting and tracking tool that has been developed to meet the requirements of the "Neuse Rules" is the Nitrogen Loss Estimation Worksheet (NLEW). In addition, NLEW was adopted by the NC Division of Soil and Water Conservation in 1996 as the method to estimate the effects of BMP on relative nutrient dynamics for projects funded with Agriculture Cost-Share Program funds.

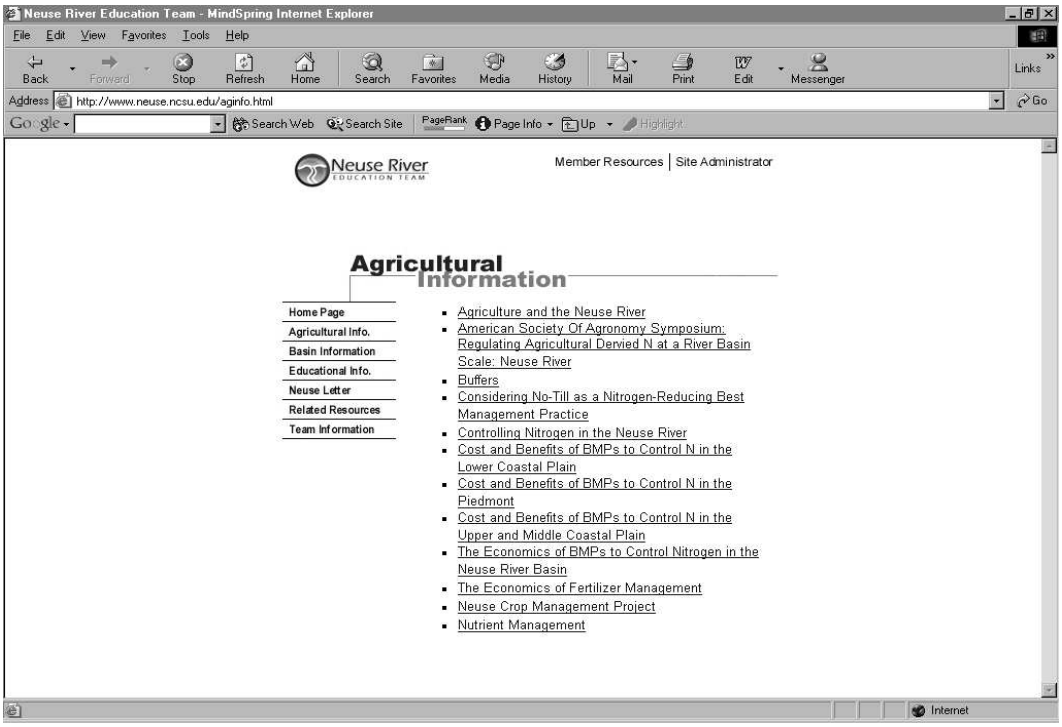
PLAT was developed in response to the new USDA-Natural Resources Conservation Service nutrient management standard (590). Each state is required to assess phosphorus (P) status during nutrient management planning if animal waste is involved or if the field is within an impaired watershed. Three selection strategies were allowed (soil test, environmental test, and P index). The North Carolina PLAT committee chose to use a modified index or assessment method, PLAT. The NC PLAT committee developed a unique P assessment method designed for North Carolina conditions.

These computer programs can be obtained by contacting Deanna Osmond (deanna_osmond@NC State University.edu) or calling 919-515-7303.

Appendix B: Neuse Education Team Website

http://www.neuse.NC State University.edu/





Appendix C: MidTerm Evaluation

The midterm evaluation was conducted in 2000 by advisory board members. The intent of the evaluation was to determine whether the project was on track to meet its projected goals. The evaluation committee consisted of: Gene Kamprath, Chair, NC State University; Jacob Crandall, USDA-Natural Resources Conservation Service; Becky McClanahan, National Cotton Council; Andy Moye, Producer; Howard Singletary, NC Plant Food Association; Jim Wilder, NC Soybean Association; and, Lin Xu, Department of Environment and Natural Resources-Division of Water Quality.

Members of the Evaluation Committee visited each demonstration farm in July 2000 and provided the following reports.

Visit to Wayne, Lenoir, and Craven Counties – July 10, 2000

Members attending: Jacob Crandall, Howard Singletary, Lin Xu, and Eugene Kamprath

I. Project in Wayne County

The committee met the morning of July 10 with Bob Pleasants, Extension Agent, Wayne County, who is responsible for the project in Wayne County and Andy Herring, Extension Technician assigned to the project in Wayne and Lenoir County.

1. Project Activities

1.1 Demonstration farms

1.1.1 Two farms have major programs underway to demonstrate best management practices. A nutrient management plan has been developed for the Mike Jones farm based on the use of turkey litter. Nutrient management plans have been developed on approximately 1500 acres in Wayne County. The Gurley farm had water control structures established in 1999 in cooperation with USDA-Natural Resources Conservation Service. A warm season grass buffer was planted on 7000 ft of ditch bank.

1.1.2 An additional four to five farmers will participate in the demonstration of best management practices next year. Soil samples will be taken this fall.

1.2 Cotton petiole nitrate monitoring

Petiole nitrate levels of cotton are being monitored on the Jones farm. Nine other farms on which poultry litter was applied are involved in the cotton petiole nitrate monitoring program.

1.3 GIS maps

GIS maps of cooperator's fields have been developed.

1.4 Weed management

Used HADSS on 450 acres to determine appropriate practices for managing weeds. On many farms HADSS is not used because Roundup Ready soybeans and cotton are being planted. This limits options for control of any weeds not controlled with Roundup. There is resistance by the farmers and to project personnel technicians to using HADSS because it is very time consuming to collect the data required for utilizing the program. Instituted a weed scouting program on the Jones farm to be used in developing a herbicide program for soybeans and cotton.

1.5 Water quality

Water samples are collected monthly from the Little River

1.6 New Activities

1.6.1 Plan to have a workshop in December on the development of nutrient management plans.

1.6.2 Plan to install water control structures on two more farms

1.6.3 Will initiate demonstrations on ditch bank management
1.6.4 Yield monitoring of soybeans on one of the new demonstration farms
1.6.5 Tentative plans to demonstrate nitrogen rate variable for corn on the Overman farm, which has large soil variability
1.6.6 Plan a number of small tours of the demonstration farms

2. Visit to the Mike Jones Farm
The committee visited the Mike Jones farm and talked with Mr. Jones about the project. At first he had doubts about the nutrient management plan, but after seeing the results he is a strong supporter of the program. Best management practices will be utilized if they increase returns and at the same time protect the environment. Mr. Jones said that after participating in the project it was easy for him to accept the “Neuse Rules”.

3. Evaluation and Recommendations
Excellent progress is being made in demonstrating the best management practices in Wayne County. The technician is being utilized very effectively in Wayne County. The project is very well managed. Mr. Pleasants is using the project as part of his overall education program in the county. The committee suggested planning field days for training sessions for interested farmers and fertilizer industry personnel, which would include CCA credits. The proposed activities are in line with the objectives and should all be implemented.

II. Project in Lenoir County

Activity has been limited primarily to the Parrot farm. Grass buffers have been established on four ditches. Sixty wells have been established in these buffers to monitor water quality. Two-water control structures have been installed. The farm has been mapped using GPS and digital soil maps. Nutrient management plans have been prepared for approximately 850 acres. Several farmers have been trained on how to collect cotton petioles for nitrate monitoring. The activity in Lenoir County has been conducted by the Extension Technician.

1. Evaluation and Recommendations
At the present time the Extension Technician is the only person involved with the project. Currently no one is providing supervision and guidance of the technician's activities in Lenoir. This has resulted in a limited implementation of the project. It is recommended that the project coordinator assume responsibility for providing supervision of the technician's activities in Lenoir County.

III. Project in Craven County
The committee met in the afternoon of July 10 in Craven County with Dr. David Hardy, Extension Agent, and Mike Carrol, Extension Technician.

1. Project Activities

1.1 Nutrient Management Plans
A total of 2114 acres in the Mosley Creek Watershed have been sampled and plans written for the nitrogen rate and timing of nitrogen application. Another 5079 acres in Core Creek have been sampled and plans written. Soil sample locations were determined by GPS.

1.2 Water Table Management
Ten ditches in Mosley Creek Watershed have been sited for water control structures. Six structures will be installed this fall. An additional 48 ditches have been sited for structures in Core Creek Watershed.

1.3 Weed Control Management
The HADSS program has been used on 186 acres with four growers.

1.4 Filter Strips
Sixteen miles of ditch bank in Core Creek Watershed was "weed wiped" to establish filter strips.

1.5 Nitrogen tests
Two nitrogen tests on rate and placement are being conducted.

1.6 Water Quality
Water samples are being collected monthly from Mosley Creek.
1.7 New Activities
1.7.1 Water control structures
Potential for eight more sites in Mosley Creek Watershed
1.7.2 Plan a winter meeting to discuss the nitrogen study on corn
1.7.3 Continue water quality monitoring
1.7.4 Develop more nutrient management plans
1.7.5 Plan to establish vegetative buffer

2. Visit to the Mosley Creek Watershed. We toured the Mosley Creek Watershed and saw locations where the water control structures will be installed. We also visited one of sites for nitrogen testing on corn. We met Clayton Mitchell, who is participating in one of the demonstrations on water table management.
3. Evaluation and Recommendations
Excellent progress is being made in preparing nutrient management plans. The installations of the water control structures will provide an excellent demonstration of water table management as an effective best management practice. The "weed wiped" system to establish filter strips along drainage ditch banks is an efficient method for managing ditch banks. The Extension Technician is being used very effectively in meeting the goals of the project.

The installation of the water control structures provides an excellent opportunity for a workshop and tour emphasizing the management of these structures for effective water table management. Efforts should be continued to find a location for establishing a vegetative buffer for reducing the amount of nitrogen going into streams and river.

The Mosley Creek Watershed Project is trying to demonstrate water quality improvement at a watershed scale by implementing a series of best management practices. This is the ultimate goal of the work in the Neuse River Basin. The committee recommends that the one-page fact sheets suggested by David Hardy be prepared as soon as possible. These would be very helpful in the education program. The suggested topics follow:

1. Nutrient Management Plan
Explain to the grower what is involved.
2. Filter Strip Weed Wipe
Explain how it should be used.
3. Water Quality Monitoring
Explain the purpose of monitoring water quality.
4. Movement of Nitrogen from Soils
Discuss loss by leaching and runoff

The format should be the same as that of the fact sheet entitled *Water Table Management and Nitrogen*.

Visit to Franklin County – July 19, 2000

1. The members of the committee attending the meeting were Jacob Crandall, Becky McClanahan, Howard Singletary, Jim Wilder, Lin Xu, and Eugene Kamprath.
The Committee met with Bill Lord, Extension Agent and Jeremy Barnes, Extension Technician, who are responsible for the project in Franklin and Wake Counties.
2. Project Activities
2.1 Nutrient management plans

The project is working with six operators who have a total of 1650 acres of cropland. Soil samples have been collected and fields mapped with a GPS unit. The cropping system is tobacco, wheat and soybean. The project in the Franklin/Wake area is located in the Piedmont. This region has tremendous variability in the soils, is highly erodible, and has small fields, 1/2 to 25 acres in size and averaging around 5 acres. Southern States provided help with the GPS mapping and grid sampling.

2.2 Demonstrations with wheat
Conducted wheat fertility tests and then held a field day with the cooperating farmers. Spot checks were made of wheat yields at 15 locations. The yield checks pointed out that farmers over estimated their yields by only looking at a field. Jeff White of the Soil Science Department will be studying sources of variability on some of the demonstration fields. This will help in the development of management plans to increase wheat yields.

2.3 Tobacco budgets
Tobacco crop production budgets were developed for the cooperators in the project. This has been a good educational tool to show the operators which costs they have some control over with good soil and crop management.

2.4 Rocky Branch stream restoration
The Rocky Branch stream was damaged by Hurricane Fran in 1996. The restoration of the stream and fencing off of the stream in the demonstration area are under way. The practice of fencing off the stream to keep out the cattle is a sensitive issue. This demonstration is critical in showing the importance of keeping the cattle out of the stream.

3. Visit to the Demonstration areas
The committee stopped at the Rocky Branch stream restoration site. We then went to visit with one of the demonstration farm cooperators, Jackie Thompson. He was very complimentary about the project and the information provided by the demonstrations for efficient crop production and use of best management practices. We also looked at the no-till tobacco demonstration. The use of no-till was very effective in reducing runoff and decreasing soil erosion.

4. Evaluation and Recommendations
Very good progress is being made in demonstrating best management practices for these erodible, highly variable, small fields. The Extension Technician is being used very effectively. The committee recommends that efforts on both the nutrient management plans and the stream restoration of Rocky Branch be continued. Both of these are important. Proper nutrient management is vital to achieve the goal of reducing the potential of nitrogen loss from these sloping, variable soils. The stream restoration demonstration will provide information that will be extremely important for dealing with similar problems in the Piedmont.

Overall Evaluation of the Project

I. Evaluation of Whether Project Objectives Are Being Met

Objective 1. The project has done a good job in implementing the nutrient management practices so that producers are willing to accept them. The HADSS program is considered to be basically sound for determining which herbicides to use but has certain operational limitations. Where Roundup ready soybeans and cotton are grown the program is not considered to be of much help. Farmers also are reluctant to spend the amount of time required to collect the input data required.

Objective 2. The project has showcased its activities using various means. This includes the NeuseLetter, The Neuse Crop Management Project web site, and the Neuse Team web site. So far there have been 2 television spots, 1 radio spot, 5 newspaper articles, and 10 displays at various meetings.

Objective 3. Five workshops on nutrient management have been conducted for employees of the fertilizer industry. These were sponsored in cooperation with the North Carolina Plant Food Association. Efforts are underway to have the fertilizer consultants, who have had the nutrient management training, certified to write nutrient management plans.

Objective 4. Another evaluation of the project should be made in the summer of 2001. By then a number of new activities, which are now being started, can be evaluated.

II. Recommendations on Project Management

The Committee made the following recommendations.

1. Demonstrations in Lenoir County
   The project coordinator should assume responsibility for supervising the activities of the Extension Technician. It would be desirable to meet with the technician once a week to discuss and plan activities.
2. Location of Project Coordinator
   The project coordinator has done a good job in getting the project activities organized and providing overall coordination. When the project was initiated it was desirable that the coordinator should be located physically in Raleigh to interact closely with the project leader and other campus faculty involved with the project. Because the project coordinator is leaving to go to a new job there is an opportunity to change where the coordinator will be located. The extension agents have suggested that the person could be located somewhere in the Neuse River Basin. This would allow more interaction with the extension agents and technicians.

Appendix D: Final Evaluation

Slinging Fertilizer Around: Participants' Views of the Neuse Crop Management Project

Elizabeth Adelski, Ph.D.
Independent Consultant

I. Introduction and Methodology

A. Purpose of the report

The North Carolina General Assembly set the goal of reducing nitrogen loads by 30% in the Neuse River Basin by 2001. The overall goal of the Neuse Crop Management Project was to help agricultural producers change their nutrient and herbicide management practices to simultaneously respond to regulations for improving water quality in the Neuse River and to maintain the economic viability of their operations. The lessons learned from the Neuse Crop Management Project about growers' adoption of practices to improve their economic and environmental performance are expected to serve as a model for growers in other regions who face public and regulatory pressure.

This report is part of the Neuse Crop Management Project final evaluation. It is a "sociological snapshot" of the project's impact. The purpose of the report is to document the views of the project's diverse stakeholders on the nontechnical aspects of the project, such as its strengths, deficits, and major results. This includes documenting growers' opinions about the project's impact on their nutrient application rates, their opinions about the utility of their nutrient management plans, and their incentives to use the plans. Recommendations for improving project performance and "lessons learned" from all the stakeholders also are in the report.

B. Methodology

The information in this report is from interviews with 32 stakeholders, who are categorized as "growers" and "nongrowers." A total of 12 growers from the four counties where the project was located were interviewed. In each of the three counties where the project worked (Franklin, Wayne, Craven) a random sample of three growers was chosen for the interviews, plus one key grower who had worked intensively with the project. One interview from Craven County was discarded because the grower's participation in the project was very shortterm. Only one grower in Lenoir county participated in the project, and he was interviewed.

Twenty "nongrowers" who represent six different sectors also were interviewed. These sectors were the project principals, the technical (field) staff, agency contacts, agribusiness contacts, and NC State University faculty. The principal investigator, who was responsible for the project but was not the project coordinator, and the project funder identified these people for the evaluation.

The consultant designed interview guides for the six types of nongrowers and the growers. The guides consisted of approximately 12 open-ended questions; those for the growers and technical staff were longer (see the Addendum). All of the growers were interviewed in person and on their farms. Four of the nongrowers were interviewed by telephone because of their distance from Raleigh, where the survey was based.

The interviews gave people an opportunity to voice their opinions about the project to a neutral outsider. They produced qualitative, self-reported information that is the basis for this qualitative

evaluation of the project and its impact. It is important to note that this self-reported information, like all self-reports, is subjective and unverified, and should be interpreted accordingly.

II. Conclusions and Recommendations

Both the growers' and the nongrowers' assessments of the Neuse Crop Management Project and its impact were positive. The project reportedly met and exceeded its objectives, and its strengths outweighed its deficits. Its multisector, multidisciplinary approach was reported to be effective, and the project staff consistently was rated as highly competent by both growers and nongrowers. There was good collaboration among the diverse stakeholders, which generated useful information, increased the agencies' knowledge of each other's technical capacities, and strengthened the links between agencies. The three problems consistently identified by the nongrowers were the inherent problem of staff turnover in a short-term project, the need for better communication among project staff, and the lack of progress in the weed management component that was mainly due to growers' widespread use of Roundup Ready seed.

When the ""Neuse Rules"" were written, the growers' general feeling was that they had been unjustly accused of using excessive nitrogen and thus being major contributors to polluting the Neuse River. Their view was that the accusation was "all politics," designed to make farmers the culprits and that urban sprawl was as much or more responsible for nitrogen loading in the Neuse. As virtually each grower pointed out, the fact that they had to control production costs meant that they could not afford to "throw around nitrogen." At the beginning of the project, the growers' basic position was that their fertilization rates were appropriate, based on their long-term experience with the land they farmed and on technical assistance from suppliers, the NC Department of Agriculture and Consumer Services, and the NC Cooperative Extension Service.

Another important factor to recognize is that growers currently face difficult economic circumstances. According to growers, part of controlling production costs was using only as much nitrogen as they needed. From the nongrowers' perspective, the current agricultural economy was likely to have a conservative influence on their behavior and the perceived risks of a change such as implementing different nutrient management practices, even if the change potentially decreased costs and maintained yields. Given this context, the project did a good job of increasing growers' awareness and use of the options to improve their nutrient management.

Interviews with growers led to the conclusion that "appropriate" nitrogen rates are subjective. Growers reported that their decisions for applying nitrogen were based on their experience with the land, soil samples, rainfall, and technical recommendations from NC State University, suppliers, and the NC Cooperative Extension Service. All the growers said that they adapted recommendations from the latter three sources based on their experience. Also, several reported that the state's Realistic Yield Expectations were too low and that they could exceed them, which influenced their fertilization rates. This factor affected their view of their nutrient management plans, in which the Realistic Yield Expectations were an important factor. At least one grower also reported that his Wagram soils were different than elsewhere, so his input rates were idiosyncratic also. The growers' general feeling was that "you can't fertilize by the book, you have to fertilize by the field" and that "sometimes someone who's in the field every day knows better than the guys who come from Raleigh."

The big growers who worked intensively with the project and had significant acreage under nutrient management plans had more confidence in their plans. This may have been the result of more contact with the project or of their greater interest in better management, but even a big grower stated that he didn't follow his nutrient management plans "like the Bible." The interviews showed that growers understand the need for good economic and environmental performance, but

at this point they are using their plans "in accordance with my experience of what's worked well for me in the past."

A. Conclusions

Two-thirds of the growers reported that they decreased their nitrogen application rates as a result of project recommendations. Most already had decreased their nitrogen rates on tobacco to some extent to produce the higher-quality, lower-nitrate crop currently in demand. Many growers felt that the project did not make significant changes in their nitrogen rates because they were not overapplying it. Some examples of estimated rate reductions as a result of the project are 15-20% on cotton, 14-28% on corn, 15-24% on tobacco, and 4-20% on wheat. An illustrative statement about these changes was: "The project helped us think through what we were doing and not just apply fertilizer according to tradition, which is how a lot of us farmers work."

Growers appreciated the project's extensive soil sampling because it improved their knowledge of an important production factor and was a key factor in designing their nutrient management plans. The project's two- or five-acre sampling blocks provided growers better information than the ten-acre blocks they generally sampled. The soil sampling gave growers a better basis for determining nutrient rates, including lime.

Growers reported that they used their nutrient management plans as guidelines: "I tried to follow them for the most part. Some fields had a better chance of producing higher yields so I used more than in the plans."

The "big" growers who worked intensively with the project were more positive about their nutrient management plans. According to a consultant who worked with the project, this was because growers who had more contact with the project and more acreage under nutrient management plans saw the benefits of improved nutrient management more clearly.

Growers' major incentives for using their nutrient management plans were to improve water quality and to control production costs: "[The plans are] good for the river and for my pocketbook." They also pointed out that they live where they work and drink the groundwater, so they have a vested interest in controlling pollution.

The project's major strengths were the preproject investment of time to build a solid foundation for multisector, multidisciplinary work; collaboration among diverse stakeholders; excellent staff, including a responsive principal investigator; having project technicians to do intensive, one-on-one work with growers; and an egalitarian structure that allowed staff to make decisions and do their work relatively independently.

The weed management component did not meet participants' expectations. This was partly because the widespread use of Roundup Ready seed made Roundup the growers' chemical of choice, and partly because growers would not invest time in the extensive scouting that the Herbicide Application Decision Support System required.

The project's major results included meeting its objective for the acreage under nitrogen management plans; producing numerous useful tools that were not required in the proposal, such as the Nitrogen Loss Evaluation Worksheet; strengthening links among agencies; and increasing growers' understanding of the benefits of water control structures, soil variability, conservation, and the fact that nutrient management plans can improve their economic and environmental performance.

B. Recommendations

These recommendations are from the nongrowers and the technical staff; the growers had little to say on the topic. The contradictory recommendations on how to define the project area are from the NC Department of Environment and Natural Resources and the project staff, respectively.

- Define the project work area in terms of an ecological unit, a watershed to conform to the federal paradigm and to better assess the impact on water quality.
- Define the project work area by "getting the right players," working with a core group of innovative growers who will serve as shining examples to others.
- More focused, intensive work with growers is necessary to get a significant amount of their acreage under nutrient management plans.
- Cost-share payments for the best management practices can be determined based on cost-benefit analyses, so that the payments function as incentives to growers to use the most effective practices.
- Involve the growers' local suppliers more at the farm level.
- Use the multiagency, collaborative approach because it was effective.
- Improve communication among the project principals with monthly meetings, and have a well-organized communication system with the technicians.
- Five years would be a more appropriate time frame for increasing growers' awareness and use of the options for improved nutrient management, and it would facilitate keeping staff.

III. Growers: Project Impact on the Use of Nutrients and Nutrient Management Plans

The growers' general feeling was that they could not afford to use more nitrogen than necessary, although as their comments here show, determining how much is "necessary" certainly is subjective. The following quotes illustrate the growers' views of their role in pollution and thus the general mindset with which the project worked:

- "This was all politics. They wanted to make farmers the culprits."
- "Farmers can't afford to overapply [fertilizer], but we get a bad rap for pollution. As far as contaminating the river goes, in the last 25 years the local population has tripled and farmland has decreased by half, and now the river that used to be clear is polluted. It's population increase that's contaminating the river; and it's not just farmers who're responsible for the problem."
- "Farmers were blamed unjustly for river pollution. The worst thing I could do is destroy my livelihood, my land, and why spend more money on fertilizer than necessary? I'm not saying that farmers didn't contribute to the problem at all, I just don't know a farmer who [can afford] to throw fertilizer around."
- "Being on the Local Allocation Committee I wanted to prove that agriculture isn't the only problem; look at suburbia and golf courses and their contribution to nutrient runoff problems."

A. Preproject application rates

The growers' bases for deciding on nitrogen application rates before the project were consistent in all four counties: their long-term experience with the land, meaning knowledge of their soil types; soil samples, annually or every two to three years; rainfall; suppliers' and consultants' recommendations; and NC State University's recommendations. Rainfall also was cited as a critical factor to be considered. In addition to these universal bases of decision-making, one grower hired a consultant to get recommendations for his cotton crop; another paid a supplier for petiole monitoring; and a third consulted the local NC County Extension Service director as well as certified advisors from his supplier. One grower said that his application rates were based on "whatever the fertilizer dealers told me to do," and another noted that suppliers' advice on fertilization rates had changed over time and therefore so had his rates. All the growers reported

that they adapted recommendations from any source based on their experience with the land. As one person said, "you can't [fertilize] by the book, you have to do it by the field."

Only one grower reported fertilizing "on the heavy side to get the most yields." The reason was that "I have mostly sandy soil and therefore I need more fertilizer. I let water [rainfall] be the limiting factor in yields, not fertilizer." His logic was that he can produce 170 bushels of corn per acre on his Wagram soils so he fertilizes for that, although the state Realistic Yield Expectation is 85 bushels.

The growers in the Franklin/Wake area reported that recent population and crop shifts have decreased their nitrogen use and therefore runoff. Since 1997 the area's tobacco acreage reportedly has decreased by about half, there is more cotton and less corn, and the soybean acreage has increased. Cotton requires only 60 to 80 units of nitrogen, versus 150 to180 units for corn, soybean crops generally do not need any nitrogen, and the tobacco companies' recent demand for quality rather than quantity are shifts that have led to less nitrogen use. Growers also pointed out the conversion of local farmland to subdivisions as a major factor that has decreased the agricultural community's responsibility for nitrogen pollution.

B. Growers and nutrient management plans

1. Soil types and Realistic Yield Expectations

All the growers had nutrient management plans for each of their fields that were in the project. Some growers in Franklin County were not definite about having nutrient management plans and said "I guess I do," or "Jeremy put something together." The big growers were more knowledgeable and enthusiastic about their plans although overall their opinions about their utility and how to use them were very similar to those of their fellow growers. The project designed the nutrient management plans, for the majority of the growers who were interviewed; Southern States Cooperative did one, and a private consulting firm in Craven did two. The Neuse Crop Management project paid for half of the cost of the latter.

According to the growers, their nutrient management plans were based on soil types and state Realistic Yield Expectations. The growers' major contribution to the plans were their cropping schedules. Only one grower, in Craven County, reported that his nutrient management plans were based on his own yield information. The growers generally felt that the state Realistic Yield Expectations were "fairly accurate." On person said that they were "pretty much in line with my experience" and another that they were "okay; the data looked reasonable in terms of my production history" but that he may adapt the project's recommended fertilizer rates based on his production records.

However, several growers felt that the state Realistic Yield Expectations were too low. One person stated that "one of my complaints is that crop scientists are not part of the picture" in calculating the Realistic Yield Expectations, as he believed that their participation would change the Realistic Yield Expectations somewhat. A grower in Wayne County said that the Realistic Yield Expectations were not high enough for corn but were "more in line for soybeans." Other growers also reported that they can exceed the state Realistic Yield Expectations, which influenced their views of appropriate nitrogen rates:

- "Most of the time I can exceed them [Realistic Yield Expectations], they're not high enough on some types of soil. So my higher yields change my fertilizer rates. If you don't have that fertilizer out there...you won't make that crop."
- "They're fairly accurate, a good basis to go by. The soil's so variable, from coarse sand to clay, so you need to vary nitrogen rates."

- "They're pretty close, pretty realistic in most cases; there are a few cases where we could beat them." This grower exceeded the state Realistic Yield Expectations by 5-10% most of the time and by 25% on his "blacker soils" some years, but not often.

Two growers said that they did not know about the state Realistic Yield Expectations and could not comment on them. "I'm not a bookworm, I'm an old-timey farmer, I just stay in the field. Sometimes someone who's in the field every day knows better than the guys who come from Raleigh," said one of them.

2. Postproject use of nitrogen and the nutrient management plans

Two-thirds of the growers reported that they decreased their nitrogen rates as a result of project recommendations. Most growers already had decreased the amount of nitrogen they used on tobacco before the project began in order to produce the lower-nitrate, higher-quality crop currently in demand. The table on the following page shows the changes in nitrogen application made by five growers; it is illustrative, not representative. Many growers felt that the project did not change their nitrogen rates much because they had not been overapplying it:

- "[The nutrient management plans] didn't change what we were doing much, I was kind of amazed."
- "I'm not doing much different [after the project] but I've got more written down now."
- "The project didn't directly cause me to use less, but it was a factor in the decrease. The soil sampling helped educate us about not using excessive nitrogen."
- "The project helped us think through what we were doing and not just apply fertilizer according to tradition, which is how a lot of us farmers work. [It] allowed us to decrease fertilizer use."
- "Yes, the project decreased my nitrogen rates." (The grower who fertilized heavily to get maximum yields.)
- "I'm using 15-20% less on cotton as a result of the project."
- "Overall I've decreased nitrogen on tobacco due to the [project's] trials."

The other one-third of the growers did not change their nitrogen application rates or could not give a definite answer. One of the latter said "I'm a conservative farmer" and his nitrogen rates confirmed that: 50 units on tobacco, 100-120 units on corn, and 50-70 units on cotton. Another could not answer the question definitively, but said that he was "probably watching my nitrogen more now than I was." His application rates on corn were "based on what different types of soil will produce," and he said that his yields were more than the state Realistic Yield Expectations, so he fertilized accordingly. The third nonchanger said that the project recommendations about nitrogen rates had "no effect" on his decisions and that he already was in compliance with the "Neuse Rules" as a result of his decreased acreage of tobacco and wheat since 1997. He had decided independently to decrease his nitrogen use on tobacco by about 20% to increase its quality.

Table D.1 Five Examples of Growers' Preproject and Postproject Nitrogen Application Rates

Grower	Cotton*			Corn*			Tobacco			Wheat		
	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change
	Lb/ac		%	Lb/ac		%	Lb/ac		%	Lb/ac		%
1				180	120-150	-17 to 33	65-75	65-75	0	125	100-120	-4 to 20
2	70	60	-14	130-140	100-120	-8 to 29	110	80-90	-18 to 27			
3	65	50-55	-15 to 23	90	75	17	75	65	-13			
4	70	70	0				75	60-62	-13 to 20			
5				130-150	115	12-23						

*Mainly Roundup Ready genetically modified cotton; some genetically modified corn.

Overall, the growers' felt that their nutrient management plans were "suggestions, not mandatory." This sentiment was consistent with their belief that they had not been overapplying nutrients before the project, based on their knowledge of the land and the economics of production. The four big growers who were interviewed were significantly more positive about their plans than the others. According to a consultant who worked with the project and did the plans for two of these big growers, their enthusiasm was the result of their intensive work with the project, which was necessary to get the plans done for their extensive landholdings. The consultant believed that growers who worked closely with the project and had all or most of their land under nutrient management plans saw the benefits more clearly than those who had only a small portion of their land under management plans and therefore had less contact with the project. As big growers their appreciation of the nutrient management plans also may have been due to greater interest in better management and economies of scale savings. According to all the growers, adapting to the weather and their long-term experience with the land gave them the bases for modifying their plans as necessary. Their comments illustrate the fact that the nutrient management plans were seen as "suggestions:"

- "I look at them but I don't follow them to the letter."
- "I use them in a practical sense, in accordance with my experience of what's worked well for me in the past."
- "After ten or twelve years of farming a field you know what it'll do more than what's on paper. Wagram soils here and elsewhere are different, plus the use of turkey litter has residual beneficial effects."
- "I referred to them, tried to follow them for the most part. Some fields had a better chance of producing higher yields so I used more than in the plans, but for the most part I followed them."
- "Not totally, but they had a bearing on what I did. You have to use common sense, adapt a plan to the weather, you can't just follow it blindly."
- "I'm not really doing different now, I don't think I was out of line before the project."

- "I'm following the litter recommendations exactly. I'd change the nutrient management plan rates on tobacco if I had a lot of rain and leaked nitrogen, but I wouldn't change the plan's rates for cotton and beans."
- "A lot of recommendations you get are unrealistic, and without GPS and all that equipment I can't change application rates within one field or between fields anyway."
- A big grower: "I definitely took the project recommendations into consideration; I can't say I followed them like the Bible, but they helped me save a little money."
- A big grower: "Yes, [I use them] every day, you know exactly what you need to do."

The growers were asked whether their nutrient management plans could be improved. The majority said "not really." One person in Wayne County said that since formerly timbered land had been cleared in his area, the local soil maps drawn in the fifties, should be revised to improve the accuracy of the maps, the Realistic Yield Expectations, and the nutrient management plans. The big growers were the most positive on this topic also: "They're perfect, I'm very pleased with them"; "[No], the project provided good hands-on information to use"; "Too bad each grower could not have had a hands-on discussion with the technicians, as I did."

3. Growers' incentives for using their nutrient management plans

The major incentives for using the nutrient management plans were improving water quality and saving money on production costs:

- "We [growers] want to do our part to improve water quality; we live here and drink the groundwater."
- "[nutrient management plans are] good for the river and for my pocketbook. I have a real concern for the effects on the environment and people living below me on the river. Just to survive you have to save a dime and this helps control costs somewhat."
- "There's no point in wasting nitrogen. It's a good practice not to overapply it, from an economic and environmental standpoint."
- "Decrease nitrogen levels, only use what's necessary for the crops. I want to protect the environment and water, and work with everybody."
- "Hope to get as good or better yields and decrease production costs. I guess we're helping the river and that was supposed to be the purpose of this project."

C. Useful knowledge from the project

The useful information that growers reported learning from the project was mainly related to appropriate nitrogen rates and the importance of improving water quality. According to two growers, the project confirmed that they were not using too much nitrogen. One grower who worked with the Local Allocation Committee said that seeing the data on water quality reinforced his belief that agriculture was not the only polluter, that there was no short-term solution for improving water quality, and that a realistic time frame for improvement was 15 years or more. In response to the question, "Did you learn anything useful from the project," growers said:

- "I've learned about the potential for my land, learned to read soil maps better and use them, not just use my eyes."
- "I'm more aware of the relationship between livestock and water quality. There's a direct change from before, when my cattle were in the stream and now I understand why I have to keep them out: they cause long-term erosion."
- "Proper fertilization rates, be a cleaner farmer, control costs."
- " If I stay within my nutrient management plans I won't hurt the Neuse any more."
- "How much fertilizer rates can vary from one side of the field to the other."
- "What we were doing before the project with nitrogen application was alright, the project verified that."

- That I didn't use too much nitrogen. Made me aware of it."

D. Training on nutrient management

Only four growers attended a county-sponsored nutrient management training session, which was one option for complying with the "Neuse Rules". Their opinion was that "overall it was good." One person said that he "already knew the information due to the project" and another that he had "already covered much of it with the Local Allocation Committee." Both felt that it was useful "in bringing a lot of farmers together who don't know as much as me about nutrient management." The other growers said:

- "I liked it, it was very educational. I got an idea about how easy nitrogen runoff can be into the river."
- "It made me more aware of the need to watch what we're doing, not to over-fertilize due to the environment and economics, especially as I have land near the river."

IV. Nongrowers and Growers: Project Expectations, Strengths, Weaknesses, and Recommendations

A. Expectations

1. Expectations of different stakeholders

Nongrowers expected to work toward reducing nitrogen runoff via best management practices and education. They expected the project to "educate growers on the proper cultural practices to decrease nitrogen runoff into the Neuse River Basin" and to "help the counties meet their nitrogen reduction goals...and identify the most cost-effective ways to do that." Many of the nongrowers' expectations focused on promoting best management practices to reduce nitrogen pollution:

- "Show growers, County Extension Service, and consultants what the best management practices were, to decrease the amount of nitrogen applied to crops and therefore in the Neuse River."
- "That the BMP demonstrations would convince growers to install them, that the best management practices were locally suitable."
- "Look at the farm economics of the best management practices."
- "Hoped we'd end up with some best management practices available for the farming community in terms of fertilizer management practices to help with water quality issues."

<u>Nongrowers</u> also expected the project to improve weed management and conservation:

- "[I] expected to get growers to improve their selection of herbicides based on actual weed levels, to consider using the Herbicide Application Decision Support System."
- "...to make some headway on weed management through the Herbicide Application Decision Support System."
- "Encourage growers' good stewardship of the land and water, the estuaries of the Neuse."
- "Help develop water quality protection through crop science."
- "Improve the environmental aspects of farming."

The technical staff's expectations were less extensive and focused on education and production:

- "That growers understand the role of nutrients in the environment."
- "Economic gains for the growers while improving water quality, and in some cases growing better crops."
- "Outreach to area growers and suppliers to produce maximum yields with minimum inputs and be environmentally friendly."
- "Kind of a demonstration for a few major crops' management systems, namely, nutrients and pesticide management."

Most of the growers' expectations were hazy or focused on specific activities. Better communication with them about the project's objectives evidently was necessary, as one technician stated. Two growers said "I had no ideas about it before it started" and one said he expected it to be "a pain in the butt. Why're they getting all in our business?" Other growers "saw an opportunity to do some testing for free on the farm" or only expected the project to "put a yield monitor in my combine to match yields with soil types." Their expectations of the project's work with nutrient management were quite narrow:

- "Trying to determine how much nitrogen runoff there was in the beginning and changes over time."
- "What nitrogen levels were to be placed in each field, exactly what needed to be put down, based on five-acre blocks of soil sampling."
- "Change from following tradition to planning ahead. That our farm would learn some new tricks for farming and more environmentally friendly farming, and meet new allies for technical assistance."
- "The project would do soil sampling and see the condition of the land, if it was high in nitrogen."

2. Meeting expectations

The project clearly met or exceeded the nongrowers' expectations. One person said that he "had a fairly high expectation of collaboration with the growers and that was met." Two nongrowers reported that the project exceeded their expectations in terms of its educational impact, the number of best management practices installed, and helping growers to comply with the " Neuse Rules." A third non-grower pointed out that, in addition to meeting the major objective of getting 100,000 acres under nutrient management plans, the project accomplished more than the proposal required, including: analyzing the economics of best management practices, analyzing the economics of nutrient management plans, developing the Nitrogen Loss Evaluation Worksheet tool, conducting some shrub buffer work, taking spatial soil samples for nutrient management, adding the new phosphorus component of the USDA-Natural Resources Conservation Service nutrient management standard, conducting research on Realistic Yield Expectations and nitrogen-use efficiency in wheat, and helping to produce nutrient management training materials.

The technical staff also reported that the project met their expectations:

- "It more than met my expectations, due to the expansion of the project" (acreage under nutrient management plans).
- "The growers' acceptance of the nutrient management plans was not as high as [I'd have liked] but it was higher than I expected."
- "Yes, we did a lot of nutrient management, met our goals, put in a lot of best management practices."

The Herbicide Application Decision Support System was the only project component that did not make the progress that nongrowers, including the technical staff, had expected. One nongrower said that "the weed management part didn't work for two reasons: the Herbicide Application Decision Support System tool seemed to be extra management and time for growers [and] people figured that their weed management was done by sowing Roundup Ready seed." Another reported that his expectations of the Herbicide Application Decision Support System were "certainly only [met] partially. The widespread use of Roundup Ready technology hurt. Growers felt 'I don't need this,' which isn't really right but as an educator it stops you in your tracks." One staff member bluntly observed that the Herbicide Application Decision Support System "came out a wash."

Because of time constraints, not all the growers were asked whether their expectations of the project were met, but overall those who were asked were positive. It was evident that most growers did not clearly understand the project's farm-level objectives and therefore were pleasantly surprised by its accomplishments. One said, "It turned out fine. I was afraid that it'd mean more time and paperwork for me, but it hasn't." Another stated that progress was "up and down, but yes, [my expectations were met]." The grower who expected the project to be a "a pain in the butt" said that "It [turned out] not really as bad as what I thought, it was a benefit, I benefited from the cost-share for the nutrient management plans and 100% payment for the water control structure."

3. Did anything turn out differently than you expected?
The nongrowers' responses to this question were more extensive and diverse than those of the technical staff and the growers:

- "Growers' tremendous amount of interest in the project and best management practices and how they're connected to the "Neuse Rules".
- "In the beginning there was a lot of cooperation between agribusiness and the growers, which didn't continue like it could have. For continuity the project hired its own technicians, which broke the link between farmers and agribusiness. We could have continued services to growers after the project left."
- "I thought we'd keep the cotton [commodity groups] a little closer."
- "I now would come to expect turnover in project management; hiring high competence for only three years is a very tough situation."
- "Roundup Ready was a killer, it really hurt [the weed management component]. It was pretty much unexpected, even Monsanto didn't expect its impact. Farmers wouldn't even let me in the door."
- "The Herbicide Application Decision Support System didn't work very well, it was too time consuming for the growers, [scouting is] too cumbersome."
- "I thought it'd be a difficult task in the beginning and I still do; it's hard to make progress and [particularly to] measure [water quality], there are a lot of variables involved."
- "Part of the payments [for best management practices] were late, part were on time."

Most of the <u>technical staff's</u> responses to the preceding question were short: "not really." Staff also made the following statements:

- "Growers are unwilling to change fertilizer applications on tobacco, they're <u>very</u> resistant to change."
- "It went pretty well considering the tense times we had [in the beginning] due to finger pointing about who was responsible for nitrogen pollution."
- "The Herbicide Application Decision Support System didn't work very well, it was too time consuming for the growers, [scouting is] too cumbersome."

Several of the growers reported that nothing in the project turned out differently than they expected. One said that he "didn't know enough initially about the water-control structures to know what they did, and learned that they made sense for his farm." Another said, "I didn't realize that they were actually going to write nutrient management plans."

B. Project strengths
A solid foundation for the project, cooperation among diverse stakeholders, excellent staff, and a good training component were some of the project strengths cited by nongrowers. One person said that the funder's preproject efforts "to get as much buy-in as he could" as the foundation for the project were positive. Buy-in from diverse stakeholders ensured that "it wasn't a stand-alone project that we made up and taped to the wall of North Carolina agriculture." The effort invested

in organizing the buy-in evidently was worthwhile, as people said that "different players and disciplines worked quite smoothly together," that there was "collaboration among agencies and with growers," and that "staff and growers worked together." One person pointed out that the project's contact with these diverse players "increased their knowledge and professional abilities."

Nongrowers identified other project strengths such as the staff's competence: "the staffing structure helped, was definitely positive." The existence of a "very strong educational component throughout the project," and the nutrient management training that "went well" and "increased the number of landowners buying-in to the best management practices" also were cited as aspects of the project that worked well. A range of other project strengths were reported by nongrowers:

- "We made significant progress toward helping certain counties reach their nitrogen reduction goals."
- "Fine-tuning nitrogen management and getting growers to have a better understanding of their soils and water-control structures."
- "The ability to use different approaches with growers, to address local resource concerns and needs and not be program-driven [by a single program]."
- "[I was] most impressed with the cost-benefit analyses for the best management practices."
- "The project was very focused; it was very clear to me what it intended to do and how it was going about it, in terms of the information available on the web and in newsletters."
- "We gained momentum over the life of the project among farmers and industry, and participants' interest was maintained."
- "We were able to get close enough to industry to know what drives them and what drives growers' decisions, due to the openness of the project environment and trust with participants."
- "Growers got the water-control structures for free, that generated interest among other growers, who [saw] the benefit of them and of conserving water."
- "The project was able to open some eyes regarding buffers and their value. Growers were impressed by the water-control structures...they [got] a better idea of what to do to improve their farms."
- "Got people thinking about herbicide decisions more, whether or not it changed anything."

The staff's overall view of project strength was that it was "well administered and organized." The specific elements of its good organization were:

- "Having technicians to implement the project was very good."
- "The funding setup to purchase equipment was very good."
- "Working one-on-one with growers."
- "Having the resources available to do farm demonstrations."
- "The Principal Investigator was always responsive."
- "Good interagency cooperation, with the Farm Service Agency, the USDA-Natural Resources Conservation Service, the Cooperative Extension Service, and the Department of Environment and Natural Resources Soil and Water Unit."
- "The Cooperative Extension Service and NC State University gave the project excellent support."
- "Good people in the field."

In addition, two staff members reported that growers' willingness to collaborate was important: "Great cooperation from the project growers was a key factor, they were genuinely interested in the project."

Growers' predictably assessed the project's strengths from a practical standpoint. "Good people to work with" was a nearly universal comment about the project staff. In addition, one person said

that the project "pulled together a good group of agricultural support people, like the suppliers who learned some new things too," and another that he "learned about and met the local soil and water quality people." "The hands-on, one-on-one work with the growers was good" according to one grower. "Good information," particularly information on soil sampling, also was widely appreciated, with one person citing it as a project strength: "Extensive soil sampling so that you know you're not wasting nitrogen." "Weed identification to let you know which herbicide to use" was reported by another. The growers also identified water-control structures and the organization of the nutrient management plans' as project strengths:

- "Water control structures would be very beneficial to any farmer in a dry year...plus they're good for the river."
- "The water-control structures were needed and are good."
- "The mapping system in the nutrient management planning is great for me, to identify fields and nitrogen rates."
- "The way the nutrient management plans are broken down, they're very easy to understand, it's easy to identify fields."

Two growers had broader views of the project's strengths. One said that it "increased awareness among a lot of people that there's a problem and we can correct it without hurting growers' profits." The second, whose philosophy before the project was to fertilize to obtain maximum yields, said that it "Makes you more aware of your potential to affect the environment and be more cautious of what you're putting on the ground."

C. Project weaknesses

All of the respondents were asked what parts of the project did not work well. One of the nongrowers felt strongly that "a project work area should be defined in terms of a watershed...not in terms of a major grower or a group of growers. There's a big push from the federal level to [work at the level of] watershed management strategy, so projects should conform." This contradicted some of the staff's conclusions that a project should be organized to work with innovative growers who would serve as "shining examples" to others.

In addition, two nongrowers noted that the Herbicide Application Decision Support System "didn't work very well" and that "pesticides were not an issue with water quality." One person, who had the most negative view of the project among all the respondents, partly due to his misconception that it was responsible for making the Local Allocation Committee function, said that NC State University and the conservationists came to the table with the "preconceived notion" that growers "were just slopping nitrogen out there, not trying to do it right." Other weak aspects of the project reported by nongrowers were:

- "Field days didn't work, we couldn't get many growers to attend to look at the demonstration farms."
- "Field days were a problem, that's not unique to this project. It's a sign of the times, growers are too busy."
- "Site selection for the best management practices may need more consideration."
- "Education needed greater reach, to reach more people through different means, not just workshops, and not just farmers but urban people too."

Some weaknesses in project administration were reported by nongrowers. Two people pointed to the problem with slow reimbursements: "trying to handle money and spending it; getting people paid on time." Two others cited "the personnel turnover in a short-term project." Other organizational deficits were:

- "Communication wasn't as good as it could have been."

- "[I'm] not sure that all the principals were on the same page about what the project as a whole was supposed to do."
- "The project's ability to pull reports together improved over time."

Personnel issues were the most common weaknesses identified by the technical staff. These included changes in the project coordinator and Craven County's inability to retain a technician. Also the "supervising the technicians wasn't well organized; it wasn't clear to them who to report to, their status, their leave." Because of the lack of a technician in Craven County "the water management part, the water-control structures and buffers, didn't go well." One technician said, "I could have had clearer communication with Raleigh, clearer answers to my questions, and clearer requests from them." A staff member said that "there was a major problem with reimbursements from NC State University." Slow turn around on research results, including soil samples, was reported by another.

Several of the growers said that the project had no weaknesses and one said that it had "no problems whatsoever, they did an exceptional job." In one grower's opinion "some [project] water-control structures were poorly placed." Many growers commented that they had not seen water in the blue-line ditches, in ten years so evidently in their eyes this is a problem with old structures as well. Others growers brought up the issues of communication, reimbursement, and the fact that growers were not solely responsible for water pollution:

- "Communication, it's not a big thing but people should have made appointments before coming out to look at stuff like the stream-bank restoration."
- "Being reimbursed late for water-control structures" (two years after he paid the contractors).
- "We need a broader perspective on managing nitrogen, which means involving the urban public in the education to do their part. The project was a good thing, to maintain water quality, but one segment of the population, farmers, can't do it for everybody."

An interesting comment on the topic of the project's shortcomings came from a person who evidently was thinking about the future and said, "What happens now? Will there be a follow-on? People think about things that are kept in front of them. Now what?"

D. Recommendations

The nongrowers' range of recommendations for "doing it better next time" reflected the diversity of the project's stakeholders. Most of their recommendations were related to project organization and administration. For similar projects in the future the nongrowers suggested:

- "Be more focused, more intensive with the growers: they need to have enough project buy-in to make it worth their time. You need to [get] all or a lot of a grower's acreage [under nutrient management plans] for them to see benefits; if you only do 50 acres they don't see any value."
- "Improve accounting at all levels, not just NC State University."
- Use the multiagency, collaborative approach again because it was effective.
- Cost-share payments for the best management practices can be determined based on cost-benefit analyses, so that the payments function as incentives to growers to use the most effective practices.
- "Involve the growers' local suppliers more, to work at the farm level."
- "Have consistent leadership at the management level."
- "Should have found funding for a fourth technician in Lenoir or another county."
- Improve communication among the project principals with monthly meetings, and have a well-organized communication system with the technicians. The latter is necessary so that a technician gets consistent directions about what to do at work..
- "Do a small pilot project, a trial-and-error phase, before scaling up."

- "There are structural limitations on weed management; [the next time I] would do it more intensively than extensively, not on the same scale as nitrogen management."
- Five years would be a more appropriate time frame for increasing the growers' awareness and use of the options to improve nutrient management and would facilitate retaining staff.
- "Knowing growers' incentives and constraints on adopting nutrient management plans might have been useful to help understand their adoption or lack of. A sociological component might have been useful."

Different views of how to define the project area, in terms of a watershed or in terms of innovative growers, emerged again in the nongrowers' recommendations:

- "Get the right players [growers]."
- "Set priorities for spending money based on protecting water that is still safe, on preserving habitats and species, that's how geographical areas can be targeted." (the watershed approach)
- "Link best management practices [across farms] to get to watershed-level management. This is better than the shotgun approach of getting some growers to adopt best management practices [and others not]."

The technical staff's recommendations focused on operational improvements. Three people said that they had no recommendations because the project "went pretty well." One staff member said that it was necessary to explain to the growers at the outset the project's purpose and goals. The technical staff's other recommendations were:

- "Focus on one idea at a time; we got overextended trying to go too many directions at once—the Herbicide Application Decision Support System, Integrated Pest Management, and Global Positioning System [precision agriculture] in combination with nutrient loss."
- "The principal investigators could spend more time with the growers, take a look at what's going on in order to improve communication and build trust, it'd make it easier to open doors for their next project."
- "Need well-organized supervision for the technicians."

The growers had few recommendations for the project. Three gave the noncommittal response of "not really" when asked if they had suggestions to improve the project. One said the project had to realize that "tenant farmers can't afford to invest in best management practices [as] they're ultimately for the landowner's benefit." Another grower pointed out the need to have more than one field trial to compensate for the effects of bad weather and to produce useful data. The growers' other recommendations were:

- "Have a project technician who does weekly visits and regular communication, and does yield monitoring."
- "If the project had more money it could work with more farmers."
- "If the next project is done as well as this one, it doesn't need any changes."

V. Nongrowers: Project Organization and Results

A. Unique aspects of the project

Many respondents reported that the project's multidisciplinary, multistakeholder organization was unique and worked well. They pointed out that growers, consultants, USDA-Natural Resources Conservation Service, NC State University, agribusiness, and commodity groups worked together on the issue of reducing nitrogen runoff. "It brought a lot of different groups of people together to address an issue in a pro-active way" and "It was a cooperative effort among a lot of different actors, more collaborative and with less [turf] battles than usual." However, three NC State University staff members said that the project was not unique and that they always worked with a range of players, at a large scale, or used the same approach with growers.

The technical staff generally reported that the project was unique because "growers got special attention, a lot of one-on-one guidance" and because of "the intensity of the focus on individual farms," which definitely contributed to project results. One staff person noted that this "buy-in with farmers made a unique working environment and a way to reach results in a nonobtrusive manner."

Other unique aspects of the project reported by the nongrowers were:

- "The amount of time it took to get to know people and find out what really mattered to the agricultural community, the issues that they'd really work on."
- "It educated some of the decision-makers about how a project like this goes from paper to implementation. They gained valuable insight into how the rules were implemented on the ground."
- "The way the project looked at the issue of maintaining crop production using good crop science and simultaneously preserving water quality was unique and important."
- "In that the work was scientifically adapted to local conditions, and [local] data and tools were used to develop the nutrient management plans."
- The principal investigator "gave others control over their work instead of being dictatorial, which unfortunately is pretty unique."
- The project "tried to grab hold of something that hadn't been attempted before," meaning that it tried to work with the many variables related to water quality, to identify concrete results, and to identify the results appropriate for analysis.

A few people felt that these unique aspects of the project contributed to its positive outcomes. One said that there was good attendance at the training sessions because numerous stakeholders were involved. The fact that the project involved many people and generated much information, in combination with the publicity about the "Neuse Rules," reportedly "eased growers' concerns about the rules." A staff member said that "supplier support helped lend credibility to the project in the growers' minds" and another person noted that the nutrient management plans were "much more defensible" because they were based on site-specific research.

B. Staffing structure

The overall evaluation of the project's staffing structure was that "it was functional and worked pretty well." It enabled the agents to get their work done, one respondent said. One staff member reported that it was "Excellent. A good chain of command, a team approach, good technicians, we worked well together. There was good communication and no hierarchy, we tried to reach decisions by consensus, a refreshing change and tribute to [the PI]." However, everybody recognized that staff turnover was a problem and characterized it as an inherent problem with short-term projects. The project lost two project coordinators and could not keep a technician in Craven County: "The structure was good but implementation was hard because it was a short-term project-you get good people and then they get good offers." Although two people said that the difficulty of keeping staff was "probably only marginally more difficult than ordinarily," all of the NC State University and technical staff felt that the turnover affected the project's progress. They also recognized that the problem does not have an obvious solution.

C. Impact on participating agencies

People from four agencies who worked with the project were asked whether it contributed to their programs (NC Department of Environment and Natural Resources-Water Quality Division, the Wake and Lenoir Counties' Soil and Water Conservation districts, and the NC Clean Water Management Trust Fund). The following quotes show that the project definitely was a positive

force in changing growers' perceptions about compliance with the "Neuse Rules," and in strengthening links between these agencies. The NC Department of Environment and Natural Resources-Division of Water Quality reported that initially their office had faced considerable backlash and skepticism from growers about the "Neuse Rules," and that the project helped change this. The project's key growers influenced many others by providing good examples of the manageable cost and the effectiveness of the project's best management practices and nutrient management plans. A major project contribution was helping the NC Department of Environment and Natural Resources-Division of Water Quality "get the message to the growers, [who] came to see the rules as a reasonable requirement, and got cost-share help."

In terms of impact the agencies also reported that:

- "We were involved with some of the educational activities, which helped get our name out, helped create closer working relations with other agencies, especially County Extension Service, that is useful. [We got] a little more exposure for our agency to other agencies."
- "[The project] opened up some avenues that we weren't using before, we hadn't had a close relationship with County Extension Service in our county and with the project we got them more involved with the technical things that we do. It opened their eyes to what we're capable of doing and that we can step up and help them out [if necessary]; it was good for both of us."
- "It helped advance our goals, both in protecting water quality at specific test sites and for evaluating best management practices for future funding."

D. Major results

Nongrowers saw a range of project results, including getting significant acreage under nutrient management plans, increasing growers' awareness of nutrient management and conservation, and producing useful tools. Nutrient management plans, the one-page BMP fact sheets, Wayne County's spreadsheet for nitrogen management plans, and the Nitrogen Loss Evaluation Worksheet that was "tremendously useful from the management standpoint to track changes in nitrogen rates" were cited as useful tools and tangible project results. Another tangible benefit was that "the water-quality people, NC State University, suppliers, and growers started out as adversaries and hopefully ended up making progress in understanding each others' positions." Nongrowers also reported that the project promoted compliance with the "Neuse Rules," by positioning the agricultural community to respond to them and by improving people's understanding of what "compliance" really meant. As one person said, "The "Neuse Rules" really are an experiment and the project helped us meet the rules."

- "Getting conservation on the ground" and acreage under nutrient management plans were reported by many nongrowers as important results:
- "It's possible to implement on-farm practices to decrease nitrogen runoff. Some best management practices do not have to be costly, and cost-share payments can be designed based on economic analyses of the practices."
- "Got over 100,000 acres using nitrogen management. I don't know any other project in the US that has gotten one-third that far in three years in terms of the number of acres."
- "Logistically, to get best management practices on the farms, the project did a wonderful job, lined those people up well."
- "Help reduce the amount of nitrogen leaving the farm."
- "The demonstration sites were very well selected and moved us light years ahead in terms of applying research done in the basin."

Increasing growers' understanding of the benefits of water-control structures, soil variability, nutrient movement in the environment, and conservation also were reported as major project results:

- "Growers saw the benefits of the water-control structures and saw results that were good for them and for the river."
- "Increased grower education about different best management practices, old and new, and about the state's regulations."
- "Increased growers' awareness of Realistic Yield Expectations on different soil types and what happens to nitrogen and other nutrients in the environment."
- "Farmers came to accept that they're part of the [pollution] problem."
- "Enhanced growers' general ethic of conservation."
- "This project has educated the whole farming community, farmers and business, that there's a community of expertise out there to help them."

The Herbicide Application Decision Support System component of the project also reported results, despite facing the constraint of working with growers who used Roundup Ready seed. Improvement in the Herbicide Application Decision Support System as a result of the feedback from the diverse sectors involved in the project was one result. Another was that working with the Herbicide Application Decision Support System component educated growers: "it had a big impact on appropriate herbicide use and refining the use of Roundup," particularly in getting growers to use variable rather than blanket herbicide rates.

The technical staff reported change in growers' attitudes and knowledge as key project results:
- "Growers realized that they were a small part of the [pollution] problem, not a major part as they were made out to be initially."
- "Growers' change in attitude, their increased awareness of their role in the nutrient cycle and how they affect it and can manage it."
- "[Growers] learned that they can do things to decrease input use and the economic knowledge that it won't break them to decrease fertilizer use."
- "Nutrient management plans, which mean change in fertilizer use, and growers' increased awareness of Realistic Yield Expectations based on crop and soil type."

E. Expected and unexpected project results

The overall evaluation was that the project definitely fulfilled all of its expected results, and even exceeded them. "Overall the project expanded rather than pulled in," as one person stated, in terms of both the acreage put under nutrient management plans and the various technical tools produced that were not specified in the proposal. The latter included cost-benefit analyses of the best management practices, the Nitrogen Loss Evaluation Worksheet, the Phosphorus Loss Assessment Tool, a nutrient management cost-benefit analysis, and Wayne County's spreadsheet to generate nitrogen management plans efficiently. These were relevant "extras" that exceeded project requirements.

The project's technical staff agreed with the nearly universal opinion that the project had more than met its goals. "We set out to do something and did it" was the general report. The staff in Wayne county did not expect to develop petiole nitrate monitoring and advise growers on the use of litter as part of nutrient management, but they "saw the opportunity, so we did it." The staff's only unmet expectations were minor: they were unable to install some buffers, and one county "didn't expect to have so much trouble keeping a technician."

Most people felt that the Herbicide Application Decision Support System component did not make as much progress as expected. The general view was that "[we] didn't expect the genetically modified organism to blow us out of the water on herbicides; that really did affect the weed management part of the project." Another view was that "the "Neuse Rules" focused on nutrient

management and water quality and best management practices, which isn't herbicides." The result was that the project "tried, but it didn't get done." However, even facing these constraints, the informal feedback from the Herbicide Application Decision Support System users reportedly was very useful and increased the scale of the fieldwork with the Herbicide Application Decision Support System component.

There were only two negative comments about the project's meeting its expectations, one minor and the other somewhat tangential. One person reported that he expected the project to work with independent consultants more than it did. Another characterized the project's "negative aspect" as "such a preconceived notion out there [among] the NC State University project people and the regulatory agencies [who] came to the table thinking that the growers were just slopping nitrogen out there, not trying to do it right." As a result, the project did not accomplish what he expected, which was "to get people motivated and accomplish a lot...and now we'll have a major problem to get best management practices in place and everything done by 12/2002. The project should have brought local committees into the meetings and had them get a real sense of urgency about taking action." However, the root of this problem evidently is that the "Local Allocation Committee has accomplished nothing."

F. Lessons learned

There is considerable diversity in the "lessons learned" from the project, due to the range of stakeholders that participated. The nongrowers' lessons are organized into the four main categories listed subsequently, plus a fifth category for the technical staff. Key lessons learned in terms of project organization are as follows: the upfront investment of time to organize the project was worthwhile; multi-stakeholder participation in planning the project contributed to its positive results; the staffing structure was appropriate despite the problem of turnover; and there was more to the project than the numeric objectives that it achieved. Evidently there are two different lessons learned about how to define the project area: in terms of an innovative group of growers or in terms of a watershed.

The lessons learned about growers include the fact that peer pressure may act against change, that they do not necessarily know how to access cost-share funds, and that projects need to reach those who do not attend field days. Several people reported that effective work with growers on nutrient management was an intensive, one-on-one activity that required the full-time technicians that the project provided, and that the NC Cooperative Extension Service county agents would not have had sufficient time to do such work. The NC County Extension Service, however, was recognized as a critical factor in the project, because working through it significantly leveraged the project's funds and broadened its contacts. The fact that agribusiness also contributed to helping the project meet its goals was another lesson learned. Agribusiness was said to be professional and technically competent, an important source of technical assistance for growers and, like the NC Cooperative Extension Service, a source of assistance for growers after the project ended.

The lessons learned by the technical staff focused on the project's operational aspects. The staff noted that quality field staff are necessary to get quality results, that change is a slow process, and that it takes a team to get the work done.

The <u>nongrowers</u>' lessons learned were:

1. <u>Project organization and coordination</u>:

- "The amount of upfront time [invested in organizing the project] was really worth it."
- "[We] learned once again the power of providing smart, conscientious, motivated people with the resources to do their jobs."

- "Getting a multi-player group together to examine all aspects of the work before starting a project like this produces a good result."
- "The staffing structure would be the same [in another proposal], there are no feasible alternatives."
- "Make sure that NC State University accounting procedures are understood before negotiating a proposal. A real clear understanding of contractual requirements of the university and its accounting procedures is necessary."
- "Get the funder's expectations about publicity clear at the very beginning."
- "Having a regulatory stick and a mandate to get participation was really useful."
- "Legislation to regulate the river basin is excellent, but [the state] also has to provide funds for the tools that the regulation requires."
- "Numeric project objectives, i.e. the number of acres under nutrient management plans, are important but they don't capture all the project intricacies."

2. Defining the project area:

- "Make sure that you have innovative growers to work with, those who are open to change."
- "Working with a core group of growers you can pick and choose certain individuals to work with, and then pull in other individuals. Working with a core group produces good working relationships and builds mutual confidence."
- "The watershed approach is more holistic."
- "Work at the watershed level even if it's difficult and takes time."

3. Grower characteristics:

- "Growers are independent, they feel that they don't need rules and regulations."
- "There are standards for being 'a good farmer,' so when a project changes something, like having ditches go to scrub, it reflects on that image and it's hard for the farmers, to some extent. It's peer pressure."
- "Growers generally are not aware of cost-share opportunities, they don't know which agencies have funds and how to get them."
- "Providing technical assistance for growers on nutrient management is pretty much a one-on-one activity."
- "Growers respond to traditional, big field days."
- "There are growers who attend field days and those who do not, and we're not reaching the latter."
- "A lot of growers the project worked with used their soil tests for lime, not phosphorus, and used standard nitrogen applications."

4. Agency participation:

- "You can never underestimate the value of the NC Cooperative Extension Service, how much it is a part of the project, it's critical."
- "It was very good to work with growers through the NC Cooperative Extension Service. [The grant funds] were greatly leveraged by working through the NC Cooperative Extension Service, otherwise the project could not have made the contacts that it did."
- "Agribusiness is professional and cooperative; it has changed a lot in the past 20 years, it is more technically competent now and helped this project meet its goals and expectations."
- "Growers rely heavily on agribusiness to make decisions and for technical assistance; agribusiness sees more growers than the County Extension Service."

- "Agencies need to be more collaborative in offering their services to growers, they should promote the network of contacts and information in the community rather than just focusing on what they do as an individual agency."
- "When a project ends, business and the County Extension Service stay as sources of technical assistance, but the latter has less [sophisticated, electronic] equipment."
- "Flexibility is needed to meet objectives; each agency brings their expertise and if they remain flexible the project is more likely to meet its objectives."

5. Technical staff:

- "Do a good job of planning and supervising personnel."
- "The only way to ensure quality results is to have quality people in the field doing the work."
- "Have more demonstrations; what growers see has more impact than talk."
- "No two growers are alike, no two farms are like, you can't take an average because there isn't one."
- "If I did it again it I'd do it on a big enough scale that an agronomy agent could work on only that, i.e., with 10,000 acres and 10-15 growers."
- "Change is a slow process. I look for people who want to work with us, spend time with them, and make them a shining example for others to follow."
- "Take everyone's advice and then come up with your own plan."
- "Thank your secretaries and technicians; everybody's job is important, it takes a team to do this job."

Addendum
Interview Guides

Interview for: Growers

Date
Name (farmer)
County
Owner or tenant

1. When did you start working with the Neuse Crop Management Project?
2. Who were your main contacts in the project?
3. What did you do with the project?
    - Demo farm
    - Nutrient Management Plans
    - Water-control structures
    - Installed other best management practices: please list (riparian buffers, field borders, ditch stabilization, conservation tillage, shrub buffers, others).
    - Petiole nitrate monitoring
    - Nitrogen rates on cotton test
    - TriCert rates on cotton test
    - HADSS
    - Other
4. How do you decide how much nitrogen to use on each of your crops?
    (NMP, RYE, soil type, other methods)
5. Have nitrogen recommendations affected how you apply nitrogen? (increased, decreased, same)
    - Whose recommendations affected you?
    - Tobacco: Do contractors give you guidelines/recommendations for nitrogen?
    - Has that changed your nitrogen application on tobacco?
6. Do you have Nutrient Management Plans?
    - Who wrote your plans (this project, a consultant, Southern States)?
    - Do you know what the amount of nitrogen in your plan is based on? (RYEs, field trials, soil tests...)
    - If RYEs: Are the RYEs from your field averages or from the state data tables?
    - What do you think of the RYEs used in your NMP?
7. How many fields do you have total, and how many with NMPs?
    - Do you use your plans?
    - If yes: what does it do for you? What are your incentives to use it?
    - If no: why not?
    - What would improve your plan or make it easier to use?
8. Did you attend the county-sponsored nutrient management training sessions?
    - Where/when/who gave the training?
    - Was it useful to you?
        - If yes: Why? What are the most useful things you learned from the training?
        - If no: Why not?
    - What does it need to be more useful?
    - Has the training affected how you operate?
        - If yes: How? what do you do differently now?
        - If no: Why not?
    - Is there other training that you'd like to have on nutrient or weed management?

9. Did you learn about HADSS through the project?
    Do you use it?
    If yes: What do you think of it? what crop/s do you use it for? what are its advantages and disadvantages? how could it be improved?
    If no: Why not? how do you decide about applying herbicides?
    Does your extension agent use it?
10. What did you expect the Neuse Crop Management Project to do?
    Were your expectations met?
    What turned out to be different than you expected?
11. What were the good things about this project, what was done well or was effective?
12. Did you learn anything useful from the project?
    What were the most useful things you learned?
13. What were the poor things about this project, that weren't done well?
14. How could they do better the next time?

Interview for: Project Principles and Agribusiness Contacts

Date
Name
Position
Organization
Location

1. What did you expect the Neuse Crop Management Project to do?
    Were your expectations met?
    What turned out to be different than you expected?
    2. Do you think that the Neuse Crop Management Project and the way it was organized were unique in any way?
    If so: How? Did that affect the project outcomes?
3. Do you think that the staffing structure was appropriate to get the work done?
4. In your opinion, what were the best aspects of this project, what parts of it worked well?
5. What do you see as its most important results?
6. Were there any project results that you didn't expect, that weren't in the project plans?
7. Were there any project results that you expected that didn't happen?
    Why not?
8. What were the poor parts of the project, that didn't work well?
9. What are your "lessons learned" from this project?
10. What recommendations would you make for doing it better next time?

Appendix E: Fact Sheets and Other Publications

The following publications were developed for this project and are used extensively to promote sound agricultural practices related to nutrient management:

Hardy, D.H., D.L. Osmond, A.G.G. Wossink. 2002. *The Economics of Fertilizer Management.* AG439-45. http://www.soil.NC State University.edu/publications/Soilfacts/AG-439-43/fertmgt07-30-021.pdf

Jennings, G.D., D.E. Line, W.G. Hunt, D.L. Osmond, and N.M. White. 2002. Neuse River Basin pollution sources and best management practices. In *Proc. AWRA Specialty Conference on Coastal Water Resources*, New Orleans, LA.

Osmond, D.L., J.W. Gilliam, and R.O. Evans. 2002. *Selected Agricultural Best Management Practices to Control Nitrogen in the Neuse River Basin.* Technical Bulletin 311. NC State Univ., Raleigh, NC. http://www.soil.NC State University.edu/publications/BMPs/.

Osmond, D.L., G.D. Jennings, S.C. Hodges, D.H. Hardy, W. Lord, and R.H. Pleasants. 2002. *Implementing Agricultural Reductions Rules at a Riverbasin Scale: The Neuse Crop Management Project*. 10th Annual Nonpoint Source Monitoring Workshop, Breckenridge, Co. Sept 7-12, 2002.

Osmond, D.L., J.W. Gilliam, and R.O. Evans. *Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution*. 2002. Technical Bull. 318, North Carolina Research Service, NC State University, Raleigh, NC.

Osmond, D.L., L. Xu, N.N. Ranells, S.C. Hodges, R.Hansard, and S.H. Pratt. 2001. Nitrogen Loss Estimation Worksheet (NLEW): An Agricultural Nitrogen Loading Reduction Tracking Tool. In *Optimizing Nitrogen Management in Food and Energy Production and Environmental Protection: Proceedings of the 2nd International Nitrogen Conference on Science and Policy*. Scientific World:1.

Wossink, G.A.A. and D.L. Osmond. 2002. Farm economics to support the design of cost-effective best management practices (BMP) programs to improve water quality: Nitrogen control in the Neuse River Basin, North Carolina. *J. Soil and Water Cons.* 57:213-220.

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Wossink, A. and D. Osmond. 2002. *Costs and Benefits of Best Management Practices to Control Nitrogen in the Upper and Middle Coastal Plain.* AG 621. http://www.neuse.NC State University.edu/ ag%20621.pdf.

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The following articles in the NeuseLetter described the Neuse Crop Management Project and can be found at http://www.neuse.NC State University.edu/neuse_letter:

- NeuseLetter Volume 3, Issue 1 (1999) "Neuse Crop Management Farm Installs Controlled Drainage Structure," http://www.neuse.NC State University.edu/neuse_letters/Vol3Issue1/letter.html

- NeuseLetter Volume 4, Annual Report (2000) "Agricultural Awareness: Neuse Crop Management Project," http://www.neuse.NC State University.edu/neuse_letters/annual_report2/letter.html

- NeuseLetter Volume 4, Issue 3 (2000) "Lenoir County Farm Implements Controlled Drainage Structures," http://www.neuse.NC State University.edu/neuse_letters/Vol3Issue1/neuse-1.pdf

- NeuseLetter Volume 4, Issue 4 (2000) "Lenoir County Farm Pilots Educational Signage," http://www.neuse.NC State University.edu/Neuse-2.pdf

- NeuseLetter Volume 5, Issue 1 (2001) "Agricultural BMP Tour Address the 'How' On Neuse Crop Management Farms," and "NC Cooperative Extension Leads Nutrient Management Training" http://www.neuse.NC State University.edu/neuse-3.pdf

- NeuseLetter Volume 5, Issue 2 (2001) "Neuse Crop Management Project Field Day Promotes Targeted Best Management Practices," http://www.neuse.NC State University.edu/Neuse-4.pdf

- NeuseLetter Volume 6, Issue 1 (2002) "Neuse Crop Management Study Yields Important Economic Insights," http://www.neuse.NC State University.edu/Neuse-6.pdf

- NeuseLetter Volume 6, Issue 2 (2002) "Neuse Crop Management Project Enables Novel Nutrient Management Planning," http://www.neuse.NC State University.edu/Neuse-7.pdf

Appendix F: Nutrient Management Data

The following nutrient management demonstrations and trials were conducted in support of project objectives:

Beaufort County
Wheat trials (2002)
Cotton nitrogen placement test (2001)
Corn nitrogen rates (2002)

Craven County
Two nitrogen corn tests implemented in Mosley Creek, nitrogen rate tests and placement test (1999, 2000)
Wheat experiment (1999, 2000)
Cotton-N placement test (2000)

Franklin County
Planted 2 acres no-till tobacco (2000)
Wheat experiment (1999, 2000)

Lenoir County
Soybean seed rate test (2002)
Corn variety test (2001)
Corn nitrogen rate test (2001)

Pamlico County
N corn rate and placement tests (1999)
Triticale cover crop tests (2002)

Pitt County
Cotton nitrogen rate test (2001)

Wayne County
Installed cotton variety test (2002)
Soybean seed rate test (2002)
Nitrogen rates test on cotton (2002)

Wilson County
Variable rate nitrogen experiment with tobacco (2000, 2001, 2002)
Variable rate nitrogen experiment with cotton (2001)

Appendix G: Franklin County Demonstration Area Activities

Nutrient Management Plan

Nutrient management plans were written for the cooperating farmers in the Rocky Branch Watershed. These farmers are all on similar crop rotations, with the only fertilized crops being tobacco and wheat. The nutrient management plans were developed using the North Carolina nutrient management software. This program combines soil type and the Realistic Yield Expectation for each crop to determine a nitrogen recommendation for each individual field.

Custom Tobacco Fertilizer Plan with an Economic Analysis

A customized fertility plan for tobacco was developed for five farmers in the Rocky Branch Watershed area. The plans were developed using current soil samples and North Carolina Department of Agriculture and Consumer Services nutrient recommendations. Two plans were developed for their fields. One plan is for fields that needed a small amount of phosphorus (New#1) and the other plan is for fields that needed no phosphorus (New#2). For these five farmers, data on the old amount of fertilizer applied, and the amount of nutrients that were saved as a result of the new nutrient management plan are given in Tables 1.E-6.E.

Table 1.E Nitrogen Reductions on Tobacco and the Economic Savings (Farmer 1)

Farmer #1	lbs/acre				
	N	P	K	Cost $/acre	Acres
Old method	105	60	220	$ 165.00	100
New #1	70	50	140	$ 110.00	20
New #2	70	0	120	$ 99.00	80
Savings /acre w/ #1	35	10	80	$ 55.00	
Savings /acre w/ #2	35	60	100	$ 66.00	
Total Savings	3500	5000	9600	$ 6,380.00	

Table 2.E Nitrogen Reductions on Tobacco and the Economic Savings (Farmer 2)

Farmer #2	lbs/acre				
	N	P	K	Cost $/acre	Acres
Old method	90	50	195	$ 138.00	120
New #1	70	40	120	$ 102.00	60
New #2	70	0	120	$ 99.00	60
Savings /acre w/ #1	20	10	75	$ 36.00	
Savings /acre w/ #2	20	50	75	$ 39.00	
Total Savings	2400	3600	9000	$ 4,500.00	

Table 3.E Nitrogen Reductions on Tobacco and the Economic Savings (Farmer 3)

Farmer #3	lbs/acre					
	N	P	K	Cost $/acre		Acres
Old method	90	75	205	$	144.00	150
New #1	70	40	120	$	101.00	75
New #2	70	0	120	$	99.00	75
Savings /acre w/ #1	20	35	85	$	43.00	
Savings /acre w/ #2	20	75	85	$	45.00	
Total Savings	3000	8250	12750	$	6,600.00	

Table 4.E Nitrogen Reductions on Tobacco and the Economic Savings (Farmer 4)

Farmer #4	lbs/acre					
	N	P	K	Cost $/acre		Acres
Old method	100	50	200	$	141.00	60
New #1	70	40	120	$	105.00	15
New #2	70	0	120	$	99.00	45
Savings /acre w/ #1	30	10	80	$	36.00	
Savings /acre w/ #2	30	50	80	$	42.00	
Total Savings	1800	2400	4800	$	2,430.00	

Table 5.E Nitrogen Reductions on Tobacco and the Economic Savings (Farmer 1)

Farmer #5	lbs/acre					
	N	P	K	Cost $/acre		Acres
Old method	90	50	200	$	138.00	40
New #1	70	0	140	$	106.00	10
New #2	70	20	140	$	104.00	30
Savings /acre w/ #1	20	50	60	$	32.00	
Savings /acre w/ #2	20	30	60	$	34.00	
Total Savings	800	1400	2400	$	1,340.00	

Table 6.E Nitrogen Savings on Tobacco due to Nutrient Management Plans (Table 1-5.E. Combined)

		Old Rate		RYE rate	
Farmer	**acres**	**lbs N/acre**	**lbs. N**	**lbs N/acre**	**lbs. N**
#1	100	105	10500	70	7000
#2	120	90	10800	70	8400
#3	150	90	13500	70	10500
#4	60	100	6000	70	4200
#5	40	90	3600	70	2800
Totals:	470		44400		32900
Average lbs N/acre:			94.47		70
lbs N saved / acre:			24.47		
lbs N saved for total Tobacco crop:			11,500		

By slightly changing the amount and type of fertilizer they used, these farmers were able to see significant nutrient and economic savings. Total nutrient reductions for the Rocky Branch Watershed tobacco crop are as follows: N 11,500 lb; P 20,650 lb, and; K 38,550 lb. This represented a total economic savings of $ $21,250.00.

Table 6.F Wheat: Nitrogen Savings Associated with Nutrient Management

Nitrogen Savings on Wheat due to Nutrient Management Plan

		old rate		RYE rate	
Farmer	**acres**	**lbs N/acre**	**lbs. N**	**lbs N/acre**	**lbs. N**
#1	120	100	12000	94	11280
#2	145	120	17400	94	13630
#3	180	110	19800	94	16920
#4	75	120	9000	94	7050
#5	50	100	5000	94	4700
Totals:	570		63200		53580
Average lbs N/acre:			110.88		94
lbs N saved / acre:			16.88		
lbs N saved for total Tobacco crop:			9620		

The reduction in nitrogen fertilizer for wheat is 17 lb/acre, which is generally about a 15% reduction in nitrogen use.

Wheat Trails: Fertilizer Recommendations, Realistic Yield Expectations (RYEs), and Actual Yields

Farmers are concerned that RYEs penalize them by reducing the amount of fertilizer nitrogen that can be applied. Wheat yields were measured on 10 different fields using a weigh wagon. Soil types varied and represented wheat RYE ranges of 45 to 65 bu/acre. Measured yields in 2000 ranged of 41% to 80% of the RYE yield levels, indicating that nitrogen fertilizer rates were more than sufficient (Table 6.G). In 2001 the difference between measured yield and actual yields was less, but with the exception of one field, all measured yields were lower than RYEs (Table 6.H). This indicates that N fertilizer recommendations using RYEs are adequate.

Table 6.G Wheat yields vs RYE for 2000

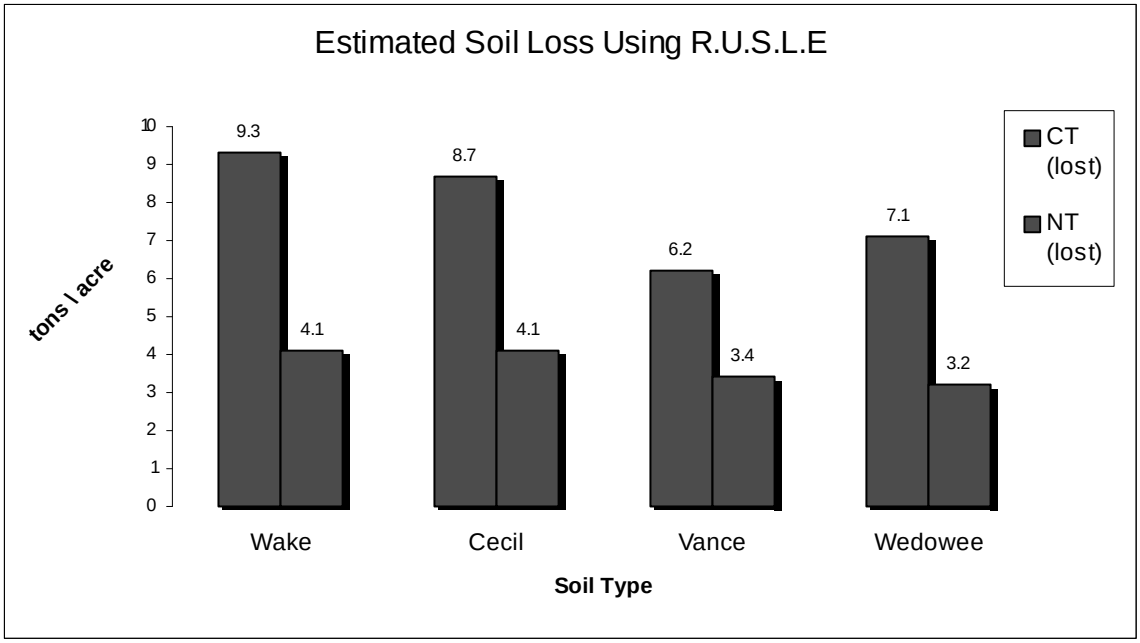
Field ID	soil type	fall N	acres	lbs. Grain	bu.	bu / acre	RYE
BM 03	DuC2	n	2.7	3830	63.83	**23.64**	45
TR 02	VaB	n	0.58	1085	18.08	**31.18**	50
TR 03	VaB	n	1.9	4580	76.33	**40.18**	50
HD 05	DuB	n	2.5	5385	89.75	**35.90**	45
HD 09	DuB	n	6.7	12855	214.25	**31.98**	45
PF 06	ApB2	n	3.8	6045	100.75	**26.51**	65
DMH 03	ApC2	n	1.4	2405	40.08	**28.63**	45
DMH 02	LwC2	n	4.6	7780	129.67	**28.19**	40
HOP 03	DuB	n	2.46	5525	92.08	**37.43**	65
HOP 04	DuB	n	1.3	3040	50.67	**38.97**	65

Table 6.H Wheat yields vs RYE for 2001

Field ID	soil type	fall N	acres	lbs. Grain	bu.	bu / acre	RYE
VS 09	LoC	y	4	8030	133.83	33.46	40
WK 01	WaB	y	6.1	15970	266.17	43.63	40
VS 01	VaB 2	n	7.7	14560	242.67	31.52	85
VS 10	WmB 2	y	6.8	15905	265.08	38.98	50
VS 10b	WmB	y	0.75	1890	31.50	42.00	50
BS 02	DuB-ApB2-WmB2	y	13.4	34560	576.00	42.99	45-65-50
GP 04	LoC	y	7.4	16880	281.33	38.02	40
HP 04	ApB 2	y	3.8	11000	183.33	48.25	65
JB 02	ApB	y	4.5	10710	178.50	39.67	65
JG 09	WmB	y	1.9	3840	64.00	33.68	50
401-1	WmB	y	6.6	13390	223.17	33.81	50
MP 01b	ApB	y	2.1	4900	81.67	38.89	65
MP 02	ApB	y	6	14800	246.67	41.11	65
MP 03	ApB	y	3.4	8420	140.33	41.27	65
MP 04	ApB	y	2.5	5460	91.00	36.40	65

Reduction in Soil Loss as a Result of BMP Implementation

During the project, several cooperators planted their tobacco using strip-till technology. Using the USDA-Natural Resources Conservation Service soil loss estimation tool (Revised Universal Soil Loss Estimation – RUSLE), project personnel estimated the reduction in soil loss using strip-till. Strip-till reduced soil loss by 50% or more, depending on soil type, as shown in the figure.



Appendix H: Evaluation of the Realistic Yield Expectations of Soil Map Units in the North Carolina Piedmont and Coastal Plain

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M.M Lohman, J. White, and D.L. Osmond

Introduction

Realistic Yield Expectations (RYEs) have been developed in North Carolina to assist in site-specific farming decisions that will improve nitrogen-use efficiency and reduce N contamination of ground and surface water, particularly in the Neuse River Basin. The Neuse River Basin is the third largest river basin in North Carolina and is located in the central and eastern portions of the state. Due to degrading water quality and increased nitrogen inputs, the "Neuse Rules" were implemented in 1998 and require a 30% N reduction from both point and nonpoint sources by 2003 (http://www.neuse.NC State University.edu/ncmp/index.html). These regulations affect North Carolina agriculture by requiring agricultural operations within the Neuse River Basin to adopt at least one of the following measures to reduce N inputs:

- Participate in a local N reduction strategy that may include specific nutrient management plans for some of the farms, OR
- Implement one of the three standard best management practices, which include buffers, water control structures and nutrient management plans (http://www.h2o.enr.state.nc.us/nps/ag.htm).

Nutrient management is an important strategy, regardless of the option the producer selects. Nutrient management utilizes RYEs, soil analysis, and cropping histories to ensure that the correct amounts of fertilizer are applied and efficiently used by the plants (http://www.neuse.NC State University.edu/ncmp/index.html).

The goal of this project is to determine whether correlations exist among RYEs, actual yields, soil map units, and soil test results. This research has the potential to improve N rate and timing decisions that can be prescribed to improve nitrogen use efficiency (NUE).

Methodology

Two locations were selected in central and eastern North Carolina to represent typical grain farms located in the Neuse River Basin. The location in the Piedmont (Franklin County) consists of three spatially related fields (Fields 3, 5 and 7) of areas 9.53 ha, 14.43 ha and 7.69 ha, respectively (Figs. H.1-H.3). The Coastal Plain location (Wayne County) comprises of two spatially related fields of total area equal to 14.7 ha (Fig. H.4). An intensive soil survey of the fields was completed in 2002 for both locations at an approximate scale of 1:3500 and will be used to compare the information to that in the 1998 Franklin County Soil Survey and the 1974 Wayne County Soil Survey. The remapped soil information was georeferenced using a differentially corrected global positioning system (GPS) with an approximate error of 1 meter. The soil map units for each location along with their associated RYE are represented in Table H.1.

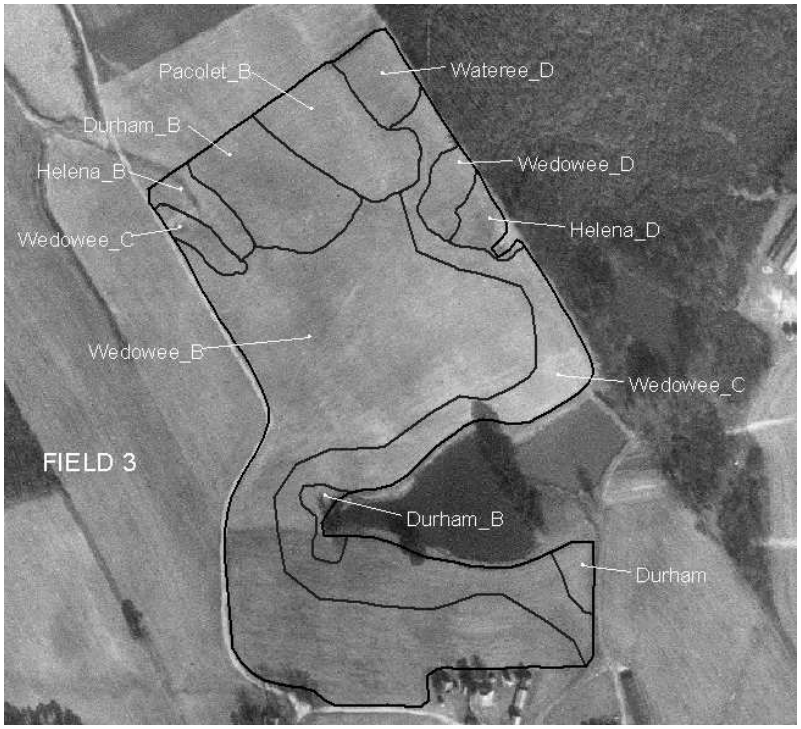

Figure H.1 Field 3 at Piedmont location. The field and soil map unit boundaries have been overlain on the aerial photograph of the site in Franklin County.

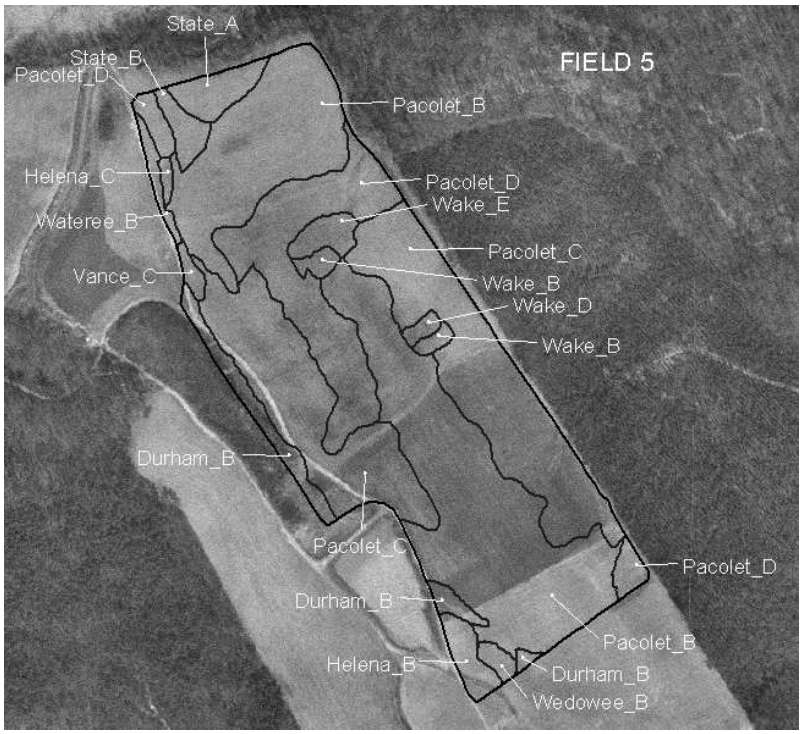

Figure H.2 Field 5 at Piedmont location.

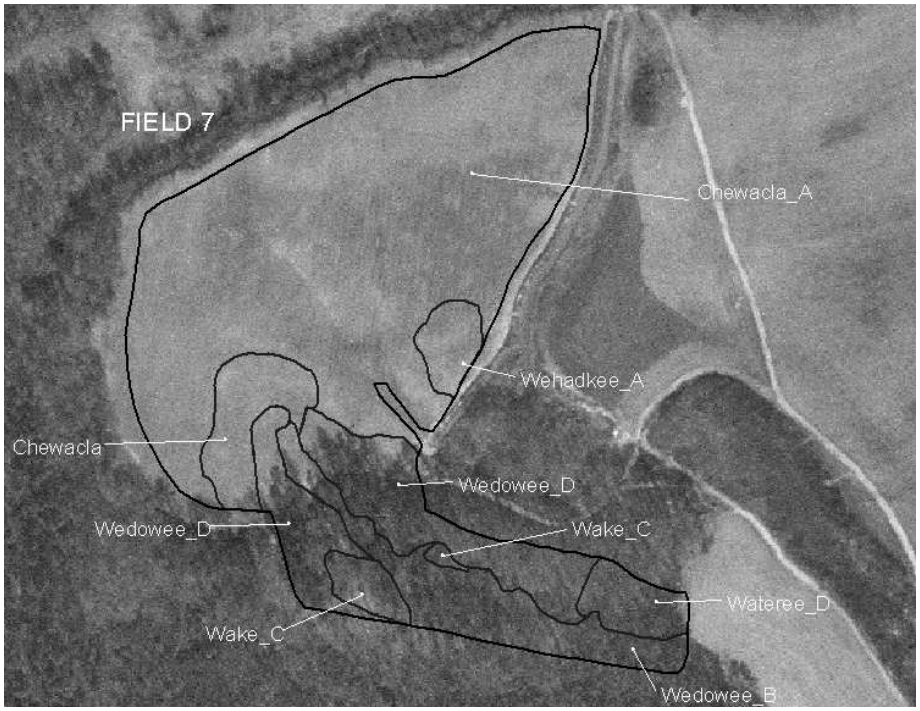

Figure H.3 Field 7 at Piedmont location.

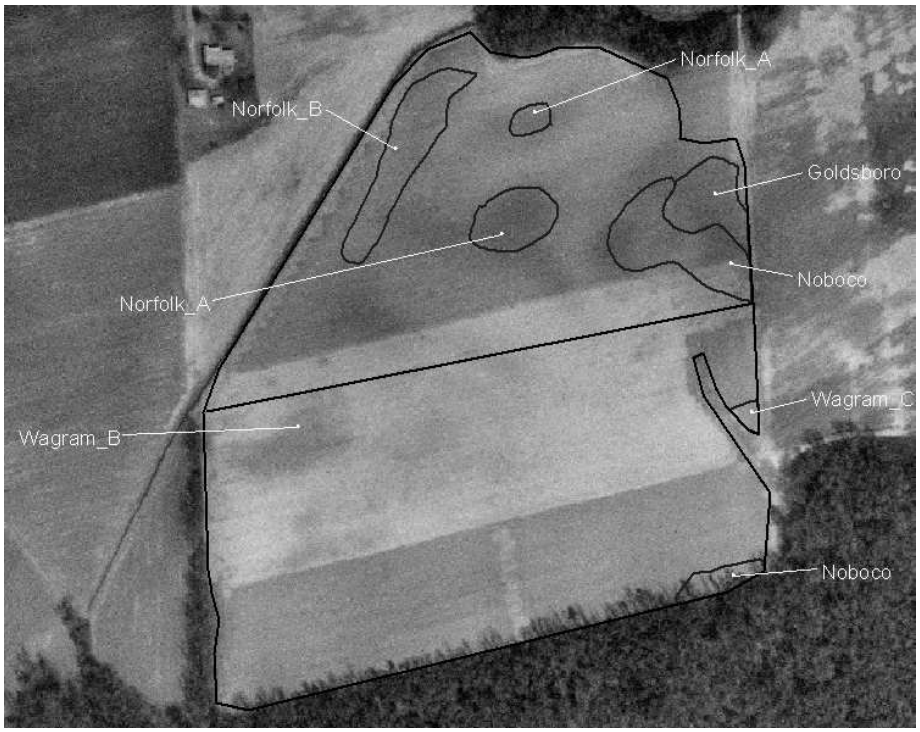

Figure H.4 Spatially related fields at the Coastal Plain site in Wayne County. Again, field and soil map unit polygons were placed on top of the aerial photograph of the site.

Table H.1 Soil map units for both sites in the study. Map units listed are from the 2002 intensive soil survey in both locations.

Soil Map Unit	RYE (kg/ha)		
Piedmont	Corn	Wheat	Soybean
Chewacla	9400	4400	3700
Durham	5600	3000	2400
Helena	6000	3400	2700
Pacolet	6900	3400	2700
State	7800	4000	3000
Vance	6600	3400	2700
Wake	2800	1300	0
Wateree	5300	2700	2000
Wedowee	6900	3400	2700
Wehadkee	5300	2700	2000
Coastal Plain			
Goldsboro	8200	4400	3000
Noboco	7200	4000	3000
Norfolk	7200	4000	2900
Wagram	7400	2700	1900

Georeferenced soil sampling was conducted at both locations using a differentially corrected GPS with an approximate error of 1 meter. Eight cores to a depth of 0.2 m were taken at each grid location and mixed to ensure that a representative sample was collected. In the Piedmont, the samples were collected on a 23-m equilateral grid, whereas in the Coastal Plain the equilateral grid spacing was 21.3 m. The samples were analyzed and will be utilized to map the spatial distribution of P, K, and lime requirements.

Yield monitoring information has been collected for one site year for wheat (*Triticum aestivum* L.) (Fig. H.5) in the Piedmont and two site years for soybean (*Glycine max* [L.] Merr.) (Fig. H.6) and wheat (Fig. H.7) in the Coastal Plain. A third site year of data for the Coastal Plain was available for corn (*Zea mays*), but an error in the yield monitoring equipment prevented this data from being assessed. The yield data were collected and mapped at both locations by an Ag Leader PF 3000 yield monitor equipped with a global positioning receiver mounted on the combine (Ag Leader Technology, Inc., Ames, IA). After the yield data were collected in the field, they were entered into a geographic information system (GIS) to be evaluated and corrected.

Results and Discussion

Preliminary evaluation of the yield maps illustrate that there was no correlation between soil map units and RYEs in the Piedmont, but there did appear to be correlation in the Coastal Plain. Statistical analyses will be completed to ensure that these observations are correct.

The 2002 wheat yield for the Piedmont location (Fig. H.5) has fairly uniform yield across the entire field. There are no patterns of yield values exclusive to a soil mapping unit polygon. The few areas that have extremely low yield patterns are waterways and irrigation roads that have not yet been georeferenced. There are no other evident yield patterns in the field, thus leading to the conclusion that there is no correlation between RYEs and soil map units at this location for this site year.

At the Coastal Plain site, the 2000 soybean yield (Fig. H.6) and 2002 wheat yield (Fig. H.7) both demonstrate correlation between yield patterns and soil map unit boundaries. As the result of a misunderstanding with the farmer, only portions of the fields were harvested with the yield monitoring equipment, resulting in missing data for the fields. There is a noticeable pattern in Figure H.6 in the lower Norfolk_A soil map unit polygon as a localized region of higher yield appears in and directly around the polygon. The Norfolk soil map unit has higher RYE values than the Wagram soil map unit, which surrounds the Norfolk soil. Another pattern of high yield occurs in both the Goldsboro and upper Noboco map unit boundaries, as these map units also have higher RYEs than the surrounding Wagram soil. The same phenomenon occurs in Figure H.7, with the upper Norfolk_A polygon and in the upper Noboco polygon.

Conclusions and Finishing Research

By evaluating the yield maps for each location, we can see that whole-field management may be more economically feasible for the Piedmont site because there are no patterns on which to base site-specific management decisions. The Coastal Plain site, however, is a candidate for zone management, using the soil map unit polygons as zones.

To finalize this project, the statistical analyses must be completed to provide the necessary correlation values comparing RYEs, actual yields, soil map units, and soil test values. At least two more site years of yield data will be collected at each location. In the Coastal Plain, the entire fields will be harvested with the yield monitoring equipment. These additional site years will provide insight into how weather and cropping systems affect these correlations.

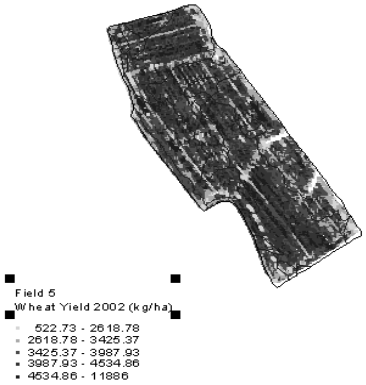

Fig. 5. 2002 wheat yield for Piedmont location.

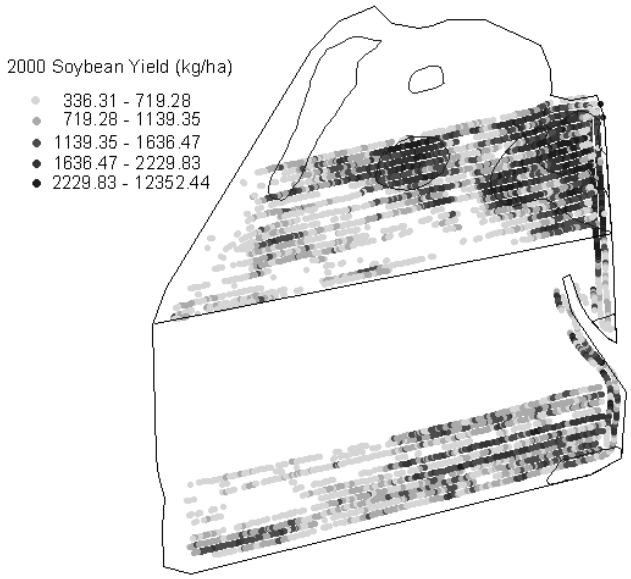

Fig. 6. 2000 soybean yield for Coastal Plain location.

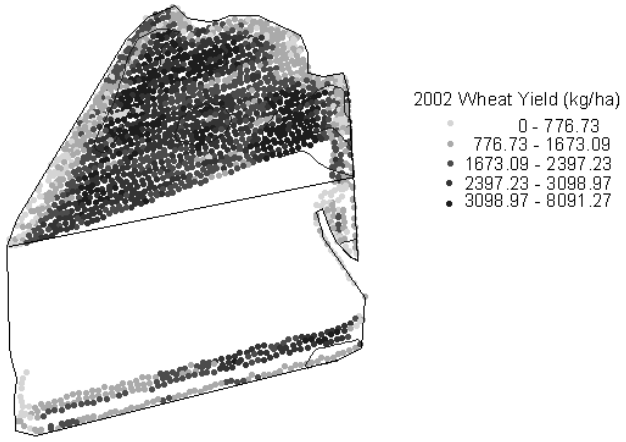

Fig. 7. 2002 wheat yield for Coastal Plain location.

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North Carolina Environmental Management Commission. Neuse Agriculture Rule [Online]. Available at http://www.h2o.enr.state.nc.us/nps/ag.htm. (Verified 09 Sept. 2002).

North Carolina State University. 2001. Neuse Crop Management Project [Online]. Available at http://www.neuse.NC State University.edu/ncmp/index.html. (Verified 09 Sept. 2002)

Appendix I: News Articles, Television and Radio

The following articles, television and radio spots describing the Neuse Crop Management Project appeared in popular press publications:

Agricultural Review, March 1999, "New Project Will Focus on Nutrient Management Practices"

Agronomic, Economic & Environmental Digest, March 2001, "Agriculture Meets Environmental Challenges"

American Farmland Trust's Research Center for Agriculture in the Environment, "The Neuse Crop Management Project," http://www.farmlandinfo.org/cae/topic.html#neuse

CALS Perspectives On Line, Spring 1999 "Responsive Action," http://www.cals.NC State University.edu/agcomm/magazine/spring99/neuse.htm

Carolina Cotton Trends, October 2001, "Neuse Crop Management BMP's Cotton Farming Impact"

Carolina Farmer, July 1999, "Balancing Ag and the Environment"

Carolina Farmer, March 1999, "Tobacco Producers Getting Their Second Wind"

Center for Agricultural Partnerships, "North Carolina Neuse Crop Management Project," http://www.agcenter.org/nc/neuse.htm

ENN Newsbites, January 29, 1999, "Crop management -- The Neuse Crop Management Project," http://lists.isb.sdnpk.org/pipermail/eco-list-old/1999-January/001667.html

Farm Chronicle of North Carolina, February 15, 1999, "Unprecedented NC Farm Environmental Collaboration Initiated in Neuse River Basin"

Four Oaks Benson News in Review, March 7, 2001, "Nutrient Management Helps Crops, Waters, Expert Says"

Goldsboro News-Argus, February 22, 2002, "Farmers Learn New Technology from Neuse Crop Project"

Goldsboro News-Argus, February 25, 2000, "Neuse Crop Management Project Unique to the Area"

Goldsboro News-Argus, June 16, 1999, "Devices Improve Water Quality"

Kinston Free Press, February 18, 2000, "Farmers Hope to Turn Tide"

NC Plant Food Association Newsletter, Spring 1999, "Neuse Crop Management"

North Carolina Farm Bureau News, April 2001, "Farmers in Neuse Watershed Receive Help to Reduce Nitrogen Runoff"

North Carolina Farm Bureau News, April 2001, "Keeping Crops Green and Water Clean on the Neuse River"

Progressive Farmer, April 1999, ""Neuse Rules" Impact Tobacco Growers Crop Management Programs"

Raleigh News & Observer, February 17, 2001, "Slow Start in Fighting Runoff"

Southeast Farm Press, July 18, 2001, "Reduced Nitrogen Rates Improve Crop"

Southeast Farm Press, July 18, 2001, "Tobacco Grower Cuts Back on Nitrogen"

Successful Farming @Agriculture Online, January 27, 1999, "Grant will Educate NC Growers on Nitrogen, Herbicide Runoff," http://www.agriculture.com/default.sph/AgNews.class?FNC=ViewArchives

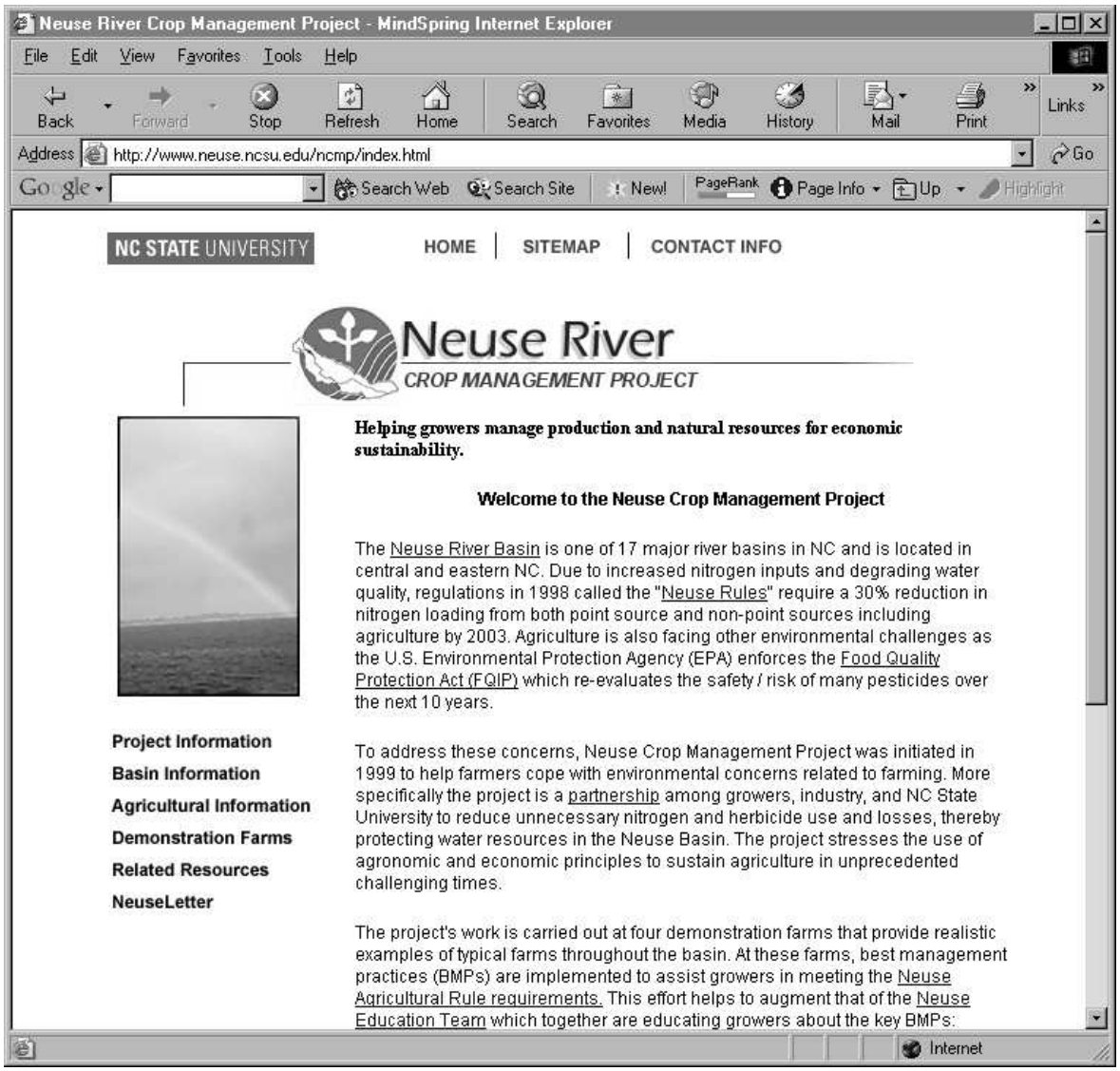
U.S. Environmental Protection Agency Nonpoint Source News-Notes, July 1999, Issue #58 ""Neuse Rules" Aim at Reducing Nitrogen in Pamlico Sound," http://www.epa.gov/owow/info/NewsNotes/issue58/agrclt58.htm#neuse

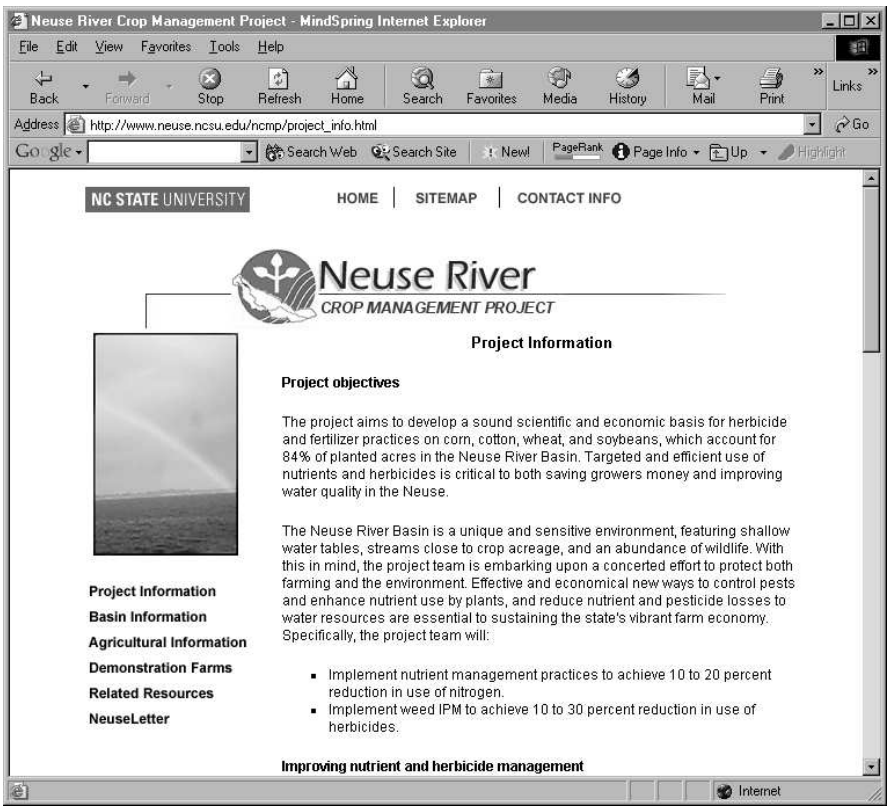
Radio Events (covered two field days – one in Franklin County and one in Lenoir County)
680am – radio (~80,000 listeners)
Capitol Broadcasting – radio piece on the AgNews network
WUNC Public Broadcasting for Central North Carolina

Television Events
Two television stations in the Neuse Basin covered a field day at the Lenoir County demonstration farm.
One television station covered the opening of the project.

Appendix J: Neuse Crop Management Project Website

http://www.neuse.NC State University.edu/ncmp




Neuse River Crop Management Project - MindSpring Internet Explorer
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Back Forward Stop Refresh Home Search Favorites Media History Mail Print Links
Address http://www.neuse.ncsu.edu/ncmp/project_info.html
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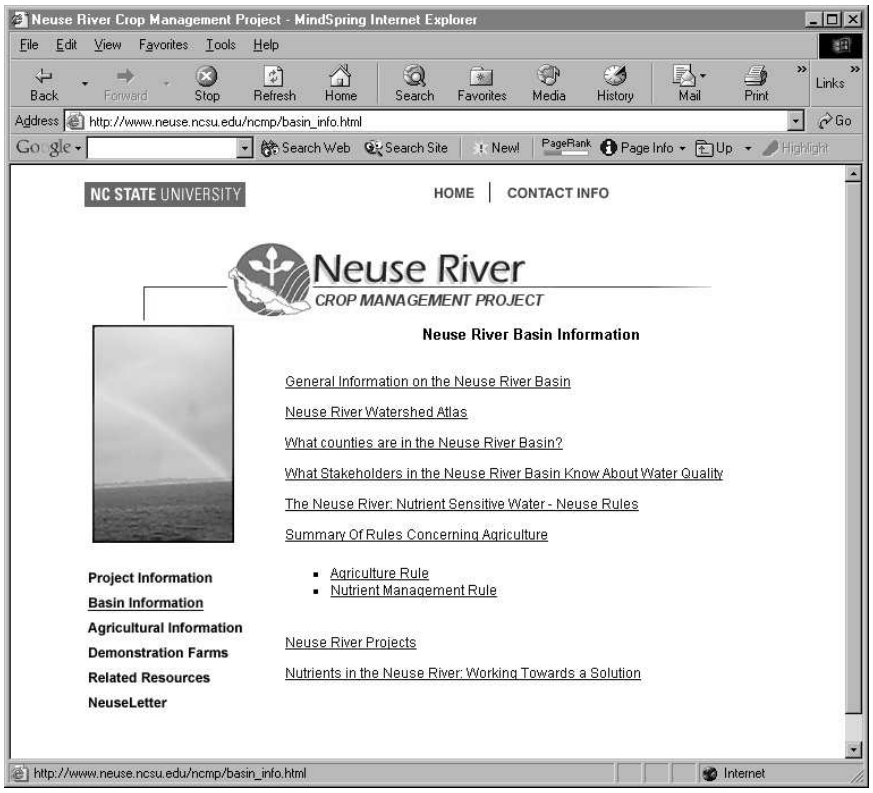
HOME | SITEMAP | CONTACT INFO
Neuse River
CROP MANAGEMENT PROJECT
Project Information
Project objectives
The project aims to develop a sound scientific and economic basis for herbicide and fertilizer practices on corn, cotton, wheat, and soybeans, which account for 84% of planted acres in the Neuse River Basin. Targeted and efficient use of nutrients and herbicides is critical to both saving growers money and improving water quality in the Neuse.
The Neuse River Basin is a unique and sensitive environment, featuring shallow water tables, streams close to crop acreage, and an abundance of wildlife. With this in mind, the project team is embarking upon a concerted effort to protect both farming and the environment. Effective and economical new ways to control pests and enhance nutrient use by plants, and reduce nutrient and pesticide losses to water resources are essential to sustaining the state's vibrant farm economy. Specifically, the project team will:
Implement nutrient management practices to achieve 10 to 20 percent reduction in use of nitrogen.
Implement weed IPM to achieve 10 to 30 percent reduction in use of herbicides.
Improving nutrient and herbicide management
Project Information
Basin Information
Agricultural Information
Demonstration Farms
Related Resources
NeuseLetter
Internet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NC STATE UNIVERSITY
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Neuse River
CROP MANAGEMENT PROJECT
Neuse River Basin Information
General Information on the Neuse River Basin
Neuse River Watershed Atlas
What counties are in the Neuse River Basin?
What Stakeholders in the Neuse River Basin Know About Water Quality
The Neuse River: Nutrient Sensitive Water - Neuse Rules
Summary Of Rules Concerning Agriculture
Agriculture Rule
Nutrient Management Rule
Neuse River Projects
Nutrients in the Neuse River: Working Towards a Solution
Project Information
Basin Information
Agricultural Information
Demonstration Farms
Related Resources
NeuseLetter
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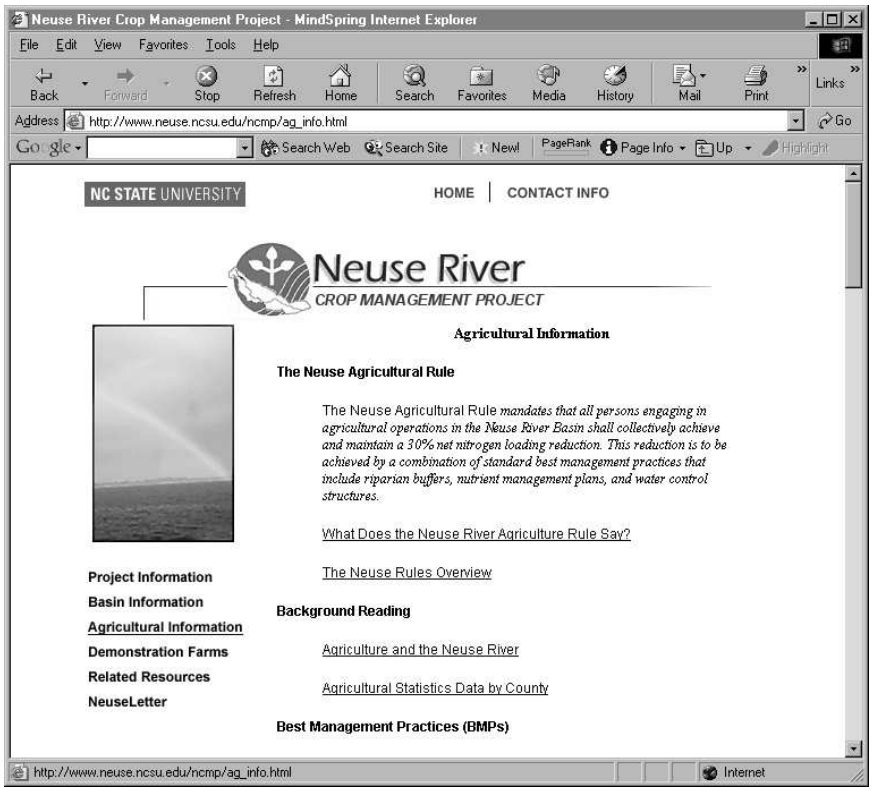
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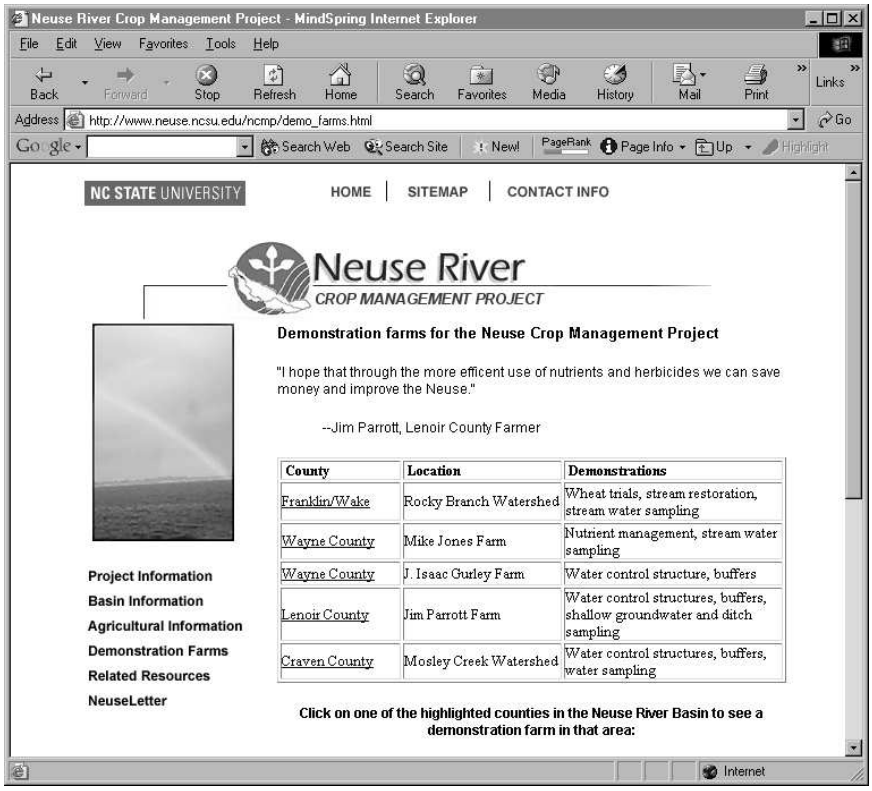
Neuse River
CROP MANAGEMENT PROJECT
Agricultural Information
The Neuse Agricultural Rule
The Neuse Agricultural Rule mandates that all persons engaging in agricultural operations in the Neuse River Basin shall collectively achieve and maintain a 30% net nitrogen loading reduction. This reduction is to be achieved by a combination of standard best management practices that include riparian buffers, nutrient management plans, and water control structures.
What Does the Neuse River Agriculture Rule Say?
The Neuse Rules Overview
Project Information
Basin Information
Agricultural Information
Demonstration Farms
Related Resources
NeuseLetter
Background Reading
Agriculture and the Neuse River
Agricultural Statistics Data by County
Best Management Practices (BMPs)
http://www.neuse.ncsu.edu/ncmp/ag_info.html
Internet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HOME | SITEMAP | CONTACT INFO
Neuse River
CROP MANAGEMENT PROJECT
Demonstration farms for the Neuse Crop Management Project
"I hope that through the more efficent use of nutrients and herbicides we can save money and improve the Neuse."
--Jim Parrott, Lenoir County Farmer
County | Location | Demonstrations
Franklin/Wake | Rocky Branch Watershed | Wheat trials, stream restoration, stream water sampling
Wayne County | Mike Jones Farm | Nutrient management, stream water sampling
Wayne County | J. Isaac Gurley Farm | Water control structure, buffers
Lenoir County | Jim Parrott Farm | Water control structures, buffers, shallow groundwater and ditch sampling
Craven County | Mosley Creek Watershed | Water control structures, buffers, water sampling
Project Information
Basin Information
Agricultural Information
Demonstration Farms
Related Resources
NeuseLetter
Click on one of the highlighted counties in the Neuse River Basin to see a demonstration farm in that area:
Internet

Appendix K: Nutrient Management Training Content

Neuse River Basin Nutrient Management Education

December 1, 2000
NC State University
North Carolina Cooperative Extension Service
Raleigh, NC

Introduction
Module 1: How Water Moves?
Module 2: Fresh Water and Estuarine Water Quality Problems
Module 3: Sources of Nutrients: Fields, Streams and Basins
Module 4: Best Management Practices to Reduce Nitrogen
Module 5: Soil Systems of the Neuse River Basin
Module 6: What is Nutrient Management Planning?

- What is a nutrient management plan?
- Fertilizer information for nutrient management planning
- Agronomic rates and realistic yield expectations

Module 7: Soil Testing for Nutrient Management
Module 8: Developing a Nutrient Management Plan
Module 9: Commodities

- Corn
- Cotton
- Cucumbers
- Potatoes
- Tobacco
- Turf
- Wheat

Appendix L: Neuse River Focus Group Session

Goldsboro, NC – February 5, 2001
Greg Fleisher and Steve Lilley, Department of Sociology /Anthropology, NC State University

Participants: Rick Holder, Dixie; Ron Perry and Doug Roberts, Southern States; Howard Singletary, NC Plant Food Association; Carlton Ipock and John Johnson, Royster-Clark.

Summary
The purpose of this study was to assess farmers' decision-making processes related to products and services offered by these agricultural industries. Also of interest was information concerning how the companies have been changing or organizing themselves to meet consumer demand.

Major Findings
The session indicated an increased need for the industry to provide services. More and more farmers want the agricultural companies to provide services in addition to products. In response, the companies have spent considerable money on new equipment and personnel to be able to provide such services.

"One of the things that has amazed me about fertilizer and pesticide dealers and what's going on in the industry—they are offering more and more services. And I have been amazed in the last 3 years to see the amount of new equipment the dealerships have purchased to be able to service their customers. Farmers with diverse operations and who are spread out over several counties can't always do everything they need to do themselves, and they're depending more and more on dealerships to pick up the slack and provide these types of application services whether they be pesticides or fertilizers. So that hinges on a decision as to what [farmers] might buy, where they might buy it, and if they use something or not—can they get it applied?"

The farmers' personal relationships with salespeople are one of the major factors affecting decision making. Farmers depend on people they trust for advice regarding which products to buy.

"The farmer listens to people that he has a relationship with and that he trusts because it's like selling anything, people buy from people. They don't buy from Southern States or Royster-Clark. They buy from the individuals that they know that work for those entities."

Farmers are improving their record keeping. Better record keeping will allow the farmer to more accurately gauge what products work best under various conditions.

"One thing we're on the verge of – and we're kind of in transition—is record keeping. I think most farmers now have got a computer, and they're going to start keeping better records. And I think they're going to use past history as a guide to make their decisions because they're going to have that information readily available. So I think you're going to see farmers rely more on their own records as a source for what they're going to buy the next year."

Responses
What factors most influence farmer purchases of products – pesticides, seeds, fertilizer – offered by your industry?

- Expected performance of the product
- Price

- Advice from consultants
- Farmer's personal relationship with salespeople the farmer trusts
- Farm media
- Safety/environmental issues
- The equipment the farmer has (i.e., if the farmer has spraying equipment, he or she will most likely buy liquid materials)
- Complexity of instructions in using the product. The more complex, the less likely the farmer is to use the product.
- Need for services. If the farmer is seeking services, that affects where he or she will go to buy products and contract services.
- Availability of certain products. The farmer will take whatever brand is available if he or she needs the job done soon.
- "Farmers today are trying to differentiate more and more between 'what I want and what I got to have.' They're looking at the bottom line real close and they're trying to differentiate between the two because they can't afford any waste right now. If they feel like the input is necessary to make that crop more effective, they buy. If they feel like they can survive without it, they don't buy."
- "You can probably boil it down to two or three main things -- economics, efficiency, ease of use."

Now thinking about these factors that influence purchases of your products, what are the significant differences in the way farmers decide to purchase seed as compared to fertilizer and pesticides?

Seed:

- Brand name is important.
- Seed is marketed more than fertilizers and pesticides
- "Seed has more of an identity than fertilizer. From a sales standpoint, you've got a better opportunity to do a sales job and a marketing job with seed than you do with fertilizer. When you get right down do it, fertilizer is fertilizer."
- "Every seed company in this country, just about, has a link with a chemical company or somebody that's into genetic engineering and that kind of thing."

Fertilizer:

- Farmers want companies to provide the right quantity at the right price
- Ability of the company to get the fertilizer to where it needs to go
- The farmer wants to make sure the company can apply it effectively
- "If you can get it in the place where the plant can use it, I don't think the plant gives a damn. Getting it in place—that's the problem, getting it in place."
- "A pound of potassium is a pound of potassium, if it is in the right place."

Pesticides:

- Technological fees associated with applying the pesticides
- Safety of the pesticides in terms of their effect on the food chain
- Worker safety
- Skilled applicators; we can't have unskilled people doing application or making decisions concerning application.
- If the applicator is familiar with that farmer's fields, the farmer is likely to hire the same applicator again.

What factors most influence farmer purchases of services related to fertilizer and pesticides and seed?

- Is it necessary? Some farmers can do it themselves, thus they do not need the services
- If the farmer is devoting more time to management, he or she most likely needs service from the companies.
- Timeliness: Can industry provide the farmer with the service when he or she needs it?
- Whether the farmer needs specific and skilled operator to operate the equipment
- Liability—if something goes wrong, the farmer does not have to shoulder the entire cost if the company provided the service.
- "The farmer's time --more and more-- every year is devoted to management, if he's smart. They're spending more and more time in the office and less and less time in the fields."

Now, thinking about the factors that influence purchases of services, what are the significant or most important differences in the way farmers decide to buy services related to seed as compared to pesticides and fertilizer?

- The farmer goes to the dealer who gives the best agronomic advice; this is often a person the farmer knows and trusts.
- "The folks that are in the dealership and supplying service are making more and more investment in their personnel, their training, and educational opportunities. I've seen more in that development in the last five years than in any period 20 years prior to."
- "A lot of times, farmers will buy from a dealer just because they value the expertise of that applicator."

Finally, how do you see your industry, in terms of both products and services, responding to ongoing changes in agriculture?

- Industry and farmers need to do better long-range planning.
- Industry needs to get paid the fair price that their services are worth.
- We need to educate the public about the importance of agriculture so that they will support public legislature allocating more money to agriculture.
- We must figure out a way to grow for the foreign market.
- Industry needs people with global experience to tell farmers what to grow and how to market their products.
- We need to find more market opportunities.
- Farmers need to keep better records—industry could be proactive in helping farmers to do this
- "We'll adapt."
- "I'd say we're responding as fast or probably faster than our customers are."
- "--this is because many farmers do not readily understand or accept the changes."
- "These changes, a lot of them, are requiring investments. And a lot of [farmers] can't afford [financially] the regulations and some of the things they are having to abide by."
- "If we're going to stay in this business, we've got to get what that service is worth if we're going to make that service available. We can't do it for free."
- "The farmer's got to make money so he can afford the services that he's going to need and the kind of equipment that he expects that we're going to have."
- "How do we educate the public about the importance of agriculture? Unless we do a much better job of that, then the support for the public monies is not going to be there."

Appendix M: Shrub Buffer Project Report

DRAFT: Do Not Cite

Carrie Wafer and Deanna Osmond
NC State University
Raleigh, NC

(Funding for this portion of the project was obtained from the NC Clean Water Management Trust Fund and the UNC Water Resources Research Institute.)

Introduction

The Neuse River Basin, North Carolina, was declared a nutrient-sensitive watershed in 1993 as a result of excess nitrogen entering the river (Karr et al., 2001). Agricultural activities were regulated in 1998 in the Neuse River Basin and best management practices have been implemented throughout the river basin to decrease nitrogen loads (NC Department of Environment and Natural Resources, 1997). One of the more important Best management practices is riparian buffers that promote NO_3^--N removal from groundwater by denitrification (Gilliam et al., 1997). Most denitrification studies in riparian buffers have been conducted in forested systems, not shrub buffers.

Nitrate-N concentrations in groundwater samples collected below the rooting zone are used to determine whether NO_3^--N concentrations are decreasing as groundwater moves through the buffers. A decrease in groundwater NO_3^--N concentrations prior to entering receiving waters indicates that denitrification may be occurring. The likelihood that denitrification is occurring in soils and is responsible for the NO_3^--N removal is determined by measuring the redox potential of the soil with platinum-tipped redox probes and a voltmeter. Studies have found that denitrification tends to occur between +200 and +350 mV, at soil pH 7 (deMars and Wassen, 1999; McBride, 1994; Kralova et al., 1992).

Objectives

The objectives of this study are to determine if groundwater NO_3^--N removal occurs under a riparian shrub-buffer system, if removal increases with increasing buffer width, and whether denitrification is the process responsible for the NO_3^--N removal.

Materials and Methods

Site Description

This study is being conducted at the Parrott Farm, in Kinston, North Carolina. The site is in the middle Coastal Plain, where the topography is very flat. The soils in the study area are predominantly Tomotely, Arapahoe and Roanoke, which are poorly to very poorly drained soils. The groundwater and redox potential sampling sites are in buffers adjacent to four of the drainage ditches (Fig. 1). The three ditches that drain south to north have 15-ft-wide buffers (blue dots). There are three transects perpendicular to each ditch. Within each transect is a set of three groundwater monitoring wells and a set of redox probes adjacent to the drainage ditch (0 ft) and 15-ft from the drainage ditch. A fourth ditch drains east to west with a 30-ft buffer (white dots) with four transects perpendicular to the ditch. Each transect in the fourth ditch has a set of three groundwater monitoring wells and a set of redox probes adjacent to the drainage ditch (0 ft), 15-ft and 30-ft from the drainage ditch.

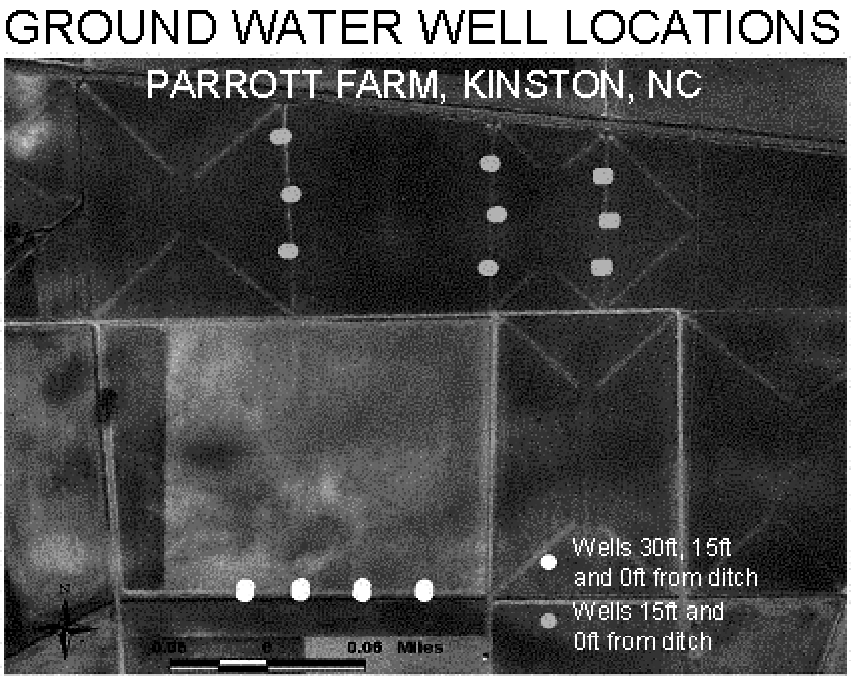

Figure 1. Site map of the Parrott Farm, Kinston, NC. Blue dots are sampling locations on the 15-ft buffers and white dots are sampling locations on the 30-ft buffer.

Groundwater Monitoring

A total of 30 sets (three wells per set) of 2-inch diameter groundwater wells are monitored at this site. Each set of wells consists of a deep, intermediate, and shallow well. The deep wells have a 2 ft well screen and are screened to a depth of approximately 9 ft. The intermediate wells have a 5 ft well screen and are screened to a depth of approximately 6.5 ft. The shallow wells have a 1-ft well screen and are screened to a depth of approximately 3 ft. The groundwater monitoring wells are installed with the shallow well between the deep and intermediate wells (Figure M.2). The deep and intermediate wells were sampled monthly from February 2000 through the present. The shallow wells were sampled monthly from March 2002 through the present. We will continue to sample the wells through May 2003.

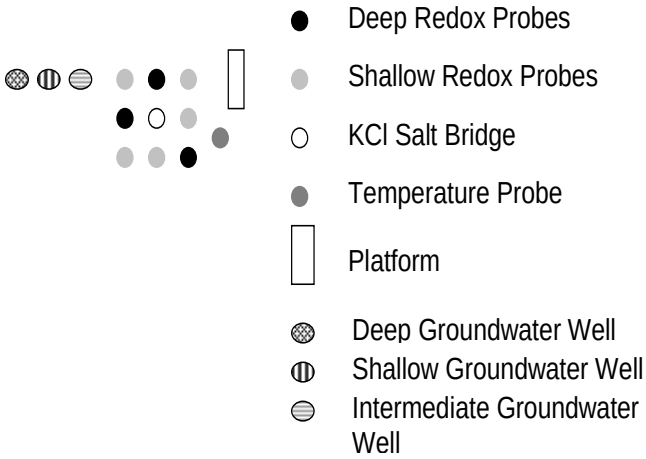

Figure M.2 Site design of groundwater monitoring wells (on the left), redox probes, potassium chloride salt bridge, temperature probe and platform.

The depth from the top of the well casing to the water is measured with an electronic tape before taking groundwater samples. A peristaltic pump with dedicated tubing is used to pump three well volumes from each well and to collect a 40-mL sample in an acid-washed glass bottle. If a well goes dry before three well volumes are purged, the pump is turned off, groundwater is allowed to seep into the well, and the sample is collected after enough water seeps back into the well. The samples are stored in a cooler, on ice, until they are brought back to the lab.

Within 24 hours of sampling, the samples are filtered using syringes and 45-um Millipore Syringe Filters. Approximately 30 mL of water are filtered for analysis. After filtering, the pH of the samples is measured with litmus paper. The pH is lowered to 2 to stop biological processes that can change nutrient concentrations in the sample. Two drops of a diluted sulfuric acid solution (5 mL concentrated reagent grade sulfuric acid diluted to 100 mL with deionized water) are added to each sample with an eyedropper. The samples are then capped tightly and stored in a refrigerated room. Every two months the samples are submitted for analysis to the Plant and Water Analysis Laboratory, managed by Guillermo Ramierez in the Soil Science Department at NC State University. The samples were analyzed for nitrate-N (NO_3^--N), ammonium (NH_4^+), and orthophosphate (OPO) until July 2001. From August 2001 through May 2003, the samples were also analyzed for dissolved organic carbon (DOC) and chloride (Cl^-). We stopped analyzing samples for NH_4^+ in April 2002 because the concentrations were consistently at or below the detection limit. The results are examined to ensure that they fall within the expected ranges.

Measuring Redox Potential

Redox measurements are made with platinum-tipped redox probes, a potassium chloride (KCl) saturated silver/silver chloride (Ag/AgCl) reference probe and a portable pH/mV meter. The redox probes were tested in tap water and in a ferrous/ferric iron solution (Light Solution) to determine their accuracy and whether they needed to be repaired before installation (Light, 1972). Five suitable probes were installed 2.5-ft deep and three suitable probes were installed 5-ft deep, above and below the average growing season water table, respectively. The redox probes are set up in a square pattern adjacent to the monitoring wells. A square pattern was used because it maximized the distance between probes while maintaining a minimal distance between the probes and the salt bridge.

Potassium chloride salt bridges were constructed to use with the reference electrode when taking redox measurements in the field. The salt bridge is essentially a PVC pipe with holes drilled from 2 ft to 5½ ft below the soil surface when the bridge is installed. The end of the pipe that is in the soil is capped and a potassium chloride agar solution is poured into the PVC pipe and allowed to congeal. The open end of the bridge is not permanently capped. Ions released from the bridge help the redox potential measurements to stabilize more quickly during drier months when the upper soil moisture content may not be high enough to conduct electrical current. When a salt bridge is not used, the reference probe must be inserted into wet soil. If the soil surface is dry, the soil must be wetted. Under this condition stabilization of readings can take much longer because the transfer of ions occurs more slowly compared to that with the salt bridge. It is also necessary to measure soil temperature when making redox measurements. Temperature probes were installed to measure temperatures at the same depths (2.5 and 5 ft) as the redox probes. The salt bridge is in the middle of the square of redox probes (Fig. M.2). The temperature probes and table for holding equipment are outside the square. This pattern was used at all sampling locations.

Redox potentials are measured by connecting a copper wire from the redox probe to the voltmeter and from the KCl reference probe to the voltmeter. The reference probe was put in the KCl salt bridge prior to making measurements. The measurements from the voltmeter are sometimes called probe measurements. The probe measurements must be corrected to take into account the

difference in probe measurements between the KCl reference probe and a standard hydrogen reference probe. The correction is made by adding +199 mV to the probe measurement to get the corrected redox potential.

The redox potential range that is expected for denitrification to occur must also be corrected for soil pH. In pH 7 soils, redox potentials (probe measurement plus +199mV correction for reference electrode) less than +200 mV to +350 mV would indicate that denitrification could occur and measurements greater than +350 mV would indicate the opposite (McBride, 1994). At the field site the soil pH is approximately 5. The critical redox potential for determining denitrification potential is adjusted to account for the pH difference by adding 59 mV/pH unit (Bohn, 1971). The soils were 2 pH units below 7, so 120 mV was added to +200 mV and +350 mV to make the redox potential range +320 mV to +470 mV for determining potential denitrification.

Results and Discussion

Groundwater chemistry data show that a decrease in NO_3^--N occurred at 2.5 ft and 5 ft in both buffer widths, with the exception of the 4th quarter in the deep wells on the 30-ft buffer (Table 1). It is likely that the water from the ditch recharged the groundwater and caused an increase in the NO_3^--N concentrations. Overall, the decrease in NO_3^--N concentrations support the redox data that show conditions are favorable for denitrification. The groundwater data show that more NO_3^--N is removed in the shallow wells. This is likely due to higher NO_3^--N concentrations in shallow groundwater and more organic matter in the shallower soils, which could lead to higher microbial activity and subsequent denitrification within the buffer. It is also important to note that NO_3^--N removal appears to be greater in the 30-ft buffers.

Table M.1 Percent NO_3^--N reduction determined by the change in NO_3^--N concentration from the edge of the buffer near the field as the water moved toward the ditch.

	Jan-Mar	Apr-June	July-Sept	Oct-Dec	Overall
Deep 15-Ft Buffer	0.52	0.20	0.44	0.12	0.32
Shallow 15-Ft Buffer	0.65	0.73	nd	nd	0.69
Deep 30-Ft Buffer	0.65	0.78	0.85	-0.98	0.71
Shallow 30-Ft Buffer	0.96	0.87	nd	nd	0.92

nd = no data from these wells

The redox potentials indicate that denitrification probably occurs at 5 ft in both the 15- and 30-ft buffers because the average redox potential measurements are less than the +320 to +470 mV expected range (Figures 3, 4). Seasonal variation in redox potentials was measured by the shallow redox probes in both the 15- and 30-ft buffers (Fig. M.3, M.4). Denitrification probably occurs from January to June and from October to December in the 15-ft buffer shallow wells (Fig. M.3). It is uncertain whether denitrification occurs in the 30-ft buffer shallow wells, because all of the redox potential values fell within or exceeded the +320 to +470 mV range (Fig. M.4). The lower rates of removal in the deep wells are probably because the NO_3^--N concentrations are low to begin with at depth (probably as a result of denitrification). It is difficult to determine whether denitrification is responsible for NO_3^--N at 2.5 ft because the redox potentials are higher than expected for denitrification to occur based on the soil pH. However, the high amount of organic matter could cause localized areas of reduced soils that could be responsible for denitrification. It is less likely that the NO_3^--N loss is due to plant uptake because there were few roots found at 2.5 ft during the installation of groundwater monitoring wells and redox probes. It appears that denitrification could be responsible for NO_3^--N removal in the deep wells.

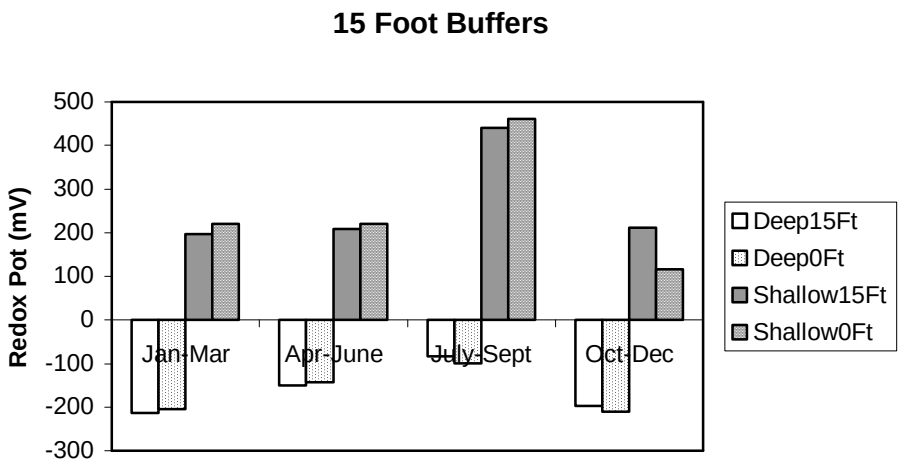

Figure M.3 Average redox potential measurements from deep (5 ft) and shallow (2.5 ft) redox probes in the 15-ft buffers.

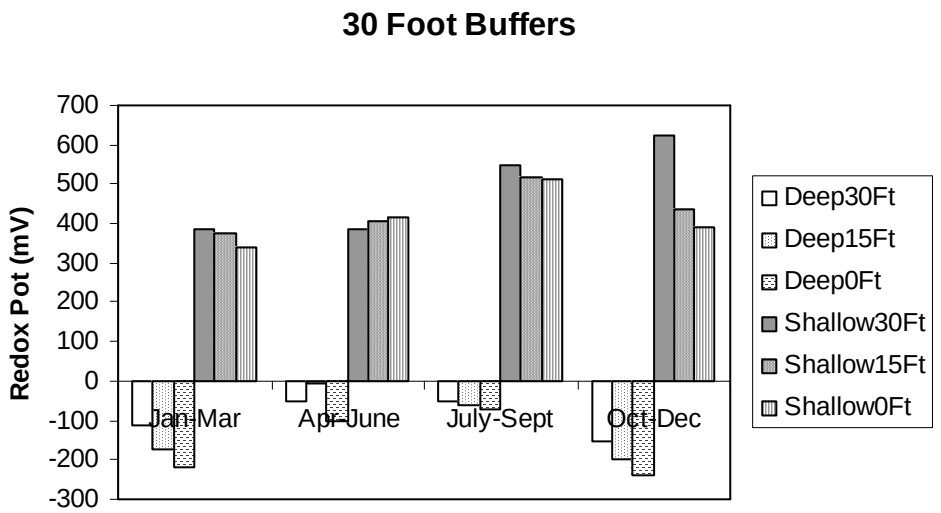

Figure M.4 Average redox potential measurements from deep (5 ft) and shallow (2.5 ft) redox probes in the 30-ft buffers.

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