2009

Biophysical economic analysis of nutrient and sediment management practices in the Mississippi Alluvial Valley

Augustus Nyako Matekole
Louisiana State University and Agricultural and Mechanical College

Recommended Citation

Matekole, Augustus Nyako, "Biophysical economic analysis of nutrient and sediment management practices in the Mississippi Alluvial Valley" (2009). *LSU Doctoral Dissertations*. 1181.
https://repository.lsu.edu/gradschool_dissertations/1181

BIOPHYSICAL ECONOMIC ANALYSIS OF NUTRIENT AND SEDIMENT MANAGEMENT PRACTICES IN THE MISSISSIPPI ALLUVIAL VALLEY

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in
The Department of Agricultural Economics and Agribusiness

by
Augustus Nyako Matekole
B.A., University of Cape Coast, 1999
M.S., University of Georgia, 2003
August 2009

To My Lord and Savior Jesus Christ
&
Parents
Augustus and Juliana Matekole.

Acknowledgements

This has been a journey which without you Lord would never have been possible. You were my song, refuge, and hope during this period. To you belongs all the glory. My deepest and warmest gratitude and thanks goes to my major advisor Dr. John Westra for his guidance, counsel and assistance during this process of flexing out the details of this research. I am also grateful to my committee members Drs Michael Salassi, Walter R. Keithly, Rex H. Caffey and William Moe for their open door policy towards me. You never ceased to listen and direct me through this life experience and dissertation process. You have shaped my character and reasoning process, thus making me a better person. Thank you and I pray that the good Lord will bless you all abundantly in the years and seasons that lie ahead.

I am thankful to Dr. Gail Cramer, the departmental head for his encouragement and advice. You have influenced my life unknowingly with the tranquility that encompasses you. My gratitude also goes to Dr. Appelboom, for providing the biophysical data used in this study. To Dr. Kenneth Paxton, my heart-most thanks goes to you. I am grateful for your assistance and time spent customizing the enterprise crop budgets for this research. The questions never ceased, and your advice was always forthcoming without any hesitancy. To Drs. Ashok Mishra, Jeffrey M. Gillespie, Richard F. Kazmierczak, Krishna P. Paudel and others, my experience will never have been complete without your numerous counsels, corrections and instruction to me. Grace, riches and blessings abound over your lives.

To my colleagues, thank you for your input, advice, suggestions, criticisms and friendship. You have made my life better, and I am very grateful. To International Christian Fellowship members, Remmy, Maggie, Tony, Diana, and present and past members, I am very grateful for your prayers, friendship and time we spent together. Special thanks also go to Phillip, Hannah, Yoseph, Holly, Sundita, David, Josephine, Hal, Ephraim and all the other members of the Thursday prayer group. Your prayers saw me through and I know your reward is forthcoming. To Albert and Karen Baptiste, and Dr. and Mrs. Muhumuza you have been such a blessing. Thank you for your friendship, assistance, encouragement and prayers during my stay at LSU. Thank you Pablo, you were of great assistance to me. God bless you richly.

Delove Nadutey, you have been a wonderful friend and colleague. I appreciate you and say thank you. Thank you Virginia Bond, you are forever cherished. To Saviour, Adeline, Gina, Lina, Enyam, Enyo, Wisdom, Eva, Doris, Ansley and all my friends who were with me at University of Georgia, thank you. You were there for me during a very challenging phase of my life. I love you all. I thank God for all my other friends and departmental appointees from secondary school, undergraduate, master's and PhD who invested into my life. Your name might not be mentioned, but the Lord will reward you all in due season.

To Ewura Adwoa, thank you for your wisdom, counsel and support during this process. I am thankful to the Lord for you and know that this is the beginning of greater things to come. To my siblings Sackitey, Dale, Teye, Djabanor and Ralph thank you for your emotional, financial and physical support through this process. To dad and mum, thank you. Words cannot express my appreciation and gratitude for the emotional, material, spiritual and financial investment you made in my life that has brought me to this position. From my innermost being, thank you.

There have been kinks along the road, trials by fire, but by the Lord I have run through the troop and leaped over the wall. To thee belong the glory, honor and power. I am confident in this one thing; that you will perfect everything that concerns me.

Table of Contents

Abstract

Conventional drainage systems and poorly drained soils tend to increase row crop agriculture nutrient and sediment effluent loads. Best management practices help reduce row crop production environmental pollution. This dissertation looked at nutrient and tillage management practices that could help farmers address future total maximum daily loads (TMDLs) for the Cabin-Teele sub-watershed, within the lower Mississippi River Basin.

The dissertation had two objectives. The first objective was to examine the economic and environmental impact of tillage and nutrient management practices in reducing agricultural pollutants to meet TMDL requirements. Relative cost effectiveness of different tillage and nutrient management practices were analyzed as part of this objective. The second objective was to evaluate and compare social net economic benefits of achieving specific sediment and nutrient criteria reductions; nitrogen, phosphorus and sediment reductions individually, and concurrently (reducing all three simultaneously) given a set of agronomic practices in the watershed.

Results showed reduced tillage system were preferred to either conventional tillage or conservation tillage in Cabin-Teele because of their higher net revenue per acre. Additionally, the intermittent occurrence of hardpan soils (due to heavy rainfalls) in this watershed required disking every four to five years to help maintain yields. Simulated results showed that nitrogen fertilizer management, and conservation tillage, were cost-effective in helping reduce nutrient effluent runoff. Changes in tillage management helped producers reduce sediment loading in the watershed. In the scenario with nutrients and sediment reduced simultaneously, the most binding cropland pollutant was phosphorus.

Chapter 1 Introduction

Planted acres of intensively fertilized crops and conventional drainage systems increase the potential of nutrient and sediment outflow from agricultural fields into neighboring water bodies (Ribaudo et al., 1999). In the Mississippi River Basin, reducing nonpoint outflow of agricultural pollutants from croplands is an area of intensive research and outreach efforts. To address this problem of agricultural pollutants, the economic literature generally suggests the use of policy tools such as economic incentives (taxes, subsidies, and market trading), standards, education, and liability rules (Ribaudo et al., 1999; Shortle and Horan, 2001).

The diverse flow-patterns of water from croplands make regulation using these policy tools quite challenging. Input-based economic incentives such as input taxes could be effective (Shortle and Horan, 2001), though producers could substitute for other pollution-causing inputs (Ribaudo et al., 1999). Likewise, standards that regulate manure or fertilizer applications will not necessarily reduce manure or fertilizer use by farmers on croplands and consequently, will not necessarily reduce nitrate-nitrogen leaching and runoff (Roka and Hoag, 1996; Innes, 2000).

The efficacy and economic efficiency of these instruments also depends on a host of factors including, but not limited to, well defined property rights, availability of information, enforcement and monitoring costs. In real life, these conditions are rarely met. Therefore, the management tool often used in addressing agricultural-related pollution is environmentally friendly agricultural management practices. Friendly agricultural management practices, commonly termed best management practices (BMPs), are farming practices or structures on farming operations which help reduce the outflow and transportation of nutrients and sediments into receiving waters.

Best management practices such as conservation buffers, crop rotation, nutrient management, drainage management, and tillage management may help increase average crop yields, reduce overall nitrogen fertilizer costs, and bring streams and rivers into compliance with total maximum daily loads (TMDLs) (Todd and Varvel, 1989; Bordovsky et al., 1994; Brevé et al., 1998; Nistor and Lowenberg-DeBoer, 2006). The United States Environmental Protection Agency (USEPA) defines TMDLs as “calculation of the maximum amount of a pollutant that a water body can receive and still meet the water quality standards and an allocation of that amount to the pollutant’s sources”. With TMDLs established for primary water bodies, farmers are now encouraged to adopt BMPs that curb nutrient and sediment effluents. Specifically, conservation programs such as the Environmental Quality Incentives Program (EQIP), Conservation Security Program (CSP), and Conservation Reserve Enhancement Program (CREP) were initiated partially to provide the required financial and technical incentives to help farmers establish and implement BMPs in their farming operation.

Adaption of BMPs in agricultural production has arisen partially due to increased third party effects. Third party effects are the action(s) of economic agent(s) that positively or negatively impact another agent(s); yet, these actions are not accounted for and priced in the market system. In agriculture, third parties are the individuals, industries, and even institutions such as municipalities and industrial water treatment facilities, that are usually negatively impacted by increased nutrient and sediment levels in streams and rivers, but have no control over the actions of farmers, and also receive no compensation for any damages incurred.

1.1 Problem Statement

The combined effects of fertilizer use on croplands, conversion of marginal lands into cropland, increased acreage of intensively fertilized crops, and conventional drainage are increased nutrient and sediment effluent loads into streams. According to Shirmohammadi et al., (1995) and Beman et al., (2005), elevated levels of phosphorus and nitrate-nitrogen have caused algae blooms, eutrophication and hypoxic conditions in water. An example is the hypoxia zone in the Gulf of Mexico where the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force notes that agricultural runoffs account for about 74 percent of the nonpoint source nitrate-nitrogen influx (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2001).

Agricultural runoff from fields in the Midwest is the major cause of this hypoxic zone (Burkart and James, 1999; Ribaudo et al., 2001; Petrolia et al., 2005). The task force has set an action plan to reduce the average size of the hypoxic zone in the Northern Gulf of Mexico to less than 5000 km^2 by 2015, which more than halves its estimated level in 1999. Reducing nutrient and sediment loading into streams is the focus of protecting and restoring basin waters and potential impacts on public health and ecosystems. In addressing this issue, current methods employed include cost sharing, and incentive payments for implementing BMPs.

Nevertheless, most farmers are risk averse (Babcock, 1992). This causes some of them to apply quantities of fertilizers exceeding agronomic needs of crops to reduce production risk and uncertainty. Nitrate-nitrogen and phosphates loadings into streams might persist if agricultural intensification continues (Berka et al., 2001). There might be some economic justification for imposing taxes on fertilizers to help fully internalize the external costs associated with damages from excess nutrients in water bodies (Lambert, 1990; Ribaudo et al., 1999). There is a possibility that imposing taxes could lower farm income. The negative political ramifications in terms of votes and negative publicity from powerful farming interest groups might obstruct the fertilizer tax policy.

Hence, BMPs which enable farmers to internalize some of the negative effects of farming by slightly increasing variable costs may assist in reducing society's welfare losses. Policies that encourage, provide incentives, or enforce watershed nutrient and sediment effluent reductions are potentially plausible means of improving the public's welfare. Reductions of nutrient and/or sediment effluent levels from agricultural lands in Louisiana would entail adjustment of cropping activities and behavioral attitudes of farmers. For example, policies directed at nitrogen fertilizer management might cause farmers to adjust expenditures on non-revenue producing aspects of the operation, and lower producer's crop yield expectations. These possible impacts might find a hard audience in farmers. Given the above scenarios, most farmers would be very hesitant and unwilling to adopt nutrient and tillage management practices. For farmers to change current practices, even with local, state and federal assistance, the economic and environmental benefits of these BMPs in the Lower Mississippi Alluvial Valley need to be demonstrated as well as documented.

To this end, water quality, hydrologic response to BMPs, crop acreage, onsite crop yields, weather and geographic information systems data for the Cabin-Teele sub-watershed located in the Mississippi Alluvial Valley, Louisiana were assembled by hydrologists at USDA-ARS Soil and Water Research Unit (SWRU). The Annualized Agricultural Non-Point Source Pollutant Loading Model (AnnAGNPS) simulates drainage hydrology, best management practices, cropland management data, and agrochemical transport using data from the research watershed. These biophysical technical coefficients from AnnAGNPS are inputs in the mathematical programming economic model that combines cropping input and output information with economic information and nutrient constraints to present a stylized version of this watershed.

1.2 Justification of the Study

All states are required to identify impaired water bodies within their borders that do not meet water quality standards under Sections 101(a), 303(c) and 303(d) of the 1972 Clean Water Act (CWA) and subsequent amendments (Federal Water Pollution Control Act, 2002). Then they establish the TMDLs for the pollutants in those water bodies and devise plan for achieving the TMDL. To help establish TMDLs, the USEPA has established maximum contaminant levels (MCLs) for water bodies. An MCL is the concentration of a pollutant above which an adverse effect on human health may occur (USEPA, 1996). For example, the MCL for nitrates in drinking waters is 10 mg/L, and for total ammonia in surface waters (to protect fishes) is between 0.07 and 2.1 mg/L (USEPA, 1986).

In the proposed TMDL rule, the USEPA requires states to establish comprehensive lists of all polluted waters every 4 years, and have a schedule for cleaning polluted waters within 10 years; an additional 5 years is granted if needed. In addition, states are to give priority to polluted waters used for drinking or which support endangered species (USEPA, 2000). The USEPA also has the authority to establish TMDLs for waters in a state if it does not approve of the state's submissions or if states fail to live up to their responsibilities (Houck, 2002).

Economic theory would indicate that as the public's demand for clean drinking water and water-based recreational activities increases, the value of these services will increase. Hence, economic damages will increase if the water bodies are impaired by environmental pollution (Ribaudo et al., 1999). This has caused local, state and federal governments to implement policies that help address nonpoint environmental pollution sources, including agricultural production practices. BMPs for agriculture are facilitated and encouraged by local, state and federal governments with financial assistance for voluntary conservation programs like EQIP (NRCS, 2004).

Research on the efficacy of nutrient and tillage management practices in reducing agricultural pollutants has varying findings. On nitrogen management plans, Smetlz et al., (2005) find them effective in reducing cropland nitrate inputs. Wossink and Osmond (2002) on the other hand, find their impact is dependent on topography of the land. Research by Haycock and Pinay (1993), and Lovell and Sullivan (2006) show that conservation buffers reduce siltation of streams and improve water quality. However, the drainage network (bayous and open-ditches) that traverses the landscape in northeast Louisiana, make buffers largely ineffective. The drainage networks circumvent buffer zones (while serving as gateways for nutrient and sediment runoffs) and prevent them from trapping agricultural pollutants.

Nutrient management practices are a potential means for farmers to reduce nutrient runoff (Yiridoe et al., 1997; Ribaudo et al., 2001; Dinnes et al., 2002) and to meet environmental goals and reduce fertilizer costs. In this study, the inter-relationships between tillage and nutrient management and crop yields are assessed. Results from this research, should help improve the evaluation and implementation of conservation programs by considering the economic ramifications of adopting such farm management practices**.**

1.3 Location and Size of Project Area

The Louisiana Department of Environmental Quality and USEPA have adopted the watershed as the level of analysis to address water quality problems from nonpoint source pollutants (LDEQ, 2006). The Cabin-Teele sub-watershed, located in Madison Parish, northeastern Louisiana was the study area (Figure 1.1). The watershed is 41,466 acres in size of which 28,414 acres are planted to row crops. Agriculturally, the watershed has more than 700 farms, with sizes ranging from one to over 1,000 acres (USDA-NASS, 2007).

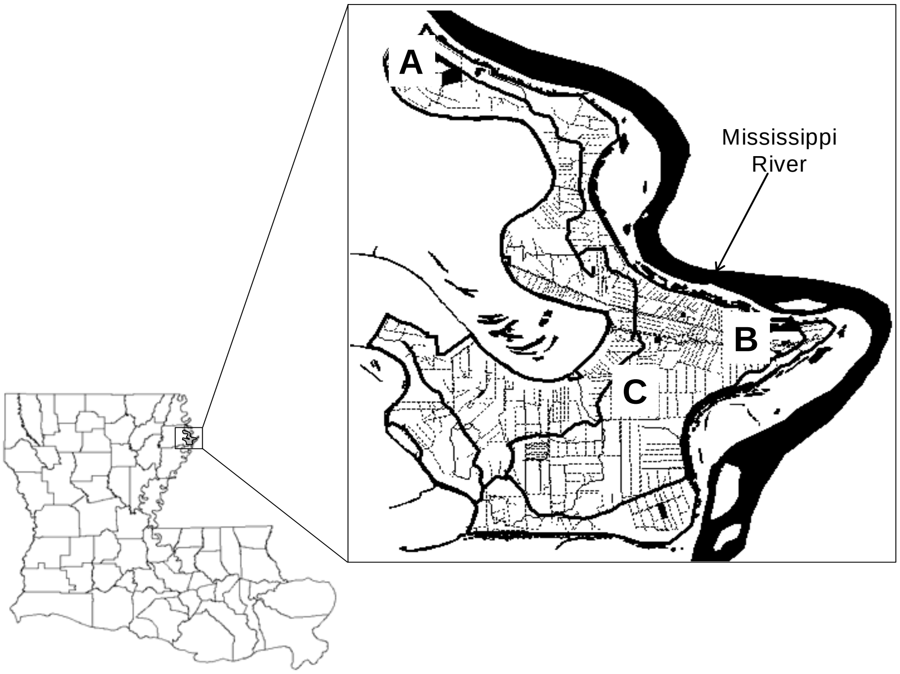

Figure 1.1: **Cabin-Teele Watershed with Reference to Louisiana Map.**

Four different soil series are found in Cabin-Teele. The soil series are Bruin, Commerce, Sharkey and Tunica. These soils are generally low in nitrogen and organic matter content, with pH ranging from highly acidic to mildly alkaline. The alluvial soils, flat topography and natural levees support agricultural crops such as corn, cotton, rice, grain sorghum and soybean.

The drainage network in this region has slopes with ranges between 0.01 and 12 percent. The major streams flowing through this sub-watershed are shown in Figure 1.2. The main drainage network in the area is the Cypress Bayou which drains both the central and northern regions (Appelboom and Fouss, 2005). The Harper and Gar Bayou drain the eastern and western parts of the region. These three bayous all converge in the area which is part of the Roundaway Bayou, located in the southwest region of the watershed. The sub-watershed has impaired waters due to excess amounts of nutrient and sediment deposition (Appelboom and Fouss, 2006).

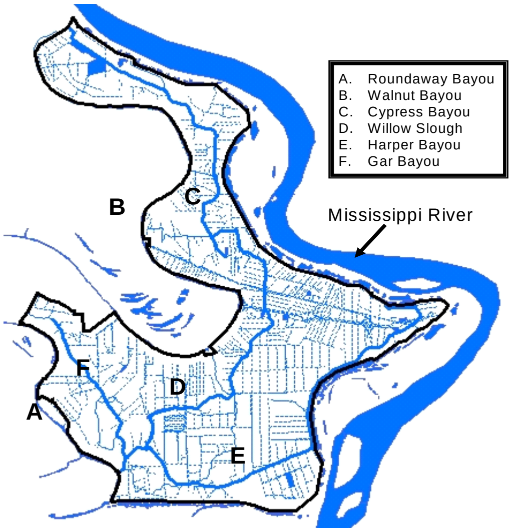

Figure 1.2: Site Map of Cabin-Teele Sub-watershed.

1.4 Objectives

The main goal of this study is to evaluate and compare social economic benefits of achieving a set of nutrient and tillage management practices in the Mississippi Alluvial Valley. Relative cost effectiveness of tillage and nutrient management practices are analyzed as part of this objective. The study is conducted on a watershed scale to evaluate the cropland management practices in Cabin-Teele Sub-Watershed, Madison Parish Louisiana. The study consists of two objectives:

a) To examine the economic and environmental impact of tillage and nutrient management practices in reducing agricultural pollutants to meet TMDL requirements; and

b) To evaluate and compare social net economic benefits of achieving specific sediment and nutrient criteria reductions; nitrogen, phosphorus and sediment reductions individually, and concurrently (reducing all three simultaneously) given a set of agronomic practices in the watershed.

1.5 Organization

The next chapter provides a theoretical and empirical review of the literature on the economics of nonpoint source pollution. Chapter three presents data, methodology and the biophysical economic model in detail. Biophysical economic simulation results for nutrient and sediment management strategies and impact on watershed net revenue and environment are presented in chapter four. Chapter five summarizes the overall study.

Chapter 2 Theory of Externalities and Literature Review

Historic and current agricultural policies that affect crop prices have resulted in over production, and agricultural-related pollution (Reichelderfer, 1990; Ribaudo and Shoemaker, 1995). The problem is a result of price and support programs, which cause farmers' to allocate more resources to farming, resulting in increased nutrient runoffs and sediment yields (Stonehouse, 1996). Conservation programs with environmental stipulations are insufficient to solve this problem because enrollment is voluntary. In this regard, the USEPA's proposed TMDLs program helps ensure that instream flows criteria are adhered to by agents within states and should help reduce agricultural nutrient and sediment pollution.

Thus I assess the cost effectiveness of various on-farm and in-stream water management practices which lessen agricultural nonpoint source (NPS) pollution. To this end, one needs to understand the divergence between private and societal goals in agricultural production as the source of pollution and as explained by the theory of externalities. Thus I review previous work on agricultural NPS pollution.

2.1 Externality Theory

Simply defined, externalities are uncompensated side effects of an agent's production or consumption activities on another. If agent(s) activities generate costs on third parties, it is termed negative externality, and conversely if third party benefits are created a positive externality results. Overall, externalities are an indication of market failure and misallocation of scarce resources. This implies that input or output prices do not show all benefits obtained or costs incurred during production and therefore, a smaller or excess amount of the commodity is produced than is socially optimal. In row crop production, upstream agricultural activities normally impose negative externalities to firms, municipalities, or farmers downstream. To ensure that negative externalities are reduced, economists normally employ two concepts: maximization of net economic benefits and cost effectiveness. Though there are diverse ways of analyzing agricultural NPS pollution, the mathematical approach of Ribaudo et al., (1999) is described below.

2.1.1 Net Economic Benefits

Assuming that production cost and revenue can be determined, allocative efficiency dictates that in using resources, additional benefits to society equate to additional costs. For the commodity market, social marginal benefits of using the resource must equate the social marginal costs incurred. Given that perfect competition exists within the output and price markets, assume that A_i is a scalar variable and shows various technologies used on farms. The variable c is used to represent climatic and other variable farming events. x_{ij}, (m×1) represents a vector of inputs j employed on the i^{th} farmland site. v_i is a farmland site stochastic variable influenced by nature-related runoffs. $r_i = r_i(x_i, A_i, v_i)$ is runoff from a site. $a = a(r_1, ..., r_n, c)$ refers to ambient concentrations (where $a_{ri}>0$). Maximization of expected net benefits for risk-neutral farmers implies:

$$z(T) = \underset{x_{ij},n}{Max} \sum_{i=1}^{n} \pi_i(x_i, A_i) - E[D(a)] \qquad (2.1).$$

In equation (2.1), expected profits, $\Pi_i(x_i, A_i)$, is strictly concave, and $E\,[D\,(a)]$ is the expected economic cost associated with damages attributable to pollution (where $\partial D/\partial x_{ij} \geq 0$ and $\partial^2 D/\partial x_{ij}^2 \geq 0$). The necessary condition for an efficient level of production for each marginal site is then:

$$\partial z/\partial x_{ij} = \partial \pi_i/\partial x_{ij} - E\{[D'(a)](\partial a/\partial r_i)(\partial r_i/\partial x_{ij})\} = 0 \;\; \forall i, j \qquad (2.2)$$

$$\Delta z/\Delta n \approx \pi_n(x_n, A_n) - E[\Delta D(a)] \approx 0 \qquad (2.3).$$

Violation of equation (2.2) results in suboptimal runoff levels. Specifically, equation (2.2) shows that in the use of input(s) on any particular site, marginal net private benefits must equal expected marginal external damages. Ignoring externalities leads to inputs that aggravate runoff increasing $\left(dr_i / \partial x_{ij} > 0\right)$ and those that reduce runoff decreasing $\left(dr_i / \partial x_{ij} < 0\right)$. This results in Pareto inefficiency.

Equation (2.3) demonstrates the marginal effect of site *n* on expected net economic benefits. The expression $\Delta D(a) = D(a(r_1,...,r_n,c)) - D(a(r_1,...,r_{n-1},c))$ shows the damage incurred attributable to site *n*. Private profits are higher than they would be if damages are not taken into account in the production process. This leads to higher output and increased pollution outflow, which is economically suboptimal. If $E[\Delta D(a)] > 0,$ it implies that the n^{th} site is optimal, and positive profits are attained on marginal site *n* (profits equate expected contribution to damages) and all infra-marginal sites (profits exceed expected contribution to damages). If profits are maximized on site *n*, the addition of another site would be suboptimal. Equations (2.2) and (2.3) indicate the efficient level of production for the marginal site.

Estimating the optimal technology $\hat{A}$ is important. The optimal technology is derived by comparing the profits obtained from all efficient technology allocations. The technology yielding the highest net economic benefits is optimal. Specifically, technology $\hat{A}$ is more efficient than $\overline{A}$ if $J(\hat{A}) - J(\overline{A}) \geq 0 \;\; \forall \overline{A}$. Employing suboptimal technologies, that is ignoring environmental effects, increases runoff.

This study looked at the social net economic benefits of achieving specific sediment and nutrient criteria reductions given a set of agronomic practices. The efficiency condition of marginal net private benefits must equal expected marginal external damages was not achieved in this analysis because of transaction costs. Transaction costs are the expenses associated with acquiring information to design, administer, implement and enforce polices. Given these limitations, a second-best policy was used in this study. Second best polices are goals that can be implemented at least cost given economic instruments and transaction costs. This study provides a second best solution of sediment and nutrient effluent load restrictions at the outlet. These environmental pollutant reductions provide incentives for farmers to adopt environmentally friendly agronomic practices and consider external damages of each site brought into production.

2.1.2 Cost Effectiveness

Damages from nonpoint source pollution is often difficult to quantify and sometimes unknown (Baumol and Oates, 1988; Shortle et al., 1998; Ribaudo et al., 1999). Given this scenario, instead of maximizing net economic benefits, the regulator could instead choose to minimize costs. Under cost effectiveness, it is assumed that the policy goal is beneficial to society. The regulator must show that the least cost method for attaining a specified goal has been adopted. Costs are minimized in line with one or a combination of these pre-specified goals: runoff (it assumes inter-linkages between damages and pollution transport mechanisms are known), ambient pollution levels, or inputs and technology constraints. The goal chosen is necessarily contingent upon instrument availability, flexibility to environmental and economic changes, complexity, political will and cost feasibility. The regulators resource problem is:

$$z(T) = \underset{x_{ij}, A_i n}{Max} \sum_{i=1}^{n} \pi_i (x_i, A_i) \qquad (2.4)$$

subject to:

$$E[a] \leq a_0 \qquad (2.5)$$

$$E[r_i] \leq r_{i0} \;\; \forall i \qquad (2.6).$$

In equations (2.5) and (2.6), a_0 and r_{i0} are all determined outside the model and respectively refer to ambient and runoff target, with the latter for the i^{th} production site. In the discussions below, an interior solution is assumed for the first derivatives.

2.1.2.1 Cost Effectiveness Solution Premised on Mean Ambient Targets

The Lagrange for setting a mean ambient target given equations (2.4) and (2.5), and first derivatives with respect to input use and number of sites are respectively:

$$L = \sum_{i=1}^{n} \pi_i(x_i, A_i) + \mu[a_0 - E(a)] \tag{2.7}$$

$$\partial L / \partial x_{ij} = \partial \pi_i / \partial x_{ij} - \mu E\{(\partial a / \partial r_i)(\partial r_i / \partial x_{ij})\} = 0 \ \forall i, j \tag{2.8}$$

$$\Delta L / \Delta n \approx \pi_n(x_n, A_n) - \mu E[\Delta a] \approx 0 \tag{2.9}$$

where $\Delta a = a(r_1,...,r_n,c) - a(r_1,...,r_{n-1},c)$. The Lagrange multiplier μ is the shadow value. It represents an optimal tax or subsidy if the regulated and regulators have equal expectations on the nonpoint process. In equations (2.8) and (2.9), the first order conditions with respect to input use and number of potential runoff sites have the same interpretations as in equations (2.2) and (2.3). Only now marginal damages are defined in terms of marginal cost of mean ambient pollution.

The efficient technology $\hat{A}$ for mean ambient targets is determined by estimating the efficient allocation for all technologies employed on farms and comparing their respective profits. Similar to the net benefits scenario, ambient target technology $\hat{A}$ is more efficient than $\overline{A}$ if $L(\hat{A}) - L(\overline{A}) \geq 0 \ \ \forall \overline{A}$. Ignoring ambient conditions in technology choice increases nutrient runoff from croplands with the attendant inefficient technology. However, for cost effectiveness, an efficient solution is attained only if there is a single site with a single production choice, or the marginal ambient pollution and marginal damage covariance matrix is zero for every site and each input.

2.1.2.2 Cost Effectiveness Solution Premised on Mean Runoff Targets

From equations (2.4) and (2.6), the Lagrange for setting a mean runoff target and first derivatives with respect to input use and number of sites are respectively:

$$L = \sum_{i=1}^{n} \pi_i (x_i, A_i) + \sum_{i=1}^{n} \eta [r_{i0} - E(r_i)] \qquad (2.10)$$

$$\partial L / \partial x_{ij} = \partial \pi_i / \partial x_{ij} - \eta_i E(\partial r_i / \partial x_{ij}) = 0 \;\; \forall i, j \qquad (2.11)$$

$$\Delta L / \Delta n \approx \pi_n (x_n, A_n) - \eta_n [r_{n0} - E(r_n)] \approx 0 \qquad (2.12).$$

Similarly to the mean ambient condition, η_i the shadow value represents an optimal tax or subsidy if farmers and regulators both have the same expectations on the nonpoint process. The shadow value represents the social cost from a marginal increase in mean runoff levels. In equation (2.11), marginal private net benefits from the use of an input on a specific site must equate social marginal costs of mean runoff levels from the use of that input. Moreover, equation (2.12) shows that zero profit is earned for the marginal site given that $E[r_{n0}] = r_n$. This situation however never materializes since input usage at the margins for a cost effective solution differs from that of competitive solutions.

The efficient technology $\hat{A}$ is determined by calculating an optimal allocation for every feasible A and then comparing expected net benefits. Technology $\hat{A}$ is more efficient than $\overline{A}$ if $L(\hat{A}) - L(\overline{A}) \geq 0 \;\; \forall \overline{A}$. Cost effective solutions for mean runoff targets are likely to be inefficient because smaller runoff targets might result in increased runoff variability for some production sites.

2.1.2.3 Cost Effectiveness Solution Premised on Input Usage

Input goals are in terms of aggregate- watershed level or site-specific. For clarity, only the latter is reviewed. Let $x_i' = [y_i, v_i]$, where y_i ($m'\times 1$) is a vector of inputs with goals defined and v_i ($m - m'\times 1$), with goals undefined. Restrictions on input goals are then expressed as:

$$y_{ij} \leq \bar{y}_{ij} \ \forall i, j \qquad (2.13).$$

In equation (2.13), $\bar{y}_{ij}$ refer to the j^{th} input used on the i^{th} site. This goal is flexible because it is either site specific or locally uniform across sites (a region). In the case of uniformity, equation (2.13) is satisfied with equality. Equation (2.13) is an input reduction goal if inputs increase runoff. It is an input expansion goal, if they decrease runoffs. The Lagrange which corresponds to equation (2.4) and (2.13) and first derivatives are:

$$L = \sum_{i=1}^{n} \pi_i\left(y_i, v_i, A_i\right) + \sum_{i=1}^{n} \sum_{j=1}^{m'} \beta_{ij} [y_{i0} - y_i] \qquad (2.14)$$

$$\partial L / \partial y_{ij} = \partial \pi_i / \partial y_{ij} - \beta_{ij} = 0 \ \ \forall i, j \qquad (2.15)$$

$$\partial L / \partial v_{ij} = \partial \pi_i / \partial v_{ij} = 0 \ \ \forall i, j \qquad (2.16)$$

$$\Delta L / \Delta n \approx \pi_n(x_n, A_n) - \beta_n\left[r_{n0} - E\left(r_n\right)\right] \approx 0 \qquad (2.17).$$

Lagrange multiplier β_{ij} is the efficient incentive rate for resource use. The meaning of equation (2.14) is the same as that of equation (2.11). Moreover, the same zero profit condition as explained under the mean runoff targets applies to equation (2.17). Cost effective solution premised on input usage is also inefficient as compared to the competitive solution. Lastly, the optimal technology has similar interpretations and definitions as pertains under the mean runoff targets.

The next section reviews empirical studies on agricultural NPS pollution. Specifically, it outlines the environmental and economic research issue, methods and findings of researchers on the environmental impact of row crop production in various regions.

2.2 Literature Review

Point sources of pollution are not addressed in this study because it is not the emphasis of this study and additionally, economic incentives, and command and control instruments have been found relatively effective in handling this issue. On the other hand, the challenge in the past two to three decades has been with the development of effective control methods for anthropogenic NPS pollution sources: agriculture, atmospheric deposition and urban development.

This study focuses on agricultural management and farm practices related to NPS pollution. Thus the agricultural economic literature review below is compartmentalized into economics of NPS pollution, biophysical linear models and biophysical non-linear models. Though these categories might appear fuzzy, the first, economics of agricultural NPS pollution, looks at studies on nonpoint pollution that generally do not link biophysical data and economic data in modeling. The second and third categories integrate biophysical and economic data, but respectively use linear and non-linear models.

2.2.1 Economics of Nonpoint Source Pollution

The early works of Taylor et al., (1978), Sharp and Bromley (1979), and Griffin and Bromley (1982) provided some of the needed impetus and insights into the economics of agricultural NPS issues. All but Taylor et al. were on theoretical underpinnings into the economics of nonpoint pollution. In general, empirical studies on nonpoint source pollution include the following:

Anderson et al., (1985); Johansson et al., (2004); Brevé et al., (1998); Vickner et al., (1998); El-Sadek et al., (2002); and Borisova et al., (2003). These studies are reviewed in-depth below.

Anderson et al., (1985) looked at the possible linkages between levels of Aldicarb (an agricultural pesticide) applications on potato fields and subsequent concentrations of this pesticide in groundwater. Data used in the analysis was obtained from Washington County Rhode Island wells. Results indicated a positive relationship between the Aldicarb application rate and groundwater contamination levels. The finding supported the speculation of other studies of nutrient and pesticide potential impact on surrounding water systems.

Johansson et al., (2004) used a frontier regression model to assess policies directed towards lessening the level of phosphorus discharge from farmlands in the Sand Creek watershed located in Southeastern Minnesota. They found that a non-targeted policy aimed at lessening phosphorus outflow by 40 percent for a typical 139 ha farmland was approximately US$9/ha. Targeted programs on the other hand will cost US$6/ha. The result suggests that targeted phosphorus policies on croplands and more importantly at the watershed level has the potential in reducing phosphate negative impacts on surrounding ecosystems.

Brevé et al., (1998) assessed the impacts of producer management treatments and drainage design on crop production, profitability, and nitrate-nitrogen loss in eastern North Carolina. A twenty year (1971-1990) simulation was conducted with DRAINMOD-N, a water balance model, on annual nitrate-nitrogen losses in two artificially poorly drained soils. They concluded that employing controlled drainage, decreasing drainage depth and improvement of surface drainage decreases nitrate-nitrogen loss from fields. Profits decreased if water quality is considered as equally important as high yields. This research suggests that adoption of BMPs increases farmers' non-revenue producing aspects of operation. Economic impacts of decreased farm income due to cropland nutrient and sediment load restrictions should be considered in designing agrarian environmental policies.

Vickner et al., (1998) employed a dynamic economic model to determine the environmental effects of corn production in the South Platte River Basin, Colorado. The analysis also looked at the effects of nitrate leaching under non-uniform irrigation conditions. The study assumed drainage constraints were absent and irrigation water was inexpensive. Findings showed most fields were over irrigated, and increased irrigation system uniformity on croplands helped decrease irrigation water and fertilizer usage. Irrigation uniformity increased residual soil nitrogen, corn grain yield and discounted net revenue (which exhibited diminishing marginal benefit).

Drainage system management on cropland impacts agricultural profits and water quality. El-Sadek et al., (2002) used DRAINMOD-N, cost-benefit analysis and climatic data from 1985-1998 to assess the influence of controlled and conventional drainage on profits and water quality. The study was conducted on an experimental field located in Kempen, Belgium. They found that controlled drainage, as compared to conventional drainage increased surface runoff but decreased subsurface drainage. In the winter seasons, nitrate-nitrogen loss was substantially reduced with controlled drainage. Similar to the results of Brevé and others, they found the use of controlled drainage reduced profits relative to conventional drainage.

Borisova et al., (2003) undertook an empirical analysis to compare the effectiveness of price and quantity instruments under uncertainty in decreasing nitrogen runoff from farmlands in the Susquehanna River Basin, Pennsylvania. They also assessed the value of information in enhancing the efficacy of nitrogen pollution control instruments. Pollution transport coefficients were obtained from the USGS SPARROW model. Results indicated that price instruments were more effective than input quantity controls. Moreover, acquiring information enhanced the efficiency of both policy instruments, especially, the quantity control instrument. This study suggests that producers' disclosure of information on crop yields, and tillage and nutrient management practices should help in designing and implementing policies that reduce environmental impacts of crop production.

2.2.2 Economic Estimation of Nonpoint Pollution: Linear Model

Since Jacobs and Timmons (1974), Taylor and Frohberg (1977), Osteen and Seitz (1978) and Jacobs and Casler (1979), linear programming techniques have been used to analyze policy impacts of restricting sediment erosion, banning or restricting pesticides, and controlling fertilizer application. These early works set the standard for later studies that linked biophysical and hydrological data with economic optimization models.

Much of the research using linear programming models is devoted to controlling agricultural pollutants. Others have looked at yield, risk, cost-effectiveness and expected net revenue. In this section, I review works by Gardner and Young (1988), Taylor et al., (1992), Saha et al., (1994), Foltz et al., (1995), Teague et al., (1995), Carpentier et al., (1998), Qiu et al., (1998), Prato and Kang (1998), Qiu and Prato (1998), Intarapapong et al., (2005), Petrolia and others (2005), and Qui (2005).

Gardner and Young (1988) used a deterministic linear programming model to simulate irrigation technology, crop production decisions, and management decisions in the Grand Valley of Western Colorado. The researchers looked at strategies that if employed could help lessen high salinity levels induced by inefficient irrigation practices. Assuming the existence of upstream and downstream users of the Colorado River, results indicated that the control strategy will amount to who holds the entitlement for water quality. If upstream users had no rights to pollution, they must pay the cost for salinity control, and vice versa. When entitlements cannot be determined between downstream and upstream users, both must share the cost of salinity control.

Taylor et al., (1992) used representative farms in the Willamette Valley of Oregon to determine strategies that lessen nutrient and sediment outflow from fields. They used EPIC output and a linear programming model to ascertain the profit maximizing crop mix and environmental outflow. They could not find a single optimal policy across all farm types examined.

Saha et al., (1994) used an expo-power utility function and four year data on fifteen wheat farms in Kansas to jointly estimate farmers' risk preference structures, degree of risk aversion, and production technology. Findings indicated Kansas wheat farmers were risk averse. Results also showed Kansas farmers exhibited a decreasing absolute risk aversion and an increasing relative risk aversion. Compared to larger farms, smaller farms had a higher absolute risk aversion and a lower relative risk aversion. Joint estimation of utility and production functions was also found to be more efficient than individual estimations of farmers' risk preference structures, degree of risk aversion, and production technology. This is important to this study because it shows that producers risk averseness plays an important role in agronomic production technology adoption and decision making.

Foltz et al., (1995) combined economic and environmental (soil and water) quality considerations in a multi-attribute decision analysis to rank alternative Midwestern cropping systems. The analysis assumed some farmers were highly environmentally friendly. Crop yield, soil erosion and nutrient movement parameters were obtained with EPIC, while Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) was used to estimate pesticide leaching and runoff values. The authors found farmers were neutral when it comes to profits or environmental concerns. Producers favored continuous corn and minimum tillage on low-yielding soils or corn-soybean rotation and minimum tillage on high-yielding soils.

Using an Environmental Target MOTAD model, Teague et al., (1995) developed an environmental index to assess the tradeoffs between environmental risks and net revenue of representative farms in the Oklahoma panhandle. Findings indicated expected net revenue were relatively less sensitive to pesticide loading restrictions compared to nitrates. This finding is important to this study because it shows that the relative impact of phosphorus, nitrogen or sediment restrictions on expected net revenue might vary.

Carpentier et al., (1998) contrasted the value of spatial information for reducing farmland NPS pollution under a uniform and targeted regulatory performance standard. The conceptual framework was written as a constrained optimization problem, and applied as a case study of dairies located in the Lower Susquehanna watershed. With a 40 percent reduction in nitrogen runoff, the authors saw that spatial information's costs decreased by 75 percent using the targeted standard as opposed to the uniform standard. Targeted standards were found to reduce nitrogen runoff by almost 80 percent compared to uniform standards.

Increasing crop yields through variable application of nitrogen on spatially diverse soil conditions has generated interest in the crop production-water quality literature. An example is Prato and Kang (1998). They looked at water quality and the economic impact of a variable and uniform application of nitrogen in the Goodwater Creek watershed, Missouri. The study was conducted under a framework that combined GIS, an Erosion Productivity Impact Calculator (EPIC) model and an economic optimization model. Results showed that for both uniform and variable application rates, profitability and water quality effects varied with crop rotation.

Variable and uniform application rates also had different impacts on nitrogen application rates, surface and ground water quality, as well as crop yield, with no application method necessarily superior to the other.

Qiu et al. (1998) advanced the model adopted by Teague et al. by using a Target MOTAD model to estimate economic risk and environmental risk for agriculture yield variability for six farming systems in Goodwater Creek watershed, north central Missouri. Results showed that farmers and watershed managers' attitude towards risk significantly impacted economic and environmental tradeoffs. Therefore, coordination of farmers and agencies attitudes on environmental risks is essential for successful implementation of watershed policies.

Qiu and Prato (1998) employed a biophysical economic model to assess the economic value of riparian buffers in reducing atrazine pollution (for farming systems in Goodwater Creek watershed, north central Missouri). The gross economic value of riparian buffers was estimated as the difference between total watershed net revenue (TWNR) with and without the buffers. The opportunity cost of riparian buffers was also factored into the estimation of TWNR. Excluding maintenance costs, results showed TWNR was higher with riparian buffers for achieving atrazine concentration level.

Intarapapong et al., (2005) compared continuous cropping with crop rotation (for three tillage practices) in attaining TMDLs in farming regions of Mississippi. The research assessed the potential impact on expected income, nutrient and sediment runoff. Crop rotation practices had higher profits than continuous cropping systems. Though reductions of both sediments and nitrates decreased net revenue to farmers, a sediment reduction policy was found to be relatively more expensive.

Petrolia and others (2005) assessed the feasibility of using agricultural drainage to attain a 20 or 30 percent reduction of nitrogen loads in Cottonwood River Watershed, southwestern Minnesota. The study showed that it was cost effective to abate nitrogen loads using tile drainage when adopting a combined policy of nutrient management and retirement of non-drained land. Removing tile drains from drained land was not cost-effective, even if land was totally retired for pasture or used for crop production.

Qui (2005) employed the weighted sum model, Soil and Water Assessment Tool (SWAT) model, and an enterprise budget generator to assess economic and environmental farm level decision making in the Goodwater Creek watershed, north central Missouri. The study sought to determine whether a coordinated watershed-level management, where farmers collaborate and share similar criterion weights, was better than an uncoordinated scenario with independent farmers. Their findings showed that though the former decreased total watershed net revenue and slightly increased soil loss, it reduced the levels of atrazine and nitrate concentration runoffs.

2.2.3 Economic Estimation of Nonpoint Pollution: Non-linear Model

There have been few studies employing non-linear models to evaluate NPS pollution problems in agriculture. This is due to data issues as well as the difficulty and complexity of modeling nonlinearities. Some relevant non-linear models in the field of nonpoint pollution include Braden et al., (1989); Bouzaher et al., (1990); Randhir and Lee (1997); Westra et al., (2002) and Aftab et al., (2007). The details of these studies are given below.

Braden et al., (1989) looked at the least cost management method of obtaining a total abatement cost frontier for sediment loads from agricultural lands located within the Long Creek Watershed, Macon County Illinois. The authors employed the sediment economics (SEDEC) model, a dynamic programming algorithm, in optimizing farming net revenue given sediment constraints. The authors concluded that failure to account for transport interventions of sediments resulted in suboptimal sediment abatement levels, which increased sediment abatement costs.

Similar to Braden et al., Bouzaher et al., (1990) used the SEDEC model to determine changes in farming practices that are cost efficient and lessens sediment deposition into the water channels of Piatt and Madison Counties, Illinois. The authors realized that compared to an erosion standard or erosion taxes, central planning was more efficient in decreasing sediment deposition.

Randhir and Lee (1997) used EPIC and a multiyear risk programming model to study the impact of taxes and regulation of farm inputs on producer income, farm risk, crop production decisions, input use, and water quality in Indiana. Findings indicated that agricultural policies which are targeted towards a specific pollutant could increase non-targeted pollutants as well as impact economic returns and farming risk levels. It was therefore important to take these tradeoffs into consideration in attaining cost effective policies. On the other hand, neglecting tradeoffs increases farmers' financial risk and new pollutant problems.

Westra et al., (2002) used a positive math programming model to investigate the cost effectiveness of either targeting or not targeting specific practices in reducing NPS pollution in the Le Sueur watershed, Minnesota. The research showed that phosphorus outflow reduction from fields was most cost effective when fields were targeted. This enabled more cropland to be farmed while meeting the required phosphorus load reduction level. However, if a uniform phosphorus reduction was required of farmers, the most cost effective alternative is land retirement.

Aftab et al., (2007) employed a biophysical economic optimization model to analyze a multiple target environmental objective. They examined the potential benefits of improving water quality through joint utilization of both nutrient pollution and maintaining a minimum river flow. The research was conducted at the West Peffer catchment area in East Lothian, Scotland**.** The authors realized that minimum river flow controls facilitated nitrogen outflow reduction. However, minimum river flow standards were insufficient by themselves to curtail nitrogen outflow from agricultural lands. Lastly, irrigation restrictions reduced the amount of economic instruments necessary in attaining nitrate concentration levels.

Chapter 3 Data and Methodology

3.1 Introduction

Two different sets of data were required for this study: biophysical and economic. The chapter begins by stating biophysical data sources. It continues by enumerating on processes involved in using the biophysical model to conduct simulations, and model limitations. The study then addresses crop yield data issues for the economic model. Economic data sources and methodology employed are desribed. The chapter ends by presenting the biophysical economic model.

3.2 Biophysical Data and Methodology

3.2.1 AnnAGNPS Data Sources

Model inputs essential for AnnAGNPS simulations include: field, schedule and operations management data, fertilizer application data, crop data, non-crop land use data and soil data. This information was acquired from the extensive work done by Appelboom and Fouss (2006) in Cabin-Teele sub-watershed. Daily weather data, critical in the modeling process, were obtained from Dr. Kevin Robbins of the Southern Regional Climate Center, Louisiana State University. In the modeling, seven years of weather data (1998-2004) were used for the simulation. The average annual rainfall for simulation period was 1,226.15mm. The actual simulation used cropping data from 2002 only because these were the most detailed available.

3.2.2 AnnAGNPS Methodology

Annualized Agricultural Nonpoint Source (AnnAGNPS) model was used to estimate sediment, nutrient and phosphorus runoffs from crop production practices, including changes to nitrogen fertilizer application rates, tillage, and producer management practices. AnnAGNPS is a watershed scale model which simulates the effects of production practices and the resulting nutrients, pesticides and sediments runoff quantities and their movement through the watershed. Sediment and nutrient runoff calculations are conducted using the Revised Universal Soil Loss Equation (RUSLE) and runoff curve numbers respectively. Before simulating production activities, the watershed is divided into homogeneous soil types, land use and land management areas. The model output allows one to estimate the environmental impact of current practices with and without nutrient and tillage BMPs.

A vital element in biophysical simulations is model calibration, which is important for validation and applicability (Taylor et al., 1992). Though the model was not calibrated to this watershed (due to insufficient stream data), the model output fell within the range of observations from the watershed. Weather conditions over the simulation period were similar to the long-term averages for that area.

The main limitations of AnnAGNPS include: (1) simulations are done on a daily basis by essentially channeling every nutrient and sediment runoffs to the watershed outlet. This is a limitation because there could be time lags in nutrient and sediment runoffs to the outlet; (2) discharges from point sources have constant loading rates throughout the simulation period. This is a limitation because point source loading rates in reality varies; and (3) it does not provide for the daily determination of the amount of nutrients attached to sediments deposited into streams. This is a limitation because nutrients attached to sediments could increase total nutrient loads at the watershed outlet.

3.3 Economic Data

3.3.1 Yield Data and Methodology

Yield data associated with various nitrogen fertilizer application rates were unavailable for Cabin-Teele watershed. Crop yield data from research station experiments were obtained for

LSU AgCenter Research Experiment Station reports (cotton, corn, soybean and rice) and Mississippi State University Research and Extension Center reports (grain sorghum) (Table 3.1). To determine the amount of nitrogen fertilizer applied on corn, cotton, rice, and grain sorghum in Cabin-Teele watershed, agricultural producers were personally interviewed by Appelboom and Fouss (2006).

Table 3.1: Experimental Crop Yield Data.

Nitrogen lb/acre	Conventional Till	Conservation Till
	Cotton (lbs/A)	
135	913	1,082
90	888	1,109
45	716	982
0	399	700
	Corn (bu/A)	
200	174	178
150	158	162
100	126	130
50	79	83
	Rice (cwt/A)	
180	65	73
150	67	69
120	67	70
90	66	65
	Grain Sorghum (bu/A)	
200	75	78
120	81	80
80	76	83
40	71	79

Because data from research experimental stations did not correspond to producer crop nitrogen application rates, I fit a quadratic equation between nitrogen application rates and corn, cotton, rice and grain sorghum yields. This form helped derive values that corresponded to farming practices in the watershed (assuming diminishing marginal product in yields at higher increments of fertilizer application). I also assumed that effects of weather and soil conditions on crop yield are minimal and following the example of Giraldez and Fox (1995), the fitted equation (using ordinary least squares) for each crop (corn, cotton, rice, and grain sorghum) was estimated as follows:

$$cyd_i = a_0 + nit_i + nit_i^2 \qquad (3.0)$$

In equation (3.0), *i*, refers to different rates of nitrogen fertilizer application. The variables *cyd* and *nit* refer to crop yield and amount of nitrogen fertilizer applied, respectively. In the equation, a_0 refers to the intercept. Values obtained from equation (3.0) corresponded well with crop yield values obtained from agronomists. Appendix A shows the estimated model and statistics.

Because data were unavailable for expected yields associated with reduced tillage, I assumed that reduced tillage values were within the continuum of conventional and conservation tillage yields. Average yield values of the sum of conventional and conservation tillage yields were assumed to represent reduced tillage. A tillage index was created based on relative productivity of the other tillage practices to conventional tillage; that is, simply dividing the other tillage yield values by conventional tillage. Table (3.2) summarizes this information. I estimated the USDA-NASS Madison Parish area weighted crop yield values by dividing crop production units by harvested crop acres (Table 3.3). Crop yields by tillage are estimated by multiplying the tillage index by corresponding average weighted yields for Madison Parish (2002-2007) (Table 3.4). These estimated values were within the range of yield observed in Louisiana.

In deriving crop yield values by soil type, the following methods were employed. The soil series map of Madison Parish (Soil Survey Map of Madison Parish) gives estimated dryland average yield per acre for farmers under the following assumptions: “rainfall is effectively used and conserved; surface drainage systems are installed; crop residue is managed to maintain soil tillage; minimum but timely tillage is used; insect, disease and weed control measures are consistently used; fertilizer is applied according to soil test and crop needs; and suitable crop varieties are used at recommended seeding rates” (USDA-NRCS, 1982).

Table 3.2: Estimated Crop Yield Data and Tillage Index.

Nitrogen	Estimated Tillage Data			Tillage Index		
lb/acre	Conventional	Reduced	Conservation	Conventional	Reduced	Conservation
			Cotton (lbs/A)			
100	906	1,011	1,116	1.00	1.12	1.23
90	888	998	1,109	0.98	1.10	1.22
80	862	978	1,094	0.95	1.08	1.21
70	830	951	1,072	0.92	1.05	1.18
			Corn (bu/A)			
200	174	176	178	1.00	1.01	1.02
180	169	171	173	0.97	0.98	1.00
160	162	164	166	0.93	0.94	0.96
140	153	155	157	0.88	0.89	0.90
			Rice (cwt/A)			
150	67	69	71	1.00	1.02	1.05
135	67	68	70	1.00	1.02	1.03
120	67	68	68	0.99	1.00	1.01
105	66	67	67	0.98	0.99	0.99
			Grain Sorghum (bu/A)			
100	79	81	83	1.00	1.02	1.05
90	78	80	82	0.99	1.02	1.04
80	77	79	81	0.98	1.01	1.03
70	76	78	80	0.96	0.99	1.02

Table 3.3: Average Weighted Crop Yields for Madison Parish (2002-07).

Crops	Production	Acres Harvested	Average Weighted Yield
Corn	57,790,000 bu	442,900	130 bu/A
Cotton	203,232,000 lbs	233,100	872 lbs/A
Rice	2,220,000 cwt	35,800	62 cwt/A
Sorghum	2,015,000 bu	23,900	84 bu/A
Soybean	12,790,000 bu	357,300	36 bu/A

Table 3.4: Crop Yield Estimates by Tillage.

N lb/acre	Conventional till	Reduced till	Conservation till
	Cotton (lbs/A)		
100	872	973	1,075
90	854	961	1,068
80	830	942	1,053
70	799	915	1,032
	Corn (bu/A)		
200	130	132	133
180	127	129	130
160	122	123	125
140	115	116	118
	Rice (cwt/A)		
150	62	64	65
135	62	63	64
120	62	62	63
105	61	61	62
	Grain Sorghum (bu/A)		
100	86	88	90
90	85	87	90
80	84	87	89
70	83	85	88

Table (3.5) gives a summary of this information. The shaded portions in Table (3.5) indicate interpolated yield data. Data for the shaded portions were derived through linear interpolation of cotton and corn yields. I assumed that corn and grain sorghum have similar yield patterns by soil type.

A soil yield index was created to determine crop yields by tillage and soil type. On research plots, corn, rice, cotton, and soybeans were planted on Sharkey clay soil, and grain sorghum on Bruin Silt loam soil. In the case of rice and grain sorghum, soil type differed from the ones found in Madison Parish. Soil types were matched with that of Madison Parish by considering permeability of the soil and soil fertility. Values for the soil index are presented in Table (3.6).

Table 3.5: Estimated Average Yield per Acre For Principal Crops in Madison Parish.

Soil Type	Symbol	Corn	Cotton	Rice	Sorghum	Soybeans
		(bu)	(lbs)	(cwt)	(bu)	(bu)
Bruin Silt Loam	Ba	100	950		100	42
Commerce Silt Loam	Cm	95	900		95	40
Commerce Silty Clam Loam	Cn	85	850		85	40
Commerce Silty Clam Loam Gently	Co	85	800		85	35
Sharkey Silty Clay Loam	Sb	75	700	130	75	40
Sharkey Clay	Sc	73	675	130	73	40
Sharkey Clay Undulating	Sd	65	600		65	35
Sharkey-Tunica Complex Gently	St	65	600		65	35
Tunica Clay	Tu	70	650	130	70	40

Table 3.6: Soil Index For Principal Crops in Madison Parish.

Soil Type	Symbol	Corn	Cotton	Rice	Sorghum	Soybeans
Bruin Silt Loam	Ba	1.38	1.41		1.00	1.05
Commerce Silt Loam	Cm	1.31	1.33		0.95	1.00
Commerce Silty Clam Loam	Cn	1.17	1.26		0.85	1.00
Commerce Silty Clam Loam Gently	Co	1.17	1.19		0.85	0.88
Sharkey Silty Clay Loam	Sb	1.03	1.04		0.75	1.00
Sharkey Clay	Sc	1.00	1.00	1.00	0.73	1.00
Sharkey Clay Undulating	Sd	0.90	0.89		0.65	0.88
Sharkey-Tunica Complex Gently	St	0.90	0.89		0.65	0.88
Tunica Clay	Tu	0.97	0.96		0.70	1.00

They are quotients of the values in Table (3.5) by experimental crop soil type. For example, cotton was cultivated on Sc. In Table 3.6, the index value for Sc is 1.00 (675/675) and that for Sb is 1.04 (700/675). Multiplying soil index by tillage yields resulted in crop yields by tillage and soil type.

3.3.2 Input Data and Methodology

Crop machinery and input requirements for tillage practices were gathered from farm management research and extension reports (Paxton, 2008). Data for physical inputs (for example, machinery complements) were gathered through personal interviews of agricultural producers in Cabin-Teele watershed. Historic prices (2002-07) were gathered from USDA-NASS (USDA-NASS, 2008). Historical payment rates, crop acres, and crop yields for direct payments and counter-cyclical payments were obtained from USDA-FSA (USDA-FSA, 2009). Information on annual per acre rental payments for conservation programs (WRP and CRP) were obtained from USDA-FSA (USDA-FSA, 2009). Extent of tillage practices or crop residue management for Madison parish were obtained from Conservation Technology Information Center (CTIC website: http://www.conservationinformation.org/?action=members_crm). Production costs and returns estimates for each cropping system, for conventional, reduced and conservation tillage practices were customized to farming practices in the sub-watershed. Input and equipment costs for the simulation period 2007/2008 were used in preparing the budgets. Input costs reflected for the most recent rise through 2008.

Negative net revenue has been projected for the cotton crop in northeastern Louisiana. In this study, cotton enterprise budgets included ginning revenue and cost. Including ginning in the budget is justified on the grounds that cotton farmers obtain additional revenue from ginning which is not included in the traditional enterprise cotton budgets. Mitchell et al., (2007) found that seed per lint ratio in Texas has been declining since the 1970's. The lint to seed ratio for the 2000's has been 1.57 (Mitchell et al.). For Louisiana, I assumed lint to seed ratio of 1.33 based on information (personal interviews) obtained from ginners for new cotton varieties in Louisiana.

Crop prices and nitrogen fertilizer prices were averaged over 6 years (2002-2007) and reflect nominal prices (Table 3.7). Averaged prices were lower compared to current and future projected crop and nitrogen prices (Good and Irwin, 2008; USDA-NASS, 2009). Sensitivity analyses were conducted to determine effects of increased crop and nitrogen price on expected net revenues in Cabin-Teele watershed.

Table 3.7: Louisiana Marketing Year Crop Prices Received and LA Nitrogen Fertilizer Prices (2002-07).

Year	Corn	Cotton	Rice	Sorghum	Soybean	LA Nitrogen
	$/bu	$/lbs	$/cwt	$/bu	$/bu	$/lbs
2002	2.40	0.52	6.50	2.42	5.52	0.21
2003	2.40	0.61	7.68	2.42	6.80	0.27
2004	2.45	0.52	7.77	2.13	6.29	0.30
2005	2.25	0.52	7.47	2.13	5.97	0.36
2006	2.80	0.52	9.83	2.75	5.94	0.39
2007	3.80	0.52	11.10	3.65	8.85	0.46
Mean	**2.68**	**0.54**	**8.39**	**2.58**	**6.56**	**0.33**

The bio-economic modeling which follows looked at the impact on farming net revenues in the sub-watershed when a policy is implemented that seeks to reduce nutrient and sediment levels in the watershed.

3.4 Economic Modeling with Environmental Constraints

The model employed in the analysis incorporates crop yield, input prices, government crop price subsidies, tillage practices, nitrogen fertilizer management, soil types, and cropland effluents of nitrogen (attached and dissolved), phosphorus (attached and dissolved) and sediments (clay, silt, and sand) in maximizing net revenues for producers in the watershed. Only continuous cropping was considered in the analysis.

Maximizing expected net revenues is the primary factor driving crop production in this study area. Net watershed income is maximized in the following equations by subtracting total cost from total revenues across various combinations of crop and soil types, tillage practices, and nitrogen fertilizer application rates. A linear programming model is used for the estimation. The objective function, equation (3.1), is maximized subject to these constraints:

$$Max\ \ NB = \left(\sum_{i,k,b,t} \left[(p_i) y_{i,k,b,t} \right] - VC_{i,t} - FC_{i,t} \right) x_{i,k,b,t} + \sum_i \begin{bmatrix} (cp_i)(pgyldcp_i) \\ (0.85)(baseacp_i) \end{bmatrix} + \sum_i \begin{bmatrix} (dp_i)(pgylddp_i) \\ (0.85)(baseadp_i) \end{bmatrix} + \left[(RP_{wrp})(x_{wrp}) + (RP_{crp})(x_{crp}) \right] \tag{3.1}$$

$$\sum_{i,k,b,t} x_{i,k,b,t} \le \overline{A} \tag{3.2}$$

$$\sum_{i,k} x_{i,k,b,t} \le \overline{\overline{A}}_{i,k} \tag{3.3}$$

$$x_{i,k,b,t} \ge 0 \quad \forall i,k,b,t \tag{3.4}$$

In the above equations, *i* represent crop type (corn; cotton; rice; sorghum; and soybean). *k* shows soil type (nine). *t* represents tillage practices (conventional; reduced; and conservation). *b* refers to fertilizer nitrogen application rates (hundred, ninety, eighty and seventy percent levels). Hundred represents current nitrogen fertilizer application in the sub-watershed. Ninety, eighty and seventy show a 10 percent, 20 percent and 30 percent reduction from current nitrogen fertilizer application rates respectively. *x* refers to cropping acres. p_i is a vector of averaged Louisiana crop prices received over the years 2002-07. *y* represents crop yields. *VC* shows variable input costs per acre. *FC* is fixed cost per acre. $\overline{\overline{A}}$ refers to soil-crop acre combinations. $\overline{A}$ represents total acres in the sub-watershed for crop production.

Moreover, cp_i and dp_i refer to vectors of averaged counter-cyclical payment rates and averaged direct payment rates for the crop *i* received over the years 2002-2007 respectively. $pgyldcp_i$ represents historical counter-cyclical payment yield for the commodity. $pgylddp_i$ refers to historical direct payments yield for the commodity. $baseacp_i$ is counter-cyclical historical payment crop acres. $baseadp_i$ shows direct payments historical payment crop acres. RP_{wrp} shows

WRP annual rental payments per acre. RP_{crp} is CRP annual rental payments per acre. x_{wrp} shows total acres under WRP in the watershed. x_{crp} is total acres under CRP in the watershed.

The first term in equation (3.1) is affected by producer planting decisions. Net revenues are a function of crop prices, crop yield, variable input costs and fixed costs. The second and third terms (in equation 3.1) refer to counter-cyclical payments and direct payments received by agricultural producers respectively. Payment rates are not affected by planting decisions. These payment programs are based on historical base acres and payment yields. Counter-cyclical payment rates (cp_i) are affected by national average market prices (cp_i = target price for the commodity – [dp_i + higher of (national average market year price for the commodity or the national loan rate for the commodity)]. The fourth term in equation (3.1) show annual revenue obtained by producers from enrolling in WRP and CRP.

The equation (3.2) constrains the simulated total acres to total watershed crop acres. Equation (3.3) constrains simulated acres by soil and crop type to current soil-crop acre combinations in the watershed (nine equations). It ensures that less productive soils are not wholly ignored in the mathematical simulation process. Equation (3.4) is a non-negativity constraint. The model was initially estimated with conventional tillage and current fertilizer applications.

The environmental impact of agricultural production is analyzed through the following equations:

$$\sum_{i,k,b,t} n_{i,k,b,t} x_{i,k,b,t} \leq \overline{N}(1-\alpha) \tag{3.5}$$

$$\sum_{i,k,b,t} s_{i,k,b,t} x_{i,k,b,t} \leq \overline{S}(1-\alpha) \tag{3.6}$$

$$\sum_{i,k,b,t} ph_{i,k,b,t} x_{i,k,b,t} \leq \overline{ph}(1-\alpha) \tag{3.7}$$

In these equations, n refers to nitrate-nitrogen loads at the outlet per acre. ph represents phosphorus loads at the outlet per acre. S is sediment yield at the outlet per acre. $\overline{S}$ shows total sediment load at the outlet. $\overline{N}$ refers to total nitrogen runoff at the outlet. $\overline{ph}$ represents total phosphorus runoff at the outlet. $s_{i,k,b,t}$ shows tons per acre sediment runoffs. $n_{i,k,b,t}$ is pounds per acre nitrogen runoffs. $ph_{i,k,b,t}$ shows pounds per acre phosphorus runoffs. The environmental equations show the limits on overall quantity of sediments, nitrogen and phosphorus loss by crops, tillage, soils and nitrogen fertilizer application in the watershed. In equations (3.5) to (3.7), α (which equals 0.10, 0.20 and 0.30) indicates 10 percent, 20 percent and 30 percent reduction from baseline loadings.

The study then evaluates and compares social economic benefits of achieving a set of tillage and nutrient management practices in addressing specific sediment and nutrient criteria reductions; nitrogen, phosphorus and sediment reductions individually and concurrently (reducing all three simultaneously). The baseline results are compared to the above scenarios (10%, 20%, and 30% reductions from baseline loadings) to evaluate environmental and economic benefits in the Cabin-Teele Sub-watershed in northeast Louisiana. The equations are solved using the General Algebraic Modeling Systems (GAMS).

Chapter 4 Model Simulation Results

Outputs from the AnnAGNPS simulations were used as technical coefficients in the integrated biophysical-economic model. The chapter begins by presenting the biophysical scenario simulation results. It assumed that only conventional tillage was used in Cabin-Teele watershed. This was used to assess conventional tillage practice contribution to nutrient and sediment effluent loads at the outlet. Agricultural producers in Cabin-Teele currently use conventional, reduced, and conservation tillage in growing crops. The biophysical-economic results looked at these tillage practices, assuming one hundred percent of current nitrogen fertilizer application rates. Rational producers however might modify the nitrogen fertilizer application rates they use, and adopt different tillage management practices to maximize potential net revenues. The economic baseline attempts to represent this situation and assesses producers' allocation decisions when nutrient and sediment effluent load restrictions occur. Finally, sensitivity analysis result of nitrogen and crop prices are presented.

4.1 Biophysical Scenario Results

Before policy scenarios were analyzed, I calculated the integrated model to assess crop production acreage, by soil type, within the watershed for 2002 (Table 4.1). Examining acreage across crops, one observes that corn is the dominant crop cultivated within this watershed, followed closely by cotton, soybeans, grain sorghum and rice.

Table (4.2) presents environmental impacts of the biophysical simulation results. One can see that corn, which represents 36 percent of total planted acres, accounted for almost 79 percent of the nitrate-nitrogen effluent load at the outlet (assuming conventional tillage is the sole tillage practice). Cotton, with 29 percent of planted acreage accounted for 11 percent of nitrogen effluent runoffs. With grain sorghum responsible for 7 percent of total planted acreage, 9 percent of nitrogen effluent. Rice had nitrogen effluent proportional to acreage planted. Similar results were found for sediment and phosphorus loadings at the watershed level.

Table 4.1: Acres Planted to Crops in Cabin-Teele Watershed, by Soil Types for Biophysical Results.

Soil Types	Corn	Cotton	Rice	Sorghum	Soybean	Totals
BA	215	108			132	454
CM	1,701	2,525			229	4,456
CN	1,714	763		68	85	2,629
CO	39	270				309
SB	672	253		146	583	1,653
SC	3,576	2,652	276	1,687	5,850	14,040
SD	29					29
ST	1,921	1,372			843	4,136
TU	238	341			129	708
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Table 4.2: Nitrogen, Phosphorus and Sediment Loading at Cabin-Teele Watershed by Crop for Biophysical Results.

	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Nitrogen (lbs)	239,351	33,838	4,209	26,171	341	303,910
Phosphorus (lbs)	602	424	16	113	455	1,609
Sediments (tons)	849	864	13	160	681	2,567

4.2 Biophysical-Economic Scenario Results

Agricultural producers in Cabin-Teele watershed use conventional, reduced and conservation tillage practices in crop production. The biophysical-economic results looked at these tillage practices using one hundred percent nitrogen fertilizer application rates. Table (4.3) presents crop acreage allocations by tillage practices under the biophysical-economic scenario. It shows that crops are grown using either conventional or reduced tillage practices (with the exception of cotton which had 16 percent of its total acreage on conservation tillage). Reduced tillage is preferred for corn and soybeans production. Grain sorghum and cotton production used a combination of conventional and reduced tillage. Rice was grown only with conventional tillage. The corresponding net revenues for these crop acreage allocations are presented in Table (4.4). One can see that corn received the highest net revenue in this watershed, followed closely by soybean, rice, cotton, and sorghum. Reduced tillage accounted for the bulk of the simulated net returns in this watershed, followed by conventional tillage. Producers using conservation tillage for cotton production did not earn profits.

Table 4.3: Acres Planted, by Crop, in Cabin-Teele Watershed for the Biophysical-Economic Scenario.

Tillage Practices	**Acres Planted**					
	Corn	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
Conventional Tillage						
100% Nitrogen Application Rate		1,413	276	68		1,757
Reduced Tillage						
100% Nitrogen Application Rate	10,104			1,833	7,850	19,787
Conservation Tillage						
100% Nitrogen Application Rate		6,871				6,871
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Table 4.4: Net Revenues ($), by Crop, in Cabin-Teele Sub-Watershed for AnnAGNPS Biophysical-Economic Scenario.

Tillage Practices	**Corn**	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
Conventional Tillage						
100% Nitrogen Application Rate		15,969	18,146	1,713		35,828
Reduced Tillage						
100% Nitrogen Application Rate	1,276,486			11,791	858,807	2,147,084
Conservation Tillage						
100% Nitrogen Application Rate						
Totals	**1,276,486**	**15,969**	**18,146**	**13,504**	**858,807**	**2,182,912**

4.3 Economic Baseline Results

Nitrogen fertilizer application rates could differ from current levels depending on weather conditions, crop rotation, risk aversion, and soil test results for example. To model such a possibility, the baseline scenario allowed the integrated model to choose between tillage practices and nitrogen fertilizer application rates to maximize net revenues in the watershed. The baseline scenario was termed economic baseline. Nutrients and sediment reductions at the outlet were assessed against this economic baseline. Annual revenue of $400,018 was obtained from WRP and CRP payments for this watershed. Additionally, estimations showed that producers received direct payments amounts of $621,357, and counter-cyclical payments of $702,365 in the watershed.

Table 4.5: Acres Planted, by Crop, in Cabin-Teele Watershed for the Economic Baseline.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Sum
Conventional Tillage						
100% Nitrogen Application Rate		1,413				1,413
90% Nitrogen Application Rate				68		68
80% Nitrogen Application Rate			276			276
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	10,104				7,850	17,954
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				1,833		1,833
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate		6,871				6,871
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Sum	10,104	8,284	276	1,900	7,850	28,414

Table (4.5) shows acreage allocations between tillage practices and nitrogen fertilizer applications for the economic baseline. Table (4.6) gives net revenues corresponding to the acreage allocation. Simulated results show that nitrogen fertilizer application rates were reduced for the least profitable crops- grain sorghum and rice. In this watershed, rice might be considered the less profitable crop due to the minimal acreage allocated to its production.

Table 4.6: Net Revenues ($), by Crop, in Cabin-Teele Sub-Watershed for Economic Baseline.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate		15,969				15,969
90% Nitrogen Application Rate				1,725		1,725
80% Nitrogen Application Rate			18,996			18,996
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,276,486				858,807	2,135,293
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				13,239		13,239
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Totals	**1,276,486**	**15,969**	**18,996**	**14,963**	**858,807**	**2,185,222**

In Appendices B1, B2 and B3, simulated model results in all cropping systems indicated negative net revenue for cotton on most of the soil types. This conforms to the negative net revenue estimated for cotton in my crop budget enterprise analyses. Plausible reasons not incorporated in the analysis why producers might continue producing cotton even with negative revenues are: contract specifications with crop procurers, and off-farm income derived as shareholders of cotton ginneries. Finally, current high yielding seed varieties increase net revenues, ceteris paribus. Table (4.5) shows conservation tillage was used for most of cotton acreage planted. For cotton cultivated using conservation tillage, profits were not earned (Table 4.6). Appendices B1, B2 and B3 also show estimated conventional, reduced and conservation tillage net revenue per acre for different nitrogen fertilizer management practices. Net revenue per acre under reduced tillage systems were the most profitable tillage system. This was followed by conventional tillage, then conservation tillage.

Table (4.7) shows the environmental impacts of management practices in Cabin-Teele for the biophysical scenario, biophysical-economic scenario and economic baseline. Note that the latter two were smaller compared to the biophysical baseline due to the relaxing of the constraint on tillage allocation by crop. Nitrogen loads were considerably less for biophysical-economic scenario and economic baseline compared to the biophysical scenario. Sediment and phosphorus loads were respectively 53 percent and 58 percent lower than the biophysical scenario, for the biophysical-economic scenario and economic baseline

Table 4.7: Environmental Impacts in Cabin-Teele Sub-Watershed.

Scenarios	Nitrogen	Phosphorus	Sediment
	(lbs)	(lbs)	(tons)
Biophysical Scenario	303,910	1,609	2,567
Biophysical Economic Scenario	155,922	748	1,077
Economic Baseline	153,287	748	1,077

4.4 Nitrogen, Phosphorus and Sediment Effluent Load Restriction Results

4.4.1 Nitrogen Effluent Load Restriction Results

Appelboom and Fouss (2006) observed an impairment of streams from excess amounts of nitrate deposition at Cabin-Teele watershed outlet. Assuming the state implemented a TMDL environmental policy to reduce nitrogen loads at the outlet in this watershed, I analyzed nitrate-nitrogen reductions of 10 percent, 20 percent and 30 percent to achieve the TMDL, relative to the economic baseline. Tables (4.8) to (4.10) show acreage reallocations or reductions given scenarios of 10 percent, 20 percent and 30 percent nitrate-nitrogen effluent load restrictions.

Table 4.8: Acres Planted, by Crop, in Cabin-Teele Watershed with a 10% Nitrate-Nitrogen Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
Conventional Tillage						
100% Nitrogen Application Rate		1,405				1,405
90% Nitrogen Application Rate						
80% Nitrogen Application Rate			276			276
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	6,208				7,850	14,058
90% Nitrogen Application Rate	3,867					3,867
80% Nitrogen Application Rate				68		68
70% Nitrogen Application Rate				146		146
Conservation Tillage						
100% Nitrogen Application Rate		3,473				3,473
90% Nitrogen Application Rate	29	3,406				3,435
80% Nitrogen Application Rate						
70% Nitrogen Application Rate				1,687		1,687
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Simulated results showed that increasing nitrogen effluent load restriction in Cabin-Teele watershed from 10 percent to 30 percent increased reductions in fertilizer application rates on planted acres. Nitrogen fertilizer application rates were reduced for these crops- corn, cotton, and grain sorghum. Planted corn acres saw the highest reduction in fertilizer application rates in this watershed. The result was reasonable because Table (4.2) shows that planted corn contributes about 79 percent of nitrate-nitrogen loading in this watershed (if conventional tillage is the only tillage system).

Adoption of conservation tillage increased with the imposition of nitrate-nitrogen effluent load restrictions (compared to the economic baseline where only planted cotton used this tillage system). Planted corn and grain sorghum used conservation tillage on the imposition of nitrate-nitrogen load reductions in the watershed. From Table (4.8), imposing a 10% nitrogen load restriction at the watershed level caused a reallocation of 29 acres of planted corn to conservation tillage (compared to the baseline). Table (4.10) shows that planted corn acres increased to 1,881 acres for a 30% nitrogen load reduction in the watershed (using conservation tillage).

Table 4.9: Acres Planted, by Crop, in Cabin-Teele Watershed with a 20% Nitrate-Nitrogen Reduction Imposed at Watershed Level.

Tillage Practices	**Planted Acres**					
	Corn	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
Conventional Tillage						
100% Nitrogen Application Rate		1,397				1,397
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate			276			276
Reduced Tillage						
100% Nitrogen Application Rate	4,341				7,850	12,191
90% Nitrogen Application Rate	3,813					3,813
80% Nitrogen Application Rate	1,298					1,298
70% Nitrogen Application Rate				213		213
Conservation Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate		6,887				6,887
80% Nitrogen Application Rate	652					652
70% Nitrogen Application Rate				1,687		1,687
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Table 4.10: Acres Planted by Crops in Cabin-Teele Watershed with a 30% Nitrate-Nitrogen Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate		1,397				1,397
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate			276			276
Reduced Tillage						
100% Nitrogen Application Rate	4,341				7,850	12,191
90% Nitrogen Application Rate	3,813					3,813
80% Nitrogen Application Rate	69					69
70% Nitrogen Application Rate				213		213
Conservation Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate		6,887				6,887
80% Nitrogen Application Rate	1,881					1,881
70% Nitrogen Application Rate				1,687		1,687
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Tables (4.11) and (4.13) give the corresponding net revenues to Tables (4.8) to (4.10). Tables (4.11) and (4.12) show that, while watershed reductions in net revenue were about one percent (compared to the economic baseline), on the imposition of a 10 percent nitrogen load reduction, it decreased by about 3 percent for a 20 percent reduction. Imposition of a 30 percent nitrogen load reduction resulted in watershed net revenues decreasing by about 6 percent.

Shadow prices for nitrate-nitrogen, phosphorus and sediment restriction are an estimate of forgone marginal net revenue per unit of nitrate-nitrogen, phosphorus and sediment runoff reduction respectively in this watershed. Table (14.4) presents the shadow prices for nitrate-nitrogen effluent reductions at the watershed level. Table (4.14) indicates that the shadow price for a 10 percent reduction in nitrogen load runoffs at the outlet was $1.69 per pound. This implies that marginal net revenue forgone by producers for a unit pound reduction in nitrate-nitrogen effluent at the 10 percent level will be $1.69 per pound. For 20 percent and 30 percent reduction in nitrogen load runoffs at the outlet, the shadow price was $3.66 per pound. Nitrogen-nitrates effluent reductions of 10 percent, 20 percent and 30 percent reductions results in declines in phosphorus by 5 percent, 6 percent and 13 percent respectively. For sediments, the corresponding reductions were 6 percent, 8 percent and 12 percent respectively

Table 4.11: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 10% Reduction in Nitrate-Nitrogen Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate		15,897				15,897
90% Nitrogen Application Rate						
80% Nitrogen Application Rate			18,996			18,996
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	950,510				858,807	1,809,317
90% Nitrogen Application Rate	314,796					314,796
80% Nitrogen Application Rate				1,634		1,634
70% Nitrogen Application Rate				1,481		1,481
Conservation Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate	193					193
80% Nitrogen Application Rate						
70% Nitrogen Application Rate				980		980
Totals	**1,265,498**	**15,897**	**18,996**	**4,095**	**858,807**	**2,163,294**

Table 4.12: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 20% Reduction in Nitrate-Nitrogen Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate		15,824				15,824
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate			18,375			18,375
Reduced Tillage						
100% Nitrogen Application Rate	759,623				858,807	1,618,430
90% Nitrogen Application Rate	374,946					374,946
80% Nitrogen Application Rate	76,597			3,084		79,681
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate	8,500					8,500
70% Nitrogen Application Rate				980		980
Totals	**1,219,667**	**15,824**	**18,375**	**4,064**	**858,807**	**2,116,737**

4.4.2 Phosphorus Effluent Load Restriction Results

Phosphorus effluent load reduction in this watershed was also of policy interest because phosphorus runoff into neighboring streams accelerates eutrophication which promotes algae growth. Algae bloom reduces dissolved oxygen in waters essential for the survival of aquatic organisms. Phosphorus presents a unique quandary since agricultural producers do not apply phosphorus on crops in this watershed. Table (4.15) shows that the initial 10 percent phosphorus load restriction reduces planted acres using conventional tillage. Most producers used reduced and conservation tillage systems for planting crops. Tables (4.16) and (4.17) indicated that for 20 percent and 30 percent phosphorus load reduction, producers adopted reduced tillage and

Table 4.13: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 30% Reduction in Nitrate-Nitrogen Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate		15,824				15,824
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate			18,375			18,375
Reduced Tillage						
100% Nitrogen Application Rate	759,623				858,807	1,618,430
90% Nitrogen Application Rate	374,946					374,946
80% Nitrogen Application Rate	4,084					4,084
70% Nitrogen Application Rate				3,084		3,084
Conservation Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate	24,935					24,935
70% Nitrogen Application Rate				980		980
Totals	**1,163,588**	**15,824**	**18,375**	**4,064**	**858,807**	**2,060,658**

Table 4.14: Environmental Impacts in Cabin-Teele Sub-Watershed for Nitrate-Nitrogen Reduction Imposed at the Watershed Level.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	($/lbs)
10% Nitrate-Nitrogen Reduction	137,958	709	1,010	1.69
20% Nitrate-Nitrogen Reduction	122,630	690	990	3.66
30% Nitrate-Nitrogen Reduction	107,301	652	950	3.66

conservation tillage practices in this watershed. Table (4.17) shows that planted acres using conservation tillage was greater than reduced tillage for the 30 percent phosphorus load reduction in Cabin-Teele watershed.

Appendices C1, C2 and C3 present simulated net revenues for phosphorus effluent reductions in this watershed. Overall simulated net revenues decreased by less than one percent for the 10 percent phosphorus effluent reduction (Appendix C1). In addition, simulated watershed net revenue was reduced by 2 percent and 8 percent for 20 percent and 30 percent phosphorus effluent reductions respectively (Appendices C2 and C3).

Table 4.15: Acres Planted, by Crop, in Cabin-Teele Watershed with a 10% Phosphorus Effluent Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate		108				108
90% Nitrogen Application Rate						
80% Nitrogen Application Rate			276			276
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	10,104	1,306			7,850	19,260
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				68		68
70% Nitrogen Application Rate				820		820
Conservation Tillage						
100% Nitrogen Application Rate		6,871				6,871
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate				1,013		1,013
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Table (4.18) shows that the shadow price for 10 percent phosphorus effluent reduction was $287 per pound. The shadow price for the 20 percent phosphorus load restriction at the watershed level was $1,717 per pound. For the 30 percent phosphorus load restriction, shadow price was $2,627 per pound. Tables (4.15) to (4.17) showed that adopting conservation and reduced tillage practices was the only option available to agricultural producers to achieve TMDL requirements for phosphorus in this watershed. Phosphorus effluent load restrictions also influenced nitrogen and sediment loads at the outlet. Phosphorus effluent reductions by 10 percent, 20 percent and 30 percent decreased nitrogen runoff by 4 percent, 22 percent and 37 percent, and sediment, by 14 percent, 24 percent and 33 percent respectively.

Table 4.16: Acres Planted, by Crop, in Cabin-Teele Watershed with a 20% Phosphorus Effluent Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	8,736	108			7,850	16,694
90% Nitrogen Application Rate			276			276
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	1,368	8,177				9,544
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				68		68
70% Nitrogen Application Rate				1,833		1,833
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

4.4.3 Sediment Effluent Load Restriction Results

Table (4.19) shows total crop acreage for a 10 percent reduction in sediment load from economic baseline. Results indicated that planted acreage using conventional tillage practice decreased compared to the economic baseline. Tables (4.20) show the implications for a 20 percent sediment effluent reduction. Producers in the watershed adopted conventional tillage for only rice production. Reduced tillage and conservation tillage were used to produce corn, cotton, grain sorghum and soybean. Table (4.21) indicates that a 30-percent restriction on sediment loads results in producers adopting only conservation and reduced tillage practices in this watershed.

Table 4.17: Acres Planted, by Crop, in Cabin-Teele Watershed with a 30% Phosphorus Effluent Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	7,204				7,007	14,211
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	2,900	8,284	276		843	12,303
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				68		68
70% Nitrogen Application Rate				1,833		1,833
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Appendices D1, D2 and D3 present watershed net revenues for sediment effluent reductions. There was virtually no impact on watershed net revenues from the 10 percent sediment load TMDL restriction (Appendix D1). Appendix D2 indicated that simulated net revenue decreased by about two percent for a 20 percent sediment effluent reduction. For the 30 percent sediment load TMDL restriction, watershed net revenue decreased by 10 percent (compared to the economic baseline).

Table 4.18: Environmental Impacts in Cabin-Teele Sub-Watershed for Phosphorus Reduction Imposed at the Watershed Level.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	($/lbs)
10% Phosphorus Reduction	146,901	673	930	287.36
20% Phosphorus Reduction	120,244	599	819	1,716.55
30% Phosphorus Reduction	95,982	524	726	2,627.06

Table 4.19: Acres Planted, by Crop, in Cabin-Teele Watershed with a 10% Sediment Effluent Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate	29	376				405
90% Nitrogen Application Rate				68		
80% Nitrogen Application Rate			276			
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	10,075	1,038			7850.015	18,962
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate				1,833		1,833
Conservation Tillage						
100% Nitrogen Application Rate		6,871				6,871
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Table 4.20: Acres Planted, by Crop, in Cabin-Teele Watershed with a 20% Sediment Effluent Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate			276			276
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	10,075				7,731	17,806
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	29	8,284			119	8,432
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				68		68
70% Nitrogen Application Rate				1,833		1,833
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Shadow prices were \$60 per ton, \$1,536 per ton and \$1,891 per ton for 10 percent, 20 percent and 30 percent sediment yield effluent reductions (Table 4.22). Importantly, nitrogen runoff was also reduced by 1 percent, 7 percent, and 27 percent, and phosphorus by 6 percent, 14 percent, and 26 percent due to sediment TMDL in the watershed.

4.4.4 Simultaneous Nutrient and Sediment Effluent Load Restriction Results

An interesting scenario in addressing nutrient and sediment criteria reductions entail reducing nitrogen, phosphorus and sediment concurrently to evaluate the most binding constraint(s) on environmental and economic activities. Table (4.23) shows that a 10 percent simultaneous load reduction increased the adoption of reduced and conservation tillage. Specifically, about ninety five percent of planted acres in the watershed used reduced and conservation tillage systems. Planted crop acres adopting conventional tillage also increased compared to the economic baseline.

Table 4.21: Acres Planted, by Crop, in Cabin-Teele Watershed with a 30% Sediment Effluent Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	8,154				6,845	14,999
90% Nitrogen Application Rate			276			276
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	1,950	8,284			1,005	11,239
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				68		68
70% Nitrogen Application Rate				1,833		1,833
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Table 4.22: Environmental Impacts in Cabin-Teele Sub-Watershed for Phosphorus Reduction Imposed at the Watershed Level.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	($/ton)
10% Sediment Reduction	151,536	706	969	60.34
20% Sediment Reduction	142,967	645	862	1,536.11
30% Sediment Reduction	111,154	553	754	1,891.19

Table 4.23: Acres Planted, by Crop, in Cabin-Teele Watershed with a 10% Simultaneous Nitrogen, Phosphorus and Sediment Effluent Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate		509				509
90% Nitrogen Application Rate						
80% Nitrogen Application Rate			276			276
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	6,866	889			7,850	15,605
90% Nitrogen Application Rate	3,209					3,209
80% Nitrogen Application Rate				68		68
70% Nitrogen Application Rate				146		146
Conservation Tillage						
100% Nitrogen Application Rate		323				323
90% Nitrogen Application Rate	29	6,564				6,593
80% Nitrogen Application Rate						
70% Nitrogen Application Rate				1,687		
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Table (4.24) presents the 20 percent simultaneous reduction in nutrient and sediments in the watershed. Results indicated that agricultural producers adopted only reduced and conservation tillage for planting crops. Similar results were obtained for the 30 percent simultaneous TMDL reduction in the watershed (Table 4.25). Simulated net revenue from concurrent reductions of nitrogen, phosphorus and sediments are given in Appendices E1, E2 and E3. Ten percent simultaneous load reduction caused net revenue to decrease by about one percent. Twenty and 30 percent simultaneous effluent restrictions decreased watershed net revenue by about 5 percent and 13 percent respectively.

Table 4.24: Acres Planted, by Crop, in Cabin-Teele Watershed with a 20% Simultaneous Nitrogen, Phosphorus and Sediment Effluent Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	8,736	108			7,850	16,694
90% Nitrogen Application Rate			276			276
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate	1,368	8,177				9,544
80% Nitrogen Application Rate				68		68
70% Nitrogen Application Rate				1,833		1,833
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Tables (4.26), (4.27) and (4.28) present the shadow prices for the simultaneous policy scenarios. It indicated that the most binding constraint in all scenarios was phosphorus. A 10 percent simultaneous load reduction showed that nitrogen and phosphorus were binding in achieving the TMDL. The respective shadow costs for nitrogen and phosphorus were $1.69 per pound and $78.85 per pound (Table 4.26). For a 20 percent effluent load reduction, the binding constraint was phosphorus. Table (4.27) shows a shadow price of $1,717 per pound for the 20 percent effluent reduction. Similarly, for the 30 percent simultaneous reduction, the only binding constraint was phosphorus with a shadow price of $2,627 per pound (Table 4.28).

Table 4.25: Acres Planted, by Crop, in Cabin-Teele Watershed with a 30% Simultaneous Nitrogen, Phosphorus and Sediment Effluent Reduction Imposed at Watershed Level.

Tillage Practices	Planted Acres					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	7,204				7,007	14,211
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	2,900	8,284	276		843	12,303
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				68		68
70% Nitrogen Application Rate				1,833		1,833
Totals	**10,104**	**8,284**	**276**	**1,900**	**7,850**	**28,414**

Table 4.26: Environmental Impacts in Cabin-Teele Sub-Watershed for a 10% Simultaneous Nitrogen, Phosphorus and Sediment Effluent Reduction Imposed at the Watershed Level.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	
10% Nitrate-Nitrogen Reduction	137,958			1.69
10% Phosphorus Reduction		673		78.85
10% Sediment Reduction			930	-

Table 4.27: Environmental Impacts in Cabin-Teele Sub-Watershed for a 20% Simultaneous Nitrogen, Phosphorus and Sediment Effluent Reduction Imposed at the Watershed Level.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	
20% Nitrate-Nitrogen Reduction	120,244			-
20% Phosphorus Reduction		599		1,717
20% Sediment Reduction			819	-

Table 4.28: Environmental Impacts in Cabin-Teele Sub-Watershed for a 30% Simultaneous Nitrogen, Phosphorus and Sediment Effluent Reduction Imposed at the Watershed Level.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	
30% Nitrate-Nitrogen Reduction	95,982			-
30% Phosphorus Reduction		524		2,627.06
30% Sediment Reduction			726	-

4.5 Results of Sensitivity Analyses of Changes in Nitrogen Fertilizer Price and Crop Price

Sensitivity analyses were conducted to assess the potential impact on net revenues and nitrogen runoff from changes in nitrogen fertilizer and crop price. Appendices F1, F2 and F3 present net revenues by crop and tillage systems for a 25 percent, 50 percent and 75 percent increase in nitrogen fertilizer price. As expected from economic theory, increased nitrogen fertilizer price decreased watershed net revenues. Nitrogen effluent restrictions at the watershed outlet to meet any potential future TMDL further decreased net revenues. Appendix F4 shows the environmental effects for a 25 percent, 50 percent and 75 percent increase in nitrogen fertilizer price in Cabin-Teele Watershed. For a 25 percent increase in nitrogen fertilizer price, shadow prices ranged from $1.08 per pound to $3.05 per pound (given nitrate-nitrogen effluent restrictions). For a 75 percent increase in nitrogen fertilizer price, shadow prices ranged from $1.84 per pound to $3.48 per pound.

Appendix G1 shows net revenues for a 25 percent decrease in corn prices for Cabin-Teele watershed. Corn net revenues further declines with nitrate-nitrogen load reductions in this watershed. For the other crops, net revenues remained the same. Results obtained for nitrate-nitrogen runoff effluent restrictions suggests that lower corn price might increase producer preference for reduced and conservation tillage practices (for planted corn) in the watershed. Appendix G5 shows the environmental implications for a 25 percent decrease in corn price. The shadow price was $1.06 per pound for 10 percent, 20 percent and 30 percent nitrate-nitrogen load reduction in Cabin-Teele watershed.

Appendices G2, G3 and G4 present net revenues by crop and tillage systems for a 25 percent, 50 percent and 75 percent increase in corn prices. With increased corn prices, producers preferred reduced tillage for planting corn. Given nitrate-nitrate load reductions, Appendix G5 shows that shadow prices ranged from $2.81 per pound to $8.12 per pound for a 25 percent increase in corn price. For a 50 percent increase in corn price, shadow prices ranged from $2.81 per pound to $8.12 per pound. Increasing corn price by seventy five percent, one can see that shadow prices ranged from $3.95 per pound to $12.81 per pound. This seems to suggest that the marginal cost of reducing nitrate-nitrogen runoffs in Cabin-Teele watershed increased with higher corn prices.

Appendices H1, H2 and H3 present net revenues for a 25 percent, 50 percent and 75 percent increase in cotton price for Cabin-Teele watershed. One can see that producers preferred conventional tillage for planting cotton as prices increased from 25 percent to 75 percent. Preference for conventional tillage increased nitrate-nitrogen loads at the outlet (Appendix H4).

Nitrate-nitrogen TMDL reductions were achieved by using conservation tillage and decreasing nitrogen fertilizer application rates for corn and grain sorghum. Appendix H4 shows shadow prices for a 25 percent, 50 percent and 75 percent increase in cotton price in the watershed. Imposing nitrogen runoff restrictions, shadow prices ranged from $1.20 per pound to $4.32 per pound for a 25 percent increase in cotton price. For a 75 percent increase in cotton price, shadow prices ranged from $1.93 per pound to $6.68 per pound.

Lastly, Appendices I1, I2 and I3 show net revenues for a 25 percent, 50 percent and 75 percent increase in soybean price in this watershed. Nitrate-nitrogen effluent restriction results showed minimal declines in watershed net revenues as soybean price increased. Reductions in nitrogen runoffs were achieved in part by increasing the adoption of conservation tillage for corn and grain sorghum. Additionally, producers reduced nitrogen fertilizer application rates. Appendix I4 shows that within this watershed, shadow prices increased in value from $1.69 per pound to $3.66 per pound as soybean price increased from 25 percent to 75 percent.

Chapter 5 Summary, Conclusions and Future Research

This dissertation examined the impact of cropping practices, tillage management and nitrogen fertilizer management in reducing pollutants from agriculture in the lower Mississippi Alluvial Valley. It assessed individually, and simultaneously the effects of nitrogen, phosphorus and sediment load restrictions on cropland acreage allocations and watershed net revenue.

Assuming perfect information on enterprise crop budgets, and favorable weather conditions, reduced tillage system under the economic baseline was more profitable than either conventional tillage or conservation tillage in the Cabin-Teele sub-watershed. With no TMDL restrictions in this watershed, reduced tillage was preferred because of higher crop net revenue per acre (partially due to reduced tillage being the dominant system in this watershed), even with decreased nitrogen fertilizer application. Results indicated that conventional tillage was more profitable than conservation tillage for most crops examined. These finding can be attributed in part to the poorly drained soils within this region. Soils form hardpan due to heavy rainfall and the high clay content of most soils. Agricultural producers therefore disk soils every three to five years. Under such conditions it is difficult to implement conservation tillage.

Analyses conducted on nitrogen effluent restrictions at the watershed outlet, to meet any potential future TMDL, showed that initial nitrate-nitrogen load restrictions did not impact watershed net revenue. Imposing a 30 percent nitrogen reduction on the watershed reduced net revenue by 6 percent. Producers also reduced crop acreage and fertilizer application intensity as effluent restrictions increased. Corn saw the highest reduction in nitrogen fertilizer application intensity, perhaps because it accounts for over seventy percent of total nitrate-nitrogen load at the outlet.

Decreasing nitrogen fertilizer application rates and the adoption of conservation tillage practices enabled producers meet the TMDL. As predicted by economic theory, shadow prices indicated that marginal costs increased with higher nitrogen load restriction. For nitrogen restrictions, shadow prices increased in value from $1.69 per pound to $3.66 per pound as effluent load restrictions increased from 10 percent to 30 percent. In Cabin-Teele watershed, these results seem to suggest that agricultural producers could reduce nitrate-nitrogen runoffs at low costs to meet any future TMDL regulation.

Environmental impacts for phosphorus and sediment effluent restrictions were different from that of nitrogen. The marginal cost to agricultural producers in reducing effluent was higher for phosphorus and sediment load reduction in the watershed. Shadow prices for phosphorus effluent restrictions ranged between $287 per pound to $2,627 per pound. With a TMDL of 20 percent and 30 percent phosphorus load reduction, net revenue decreased by about 5 percent and 12 percent respectively. For sediments, the range was $60 per ton to $1891 per ton. Net revenues decreased by 2 percent and 10 percent respectively for a 20 percent and 30 percent sediment load reduction. Results suggested that a 20 percent to 30 percent reduction in phosphorus or sediment load in this watershed increased producer adoption of conservation tillage.

In the scenario with all nutrient and sediment being reduced simultaneously, the constraining element varied, though the most binding was phosphorus. For example, at the 10 percent reduction from the economic baseline scenario, nitrogen and phosphorus were binding. At the 20 percent and 30 percent reduction scenarios, only phosphorus was binding. In all scenarios with phosphorus reduction being the binding constraint, the shadow price per pound of phosphorus reduced was substantial – ranging from $78 per pound to $2,627 per pound. Simultaneous policy scenarios also showed a preference for reduced tillage and conservation tillage compared to conventional tillage. Findings suggest that producers might increase the use of conservation tillage with the imposition of simultaneous effluent restrictions in Cabin-Teele watershed.

Results on nitrate-nitrogen, phosphorus and sediment reduction in the watershed show the tradeoffs between cropland acreage, net revenue and environmental goals for improving water quality. It showed that producers could use conservation tillage to help decrease fertilizer application rates in the watershed (and potentially remain profitable). Findings suggest that without the flexibility of farmers to decide on tillage management and the amount of nitrogen fertilizer they will apply to crops, reductions in net revenue would have been greater.

Sensitivity analysis results varied for planted crops in the watershed. Higher corn price increased producer preference for reduced tillage (for planting corn). Shadow prices ranged from \$2.81 per pound to \$8.12 per pound for a 25 percent increase in corn price, and from \$3.95 per pound to \$12.81 per pound for a 75 percent increase in corn price (given nitrate-nitrogen effluent restrictions). This suggests that higher corn prices increases the marginal cost of reducing nitrate-nitrogen loads. For cotton, higher cotton price increased nitrate-nitrogen loads at the outlet (compared to the scenario where cotton price was unchanged) because of producer preference for conventional tillage. For a 75 percent increase in cotton price, shadow prices ranged from \$1.93 per pound to \$6.68 per pound. The results suggest that increasing cotton price might lead to higher nitrate-nitrogen runoff in this watershed.

This research provides policymakers and agricultural producers with the needed information on alternative methods for addressing some of the negative effects from current agricultural practices in northeast Louisiana and the lower Mississippi River Basin. It suggests that a shift from conventional to reduced tillage and conservation tillage as well as the adoption of nitrogen management practices might be ways to reduce nitrogen and sediment loads in the lower

Mississippi River Basin. Though increased restrictions on nitrates, phosphorus and sediments all decreased simulated net revenue to producers, results indicated that sediment and phosphorus restriction policies were relatively more expensive. This research shows that in croplands where soils are currently saturated with phosphorus, policy options may include the adoption of tillage management.

Some suggestions for future research include the following. Agricultural producers within this watershed currently use crop rotation to increase crop yields and reduce nutrient outflow. Future studies should therefore incorporate crop rotation practices into the analyses. This should provide a more complete picture of management practices and associated nutrient-sediment loads from the watershed. Most agricultural producers are known to be risk averse. Incorporating risk preferences in the analysis would provide more realistic representation of the watershed. Preliminary analysis of this yielded results found as inconsistent with farmers' attitudes towards risk aversion. Therefore more research needs to be undertaken.

References

2006 Louisiana Water Quality Inventory: Integrated Report. Fulfilling Requirements of the Federal Clean Water Act Sections 305(b) and 303(d). Louisiana Department of Environmental Quality. Internet site: http://www.deq.louisiana.gov/portal/tabid/2692/Default.aspx (Accessed October 20, 2008).

99th Annual Research Report Rice Research Station. Crowey, Louisiana 2007. Louisiana State University Agricultural Center Research and Extension.

Aftab, A., N. Hanley and A. Kampas. "Co-ordinated Environmental Regulation: Controlling Non-point Nitrate Pollution while Maintaining River Flows." Environmental Resource Economics 38 (2007):573–593.

Amatya, D. M., R. W. Skaggs and J. D. Gregory. "Effects of Controlled Drainage on the Hydrology of Drained Pine Plantations in the North Carolina Coastal Plain." Journal of Hydrology, 181(1996): 211-232.

Anderson, G. D., J. J. Opaluch and W. M. Sullivan. "Nonpoint Agricultural Pollution: Pesticide Contamination of Groundwater Supplies." American Journal of Agricultural Economics, 67(1985):1238-1243.

Apland, J., B.A. McCarl and W.L. Miller. "Risk and the Demand for Supplemental Irrigation: A Case Study in the Corn Belt." American Journal of Agricultural Economics, 62(1980):142-145.

Appelboom, T.W., and J.L. Fouss. "Cabin-Teele Sub-Watershed Modeling/Simulation Project in Northern Louisiana to Evaluate Stream Nitrate-Load Reduction by In-Stream Processes, BMPS Targeting, and Wetland Diversions." Paper presented at American Ecological Engineering Society 5th Annual Meeting, Ohio State University, Columbus, Ohio, May 18-20, 2005.

Appelboom, T.W., and J.L. Fouss. "Reduction of Riverine Nitrate Loads through Field Targeting of Best Management Practices, Placement of Wetlands, and In-stream Denitrification: A Modeling/Simulation Project." Coastal Environment and Water Quality: Proceedings of the American Institute of Hydrology 25th Anniversary Meeting and International Conference, 2006, pp. 21-24.

Babcock, B.A. "The Effects of Uncertainty on Optimal Nitrogen Applications." Review of Agricultural Economics, 14(1992):271-280.

Baumol, W.J., and W.E. Oates. The Theory of Environmental Policy. New York: Cambridge University Press, 1988.

Beman, J. M., K. R. Arrige, and P. A. Matson. "Agricultural Runoff Fuels Large Phytoplankton Blooms in Vulnerable Areas of the Ocean." Nature, 434(2005):211-214.

Bengston, R. L., R. S.Garzon, and J. L. Fouss. "Fluctuating Water Table Model for the Management of a Controlled-Drainage/Subirrigation System." American Society of Agricultural and Biological Engineers, 36(1993):437-443.

Berka C., H. Schreier, K. Hall. "Linking Water Quality with Agricultural Intensification in a Rural Watershed." Water, Air and Soil Pollution, 127(2001):389-401.

Bordovsky, J.P., W.M. Lyle, and J.W. Keeling. "Crop Rotation and Tillage Effects on Soil Water and Cotton Yield." Agronomy Journal 86(1994):1-6.

Borin, M., G. Bonaiti and L.Giardini. "Controlled Drainage and Wetlands to Reduce Agricultural Pollution: A Lysimetric Study." Journal of environmental Quality, 30(2001):1330-1340.

Borisova T., J. S. Shortle, R. D. Horan and D. G. Abler. "The Value of Ecological and Economic Information in Water Quality Management." Paper Prepared for Presentation at the American Agricultural Economics Association Annual Meeting, Montreal, Canada, July 27-30, 2003.

Bouzaher, A., J. B. Braden, and G. V. Johnson. "A Dynamic Programming Approach to a Class of Nonpoint Source Pollution Control Problems." Management Science, 36(1990):1-15.

Braden, J. B., G. V. Johnson, A. Bouzaher, and D. Miltz. "Optimal Spatial Management of Agricultural Pollution." American Journal of Agricultural Economics, 71(1989):404-413.

Brevé, M. A., R. W. Skaggs, J. E. Parsons and J. W. Gilliam. "Using the DRAIMOD-N Model to Study Effects of Drainage System Design and Management on Crop Productivity, Profitability and NO_3-N Losses in Drainage Water." Agricultural Water Management 35(1998):227-243.

Burkart, M.R., and D.E. James. "Agricultural-Nitrogen Contributions to Hypoxia in the Gulf of Mexico." Journal of Environmental Quality 28(1999): 850-859.

Carpentier, C. L., D. J. Bosch, and S. S. Batie. "Using Spatial Information to Reduce Costs of Controlling Agricultural Nonpoint Source Pollution." Agricultural and Resource Economics Review, 27(1998):72-84.

Chescheir, G.M., R.W. Skaggs, J.M. Gilliam, and R. G. Broadhead. "Hydrology of two forested wetlands that receive pumped agricultural drainage water in Eastern North Carolina." Wetlands, 11(1991):29-54.

Conservation Technology Information Center. Internet site: http://www.conservationinformation.org/?action=members_crm. (Accessed on May 4, 2009).

Cronshey, R.G., and F.G. Theurer. AnnAGNPS Non-point Pollutant Loading Model. In Proc.1st Federal Interagency Hydrologic Modeling Conference, April 1998, Las Vegas, NV.

Dinnes, D.L., D.L. Karlen, D.B. Jaynes, T.C. Kaspar, J.L. Hatfield, T.S. Colvin and C.A. Cambardella. "Nitrogen Management Strategies to Reduce Nitrate Leaching in Tile-Drained Midwestern Soils." Agronomy Journal, 94(2002):153-171.

El-Sadek, A., J. Feyen, W. Skaggs, and J. Berlmont. "Economics of Nitrate Losses from Drained Agricultural Land." Journal of Environmental Engineering, 28(2002): 376-383.

Epplin, F.M. and G.A. Al-Sakkaf. "Risk-Efficient Tillage Systems and Program Participation Strategies for Land Subject to Conservation Compliance." Review of Agricultural Economics, 17(1995): 311-321.

Evans, R.O., J.W. Gilliam, R.W. Skaggs. "Controlled Drainage Management Guidelines for Improving Drainage Water Quality." North Carolina Cooperative Extension Service, Publication Number: AG 443, 1996.

Evans, R.O., J.W. Gilliam, R.W. Skaggs. "Effects of Agricultural Water Table Management on Drainage Water Quality." The Water Resources Research Institute, Report No. 237, 1989.

Evans, R.O., P.W. Westerman, and M.R. Overcash. "Subsurface Drainage Water Quality from Land Application of Swine Lagoon Effluent." Transactions from American Society of Agricultural and Biological Engineers, Paper No. 89-2695 (1984), American Society of Agricultural and Biological Engineers, St. Joseph, Michigan.

Evans, R.O., R.W. Skaggs, and W.J. Gilliam. "Controlled versus Conventional Drainage Effects on Water Quality." Journal of Irrigation Drainage Engineering, 121(1995):271-276.

Federal Water Pollution Control Act [As Amended Through P.L. 107–303, November 27, 2002]. Internet site: http://epw.senate.gov/water.pdf (Assessed on July 2, 2009).

Foltz, J.C., J. G. Lee, M. A. Martin, and P.V. Preckel. "Multiattribute Assessment of Alternative Cropping Systems." American Journal of Agricultural Economics, 77(1995):408-420.

Gardner, R.L. and R.A. Young. "Assessing Strategies for Control of Irrigation-Induced Salinity in the Upper Colorado River Basin." American Journal of Agricultural Economics, 70(1988):37-49.

Gergel, S.E., M.G. Turner, and T.K. Kratz. "Dissolved Organic Carbon as an Indicator of the Scale of Watershed Influence on Lakes and Rivers." Ecological Applications, 9(1999):1377-1390.

Giraldez, C., and G. Fox. "An Economic Analysis of Groundwater Contamination from Agricultural Nitrate Emissions in Southern Ontario." Canadian Journal of Agricultural Economics, 43(1995):387-402.

Good, D. and S. Irwin. "The New Era of Corn, Soybean, and Wheat Prices." Marketing and Outlook Briefs, Sept. 2, 2008, MOBR 08-04. Internet site:

http://www.farmdoc.uiuc.edu/marketing/mobr/mobr_08-04/mobr_08-04.pdf (Accessed on September 20, 2008).

Goolsby, D. A., and W. A. Battaglin. “Long-term Changes in Concentrations and Flux of Nitrogen in the Mississippi River Basin, USA.” Hydrological Processes 15(2001):1209-1226.

Griffin, R. C., and D. W. Bromley. “Agricultural Runoff as a Nonpoint Externality: A Theoretical Development.” American Journal of Agricultural Economics, 64(1982):547-552.

Grigg, B. C., L. M. Southwick, J. L. Fouss and T. S. Kornecki. “Drainage System Impacts on Surface Runoff, Nitrate Loss, and Crop Yield on a Southern Alluvial Soil.” American Society of Agricultural and Biological Engineers, 46(2003):1531-1537.

Grigg, B. C., L. M. Southwick, J. L. Fouss, and T. S. Kornecki. “Climate Impacts on Nitrate Loss in Drainage Waters from a Southern Alluvial Soil.” Transactions of the American Society of Agricultural and Biological Engineers, 47(2004):445-451.

Hann, P. K. and R. W. Skaggs. “Effect of Parameter Uncertainty on DRAINMOD Predictions: I, Hydrology and Yield.” American Society of Agricultural and Biological Engineers, 46(2003):1061-1067.

Hartwick, J. M., and N. D. Olewiler. The Economics of Natural Resource Use. 2nd Edition, Massachusetts: Addison-Wesley, 1998.

Haycock, N.E., and G. Pinay. “Nitrate Retention in Grass and Poplar Vegetated Buffer Strips during Winter.” Journal of Environmental Quality, 22(1993):273–278.

Hope, D., M. F. Billett and M. S. Cresser. “A Review of the Export of Carbon in River Water: Fluxes and Processes.” Environmental Pollution, 84(1994):301-324.

Houck, O.A. The Clean Water Act TMDL Program: Law, Policy, and Implementation. 2nd Edition, Washington, D.C: Environmental Law Institute, 2002.

Innes, R. “The Economics of Livestock Waste and Its Regulation,” American Journal of Agricultural Economics, 82(2000):97-117.

Intarapapong, W., D. Hite, and M. Isik. “Optimal Profits under Environmental Constraints: Implications of Nutrient and Sediment Standards.” Journal of the American Water Resources Association, 41(2005):1361-1376.

Jacobs, J. J., and G. L. Casler. “Internalizing Externalities of Phosphorus Discharges from Crop Production to Surface Water: Effluent Taxis versus Uniform Reductions.” American Journal of Agricultural Economics, 61(1979):309-312.

Jacobs, J. J., and J. H. Timmons. “An Economic Analysis of Agricultural Land Use Practices to Control Water Quality.” American Journal of Agricultural Economics, 56(1974):791-798.

Johansson, R. C., P. H. Gowda, D. J. Mulla, and B. J. Dalzell. “Metamodelling Phosphorus Best Management Practices for Policy Use: A Frontier Approach.” Agricultural Economics, 30(2004):63-74.

Johnson, S.C., R.M. Adams, and G. M. Perry. “The On-Farm Costs of Reducing Groundwater Pollution.” American Journal of Agricultural Economics, 73(1991):1063-1073.

Kerby, T. A., B. Hugie, D. Albers, and K.E. Lege. “Historical versus Recent Yield and Fiber Quality Trends.” Paper presented at the 2007 Beltwide Cotton Conference, New Orleans, Louisiana, January 9-12, 2007.

Koch, B., R. Khosla, W.M. Frasier, D.G. Westfall, and D. Inman. “Site-Specific Management. Economic Feasibility of Variable-Rate Nitrogen Application Utilizing Site-Specific Management Zones.” Agronomy Journal 96(2004):1572–1580.

Kornecki, T.S., B.C. Grigg, J.L. Fouss, and L.M. Southwick. “Polyacrylamide (PAM) Application Effectiveness in Reducing Soil Erosion from Sugarcane Fields in Southern Louisiana.” Applied Engineering in Agriculture, 21(2005):189-196.

Lalonde, V., C. A. Madramootoo, L. Trenholm, and R. S. Broughton. “Effects of Controlled Drainage on Nitrate Concentrations in Subsurface Drain Discharge.” Agricultural Water Management, 29(1996):187-199.

Lambert, D.K. “Risk Considerations in the Reduction of Nitrogen Fertilizer Use in Agricultural Production.” Western Journal of Agricultural Economics, 15(1990):234-244.

Laughlin, D., and S.R. Spurlock. 2006. Mississippi State Budget Generator Users Guide (version 6.0) [Online]. Available at http://www.agecon.msstate.edu/ laughlin/msbg.php.

Lovell, S.T., and W.C. Sullivan. “Environmental Benefits of Conservation Buffers in the United States: Evidence, Promise, and Open Questions.” Agriculture, Ecosystems and Environment, 112(2006):249–260.

Mapp, H. P., D. J. Bernardo, G. J. Sabbagh, S. Geleta and K. B. Watkins. “Economic and Environmental Impacts of Limiting Nitrogen Use to Protect Water Quality: A Stochastic Regional Analysis.” American Journal of Agricultural Economics, 76(1994):889-903.

Mascagni, H.J., R.L. Hutchinson, D.B. Reynolds, B.R. Leonard, and D.R. Burns. “Conservation Tillage Systems for Corn Production on a Loessial Silt Loam and Alluvial Clay in Louisiana.” 18th Annual Southern Conservation Tillage Conference for Sustainable Agriculture Proceedings, 1995, pp. 37-40.

Mascagni, H.J., R.L. Hutchinson, D.B. Reynolds, B.R. Leonard, and D.R. Burns. “Influence of Cover Crop and Tillage on Grain Yield and Nitrogen Status of Corn Grown on a Loessial Silt Loam and Alluvial Clay in Louisiana.” 19th Annual Southern Conservation Tillage Conference for Sustainable Agriculture Proceedings, 1996, pp.113-118.

McCarl, B.A., and D.A. Bessler. “Estimating an Upper Bound on the Pratt Risk Aversion Coefficient when the Utility Function is Unknown.” Australian Journal of Agricultural Economics, 33(1989): 56-63.

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico. Washington, DC, 2001.

Mitchell, D.M., J. Johnson, and C. Wilde. “Impacts of Decreasing Cottonseed to Lint Ratio on Cotton seed Markets.” Paper presented at the 2007 Beltwide Cotton Conference, New Orleans, Louisiana, January 9-12, 2007.

Nistor, A.P., and J. Lowenberg-DeBoer. “Drainage Water Management Impact on Farm Profitability.” Paper presented at the American Agricultural Economics Association Annual Meeting, Long Beach, California, July 23-26, 2006.

Northeast Research Station: Louisiana agriculture depends on it. Internet site: http://www.lsuagcenter.com/en/our_offices/research_stations/northeast/news/northeast+research+station+louisiana+agriculture+depends+on+it.htm (Accessed on January 4, 2009).

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

Osteen, C., and W.D. Seitz. “Regional Economic Impacts of Policies to Control Erosion and Sedimentation in Illinois and Other Corn Belt States.” American Journal of Agricultural Economics, 60(1978):510-517.

Parsons, J.E., R.W. Skaggs and C.W. Doty. “Simulation of Controlled Drainage in Open-Ditch Drainage Systems."Agricultural Water Management 18 (1990):301-316.

Paudel, K.P., L. Lohr, and N.R. Martin, Jr. “Effect of Risk Perspective on Fertilizer Choice by Sharecroppers.” Agricultural Systems 66 (2000):115-128.

Paxton, K.W. (2008). 2008 Northeast Louisiana Projected Cotton, Soybeans, Corn, Milo, and Wheat Production Costs. A.E.A. Information Series No. 254, January 2008. Online at: http://www.lsuagcenter.com/NR/rdonlyres/4623F715-5547-4B45-966E-514D78F4FB97/42760/2008NortheastBudgets.pdf.

Paz, J.O., W.D. Batchelor, B.A. Babcock, T.S. Colvin, S. D. Logsdon, T.C. Kaspar, and D.L. Karlen. “Model-based Technique to Determine Variable Rate Nitrogen for Corn.” Agricultural Systems, 61(1999):69-75.

Petrolia, D.R., P.H. Gowda, and D. J. Mulla. “Agricultural Drainage and Gulf Hypoxia: Economic Targeting of Farmland to Reduce Nitrogen Loads in a Minnesota Watershed.”

Paper presented at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, July 24-27, 2005.

Prato, T., and C. Kang. “Economic and Water Quality Effects of Variable and Uniform Application of Nitrogen.” Journal of the American Water Resources Association, 34(1998):1465-1472.

Qiu, Z., T. Prato and M. Kaylen. “Watershed-Scale Economic and Environmental Tradeoffs Incorporating Risks: A Target Motad Approach.” Agricultural and Resource Economics Review, 27(1998):231-240.

Qui, Z. “Using Multi-Criteria Decision Models to Assess the Economic and Environmental Impacts of Farming Decisions in an Agricultural Watershed.” Review of Agricultural Economics, 27(2005):229-244.

Qui, Z., and T. Prato. “Economic Evaluation of Riparian Buffers in an Agricultural Watershed.” Journal of the American Water Resources Association, 34(1998):877-890.

Randhir, T.O., and J.G. Lee. “Economic and Water Quality Impacts of Reducing Nitrogen and Pesticide Use in Agriculture.” Agricultural and Resource Economics Review, 26(1997):39-51.

Reginelli, D.B., N.W. Buehring, W.F. Jones, and J.J. Varco. Effects of Legume Cover Crops and Tillage on Grain Sorghum Yield. Internet site: www.ag.auburn.edu/auxiliary/nsdl/scasc/Proceedings/1990/Reginelli.pd (Assessed October 7, 2008).

Reichelderfer, K.. “Environmental Protection and Agricultural Support: Are Tradeoffs Necessary?” in K.Allen (ed.), Agricultural Policies in a New Decade Washington, DC: Resources for the Future (1990):201-230.

Rejesus, R.M., and R.H. Hornbaker. “Economic and Environmental Evaluation of Alternative Pollution-Reducing Nitrogen Management Practices in central Illinois Agriculture.” Agriculture, Ecosystems and Environment 75(1999): 41–53.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder. coordinators,. Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE). USDA Agricultural Handbook No. 703, Washington, DC, 1997.

Ribaudo, M. O., R. D. Horan, and M. E. Smith. “Economics of Water Quality Protection from Nonpoint Sources: Theory and Practice.” Resource Economics Division, Economic Research Service, United States Department of Agriculture, Agricultural Economic Report No. 782, Nov., 1999.

Ribaudo, M.O., and R.A. Shoemaker. “The Effect of Feedgrain Program Participation on Chemical Use.”Agricultural and Resource Economic Review 24(1995):211-220.

Ribaudo, M.O., R. Heimlich, R. Claassen, and M. Peters. “Least-cost Management of Nonpoint Source Pollution: Source Reduction versus Interception Strategies for Controlling Nitrogen Loss in the Mississippi Basin.” Ecological Economics 37(2001):183-197.

Roka, F.M., and D.L. Hoag. “Manure Value and Liveweight Swine Decisions,” Journal of Agricultural and Applied Economics, 28(1996):193-202.

Saha, A., C.R. Shumway, and H. Talpaz. “Joint Estimation of Risk Preference Structure and Technology Using Expo-Power Utility.” American Journal of Agricultural Economics, 76(1994): 173-184.

Schwabe K.A. “Nonpoint Source Pollution, Uniform Control Strategies and the Neuse River Basin.” Review of Agricultural Economics, 23(2001):352-369.

Sharp, B.M.H., and D.W. Bromley. “Agricultural Pollution: The Economics of Coordination.” American Journal of Agricultural Economics, 61(1979):591-600.

Shirmohammadi, A., R.D. Wenberg, W.F. Ritter, and F.S. Wright. “Effect of Agricultural Drainage on Water Quality in Mid-Atlantic States.” Journal of Irrigation and Drainage Engineering, 121(1995):302-306.

Shortle, J.S., and D.R. Horan. “Economics of Nonpoint Pollution Control.” Journal of Economic Surveys, 15 (2001): 251–253.

Shortle, J.S., R.D. Horan, and D.G. Abler. “Research Issues in Nonpoint Pollution Control.” Environmental and Resource Economics 11(1998):571-585.

Singh, R., M.J. Helmers, W.G. Crumpton, and D.W. Lemke. “Predicting effects of drainage water management in Iowa's subsurface drained landscapes.”Agricultural Water Management, 92(2007): 162-170.

Smeltz, H.L., R.O. Evans, D.L. Osmond, and G.D. Jennings. “Nitrate Reduction through Controlled Drainage and Nutrition Management Plans.” American Society of Agricultural and Biological Engineers Annual Meeting, Paper number 052236, 2005.

Stonehouse, D.P. “A Targeted Policy Approach to Inducing Improved Rates of Conservation Compliance in Agriculture.” Canadian Journal of Agricultural Economics, 44(1996):105-119.

Taylor, C. R. and K. K. Frohberg. “The Welfare Effects of Erosion Controls, Banning Pesticides, and Limiting Fertilizer Application in the Corn Belt.” American Journal of Agricultural Economics, 59(1977):25-36.

Taylor, C.R., K.K. Frohberg and W.D. Seitz. “Potential Erosion and Fertilizer Controls in the Corn Belt: An Economic Analysis.” Journal of Soil and Water Conservation, 33(1978): 173-176.

Taylor, M.L., R.M. Adams, and S.F. Miller. “Farm-Level Response to Agricultural Effluent Control Strategies: The Case of the Willamette Valley.” Journal of Agricultural and Resource Economics, 17(1992):173-185.

Teague, M. L., D. J. Bernardo and H. P. Mapp. “Farm-Level Economic Analysis Incorporating Stochastic Environmental Risk Assessment.” American Journal of Agricultural Economics, 77(1995):8-19.

Thrikawala, S., A. Weersink, G. Kachanoski, and G. Fox. “Economic Feasibility of Variable-Rate Technology for Nitrogen on Corn.” American Journal of Agricultural Economics, 81(1999):914-927.

Todd, A.P., and G.E. Varvel. “Crop Yield as Affected by Rotation and Nitrogen Rate. I. Soybean.” Agronomy Journal 81(1989):727-731.

Turner, R.E. and N.N. Rabalais. "Suspended sediment, C, N, P, and Si yields from the Mississippi River Basin," Hydrobiologia 511(2004):79-89.

U.S. Environmental Protection Agency, Drinking water regulations and health advisories: U.S. Environmental Protection Agency report EPA 822-B-96-001, 1996.

U.S. Environmental Protection Agency, Quality criteria for water--1986: U.S. Environmental Protection Agency report EPA 440/5-86-001, 1986.

United States Department of Agriculture–Natural Resources Conservation Service. Fact Sheet, Farm Bill 2002, EQIP/Ground and Surface Water Conservation. Internet site: http://www.nrcs.usda.gov/programs/farmbill/2002/pdf/EQIPFct.pdf (Accessed on September 20, 2008).

United States Environmental Protection Agency. July 2000. Final TMDL Rule: Fulfilling the Goals of the Clean Water Act. EPA 841-F-00-008. Internet site: http://www.epa.gov/owow/tmdl/finalrule/factsheet1.pdf (Accessed on November 5, 2008).

USDA-FSA. Conservation Reserve Program, January 2009. Internet site: http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=landing. (Accessed on July 4, 2009).

USDA-FSA. Direct Payment and Counter-cyclical Information, June 2009. Internet Site: http://www.fsa.usda.gov/FSA/webapp?area=home&subject=dccp&topic=landing. (Accessed on July 4, 2008).

USDA-FSA. Fact Sheet Nonrecourse Marketing Assistance Loan and Loan Deficiency Payment Program, June 2007. Internet Site: http://www.fsa.usda.gov/Internet/FSA_File/nonrecmktg.pdf. (Accessed on October 8, 2008).

USDA-NASS 2007 Census of Agriculture, Louisiana State and Parish Data Volume 1 Geographic Area Series, Part 18, February 2009. Internet site: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Louisiana/lav1.pdf (Accessed on July 2, 2009).

USDA-NASS Agricultural Projections to 2017 Interagency Agricultural, February 2008. Internet site: http://www.usda.gov/oce/commodity/archive_projections/USDAAgriculturalProjections2017.pdf. (Accessed on July 4, 2009).

USDA-NASS. Agricultural Prices 2007 Summary, July 2008. Internet site: http://usda.mannlib.cornell.edu/usda/current/AgriPricSu/AgriPricSu-07-31-2008_revision.pdf. (Accessed on October 8, 2008).

USDA-NASS. Internet site: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1003. (Accessed on October 8, 2008).

USDA-NRCS and USDA-ARS. Fact Sheet Watershed-Scale Pollutant Loading Model - Annualized Agricultural Non-Point Source Pollutant Loading Model, version 2.01, February 2001. Internet site: www.broel.nrw.de/links/Fact_Sheet_AnnAGNPS.pdf (Accessed on August 29, 2008).

USDA-NRCS. Soil Survey of Madison Parish, Louisiana, May 1982.

Vieth, G.R. and P. Suppapanya. An Evaluation of Selected Decision Models: A Case of Crop Choice in Northern Thailand. Journal of Agricultural and Applied Economics, 28(1996): 381-391.

Weems, T.A., E.F. Reynolds, R.L. Venson, E.T. Allen, and T.J. Smith "Soil Survey of Madison Parish, Louisiana." United States Department of Agriculture, Soil Conservation Service in Corporation with the Louisiana Agricultural Experiment Station.

Wesström, I., I. Messing, H. Linner, and J. Lindström. "Controlled Drainage – Effects on Drain Outflow and Water Quality." Agricultural Water Management. 47(2001):85-100.

Westra, J.V., J.K.H. Zimmerman, and B. Vondracek. "Bioeconomic Analysis of Selected Conservation Practices on Soil Erosion and Freshwater Fisheries." Journal of the American Water Resources Association, 41 (2005):309-322.

Westra, J.V., K.W. Easter, and K.D. Olson. “Targeting Nonpoint Source Pollution Control: Phosphorus in the Minnesota River Basin.” Journal of the American Water Resources Association, 38 (2002):493-505.

Wossink, G. A. A. and D. L. Osmond “Costs and Benefits of Best Management Practices to control Nitrogen in the Lower Coastal Plains.” North Carolina State University A&T State University Cooperative Extension, AG-620.

Wossink, G. A. A. and D. L. Osmond. “Cost Analysis of Mandated Agricultural Best Management Practices to Control Nitrogen Losses in the Neuse River Basin, North Carolina.” Journal of Soil and Water Conservation, 57(2002):213-220.

Wright, J. A., A. Shrimohammadi, , W. L. Magette, J. L. Fouss, R. L. Bengston, and J. E. Parsons. “Water Table Management Practices Effects on Water Quality.” American Society of Agricultural and Biological Engineers, 35(1992):823-831.

Wu, J., M.L. Teague, H.P. Mapp, and D.J. Bernardo. “An Empirical Analysis of the Relative Efficiency of Policy Instruments to Reduce Nitrate Water Pollution in the US Southern High Plains.” Canadian Journal of Agricultural Economics, 43(1995):403-420.

Yiridoe, E.K., R.P. Voroney, and A. Weersink. “Impact of Alternative Farm Management Practices on Nitrogen Pollution of Groundwater: Evaluation and Application of CENTURY Model.” Journal of Environmental Quality, 26(1997):1255-1263.

Appendix A: Model Statistics for Crop Yields and Nitrogen Fertilizer Application Rates.

1. a) Corn – Conventional Tillage

   $\widehat{cyd_i} = 16.25 + 1.409 nit_i - 0.0031 nit_i^2$
   (t-stats) (26.11) (124.06) (-69.32)
   R-squared = 99.99; F-stats (p-value) = 0.0031

   b) Corn – Conservation Tillage

   $\widehat{cyd_i} = 20.25 + 1.409 nit_i - 0.0031 nit_i^2$
   (t-stats) (32.53) (124.06) (-69.32)
   R-squared = 99.99; F-stats (p-value) = 0.0031

2. a) Cotton – Conventional Tillage

   $\widehat{cyd_i} = 398.9 + 8.686 nit_i - 0.0362 nit_i^2$
   (t-stats) (610) (372) (-218)
   R-squared = 99.99; F-stats (p-value) = 0.0016

   b) Cotton – Conservation Tillage

   $\widehat{cyd_i} = 700.0 + 7.979 nit_i - 0.0382 nit_i^2$
   (t-stats) (3212) (1026) (-691)
   R-squared = 99.99; F-stats (p-value) = 0.0007

3. a) Rice – Conventional Tillage

   $\widehat{cyd_i} = 49.50 + 0.2513 nit_i - 0.0009 nit_i^2$
   (t-stats) (14.60) (4.779) (-4.529)
   R-squared = 96.56; F-stats (p-value) = 0.1856

   b) Rice – Conservation Tillage

   $\widehat{cyd_i} = 56.13 + 0.1200 nit_i - 0.0002 nit^2$
   (t-stats) (3.084) (0.425) (-0.147)
   R-squared = 88.86; F-stats (p-value) = 0.3337

4. a) Grain Sorghum – Conventional Tillage

   $\widehat{cyd_i} = 62.17 + 0.2676 nit_i - 0.0010 nit_i^2$
   (t-stats) (82.02) (14.72) (-11.88)
   R-squared = 99.27; F-stats (p-value) = 0.0073

   b) Grain Sorghum – Conservation Tillage

   $\widehat{cyd_i} = 68.47 + 0.2410 nit_i - 0.0010 nit_i^2$
   (t-stats) (24.43) (3.586) (-3.132)
   R-squared = 87.37; F-stats (p-value) = 0.1263

Appendix B1: Cabin-Teele Watershed Conventional Tillage Systems Net Revenue (2008-09).

	Soil Type	Corn	Cotton	Rice	Sorghum	Soybean
100% N Fertilizer Application	BA	71.66	41.06			46.74
	CM	64.47	8.85			42.14
	CN	51.33	-19.34		25.31	41.09
	CO	50.37	-47.53			
	SB	36.13	-107.93		6.46	37.79
	SC	32.10	-124.03	65.81	1.76	37.18
	SD	8.76				
	ST	21.02	-168.32			27.38
	TU	28.07	-140.14			36.58
90% N Fertilizer Application	BA	69.54	32.88			46.31
	CM	62.54	1.31			41.74
	CN	49.74	-26.31		25.47	40.71
	CO	48.80	-53.94			
	SB	34.92	-113.13		6.89	37.47
	SC	31.00	-128.91	68.62	2.24	36.88
	SD	8.19				
	ST	20.20	-172.32			27.11
	TU	27.07	-144.69			36.30
80% N Fertilizer Application	BA	65.55	20.16			45.72
	CM	58.82	-10.51			41.18
	CN	46.55	-37.34		25.03	40.18
	CO	45.63	-64.17			
	SB	32.31	-121.67		6.81	37.04
	SC	28.54	-137.01	68.90	2.24	36.46
	SD	6.51				
	ST	18.18	-179.17			26.73
	TU	24.78	-152.34			35.89
70% N Fertilizer Application	BA	59.68	2.90			44.96
	CM	53.33	-26.60			40.46
	CN	41.76	-52.42		23.99	39.50
	CO	40.88	-78.24			
	SB	28.30	-133.56		6.21	36.47
	SC	24.74	-148.32	66.65	1.74	35.92
	SD	3.73				
	ST	14.96	-188.89			26.25
	TU	21.18	-163.07			35.37

Appendix B2: Cabin-Teele Watershed Reduced Tillage Systems Net Revenue (2008-09).

	Soil Type	Corn	Cotton	Rice	Sorghum	Soybean
100% N Fertilizer Application	BA	227.04	5.26			138.52
	CM	204.34	3.47			125.89
	CN	163.18	1.89		23.77	122.76
	CO	159.88	0.32			
	SB	114.95	-3.04		9.65	112.93
	SC	102.24	-3.94	25.36	6.16	111.15
	SD	25.26				
	ST	67.31	-6.41			84.48
	TU	89.54	-4.84			109.36
90% N Fertilizer Application	BA	220.89	5.02			137.73
	CM	198.73	3.25			125.14
	CN	158.61	1.70		24.17	122.05
	CO	155.35	0.15			
	SB	111.50	-3.18		10.19	112.35
	SC	99.10	-4.07	25.37	6.73	110.58
	SD	23.50				
	ST	65.02	-6.50			83.98
	TU	86.71	-4.95			108.82
80% N Fertilizer Application	BA	208.96	4.55			136.48
	CM	187.64	2.81			123.96
	CN	149.11	1.29		24.14	120.93
	CO	145.91	-0.23			
	SB	103.73	-3.49		10.36	111.42
	SC	91.81	-4.35	24.89	6.95	109.69
	SD	18.35				
	ST	59.02	-6.74			83.19
	TU	79.89	-5.22			107.97
70% N Fertilizer Application	BA	191.24	3.85			134.76
	CM	171.05	2.16			122.34
	CN	134.68	0.68		23.68	119.40
	CO	131.57	-0.80			
	SB	91.64	-3.96		10.18	110.16
	SC	80.36	-4.81	23.94	6.83	108.48
	SD	9.80				
	ST	49.33	-7.13			82.11
	TU	69.08	-5.65			106.80

Appendix B3: Cabin-Teele Watershed Conservation Tillage Systems Net Revenue (2008-09).

	Soil Type	Corn	Cotton	Rice	Sorghum	Soybean
100% N Fertilizer Application	BA	42.24	3.01			30.21
	CM	38.32	2.30			27.55
	CN	31.27	1.67		1.31	26.85
	CO	30.66	1.05			
	SB	22.91	-0.29		0.68	24.63
	SC	20.72	-0.65	2.36	0.52	24.22
	SD	6.89				
	ST	14.70	-1.63			18.67
	TU	18.53	-1.00			23.82
90% N Fertilizer Application	BA	41.27	2.99			30.12
	CM	37.44	2.28			27.46
	CN	30.56	1.66		1.34	26.76
	CO	29.95	1.04			
	SB	22.37	-0.29		0.71	24.56
	SC	20.23	-0.65	2.27	0.56	24.16
	SD	6.59				
	ST	14.35	-1.62			18.61
	TU	18.09	-1.00			23.76
80% N Fertilizer Application	BA	39.32	2.88			29.93
	CM	35.63	2.18			27.29
	CN	29.01	1.56		1.35	26.59
	CO	28.41	0.95			
	SB	21.11	-0.36		0.73	24.42
	SC	19.05	-0.71	2.15	0.58	24.02
	SD	5.73				
	ST	13.38	-1.67			18.49
	TU	16.99	-1.06			23.63
70% N Fertilizer Application	BA	36.40	2.68			29.64
	CM	32.89	1.99			27.01
	CN	26.63	1.39		1.35	26.34
	CO	26.05	0.79			
	SB	19.12	-0.49		0.73	24.21
	SC	17.16	-0.83	2.01	0.58	23.82
	SD	4.29				
	ST	11.78	-1.77			18.31
	TU	15.21	-1.18			23.43

Appendix C1: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 10% Reduction in Phosphorus Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,185,648	566			858,807	2,045,022
90% Nitrogen Application Rate			6,994			6,994
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	19,873	3,001				22,874
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				92		92
70% Nitrogen Application Rate				1,087		1,087
Totals	**1,205,521**	**3,567**	**6,994**	**1,178**	**858,807**	**2,076,067**

Appendix C2: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 20% Reduction in Phosphorus Effluent at the Mouth of the Watershed.

Tillage Practices	**Corn**	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,185,648	566			858,807	2,045,022
90% Nitrogen Application Rate			6,994			6,994
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	19,873	3,001				22,874
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				92		92
70% Nitrogen Application Rate				1,087		1,087
Totals	**1,205,521**	**3,567**	**6,994**	**1,178**	**858,807**	**2,076,067**

Appendix C3: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 30% Reduction in Phosphorus Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,052,326				787,619	1,839,945
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	47,595	3,325	650		15,730	67,299
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				92		92
70% Nitrogen Application Rate				1,087		1,087
Totals	**1,099,921**	**3,325**	**650**	**1,178**	**803,349**	**1,908,422**

Appendix D1: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 10% Reduction in Sediment Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate	256	6,790				7,046
90% Nitrogen Application Rate				1,725		1,725
80% Nitrogen Application Rate			18,996			18,996
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,275,748	3,596			858,807	2,138,151
90% Nitrogen Application Rate						
80% Nitrogen Application Rate			13,239			13,239
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Totals	**1,276,004**	**10,386**	**32,235**	**1,725**	**858,807**	**2,179,157**

Appendix D2: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 20% Reduction in Sediment Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate			18,996			18,996
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,275,748				845,533	2,121,281
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	201	3,325			2,909	6,435
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				92		92
70% Nitrogen Application Rate				1,087		1,087
Totals	**1,275,949**	**3,325**	**18,996**	**1,178**	**848,442**	**2,147,891**

Appendix D3: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 30% Reduction in Sediment Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,146,468				767,420	1,913,888
90% Nitrogen Application Rate			6,994			6,994
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	28,427	3,325			20,149	51,901
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				92		92
70% Nitrogen Application Rate				1,087		1,087
Totals	**1,174,895**	**3,325**	**6,994**	**1,178**	**787,569**	**1,973,961**

Appendix E1: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 10% Simultaneous Reduction in Nitrogen, Phosphorus and Sediment Effluent at the Mouth of the Watershed

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate		7,967				7,967
90% Nitrogen Application Rate						
80% Nitrogen Application Rate			18,996			18,996
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,017,796	3,081			858,807	1,879,684
90% Nitrogen Application Rate	249,576					
80% Nitrogen Application Rate				1,634		1,634
70% Nitrogen Application Rate				1,481		1,481
Conservation Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate	193					193
80% Nitrogen Application Rate						
70% Nitrogen Application Rate				980		980
Totals	**1,267,564**	**11,047**	**18,996**	**4,095**	**858,807**	**2,160,510**

Appendix E2: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 20% Simultaneous Reduction in Nitrogen, Phosphorus and Sediment Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,185,648	566			858,807	2,045,022
90% Nitrogen Application Rate			6,994			6,994
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	19,873	3,001				22,874
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				92		92
70% Nitrogen Application Rate				1,087		1,087
Totals	**1,205,521**	**3,567**	**6,994**	**1,178**	**858,807**	**2,076,067**

Appendix E3: Net Revenues ($), by Crop, for Cabin-Teele Sub-Watershed with a 30% Simultaneous Reduction in Nitrogen, Phosphorus and Sediment Effluent at the Mouth of the Watershed.

Tillage Practices	Corn	Cotton	Rice	Sorghum	Soybean	Totals
Conventional Tillage						
100% Nitrogen Application Rate						
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Reduced Tillage						
100% Nitrogen Application Rate	1,052,326				787,619	1,839,945
90% Nitrogen Application Rate						
80% Nitrogen Application Rate						
70% Nitrogen Application Rate						
Conservation Tillage						
100% Nitrogen Application Rate	47,595	3,325	650		15,730	67,299
90% Nitrogen Application Rate						
80% Nitrogen Application Rate				92		92
70% Nitrogen Application Rate				1,087		1,087
Totals	**1,099,921**	**3,325**	**650**	**1,178**	**803,349**	**1,908,422**

Appendix F1: Net Revenues, by Crop, Sensitivity Analysis for a 25 Percent Increase in Nitrogen Fertilizer Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
	Economic Baseline					
Conventional Tillage		3,563	16,871			20,433
Reduced Tillage	1,161,585	2,691		10,019	858,807	2,033,103
Conservation Tillage						
Totals	**1,161,585**	**6,254**	**16,871**	**10,019**	**858,807**	**2,053,536**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		3,563	16,871			20,433
Reduced Tillage	1,154,093	2,691		2,569	858,807	2,018,160
Conservation Tillage	142			808		950
Totals	**1,154,235**	**6,254**	**16,871**	**3,376**	**858,807**	**2,039,543**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		3,563	16,516			20,078
Reduced Tillage	1,108,117	2,691		2,569	858,807	1,972,185
Conservation Tillage	8,180			808		8,987
Totals	**1,116,297**	**6,254**	**16,516**	**3,376**	**858,807**	**2,001,250**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		3,563	16,516			20,078
Reduced Tillage	1,048,003	2,691		2,569	858,807	1,912,070
Conservation Tillage	22,445			808		23,252
Totals	**1,070,447**	**6,254**	**16,516**	**3,376**	**858,807**	**1,955,400**

Appendix F2: Net Revenues, by Crop, Sensitivity Analysis for a 50 Percent Increase in Nitrogen Fertilizer Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
	Economic Baseline					
Conventional Tillage		2,707	14,745			17,452
Reduced Tillage	1,046,611	1,101		5,423	858,807	1,911,942
Conservation Tillage	92					92
Totals	**1,046,703**	**3,808**	**14,745**	**5,423**	**858,807**	**1,929,486**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		2,707	14,656			17,363
Reduced Tillage	1,044,453	1,101		2,054	858,807	1,906,416
Conservation Tillage	92			635		727
Totals	**1,044,545**	**3,808**	**14,656**	**2,689**	**858,807**	**1,924,505**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		2,707	14,656			17,363
Reduced Tillage	1,007,876	1,101		2,054	858,807	1,869,838
Conservation Tillage	7,038			635		7,673
Totals	**1,014,914**	**3,808**	**14,656**	**2,689**	**858,807**	**1,894,874**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		2,707	14,656			17,363
Reduced Tillage	958,876	1,101		2,054	858,807	1,820,839
Conservation Tillage	19,421			635		20,055
Totals	**978,297**	**3,808**	**14,656**	**2,689**	**858,807**	**1,858,257**

Appendix F3: Net Revenues, by Crop, Sensitivity Analysis for a 75 Percent Increase in Nitrogen Fertilizer Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
	Economic Baseline					
Conventional Tillage		404	12,796			13,200
Reduced Tillage	935,300			1,539	858,807	1,795,646
Conservation Tillage	42			462		504
Totals	935,341	404	12,796	2,001	858,807	1,809,350
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		404	12,796			13,200
Reduced Tillage	908,541			1,539	858,807	1,768,887
Conservation Tillage	5,502			462		5,964
Totals	914,044	404	12,796	2,001	858,807	1,788,052
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		404	12,796			13,200
Reduced Tillage	874,893			1,539	858,807	1,735,240
Conservation Tillage	14,821			462		15,283
Totals	889,714	404	12,796	2,001	858,807	1,763,723
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		404	12,796			13,200
Reduced Tillage	845,097			1,113	858,807	1,705,017
Conservation Tillage	15,827			524		16,350
Totals	860,923	404	12,796	1,636	858,807	1,734,567

Appendix F4: Nitrogen Fertilizer Price Sensitivity Analysis: Environmental Impacts for Cabin-Teele Sub-Watershed.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	($/lbs)
	25 Percent Increase in Nitrogen Fertilizer Price			
Economic Baseline	150,232	695	958	-
10% Nitrogen-Nitrate Reduction	135,209	657	893	1.08
20% Nitrogen-Nitrate Reduction	120,186	636	872	3.05
30% Nitrogen-Nitrate Reduction	105,162	599	833	3.05
	50 Percent Increase in Nitrogen Fertilizer Price			
Economic Baseline	149,738	694	941	-
10% Nitrogen-Nitrate Reduction	134,764	657	892	0.47
20% Nitrogen-Nitrate Reduction	119,790	636	871	2.45
30% Nitrogen-Nitrate Reduction	104,816	599	832	2.45
	75 Percent Increase in Nitrogen Fertilizer Price			
Economic Baseline	132,304	653	879	-
10% Nitrogen-Nitrate Reduction	119,074	634	859	1.84
20% Nitrogen-Nitrate Reduction	105,843	602	825	1.84
30% Nitrogen-Nitrate Reduction	92,613	589	811	3.48

Appendix G1: Net Revenues, by Crop, Sensitivity Analysis for a 25 Percent Decrease in Corn Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
	Economic Baseline					
Conventional Tillage		15,969	18,996	1,725		36,690
Reduced Tillage	425,643			13,239	858,845	1,297,727
Conservation Tillage	5,092					
Totals	**430,735**	**15,969**	**18,996**	**14,963**	**858,845**	**1,339,508**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,969	18,996			34,965
Reduced Tillage	418,159			14,631	858,845	1,291,635
Conservation Tillage	6,474					6,474
Totals	**424,633**	**15,969**	**18,996**	**14,631**	**858,845**	**1,333,074**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,969	18,996			34,965
Reduced Tillage	398,873			14,631	858,845	1,272,349
Conservation Tillage	12,699					12,699
Totals	**411,572**	**15,969**	**18,996**	**14,631**	**858,845**	**1,320,013**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,969	18,996			34,965
Reduced Tillage	379,587			14,631	858,845	1,253,063
Conservation Tillage	18,923					18,923
Totals	**398,510**	**15,969**	**18,996**	**14,631**	**858,845**	**1,306,951**

Appendix G2: Net Revenues, by Crop, Sensitivity Analysis for a 25 Percent Increase in Corn Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
	Economic Baseline					
Conventional Tillage		15,969	18,996	1,725		36,690
Reduced Tillage	2,134,449			13,239	858,807	3,006,495
Conservation Tillage						
Totals	**2,134,449**	**15,969**	**18,996**	**14,963**	**858,807**	**3,043,184**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,830	18,375			34,206
Reduced Tillage	2,116,183			3,084	858,807	2,978,074
Conservation Tillage				980		980
Totals	**2,116,183**	**15,830**	**18,375**	**4,064**	**858,807**	**3,013,260**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		4,418	18,375			22,794
Reduced Tillage	2,054,238	4,468		3,084	858,807	2,920,597
Conservation Tillage	494			980		1,474
Totals	**2,054,732**	**8,887**	**18,375**	**4,064**	**858,807**	**2,944,865**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		4,418				4,418
Reduced Tillage	1,934,024	4,468	6,864	1,603	858,807	2,805,766
Conservation Tillage	17,921			1,087		19,008
Totals	**1,951,946**	**8,887**	**6,864**	**2,690**	**858,807**	**2,829,193**

Appendix G3: Net Revenues, by Crop, Sensitivity Analysis for a 50 Percent Increase in Corn Price for Cabin-Teele Watershed.

Tillage Practices	**Annual Net Revenue ($ in Watershed)**					
	Corn	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
	Economic Baseline					
Conventional Tillage		15,969	18,996	1,725		36,690
Reduced Tillage	2,992,454			13,239	858,807	3,864,500
Conservation Tillage						
Totals	**2,992,454**	**15,969**	**18,996**	**14,963**	**858,807**	**3,901,190**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,824	18,375			34,199
Reduced Tillage	2,966,534			3,084	858,807	3,828,425
Conservation Tillage				980		980
Totals	**2,966,534**	**15,824**	**18,375**	**4,064**	**858,807**	**3,863,604**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		4,418				4,418
Reduced Tillage	2,898,360	4,468	6,864	1,603	858,807	3,770,102
Conservation Tillage				1,087		1,087
Totals	**2,898,360**	**8,887**	**6,864**	**2,690**	**858,807**	**3,775,607**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		4,418				4,418
Reduced Tillage	2,742,893	3,938	6,864	1,603	858,807	3,614,104
Conservation Tillage	3,850			1,087		4,937
Totals	**2,746,743**	**8,356**	**6,864**	**2,690**	**858,807**	**3,623,460**

Appendix G4: Net Revenues, by Crop, Sensitivity Analysis for a 75 Percent Increase in Corn Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
	Economic Baseline					
Conventional Tillage	404	15,969	18,996	1,725		37,094
Reduced Tillage	3,850,460			13,239	858,807	4,722,506
Conservation Tillage						
Totals	**3,850,864**	**15,969**	**18,996**	**14,963**	**858,807**	**4,759,600**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		4,418	18,375			22,794
Reduced Tillage	3,825,561	4,468		3,084	858,807	4,691,920
Conservation Tillage				980		980
Totals	**3,825,561**	**8,887**	**18,375**	**4,064**	**858,807**	**4,715,694**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		4,418				4,418
Reduced Tillage	3,731,868	4,468	6,864	1,603	858,807	4,603,610
Conservation Tillage				1,087		1,087
Totals	**3,731,868**	**8,887**	**6,864**	**2,690**	**858,807**	**4,609,115**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		4,418				4,418
Reduced Tillage	3,553,949	3,727			858,807	4,416,483
Conservation Tillage	1,048		554	1,178		2,781
Totals	**3,554,997**	**8,145**	**554**	**1,178**	**858,807**	**4,423,682**

Appendix G5: Corn Price Sensitivity Analysis: Environmental Impacts for Cabin-Teele Sub-Watershed.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	($/lbs)
	25 Percent Decrease in Corn Price			
Economic Baseline	122,839	688	1,000	-
10% Nitrogen-Nitrate Reduction	110,555	679	990	1.06
20% Nitrogen-Nitrate Reduction	98,271	652	956	1.06
30% Nitrogen-Nitrate Reduction	85,988	625	921	1.06
	25 Percent Increase in Corn Price			
Economic Baseline	153,287	748	1,077	-
10% Nitrogen-Nitrate Reduction	137,958	710	1,025	2.81
20% Nitrogen-Nitrate Reduction	122,630	658	895	5.41
30% Nitrogen-Nitrate Reduction	107,301	622	857	8.12
	50 Percent Increase in Corn Price			
Economic Baseline	153,287	748	1,077	-
10% Nitrogen-Nitrate Reduction	137,958	710	1,025	3.93
20% Nitrogen-Nitrate Reduction	122,630	647	898	7.05
30% Nitrogen-Nitrate Reduction	107,301	643	879	12.81
	75 Percent Increase in Corn Price			
Economic Baseline	153,287	748	1,077	-
10% Nitrogen-Nitrate Reduction	137,958	658	910	5.05
20% Nitrogen-Nitrate Reduction	122,630	647	898	8.69
30% Nitrogen-Nitrate Reduction	107,301	642	878	16.33

Appendix H1: Net Revenues, by Crop, Sensitivity Analysis for a 25 Percent Increase for Cotton Price in Cabin-Teele Watershed.

Tillage Practices	**Annual Net Revenue ($ in Watershed)**					
	Corn	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
	Economic Baseline					
Conventional Tillage		631,329	22,150	2,491		655,970
Reduced Tillage	1,406,195	690		25,984	947,332	2,380,201
Conservation Tillage		1,237				
Totals	**1,406,195**	**633,256**	**22,150**	**28,474**	**947,332**	**3,037,407**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		620,204	22,134	2,486		644,824
Reduced Tillage	1,405,692	9,192		25,440	947,332	2,387,655
Conservation Tillage	127	1,221				1,348
Totals	**1,405,819**	**630,617**	**22,134**	**27,926**	**947,332**	**3,033,826**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		620,204	21,394			641,598
Reduced Tillage	1,376,424	8,502		19,763	947,332	2,352,020
Conservation Tillage	167	1,803		519		2,490
Totals	**1,376,591**	**630,509**	**21,394**	**20,282**	**947,332**	**2,996,108**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		620,204	21,394			641,598
Reduced Tillage	1,316,433	8,502		4,678	947,332	2,276,945
Conservation Tillage	7,104	1,803		1,524		10,431
Totals	**1,323,537**	**630,509**	**21,394**	**6,202**	**947,332**	**2,928,974**

Appendix H2: Net Revenues, by Crop, Sensitivity Analysis for a 50 Percent Increase in Cotton Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
	Economic Baseline					
Conventional Tillage		1,738,200	25,380	6,973		1,770,553
Reduced Tillage	1,535,862			35,228	1,035,856	2,606,946
Conservation Tillage						
Totals	**1,535,862**	**1,738,200**	**25,380**	**42,200**	**1,035,856**	**4,377,498**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		1,738,200	24,413			1,762,613
Reduced Tillage	1,503,138			40,521	1,035,856	2,579,515
Conservation Tillage	167					167
Totals	**1,503,305**	**1,738,200**	**24,413**	**40,521**	**1,035,856**	**4,342,295**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		1,738,200	24,413			1,762,613
Reduced Tillage	1,402,435			40,521	1,035,856	2,478,812
Conservation Tillage	15,935					15,935
Totals	**1,418,371**	**1,738,200**	**24,413**	**40,521**	**1,035,856**	**4,257,361**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		1,738,200	24,413			1,762,613
Reduced Tillage	1,322,943			9,102	1,035,856	2,367,901
Conservation Tillage	33,166			1,896		35,062
Totals	**1,356,109**	**1,738,200**	**24,413**	**10,998**	**1,035,856**	**4,165,576**

Appendix H3: Net Revenues, by Crop, Sensitivity Analysis for a 75 Percent Increase in Cotton Price for Cabin-Teele Watershed.

Tillage Practices	**Annual Net Revenue ($ in Watershed)**					
	Corn	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
	Economic Baseline					
Conventional Tillage		2,925,228	28,610	58,194		3,012,032
Reduced Tillage	1,665,581				1,124,381	2,789,962
Conservation Tillage						
Totals	**1,665,581**	**2,925,228**	**28,610**	**58,194**	**1,124,381**	**5,801,994**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		2,925,228	28,409	4,009		2,957,646
Reduced Tillage	1,646,575			50,270	1,124,381	2,821,226
Conservation Tillage	193					193
Totals	**1,646,768**	**2,925,228**	**28,409**	**54,280**	**1,124,381**	**5,779,065**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		2,925,228	27,432			2,952,660
Reduced Tillage	1,553,532			53,481	1,124,381	2,731,394
Conservation Tillage	9,736					9,736
Totals	**1,563,268**	**2,925,228**	**27,432**	**53,481**	**1,124,381**	**5,693,790**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		2,925,228	27,432			2,952,660
Reduced Tillage	1,428,385			46,482	1,124,381	2,599,248
Conservation Tillage	33,550			401		33,951
Totals	**1,461,936**	**2,925,228**	**27,432**	**46,882**	**1,124,381**	**5,585,859**

Appendix H4: Cotton Price Sensitivity Analysis: Environmental Impacts for Cabin-Teele Sub-Watershed.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	($/lbs)
	25 Percent Increase in Cotton Price			
Economic Baseline	172,635	990	1,603	-
10% Nitrogen-Nitrate Reduction	155,371	857	1,384	1.20
20% Nitrogen-Nitrate Reduction	138,108	843	1,360	3.32
30% Nitrogen-Nitrate Reduction	120,844	804	1,313	4.32
	50 Percent Increase in Cotton Price			
Economic Baseline	184,033	1,081	1,742	-
10% Nitrogen-Nitrate Reduction	165,629	1,078	1,723	4.00
20% Nitrogen-Nitrate Reduction	147,226	1,050	1,693	4.98
30% Nitrogen-Nitrate Reduction	128,823	985	1,616	5.00
	75 Percent Increase in Cotton Price			
Economic Baseline	189,531	1,101	1,772	-
10% Nitrogen-Nitrate Reduction	170,578	1,079	1,724	1.93
20% Nitrogen-Nitrate Reduction	151,625	1,061	1,705	5.64
30% Nitrogen-Nitrate Reduction	132,672	1,014	1,654	6.68

Appendix I1: Net Revenues, by Crop, Sensitivity Analysis for a 25 Percent Increase in Soybean Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
	Economic Baseline					
Conventional Tillage		15,969	18,996	1,725		36,690
Reduced Tillage	1,276,486			13,239	1,221,255	2,510,980
Conservation Tillage						
Totals	**1,276,486**	**15,969**	**18,996**	**14,963**	**1,221,255**	**2,547,669**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,897	18,996			34,893
Reduced Tillage	1,265,306			3,115	1,221,255	2,489,676
Conservation Tillage	193			980		1,173
Totals	**1,265,498**	**15,897**	**18,996**	**4,095**	**1,221,255**	**2,525,741**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,824	18,375			34,199
Reduced Tillage	1,211,155			3,084	1,221,267	2,435,507
Conservation Tillage	8,500			980		9,480
Totals	**1,219,655**	**15,824**	**18,375**	**4,064**	**1,221,267**	**2,479,186**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,824	18,375			34,199
Reduced Tillage	1,138,642			3,084	1,221,267	2,362,993
Conservation Tillage	24,934			980		25,914
Totals	**1,163,576**	**15,824**	**18,375**	**4,064**	**1,221,267**	**2,423,106**

Appendix I2: Net Revenues, by Crop, Sensitivity Analysis for a 50 Percent Increase in Soybean Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	Cotton	Rice	Sorghum	Soybean	Totals
	Economic Baseline					
Conventional Tillage		15,969	18,996	1,725		36,690
Reduced Tillage	1,276,457			13,239	1,583,727	2,873,423
Conservation Tillage						
Totals	**1,276,457**	**15,969**	**18,996**	**14,963**	**1,583,727**	**2,910,112**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,897	18,996			34,893
Reduced Tillage	1,265,244			3,115	1,583,760	2,852,119
Conservation Tillage	193			980		1,173
Totals	**1,265,437**	**15,897**	**18,996**	**4,095**	**1,583,760**	**2,888,185**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,824	18,375			34,199
Reduced Tillage	1,211,108			3,084	1,583,760	2,797,952
Conservation Tillage	8,499			980		9,480
Totals	**1,219,608**	**15,824**	**18,375**	**4,064**	**1,583,760**	**2,841,631**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,824	18,375			34,199
Reduced Tillage	1,138,595			3,084	1,583,760	2,725,439
Conservation Tillage	24,934			980		25,914
Totals	**1,163,529**	**15,824**	**18,375**	**4,064**	**1,583,760**	**2,785,552**

Appendix I3: Net Revenues, by Crop, Sensitivity Analysis for a 75 Percent Increase in Soybean Price for Cabin-Teele Watershed.

Tillage Practices	Annual Net Revenue ($ in Watershed)					
	Corn	**Cotton**	**Rice**	**Sorghum**	**Soybean**	**Totals**
	Economic Baseline					
Conventional Tillage		15,969	18,996	1,725		36,690
Reduced Tillage	1,276,423			13,239	1,946,214	3,235,876
Conservation Tillage						
Totals	**1,276,423**	**15,969**	**18,996**	**14,963**	**1,946,214**	**3,272,565**
	10% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,897	18,996			34,893
Reduced Tillage	1,265,243			3,115	1,946,214	3,214,572
Conservation Tillage	193			980		1,173
Totals	**1,265,436**	**15,897**	**18,996**	**4,095**	**1,946,214**	**3,250,638**
	20% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,824	18,375			34,199
Reduced Tillage	1,211,105			3,084	1,946,214	3,160,403
Conservation Tillage	8,500			980		9,480
Totals	**1,219,605**	**15,824**	**18,375**	**4,064**	**1,946,214**	**3,204,082**
	30% Nitrogen-Nitrate Reduction from Economic Baseline					
Conventional Tillage		15,824	18,375			34,199
Reduced Tillage	1,138,592			3,084	1,946,214	3,087,890
Conservation Tillage	24,934			980		25,914
Totals	**1,163,527**	**15,824**	**18,375**	**4,064**	**1,946,214**	**3,148,003**

Appendix I4: Soybean Price Sensitivity Analysis: Environmental Impacts for Cabin-Teele Sub-Watershed.

Scenarios	Nitrogen	Phosphorus	Sediment	Shadow Price
	(lbs)	(lbs)	(tons)	($/lbs)
	25 Percent Increase in Soybean Price			
Economic Baseline	153,287	748	1,077	-
10% Nitrogen-Nitrate Reduction	137,958	709	1,010	1.69
20% Nitrogen-Nitrate Reduction	122,630	690	990	3.66
30% Nitrogen-Nitrate Reduction	107,301	652	950	3.66
	50 Percent Increase in Soybean Price			
Economic Baseline	153,286	748	1,077	-
10% Nitrogen-Nitrate Reduction	137,958	709	1,010	1.69
20% Nitrogen-Nitrate Reduction	122,629	690	990	3.66
30% Nitrogen-Nitrate Reduction	107,300	652	950	3.66
	75 Percent Increase in Soybean Price			
Economic Baseline	153,286	748	1,077	-
10% Nitrogen-Nitrate Reduction	137,958	709	1,010	1.69
20% Nitrogen-Nitrate Reduction	122,629	690	990	3.66
30% Nitrogen-Nitrate Reduction	107,300	652	950	3.66

Vita

Augustus Nyako Matekole completed his Ordinary Level Certificate education at Saint Augustine’s College, Cape Coast, Ghana, in 1992. He obtained Advanced Level Certificate at Presbyterian Boys Secondary School, Legon-Accra, in 1994. He enrolled at the University of Cape Coast, Ghana, and received a Bachelor of Arts degree in economics in 1999. He attended University of Georgia, Athens-US, and earned a Master of Science in Environmental Economics degree in 2003. In the spring of 2005, he enrolled in the agricultural economics doctoral program at Louisiana State University, Baton Rouge-US. He is currently a candidate for the degree of Doctor of Philosophy, which will be conferred in August of 2009.