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# BMP Adoption in Two East Tennessee Watersheds

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To the Graduate Council:

I am submitting herewith a thesis written by Michael Barrowclough entitled "BMP Adoption in Two East Tennessee Watersheds." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of , with a major in Agricultural Economics.

Ernest Bazen, Major Professor

We have read this thesis and recommend its acceptance:

Forbes Walker, Seong-Hoon Cho

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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And recommend its acceptance:

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Seong-Hoon Cho

Accepted for the Council:

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Vice Chancellor and
Dean of Graduate Studies

(Original signatures are on file with official student records.)

# BMP Adoption in Two East Tennessee Watersheds

A Thesis
Presented for the
Masters of Science
Degree
The University of Tennessee, Knoxville

Michael John Barrowclough
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# Dedication

This thesis is dedicated to my parents and grandparents.

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**Abstract**

Voluntary adoption of Best Management Practices (BMPs) has been the foundation among many environmental conservation programs geared towards non-point source pollution. While farmers view BMPs as being both appropriate and problematic, there remain many constraints to BMP adoption on the farm. The objective of this research was to determine the criteria beef and dairy producers used in their decision making process on whether or not to adopt a given BMP or set of BMPs in the Pond Creek and Oostanaula Creek watersheds located in East Tennessee. Results are presented of exploratory sociological research designed to better understand how farmers select agricultural practices with the potential to effect water quality and soil erosion. Data establishes that a variety of economic, institutional, organizational and social factors interact in dynamic ways to influence farmer resource management decisions and that the resulting agricultural practices have the potential for subtle and dramatic effects on water quality in Pond Creek, Oostanaula Creek, and surrounding water bodies.

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# CHAPTER 1. INTRODUCTION

## 1.1 Problem Statement

The traditional view of farmers as environmental stewards has been challenged by increased concern about the relationship between agricultural production and environmental quality (Rahelizatovo and Gillespie, 2004). Currently in the United States of America (U.S.) the quality of the nation's water resources and how to protect them are being debated by both policy makers and the American public. "Over one-quarter of surface water contamination from agricultural sources in the U.S. has been attributed to livestock production. Agricultural sources have been found to be a source of contamination in almost three-quarters of rivers and streams and about one-half of lakes and estuaries that have been identified by the U.S. Environmental Protection Agency (EPA) as environmentally impaired" (Innes, 2000; U.S. Environmental Protection Agency, 1994).

The United States Department of Agriculture (USDA) classifies water pollution into two categories, point-source and nonpoint-source. Point-source pollution is pollution that can be directly linked back to a single source. Examples of point-source pollution are a pipe, drain, or even storm water runoff that feeds directly into a water body. Currently, a National Pollutant Discharge Elimination System (NPDES) permit must be obtained for all locations that contribute to point-source pollution. This permit restricts how much pollution can be released into water bodies. Depending on the types of water bodies, some permits might be stricter than others. If an agency is found in violation, they may be fined up to $25,000 per day until all guidelines have been met. Unlike point-source pollution, nonpoint-source has

been the most difficult to address due to the fact that it cannot be traced back to one single source (Leeds, Brown and Watermeier, 2006).

Nonpoint-source pollution is pollution due to runoff or leaching of nutrients and pesticides that comes from a large area and is closely associated with certain land uses. It has been established that nonpoint-source pollution is a key factor in dealing with our nation's water quality problems (Ribaudo, 1999; Robbins, 1979). "Despite some progress in reducing agricultural production practices believed harmful to water quality, agriculture is generally recognized as the largest contributor to nonpoint-source water pollution in the U.S." (Ribaudo, 1999). Effective policy designed to reduce nonpoint-source pollution in agriculture will be crucial in the future because of increasing public desire for water quality protection, limited public funds for reducing water pollution, and ambivalence about command and control practices (Carpentier, Bosch, and Batie, 1998).

Even before the passing of the Clean Water Act in 1972, the American public began demanding government officials for stronger and more effective environmental quality standards to help curb non-point source pollution from farming practices (Viets, 1971). Due to the public's environmental concerns, arrays of best management practices (BMPs) have been developed to assist the farmer in practicing a more environmentally friendly operation. The purpose in designing and implementing BMPs is to reduce the impacts of nonpoint-source pollution on the environment while improving the farmer's production rate. No single or set of BMPs is best for every circumstance. Each will have benefits and drawbacks associated with its implementation. Individual producers are left with the tasks of determining which single or set of BMPs is best for them. Profit maximizing producers are

especially interested in learning the economic tradeoffs between implementation and production for each BMP prior to adoption. Labor needs, cost of setup and maintenance, regulations, convenience, and technical competency of the individual available to oversee operations are just some of the tradeoffs that need to be taken into consideration.

It is in every producer's best interest to preserve the quality of their land. However, not all producers have the same goals towards the quality of their neighbors land. Farm operators have little financial motivation to reduce offsite impacts, and farming remains a source of sedimentation and nutrient loading in some watersheds (Lambert et al., 2006). Producers not able to see the additional personal benefits created by Natural Resource Conservation Service's (NRCS) conservation practices are more likely to be discouraged of their adoption.

To increase the adoption rate of voluntary BMPs, government funded programs such as the Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Wetlands Reserve Program (WRP), Grasslands Reserve Program (GRP), and Environmental Quality Incentives Program (EQIP) have been created to help provide technical, financial and informational support to producers.

With the passing of the Clean Water Act of 1972, every state was required to assess water quality in all rivers, streams, lakes or water bodies that are open to the public and report the findings. Section 303(d) of the Clean Water Act of 1972 sets a provision for a Total Maximum Daily Load (TMDL) in which individual states were to assess and implement plans for reducing pollutants in impaired rivers, streams and water bodies. A TMDL is a provision that: 1) quantifies the amount of a pollutant in a stream, 2) identifies

the sources of the pollutant, and 3) recommends regulatory or other actions that may need to be taken in order for the stream to cease being polluted. In 1998, Tennessee Department of Environment and Conservation (TDEC) findings stated that 792 water bodies in Tennessee were impaired. In 2005, this number had risen to 974 impaired water bodies. In Tennessee, two documents (the 305(b) and 303(d) Reports) are prepared by TDEC to complete the guidelines set forth by the Federal Act. Impaired water bodies in Tennessee and sources of the impairment are acknowledged in these findings. Findings from the 305(b) Report in 2000 stated that Tennessee rivers and streams were being polluted by agricultural practices. Grazing related activities were estimated to be responsible for 42 percent of agricultural pollution sources with in-stream watering of livestock being cited as a significant source of fecal coli form bacteria (TDEC, 2000). In 2001, it was estimated that there were approximately 2.1 million cattle and calves on about 50,000 livestock operations and about 95,000 dairy cows on 1,600 operations in Tennessee (TDA, 2000). In 2005, it was estimated that only 300 dairy operations were in business milking 70,000 dairy cows in Tennessee. The majority of these animals are raised on pastures, many of them in fields adjacent to or with direct access to surface waters (Walker et al., 2003).

In Tennessee, EQIP is the most widely used program for implementing voluntary BMPs. Farmer's willingness to adopt, as well as the application process and conservation program priority scoring and ranking procedures coupled with the program's limited budgets are major components that determine the effectiveness of environmental voluntary programs. Although it is not always profit maximization that influences a farmer to adopt conservation practices, environmental views, labor intensity of practice, budget constraint,

off-farm commitments and personal goals are a few that affect decisions producers are willing to make regarding voluntary BMP adoption. It is important to understand what motivates or hinders a producer to adopt in order to preserve the quality of our environment. Applied research is required to identify technologies that will enable Tennessee producers (especially livestock producers) to remain competitive while complying with current and emerging federal and state environmental regulations.

## 1.2 Objectives

### 1.2.1 General Objectives

The main objective of this study is to determine the criteria beef and dairy producers in two East Tennessee watersheds use in their decision-making process for voluntarily adopting BMPs. By determining what motivates producers to voluntarily adopt, law makers and regulators can better target policies toward improving the nation's water quality. The two watersheds chosen for this study were Pond Creek and Oostanaula Creek in Southeastern Tennessee.

### 1.2.2 Specific Objectives

The specific objectives of this study are to:

1) Review the literature concerning voluntary BMP adoption by agricultural producers;

2) Analyze the survey data from the Pond Creek watershed and Oostanaula Creek watershed to determine what factors motivate producers to adopt BMPs;

3) Conduct a cross-survey analysis between the Pond Creek watershed and Oostanaula Creek watershed to determine any similarities or differences between the watersheds;

4) Evaluate the impact of receiving cost-share funding on adoption of BMPs; and

5) Evaluate the impact that the Tennessee Department of Agriculture (TDA) and NRCS funding have on promoting BMP adoption.

### 1.3 The General Procedures and Outline of the Thesis

This thesis is organized into five chapters. Chapter Two reviews the literature that researchers have previously conducted on farmer’s willingness to voluntarily adopt BMPs. The methods used to determine the positive and negative factors that the Pond Creek watershed and Oostanaula Creek watershed farmers use in voluntarily adopting BMPs are included in Chapter Three. Chapter Four presents the summary statistics of the variables and the empirical analysis. The findings of the study and conclusions are included in Chapter Five.

# CHAPTER 2. LITERATURE REVIEW

## 2.1 Literature Review

### 2.1.1 Environmental Studies

Previous research has shown the impacts of animal waste on water resources under poor and best management practices (Ashraf and Christensen, 1974; Innes, 2000; Mussell and Martin, 2000; Osei et al., 2003). Ackerman and Taylor (1995) identified intensive livestock operations as point sources of pollution to streams. One livestock operations in their study was a swine facility that was linked to ongoing fish kills in an adjacent stream. Their investigation revealed that the facility lacked any waste collection structure to collect nutrient rich runoff. Manure drained directly from the feedlot into the adjacent stream. In this case dissolved oxygen, phosphorous and ammonia concentrations exceeded Illinois water quality standards. If not properly managed, animal waste can have major impacts that negatively effect the environment. Animal waste is not the only pollutant that is of concern when dealing with agricultural production. Fertilizer waste can have the same detrimental effects to the environment as well. Fertilizer waste comes from the over application of plant nutrients (nitrogen and phosphorous) on pasture and crop land.

The application of plant nutrients in excess of pasture or crop demand can result in the contamination of surface and ground water. For example, Andres (1995) found nitrate contamination in ground water under cropland that received excessive applications of manure and that nitrate contamination was more severe in areas with intensive animal production than elsewhere. Factors revealed to be contributing to the nitrate contamination included: agricultural land use; flat topography; well drained, highly permeable soils and

aquifer characteristics. The type of agricultural land use chosen can have a significant impact on ground water contamination. Robbins (1979) found that runoff is proportionately higher from a heavily grazed watershed than moderately or lightly grazed watersheds. High runoff is due to the compaction of soil from cattle's hooves and grazing practices. Runoff from pastures and the direct deposition of manures from in-stream watering of animals can produce significant loadings of a number of potential pollutants from manure (Walker et al., 2003). Some of these pollutants can have quite a health impact on the people living in the watershed. Potential pathogens like Escherichia coli and Cryptosporidium are just two of the deadly pollutants that can be found.

By teaching farmers to use more conservation practices, the harmful effects of agricultural production can be greatly reduced. In a study by Eghball et al. (2000), they found that by installing grass hedges, the concentration and total amounts of phosphorous (P) and nitrogen (N) in runoff would be effectively reduced. The reductions in P and N concentrations and quantities in runoff as a result of using a single grass hedge were significant (Eghball et al., 2000). The reductions in total P and total N ranged from 38% to 40% and 52% to 60% respectively from implementing grass hedges. In a study done by Vandyke et al. (1999) on the effectiveness of nutrient management practices, results showed that the adoption of nutrient management practices decreased the field-level nitrogen and phosphorous losses. Within each farm, nutrient loss reductions are dependent on site-specific physical characteristics and management practices (Vandyke et al., 1999).

Management decisions are going to differ depending on characteristics of the farm and the farmer's goals, objectives and management capabilities to name a few. For example,

75 percent of the reduction in soil erosion by corn producers between 1982 and 1997 can be attributed to the adoption of conservation tillage practices for business reasons (Lambert et al., 2006; Hopkins and Johansson, 2004). The size of the farm, the age of the farmer, the household's gross income and the farmer's goals are just some of the characteristics that need to be taken into consideration. In a study by Rahelizatovo and Gillespie (2004) on the characteristics of Louisiana dairy producers, the farm's net worth, the age of the farmer, the farmer's off-farm income and the size of the farms herd all effect the adoption process. Another study by Lynch and Brown (2000) revealed that the land's resale value effects whether or not producers are likely to adopt riparian buffers.

### 2.1.2 Adoption Theory

Many economists and sociologists have conducted research to examine what motivates producers to voluntarily adopt conservation practices. The basic principles of economics tell us that all decision making comes down to the issue of profit-maximization. Economically it does not make sense to voluntarily adopt a practice that will not increase revenue or decrease costs. With all the risks involved in agriculture an incentive of some kind must come from voluntarily changing working management practices. Lambert et al. (2006) evaluated adoption criteria for crop production on a national scale and suggest that cost-sharing and incentive payments are the way to go. Specific business, operator, and household characteristics were used to determine which variables are significant for corn producers to adopt management-intensive conservation techniques. By using a cumulative probit model, also known as an ordered response, Lambert et al. (2006) was able to estimate the correlation between farm structure, household demographics, environmental factors,

regional economic indicators, and the level of conservation-compatible practices used by corn producers in the U.S. A second analysis involved the use of a multinomial logit model. This model allowed for the estimation of the correlation between farm structure, household demographics, environmental factors, and regional economic indicators.

In contrast to the assumption that profit maximization is the principal factor in adopting conservation practices, Napier, Tucker, and McCarter (2000) and Napier and Bridges (2002) contests that through the exposure to information, producers will be more inclined to adopt. Both studies justify this argument through the use of the diffusion theory. The adoption-diffusion perspective of technology adoption presupposes that a farmer must be aware of the need for the technology, be able to obtain valid agronomic and economic information to evaluate potential consequences, and receive assistance on transferring technology and adapting it to unique climate, soil, managerial, and social conditions (Cary and Wilkinson, 1997; Nowak, 1987). The diffusion theory assumes that when people become aware of problems they will act to resolve them (Napier and McCarter, 2002). Now, the question that has to be asked is whether profit alone is the deciding reason to adopt a specific conservation practice.

While it has been shown that economic incentives can encourage adoption of conservation production systems as long as subsidies continue to be received, economic subsidies alone are not sufficient to motivate land owner-operators to adopt and use conservation production systems (Napier, Tucker, and McCarter, 2000). Napier and Bridges (2002) developed the Information, Education, Technical Assistance, and Economic Subsidies (IETS) conservation approach to determine the decision criteria that motivates

producers to adopt conservation practices. By comparing two like watersheds in Ohio, Napier and Bridges (2002) proposed that the watershed with the most educational and informational assistance will be the watershed that exhibits a greater rate of voluntary adoption of conservation practices. Results showed this hypothesis not to be true. Producers in the Darby Creek watershed who received extra informational and educational assistance did not adopt conservation practices any more than producers in the Upper Scioto River watershed. Findings from these and other studies bring into serious question the use of conservation initiatives that employ IETS-type programs (Napier and Bridges, 2002).

In a recent study by Bosch, Bonham, and Pease (2004) a different approach to adopting conservation practices is taken by looking at mandatory nutrient management planning and riparian buffer policies. This study analyzed four alternative spatial scenarios in a watershed that can be mandated to adopt nutrient management planning and riparian buffers. From the four scenarios, the cost effectiveness of each and the reductions in pollution gained were determined. The empirical model used was a Benefit/Cost analysis developed to approximate the profit maximizing solution for each scenario. The spatial representation of farms significantly affects the estimated costs and effectiveness of pollution control practices (Bosch, Bonham, and Pease, 2004). Bosch, Bonham, and Pease (2004) claim that if spatial information can be obtained at a reasonable price, than it should be used to maximize the effectiveness of evaluating policies.

## CHAPTER 3. METHODOLOGY AND PROCEDURES

### 3.1 Data Collection

Data for the model was gathered in the Pond Creek watershed and Oostanaula Creek watershed. Both watersheds are in close proximity to one another and are typical of other agricultural watersheds throughout the southeast region of the U.S. Most importantly however, in 1998 both watersheds were placed on the nation's 303(d) list for impaired water bodies. The findings of the report state that agricultural practices played a significant role in the impairment. A survey was developed and conducted within both watersheds. The survey consists of twenty six questions and included twenty seven inquiries of demographic information (i.e., farm characteristics, age, income, farm size, etc.). It is anticipated that a variety of economic, institutional, organizational and social factors all interact in dynamic ways to influence farmer resource management decisions.

#### 3.1.1 Survey Administration

Producers from both watersheds were surveyed in early 2004. An initial goal of covering 50 percent of the 14,520 and 16,419 agricultural acres, in Pond Creek and Oostanaula Creek respectively, was set. I traveled to all three counties (McMinn, Monroe and Loudon County, Tennessee) in the Pond Creek watershed along with watershed coordinator Lena Beth Carmichael distributing surveys in person to farmers. A total of six trips were made to the Pond Creek watershed with twenty nine surveys being completed. Initially, producers with larger tracts of agricultural lands were visited and asked to participate first. In addition, I traveled to McMinn County to attend a livestock extension workshop to distribute surveys to Oostanaula Creek producers. Twenty nine surveys were

returned complete. By conducting these surveys in person, producers had the opportunity to express their personal insights and concerns about conservation programs, practices and water quality in the watershed. Not one producer from either watershed rejected taking the survey. However, some producers were hesitant at first because they were concerned about how it might affect them in the future. One producer spoke of a particularly bad experience after filling out a survey for another research study. All producers were told that the survey was strictly confidential and that their name would not be put on any survey.

### 3.1.2 Characteristics of the Pond Creek Watershed

The Pond Creek watershed is part of the larger Watts Bar watershed located along Interstate 75 with land coverage in McMinn, Monroe and Loudon County, Tennessee. Pond Creek's Hydrological Unit Code (HUC) is TN060102010013. The Pond Creek watershed is 16 miles in length and 4 miles at its widest section. In 2000, the Tennessee Valley Authority (TVA) found that there were 14,520 acres of agricultural land that accounts for 61.7% of the total land mass in the watershed. Agricultural land is defined as any land that is in use for agricultural production. Forested areas make up the next largest group of land. Refer to Tables 1 and 2 for watershed land uses (All tables located in Appendix). According to the NRCS, there were 240 farms in the watershed in 1999. This included 25 dairies, 45 cow/calf operations and 60 limited resource farmers. Since this time, dairy farms have been decreasing and typically converting to cow/calf operations. Today, there are only 10 dairy farms in the watershed. Beef cow/calf operations raised on pasture and dairy operations raised on corn silage and pasture are the leading agricultural commodities. Corn silage and soybeans are the predominant crops in production. According to the 2000 U.S. Census data,

there were 1,441 people located inside the watershed. Out of this, 1,152 were considered to be rural while only 70 were considered to be farmers. The average per capita income for the watershed was $14,048.

### 3.1.3 Characteristics of the Oostanaula Creek Watershed

The Oostanaula Creek watershed is a tributary of the Hiawassee River watershed located with land coverage in McMinn and Monroe County, Tennessee. Oostanaula Creeks HUC is TN060200020702. The watershed covers approximately 70.3 square miles or 44,864 acres. According to the TVA, in 2000 there were 16,419 acres of agricultural land that accounts for 36.6% of the total land mass in the watershed. The predominant land use in the watershed is forest covering 47.7% of the land acreage in the watershed. Refer to Tables 1 and 2 for watershed land uses. Beef cow/calf operations raised on pasture is the largest agricultural commodity raised in the watershed with 2,520 head of cattle in the watershed. Over 1,200 head of dairy cattle on 6 dairies are raised in the watershed along with eighty-five horses. According to the 2000 U.S. Census data, there were 1,538 people located inside the watershed. Out of this, 835 were considered to be rural while only 37 were considered to be farmers. The average per capita income for the watershed was $17,020. Typically, producers in this watershed are not full time farmers. Instead, many of the producers are hobby farmers receiving the majority of their income from off farm employment.

### 3.1.4 IPSI Data of both Watersheds

In 2002, with the help and involvement of the TVA, the TDA began funding watershed investment development projects. The Pond Creek watershed and Oostanaula Creek watershed were part of the first group to be assessed. A detailed assessment of land-

use in the watersheds was conducted based on the interpretation of color infrared photography and the revised universal soil loss equation (RUSLE) using the Integrated Pollutant Source Identification (IPSI) system developed by the TVA. Major land-uses in both watersheds were identified by the development of the GIS database and the use of the IPSI model. Tables 1 and 2 show estimated major land-use acreages and agricultural land-use acreages for Pond Creek and Oostanaula Creek respectively. Analysis of this data suggests that in both watersheds, overgrazed, poor and fair pastures, as well as row crops with low residue are major contributors to the sediment, nitrogen and phosphorous loads. This information is now being used to better plan for the implementation of BMPs to improve water quality across both watersheds.

#### 3.1.5 TDA and NRCS Data

To better understand the efforts that have been taken by policymakers to protect and improve our nation's water resources, it is important to evaluate programs that could have a direct impact on producers' willingness to adopt conservation practices. Two specific conservation programs were of interest in this study, EPA's 319 program administered by TDA and Tennessee's NRCS EQIP program. "Section 319 of the Clean Water Act (EPA funding) goes for restoration of 303(d) listed (impaired waters) and protection (threatened watersheds) projects in Tennessee. There is an education and outreach component that is included in 319 projects" (Webster, 2003).

The mission of EPA's 319 program is to measurably reduce nonpoint source pollution in Tennessee and improve Tennessee's water quality. Funding for this program all comes from the EPA so its success depends on public and nonprofit agencies and

organizations to enter into contracts to help meet the desired goals. "Through EQIP, the NRCS assist farmers and ranchers who face threats to soil, water, air, and related natural resources on their land" (Federal Register, 2005). The objective of EQIP is to optimize environmental benefits through the process of defining national priorities. Two of these national priorities are the reduction in nonpoint-source pollution and the promotion of at-risk species habitat conservation. From these priorities, the Chief of NRCS allocates available EQIP funds to state conservationist. After this, the State Technical Committee decides how the funds will be used, what the cost share rate will be and the ranking process used to prioritize contracts. Because of this, EQIP can be different among states and even among counties. Data sets were obtained from both the Tennessee NRCS and the TDA. The TDA data consisted of years 1996 and 1999 through 2005. This data set listed the practices installed, the cost share financed, the program the cost share was financed by, the county the practice was installed and the amount of acres impacted from the practice. The NRCS data consisted of years 1997 through 2002 for the EQIP program only. The data set listed the practice installed, the amount installed, the cost share of the installation, where it was installed and the amount of acres impacted. Unlike the TDA data which gave acres impacted only, the NRCS data tells us not only acres impacted, but also foot length measurements of practices and number of actual units installed.

### 3.2 Statistical Analysis

#### 3.2.1 Descriptive Statistics

Descriptive statistics were taken from the survey to better understand how the producers responded to the individual questions. Results were evaluated and compared for both watersheds.

#### 3.2.2 Comparison of Means Tests

Three different statistical tests were run to compare the means of the explanatory variables from both watersheds. The three statistical tests were: 1) t – test; 2) Chi square; and 3) Multiple Analysis of Variance (MANOVA).

##### 3.2.2.1 t – test

The t-test employs the statistic (**t**) to test a given statistical hypothesis about the mean of a population. In this case, it is testing a given statistical hypothesis about the means of two populations. “This statistic is a measure on a random sample (or pair of samples) in which a mean (or pair of means) appears in the numerator and an estimate of the numerator’s standard deviation appears in the denominator. If these calculations yield a value of (t) that is sufficiently different from zero, the test is considered to be statistically significant” (Hoffman, 2006).

##### 3.2.2.2 Chi square test

“The statistic Chi Square ( $X^2$ ) is what statisticians call an enumeration statistic. Rather than measuring the value of each of a set of items, a calculated value of Chi Square compares the frequencies of various kinds (or categories) of items in a random sample to the

frequencies that are expected if the population frequencies are as hypothesized by the investigator” (Hoffman, 2006). Chi square is often used to assess the "goodness of fit" between an obtained set of frequencies in a random sample and what is expected under a given statistical hypothesis.

**3.2.2.3 Multiple Analyses Of Variance (MANOVA)**

Multiple Analyses Of Variance is a technique used for assessing group differences across multiple metric dependent variables simultaneously, based on a set of categorical (non-metric) variables acting as independent variables (Babcock and Sears, 2006). Very similar to an ANOVA test that measures the differences in means of the interval dependent for various categories of the independent(s), MANOVA compares samples based on two or more dependent variables. The Wilks’ Lambda is one of the four principal statistics used for testing the null hypothesis in a MANOVA test. The Wilks’ Lambda is sometimes referred to as the maximum likelihood criterion or the U statistic.

**3.2.3. Conditional Logistic Regression**

In this study, a Conditional Forward Stepwise Regression analysis was used to determine the effect of independent variables such as production characteristics, farm concerns, environmental attitudes and producer and farm characteristics on the probability that a producer will voluntarily adopt a given BMP.

The equation for this model is:

(1) $$P = \frac{e^z}{1+e^z}$$

In Equation (1), P takes the values between 0 and 1 and is the probability that a producer will voluntarily adopt a certain BMP; $e$ is defined as the base of the natural logarithm (about 2.718); and z is the simplified regression equation ($Z_i = B_0 + B_i X_i$) in the logistic function and takes the values between $-\infty$ and $\infty$. Thus, Equation (1) is transformed to:

(2) $$P_i = \frac{e^{B_O+B_iX_i}}{1+e^{B_O+B_iX_i}}$$

In Equation (2), $X_i$ is defined as the independent variable(s); and $B_0$ and $B_i$ are the parameters of the model. The value of $B_0$ yields P when $X_i$ is zero. $B_i$ adjusts how quickly the probability changes with changing $X_i$ a single unit. Due to the dependent variable having a nonlinearly relationship to the independent variable(s), $B_i$ will not have the same interpretation as it does in an ordinary linear regression.

A conditional logistic regression is a function approximation algorithm that uses data to directly estimate P(Y/X). "In this sense, logistic regression is often referred to as a discriminative classifier because we can view the distribution of P(Y/X) as directly

discriminating the value of the target value Y for any given instance X"(Mitchell, 2005). The reason for choosing this model over other regression models was due to survey format and data collected from respondents. Respondents were asked questions that required ranking of choices as well as selecting from a list of categories that best represents them. In this case, the conditional logit regression was applied to choices rather than matched pairs. The regression analysis was broken into three conditional models based upon the amount of cost-share producers were willing to accept (e.g., 50%, 70% and 90%) across each of the eleven chosen BMPs. The cost-share levels (50%, 70% and 90%) were chosen because 50% is the typical NRCS cost-share level associated with each BMP, but NRCS has been willing to increase this rate to 70% and 90% in certain circumstances. In total, 27 variables along with 11 dependent variables were placed into each model. Because there were 11 dependent variables, 11 equations were created for each cost-share model. The dependent variables were chosen based upon NRCS conservation program priorities for the agricultural activities within the study watersheds. The dependent variables used in the analysis were Alternative Water Sources, Buffer Strips, Improved Pasture, Cattle (Stream) Crossings, Fencing, Manure Testing, Nutrient Management Plan, Manure Composting, Protected Heavy-Use Area(s), Integrated Pest Management, and Soil Testing.

### 3.2.4 Explanatory Variables

Independent variables for the comparison of means tests and conditional logistic regression analysis for producers in the Pond Creek watershed and Oostanaula Creek watershed are categorized into two sections: (1) Producer and Farm Characteristics; and (2)

Economic, Institutional, Organizational and Social Characteristics. Expected effects of independent variables can be found in Table 5.

**3.2.4.1 Producer and Farm Characteristics**

This section contains the independent variables that pertain to the producer's individual and farm characteristics. The independent variables include:

Age ≡ The age (years) of the producer. Age is included in the analysis to investigate its association with voluntarily adopting the eleven chosen BMPs. It is anticipated that age will have a positive effect on adopting BMPs that are less time consuming and a negative effect on adopting BMPs that require more intensive labor to install and maintain. As farmers get older they cannot maintain the work load that they once held. Because of this, they will prefer to adopt the less time consuming practices.

Crop ≡ Whether the producer grows any types of crops. The crops listed for the producer to reply to were corn, soybeans, wheat, tobacco, cotton, vegetables, hay and other. Producers who grew crops received a 1 and those who did not received a 0. It is expected that crops have a positive effect on adopting soil testing and a negative effect on practices such as cattle crossings that have no relevance to their farm.

Animal ≡ Whether the producer raises either beef or dairy cattle. Those who raised livestock received a 1 and those who did not received a 0. Producers who raise livestock can have a serious effect on the quality of the surrounding water bodies. In order to solve the problem of nonpoint-source pollution, livestock producers must be taken into consideration.

Pastureland ≡ The amount of pastureland (acres) the producer either owns or rents and

uses in his/her farming operation. For many of the producers in both watersheds, particularly beef producers, pasture is the main source of feed for their livestock. Therefore, it is presumed that pasture will have a positive effect on adopting improved pasture in order to keep cost of feed inputs low.

Beef ≡ The amount of beef cattle the producer raises on their farming operation. Runoff from beef cattle poses a serious threat to water quality. Producers can reduce the runoff from their pastures by implementing practices such as improved pasture and buffer strips. Producers who raise beef cattle are expected to have a negative perception on adopting manure testing due to the fact that the cattle are in the fields all day and not in stalls. Therefore, there is no waste to dispose of.

Dairy ≡ The amount of dairy cattle the producer raises on their farming operation. Dairy producers are expected to adopt practices that are less costly to install and maintain. This is because of the low profit margins associated with dairy cattle farming.

Acres Owned ≡ The amount of acres of land in production that are owned by the producer. In general, as the size of a farm increases the more time is required to maintain and run that farm efficiently. Because of the increased time spent running a larger farm, less time is available for off farm commitments. Thus, less income is typically received from off farm employment as a farming operation increases in size.

Acres Rented ≡ The amount of acres of land in production that are rented by the

producer. Producers who rent land are expected to be less likely to adopt any BMP with low net returns. Rented land is considered non-equity and therefore producers who rent land are expected to view BMP adoption as another input cost.

Off Farm Income ≡ The amount of household income that is received from off-farm employment. Producers were given the choice of 0% to 90% in 10% increments. Typically, the more time spent working off farm means the less time able to dedicate to on farm commitments. Thus, it is expected that the larger the producer's off-farm income is, the less likely to adopt any BMP that requires more time and labor.

Pond Creek ≡ Dummy variable indicating where the producer is located. The variable takes the value of 1 if the producer is located in Pond Creek and a 0 if located in Oostanaula Creek. Producers in Pond Creek are expected to be more likely to adopt practices that are related to dairy farming than Oostanaula Creek producers due to the low number (5) of dairy farms in the Oostanaula Creek watershed.

**3.2.4.2 Economic, Institutional, Organizational and Social Characteristics**

This section contains the independent variables that pertain to the producer's economic, institutional, organizational and social characteristics. The independent variables include:

Farm Improvements ≡ How producers viewed making farm improvements compared to preserving water quality. The three possible responses were: (1) Farm improvements are more important than Water quality; (2) Farm improvements are equally important as Water quality; and (3) Farm improvements are less important than Water quality. This variable is one of two categorical variables in the model and is regressed

differently from the other variables. When this variable is regressed, responses: (1) Farm improvements are more important than Water quality and (3) Farm improvements are less important than Water quality are compared to the response: (2) Farm improvements are equally important as Water quality. It is anticipated that producers who view Water quality to be of greater importance than Farm improvements will be more willing to adopt any of the eleven selected BMPs.

NFI (Net Farm Income) ≡ The change in the producer's income in the last five years. The three possible responses were: (1) Increase; (2) Decrease; and (3) No change. This variable is the second of the two categorical variables in the model. When this variable is regressed, responses: (1) Increase and (2) Decrease are compared to the response: (3) No change. It is anticipated that producers who have had an increase in income in the last five years will be more willing to adopt any of the eleven selected BMPs.

Conservation Knowledge ≡ The amount of knowledge each producer knew of seven different conservation programs. The programs were: Stewardship Incentive Program (SIP), Environmental Quality Incentive Program (EQIP), National Conservation Buffer Initiative (NCBI), Grassland Reserve Program (GRP), Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP) and Wetlands Reserve Program (WRP). The choices given were: High; Moderate; Low; and None. Weights were assigned to each response with 4 = High, 3 = Moderate, 2 = Low and 1 = None. Points were added up for all programs and divided by seven to get an average conservation knowledge score. Producers with a

higher conservation score would be expected to be more willing to adopt BMPs. However, research by Napier and Bridges, 2002, showed that information of conservation programs does not necessarily increase the probability of adopting a BMP.

Government Information Sources ≡ Whether the producer uses government sources to learn about conservation practices. Producers received a 1 if they attained information about conservation practices from government sources and received a 0 if they did not. A watershed specialist through the University of Tennessee Extension Service, Lena Beth Carmichael, has been hired in the Pond Creek watershed to help encourage producers to voluntarily adopt BMPs. It was expected that all Pond Creek producers would positively respond to using government sources.

Good Pasture ≡ The condition of the producer's pasture. Producers were asked to classify their pasture as either: Good to excellent or Poor to fair. Those producers who had Good to excellent pasture were expected to be more willing to adopt practices that would continue to help maintain the upkeep of their pasture. It was also expected that Good to excellent pastures would be found more with full time farmers compared to hobby farmers. This is because full time farmers have more at stake than hobby farmers and so they make sure their pasture is in as good a condition as possible.

Soil Testing – Improves Decision Making ≡ Whether the producer believes that soil testing improves decision making on the farm. Producers received a 1 if they believed soil testing improves farm decision making and a 0 if they did not. Those who believe this are expected to be more likely to adopt soil testing.

Soil Testing – Improves Profitability ≡ Whether the producer believes that soil testing improves their farm profitability. Producers received a 1 if they believed soil testing improves farm profitability and a 0 if they did not. Those who believe this are expected to be more likely to adopt soil testing.

Soil Testing – Takes to much time ≡ Whether the producer believes that soil testing takes up too much time on their farming operation. Producers received a 1 if they believed soil testing took up too much time and a 0 if they did not. Those who believe this are expected to be less likely to adopt soil testing. It is anticipated that those who raise livestock and do not grow crops would believe this to be true.

Conservation Program Participation ≡ Whether producers have ever signed up for a conservation program with USDA, EPA, NRCS, etc. that uses cost share as an incentive to participate. Producers received a 1 if they have signed up before and a 0 if they had not. It is expected that those who have signed up for a cost share program before would be more willing to participate in a conservation program again.

The final eight variables all came from the same question. Producers were asked to rank the following farm operation concerns in order from most concerned (8) to least concerned (1): Financial Solvency, Environmental Regulations, Zoning/Planning, Labor, Odor Nuisance Complaints, Liability, Estate/Trusts/Wills and Health/Age/Physical Abilities. This question was asked to better understand the concerns that individual producers had about their farming operation.

Financial Solvency ≡ The producer's concern of financial solvency. It is expected that

producers who are concerned of financial solvency will not adopt any BMP that does not have positive net returns upon its implementation. Practices such as buffer strips and fencing are two that do not necessarily have visible positive net returns.

Environmental Regulations ≡ The producer's concern of environmental regulations. It is expected that producers who are concerned about environmental regulations will be more willing to adopt practices out of fear that they will soon be forced to comply and will receive no cost share.

Zoning/Planning ≡ The producer's concern of zoning and planning. Like the variable, Environmental Regulations, it is expected that producers who are concerned about zoning and planning to be more willing to adopt practices out of fear of being forced into compliance in the future.

Labor ≡ The producer's concern of labor. It is expected that producers who are concerned about labor will be less willing to adopt any conservation practice that is labor intensive. Two conservation practices that are labor intensive are fencing and cattle crossings.

Odor Nuisance Complaints ≡ The producer's concern of odor nuisance complaint. This typically applies to only livestock producers and mainly then dairy producers. It is expected that if the producer is concerned with odor nuisance complaints, than they will be more willing to adopt practices such as manure composting and a nutrient management plan.

Liability ≡ The producer's concern of liability. This variable is very similar in effect to

environmental regulations, zoning and planning and odor nuisance complaints. If producers are worried that they might face some legal issue regarding their farming practices than they will be more willing to adopt conservation practices out of concern to stay out of trouble.

Estate/Trusts/Wills ≡ The producer's concern of estate, trusts and wills. It is expected that those concerned about their estate, trusts and wills will be more likely to think about the long term planning of the farm. Because of this, they will be more willing to adopt practices that have payoffs in the long term.

Health/Age/Physical Abilities ≡ The producer's concern of health, age and physical abilities. It is expected that those concerned with their health, age or physical abilities will be older farmers and do not have the labor strength to adopt labor intensive practices.

# CHAPTER 4. RESULTS AND DISCUSSION

## 4.1 Descriptive Statistics of the Survey for Watershed Producers

### 4.1.1 Pond Creek Producers

#### 4.1.1.1 Producer Demographics

This survey was conducted with 29 producers in the Pond Creek watershed participating. Table 3 depicts the demographic results of the Pond Creek watershed producers. The average age of the 29 producers surveyed was 50 years old with a range of 77 years old being the maximum and 20 years old being the minimum. The percentage of farmers under the age of 40, being 17.2%, slightly skewed this demographic down in relation to the state average of 55. The greatest percentage of respondents (37.9%) was between the ages of 50 – 60. Over 75% of the producers surveyed had been farming for life.

When compared to the average Tennessee farm demographics, producers surveyed in the Pond Creek watershed were very similar. In 2004, the average Tennessee farm size was 136 acres (USDA, 2004), and the greatest concentration (35%) of respondents in the survey fit in the 100 – 299 acres category. However, of producers surveyed, 69% owned farms over 300 acres, with 24.1% falling into the 300 – 499 acres category. Nearly 14% of the producers surveyed had farms of less than 100 acres in size. Thirty-one percent of the producers responded that they rented no land. The largest percentage (37.9%) of those who did rent land, rented between 100 – 299 acres.

A wide variety of crops were grown by these producers. Some of these crops included corn, soybeans, wheat and tobacco. The average acreage of corn planted per producer was 93 acres with 300 acres being the maximum grown by any producer. The

average acreage of soybeans planted per producer was 110 acres with 600 acres being the maximum grown by any producer. The average acreage of wheat planted per producer was 107 acres with 400 acres being the maximum grown by any producer. The average acreage for tobacco was much smaller at less than 1/2 acre planted per producer. The average acreage for Hay/Pasture grown was 222 acres per producer with 800 acres being the maximum.

A large variety of animals were also raised by these 29 producers. Some types of these animals are beef cattle, dairy cattle, goats, swine, poultry, sheep, horses and Holstein steers. The largest number of animals came from dairy cattle. A total of 2,861 dairy cattle were accounted for in the 29 surveys. This came to an average of 99 head of dairy cattle per farm with the maximum number of head on a farm being at 600. Along with those 2,861 head of dairy cattle, 460 heads were sold previously that year from the 29 producers. The next largest group of animals is beef cattle. A total of 1,390 head of beef cattle were accounted for in the 29 surveys. This came to an average of 48 head of beef cattle per farm with the maximum number of head on a farm being at 300. Along with those 1,390 head of beef cattle, 712 heads were sold previously that year from the 29 producers. The third largest groups of animals were Holstein steers. A total of 350 steers were accounted for in this survey in which they all came from the same farm. The fourth largest groups of animals owned were horses. Eighty percent of the 79 horses accounted for by the survey came from one producer who owned 63.

When asked whether or not in the last 5 years if their farm net income has increased, decreased or stayed the same, 55% of the producers responded that their net income has

decreased. Nearly 21% reported that their net income had increased while 24% reported no change. When asked about how much off-farm income makes up their total family income, 48% responded that no off-farm income was received. However, of the producers surveyed, 14% received over 70% of their income from off-farm sources.

**4.1.1.2 Producer Survey Results**

The most recent farm improvement chosen by the Pond Creek producers was Farm Equipment Upgrade/Repair at 27.6%. This was not surprising since repairs on the farm are always common. The next highest response was Install/Upgrade Manure Systems with 20.7%. Install Alternative Water Source, Cattle Crossings, Buffer Strips, Built New Pond and Improve Pond received no responses. The maximum investment of $200,000 was a new barn. This expense only represented half of the producer's total cost due to the budget constraints. The minimum investment of $150 was spent on fencing. The average dollar amount spent on these investments was $25,080.36. After taking out the original maximum and minimum, the new maximum was at $100,000 and the new minimum was at $500. The average amount spent is now $18,178.64. Both these averages are very high and were not expected. These results show us that the average producer in Pond Creek had heavy overhead costs.

There were a wide variety of improvements that producers listed as projects that currently need to be made. Some of these improvements were cattle crossing, barn repair, fencing, manure storage, a new pond and buffer strips. The highest listed improvement that needed to be made was barn repair with an average cost estimate of $8,000. Prices for all these improvements ranged from $200,000 for manure storage to $700 for fencing. Over

twenty-four percent of the respondents answered that they were going to make these improvements in 1 – 2 years. Nearly twenty-one percent planned on making these improvements within a year. Seventeen percent of the producers did not respond to this question. These results tell us that the majority of the producers have other farm obligations that are in need of being completed in order to continue on with their current farm operation. When asked about their preferences over water quality and farm improvements, the largest response (65.5%) from the producers indicated that they felt as though farm improvements were equally important to water quality. Only 6.9% felt as though farm improvements were less important than water quality. These results on the producer's feelings were very surprising and could have been brought on by a misunderstanding of the question and the thought of choosing a "right" answer rather than how they actually feel and think. It was expected that producers would choose farm improvements over water quality.

Respondents were asked about their knowledge of conservation programs. Over sixty-five percent knew nothing about the Stewardship Incentive Program (SIP), while only 28% had a moderate amount of knowledge about it. Thirty-one percent knew nothing about the Environmental Quality Incentive Program (EQIP) with 45% knowing a moderate amount and only 3% (1 response) having a high knowledge about it. Over sixty-two percent knew nothing about the National Conservation Buffer Initiative (NCBI) with another 14% knowing very little about the program. Knowledge about the Grassland Reserve Program (GRP) was at 38% for both moderate knowledge and no knowledge. The Conservation Reserve Program (CRP) had the highest level of knowledge with 14% having a "high" knowledge of the program and 17% having a "moderate" amount of knowledge about CRP.

The Conservation Reserve Enhancement Program (CREP) was the least known about. More than 74% responded that they knew nothing about the program. Nearly 14% responded with a “low” knowledge of the program. The Wetland Reserve Program (WRP) was the final program asked about. Over 41% of the respondents said they had no knowledge of the program while 38% said they had a “moderate” amount of knowledge about the program. Only 2 out of the 7 programs had a response of a “high” knowledge. These two programs were EQIP and CRP. Both EQIP and CRP are 2 major conservation programs and these results show a major problem that is occurring in the Pond Creek watershed.

Knowing where a producer obtains their information about conservation programs can be very helpful in promoting voluntary BMP adoption. The largest source that Pond Creek producers use to learn about conservation programs is their Extension Agent (86%). This is followed by 66% using Newspaper/Magazine, 48% using NRCS Staff, 41% using Family, 38% using neighbor and 14% using a Farm Bureau Agent. One producer responded that they were not interested in conservation programs. More than 20% responded to using other sources to learn about conservation programs. The responses to these questions were very alarming and call for a change in how producers receive information about different conservation programs. The use of the Extension Agent is a large number and compliments the University of Tennessee Extension greatly. This could be the reason for the responses we saw in Question 6. The Extension Agent doesn’t cover all these programs (SIP, EQIP, NCBI, GRP, CRP, CREP and WRP) and so the farmer is getting a limited view of programs. Additional education efforts could be done on behalf of NRCS and Farm Bureau.

The condition of a producer's pasture can have a significant impact on the amount of runoff that comes from that pasture. More than 48% of the respondents reported that their pasture was in "good" condition while only 3% reported that their pasture was in "excellent" condition. The two responses "poor" and "fair" were both chosen 24%. These results from this tell us that the majority of the pasture land in the watershed is not in the best of condition and that Improved Pasture would be a big benefit for the entire watershed. When asked how often they plant new seed on their pastureland, more than 55% said that they had planted new seed 1 year ago followed by 28% planting new seed 2 years ago on their pasture land. Further questioning about what type of seed used would be beneficial to understanding why not more of the pasture land is ranked at a higher condition. Knowing how often producers fertilized their land is also very important. All but one response for fertilizing pasture and crop land reported doing so 1 year ago. However, this differed when asked about lime. Sixty-nine percent reported liming their pasture land 1 year ago while 83% reported liming their crop land 1 year ago. When fertilizing their pasture land, 97% used commercial fertilizer, 69% used livestock manure, 62% used lime and 24% used Synagro, a company created in 1986 that specializes in providing biosolid residuals to municipalities and industrial customers. When fertilizing their crop land, 100% used commercial fertilizer, 69% used livestock manure, 59% used lime and 17% used Synagro. Responses were very similar for each of the two categories. Over 48% reported that they did not know the nutrient content that they had used in their fields. Of the responses that were obtained, an average of 79 lbs/acre of nitrogen was used, 60 lbs/acre of phosphorous was used and 56 lbs/acre of

potassium was used. Knowing what and how much the farmer is putting out on the ground is vital to making an educated decision on what to do about water quality concerns.

Taking soil samples is a very effective way of cutting back on the over application of unneeded nutrients. Forty-five percent responded that they take soil samples every year on their pasture land and 20.7% take soil samples both every 2 years and every 3 years. Sixty-two percent reported taking soil samples every year on their crop land followed by 27.6% taking samples every 2 years. These results were expected seeing as how it is more important to have your cropland properly adjusted compared to your pasture land. Approximately eighty-three percent reported that soil testing "improves decision making" followed by 65.5% saying it "improves profitability." Only 6.9% of the respondents said that it "takes up too much time" while no one reported that it gives them no benefit.

When asked about their net farm income level, the largest group of respondents (55.2%) said that their farm net income had decreased in the last five years. The next highest number (24.1%) reported that there had been no change in farm net income. Only 21% of the respondents had seen an increase in income. The majority of the respondents that had seen a decrease in net income were dairy cattle operators along with a horse farm while the majority that saw an increase in income was beef cattle operators.

By understanding the concerns of producers, lawmakers can create policies that will better target these farm concerns. Producers were asked to rank their own farm concerns. The following are producer's concerns ranked in order from most concerned (1) to least concerned (8): 1) Financial Solvency 2) Environmental Regulations 3) Labor 4) Liability 5) Health/Age/Physical Abilities 6) Estate/Trusts/Wills 7) Zoning/Planning and 8) Odor

Nuisance Complaints. Financial Solvency far outweighed any of the other farm concerns. Environmental Regulations, Labor, Liability and Health/Age/Physical Abilities were very similar in their rankings. Odor Nuisance Complaints were found to be the least among all of the respondents.

It was expected that many of the producers in these two watersheds had participated before in cost share conservation programs. As anticipated, a large percentage (69%) of the respondents chose "yes" in that they had participated in such programs involving cost share. However, the remaining 31% that answered "no" is a rather alarming discovery and goes along with the previous findings of the survey.

The BMP that was most willing to be adopted was Improved Pasture with a 90% response. The next BMP most willing to be adopted was a Soil Testing Program at an 83% response. Fencing was the BMP that producers were least willing to adopt with 66% responding. Alternative Water Sources, Cattle Crossings, Manure Testing, Nutrient Management Plan and Integrated Pest Management were all BMPs that the producers ranked as fairly willing to adopt. Producers felt reasonably neutral towards Manure Testing.

Fencing and Manure Composting were the two BMPs that had the highest average cost-share, being at nearly 90% (Table 4). Buffer Strips, Cattle Crossings, Protected Heavy-Use Area(s) and Integrated Pest Management were the next highest with cost-share averaging near 80%. Slightly below these four were Alternative Water Source, Manure Testing and Nutrient Management Plan at 70% cost-share. Improved Pasture and Soil Testing Programs required the lowest cost-share at 50% and 40% respectively.

By finding out what producers like and do not like about using improved pasture practices we can better suit our recommendations in a way that is consistent with their responses and target BMP(s) with the highest potential adoption success. The following benefits from using improved pasture practices are ranked in order from most beneficial (1) to least beneficial (5): 1) Increased Carrying Capacity 2) Higher Weaning Weights 3) Increase in Property Value 4) Greater Value of Cull Stock 5) Lower Death Rate. Rankings 3 & 4, Increase in Property Value and Greater Value of Cull Stock had very similar results with Increase in Property Value just slightly ranking higher than Greater Value of Cull Stock. The benefit of a Lower Death Rate ranked substantially lower than the other four benefits. The following disadvantages from using improved pasture practices are ranked in order from most harmful (1) to least harmful(5): 1) Initial Costs 2) Regular Maintenance Costs 3) Increased Maintenance Planning 4) Selective Grazing by Stock 5) Ecological Disruption. Initial costs far outweighed the other disadvantages with 76.2% choosing it as the most harmful disadvantage of using improved pasture practices. On the other spectrum, Ecological Disruption was chosen as the least harmful disadvantage by 76.2% of the respondents.

**4.1.2 Oostanaula Creek Producers**

**4.1.2.1 Producer Demographics**

This survey was conducted with 29 producers in the Oostanaula Creek watershed participating. Table 3 depicts the demographic results of the Oostanaula Creek watershed producers. The average age of the 29 producers surveyed was 51 years old with a range of 75 years old being the maximum and 28 years old being the minimum. Twenty-four percent

of the farmers were under the age of 40. The greatest percentage of respondents (27.6%) was between the ages of 50 – 60. Seven of the producers (24.1%) surveyed had been farming for life.

When compared to the average Tennessee farm demographics, producer surveyed in the Oostanaula Creek Watershed were very similar. In 2004, the average Tennessee farm size was 136 acres (USDA, 2004), and the greatest concentration (27.6%) of respondents in Oostanaula Creek fit in the 100 – 299 acres category. However, of producers surveyed, 28% owned farms over 300 acres, with 17% falling into the 300 – 499 acres category. Thirty-one percent of the producers responded that they rented no land. The largest percentage (41.4%) of those who did rent land, rented less than 50 acres.

A wide variety of crops were grown by these producers. Some of these crops included corn, wheat, tobacco and vegetables. The average acreage of corn planted per producer was just over 1 acre with 23 acres being the maximum grown by any producer. The average acreage of wheat planted per producer was 1.5 acres with 40 acres being the maximum grown by any producer. The average acreage for tobacco was a little larger at nearly 2 acres planted per producer with 40 acres being the maximum grown by any producer. The average acreage for Hay/Pasture grown was 160 acres per producer with 420 acres being the maximum. Sixty-five acres of other crops were produced.

A variety of animals were also raised by these 29 producers. Some types of these animals are beef cattle, goats, poultry and horses. The largest number of animals came from beef cattle. A total of 1,957 beef cattle were accounted for in the 29 surveys. This came to an average of 67 head of beef cattle per farm with the maximum number of head on a farm

being at 300. Along with those 1,957 head of beef cattle, 1,056 heads were sold previously that year from the 29 producers. The next largest groups of animals were horses. A total of fifty-seven horses were accounted for with twenty coming from the same farm.

When asked whether or not in the last 5 years if their farm net income has increased, decreased or stayed the same, 48% of the producers responded that their net income has increased. Over twenty-four percent reported that their net income had decreased while 28% reported no change. When asked about how much off-farm income makes up their total family income, only one (3.4%) responded that no off-farm income was received. However, of the producers surveyed, 41% received 90% of their income from off-farm sources.

**4.1.2.2 Producer Survey Results**

The most recent farm improvement chosen by the Oostanaula Creek producers was Improved Pasture at 25%. This follows along with the IPSI data that states that there are over 11,000 acres of "fair" pasture. The next highest response was a tie between Farm Equipment Upgrade/Repair and Fencing with 21%. Install/Upgrade Manure System, Cattle Crossings, Buffer Strips, Built New Pond, Improve Pond and Renovate Farm received no responses. The maximum investment of $40,000 was a farm equipment upgrade/repair. The minimum investment of $250 was spent on fencing. The average dollar amount spent on these investments was $7,613.

There were a wide variety of improvements that producers listed. Some of these improvements were protected heavy-use areas, cattle crossing, barn repair, fencing and buffer strips. The most listed improvement that needed to be made was fencing with an average cost estimate of $3,917. Prices for all these improvements ranged from $30,000 for

farm equipment to $250 for fencing. Nearly 52% of the respondents answered that they were going to make these improvements in 1 to 2 years. Over 11% planned on making these improvements within a year. Seven percent of the producers did not respond to this question. These results tell us that the majority of the producers have other farm obligations that are in need of being completed in order to continue on with their current farm operation. When asked about their preferences over water quality and farm improvements, the largest response (55.2%) from the producers indicated that they felt as though farm improvements were equally important to water quality. Only 21% felt as though farm improvements were less important than water quality. The expected results were that producers would feel that farm improvements were greater than water quality.

Respondents were asked about their knowledge of conservation programs. Over 55% knew nothing about the Stewardship Incentive Program (SIP), while only 21% stated that they had a moderate amount of knowledge. Almost 35% knew nothing about the Environmental Quality Incentive Program (EQIP), 24% stated that they had a moderate amount of knowledge and only 10% (3 responses) having a high knowledge. Over 44% knew nothing about the National Conservation Buffer Initiative (NCBI) with another 28% knowing very little about the program. Knowledge about the Grassland Reserve Program (GRP) was at 24% for moderate knowledge and 28% for no knowledge. The Conservation Reserve Program (CRP) had 3% (1 response) having a “high” knowledge of the program and 21% having a “moderate” amount of. The Conservation Reserve Enhancement Program (CREP) had the most responses (93%) that knew little or nothing about the program. No producer had a “high” level of knowledge about the CREP program. The Wetland Reserve

Program (WRP) had over 37% of respondents answer that they had no knowledge of the program while 17.% answered that they had a "moderate" amount of knowledge about the program. Only 2 out of the 7 programs had a response of a "high" knowledge, these two programs being EQIP and CRP. Both CRP and EQIP are 2 major conservation programs and these results show a major problem that is occurring in the Oostanaula Creek watershed.

Knowing where a producer obtains their information about conservation programs can be very helpful in promoting voluntary BMP adoption. The largest source that Oostanaula Creek producers use to learn about conservation programs is their Extension Agent (62.1%). This is followed by 59% using Newspaper/Magazine, 24% using NRCS Staff and Neighbor, 14% using Family and 3% using a Farm Bureau Agent. No producer responded that they were not interested in conservation programs. Two respondents (6.9%) reported using other sources to learn about conservation programs. The responses to this question were very alarming and call for a change in how producers receive information about different conservation programs. As in the Pond Creek watershed, the use of the Extension Agent is the predominant source of knowledge. This could be the reason for the responses we saw in Question 6. The Extension Agent does not cover all these programs (SIP, EQIP, NCBI, GRP, CRP, CREP and WRP) and so the farmer is getting a limited view of programs. Additional education efforts could be done on behalf of NRCS and Farm Bureau.

The condition of a producer's pasture can have a significant impact on the amount of runoff that comes from that pasture. More than 41% of the respondents reported that their pasture was in "good" condition while not one reported that their pasture was in "excellent"

condition. The response “fair” was chosen 55% and “poor” chosen 3%. This is consistent with the IPSI data that states there are over 11,000+ acres of “fair” pasture land in the watershed. When asked how often they plant new seed on their pastureland, more than 55% said that they had planted new seed 1 year ago on their pasture land. One (3.4%) responded planting new seed 2 years ago and 18% responded planting new seed 3 years ago on their pasture land. Further questioning about what type of seed used would be beneficial to understanding why not more of the pasture land is ranked at a higher condition. Knowing how often producers fertilized their land is also very important. Seventy-five percent reported fertilizing their pasture land one year ago and 86% reported fertilizing their crop land one year ago. Forty-four percent reported liming their pasture land 1 year ago while 46% reported liming their crop land 1 year ago. When fertilizing their pasture land 97% used commercial fertilizer, 79% used livestock manure, 57% used lime and 3% used Synagro. When fertilizing their crop land 100% used commercial fertilizer, 80% used livestock manure, 53% used lime and 0% used Synagro. Responses were very similar for each of the two categories. The lack of use of Synagro can be explained by the small amount of crop production inside the Oostanaula Creek watershed. This is due to the large number of hobby beef farmers inside the watershed as compared to Pond Creek. Nearly 68% reported that they did not know the nutrient content that they had used in their fields. Of the responses that were obtained, an average of 64 lbs/acre of nitrogen was used, 58 lbs/acre of phosphorous was used and 55 lbs/acre of potassium was used. Knowing what and how much the farmer is putting out on the ground is vital to making an educated decision on what to do about water quality concerns.

Taking soil samples is a very effective way of cutting back on the over application of unneeded nutrients. Over 79% reported that soil testing "improves decision making" followed by 52% saying it "improves profitability." Only one respondent (3.4%) reported that soil testing "takes up too much time." Two (6.9%) reported that it gives them no benefit. Fourteen percent responded that they take soil samples every year on their pasture land and 29% take soil samples every 2 years. Eighteen percent reported never taking soil samples on their pasture land. Nearly 10% reported taking soil samples every year on their crop land and 14% taking soil samples every 2 years. Over 52% reported never taking soil samples on their crop land. These results were unexpected due to the fact that it is important to keep your pasture and crop land in proper condition. However, the lack of crop production in the watershed could explain the low number of soil samples on crop land.

When asked about net farm income, the largest response (48.3%) said that net farm income had increased in the last five years. The next highest number (27.6%) reported that there had been no change in net farm income. Only 24% of the respondents had experienced a decrease. With no dairy producers surveyed from Oostanaula Creek, it was assumed that the majority of farmers would have seen an increase in income.

By understanding the concerns of producers, lawmakers can create policies that will better target these farm concerns. Producers were asked to rank their own farm concerns. The following are producer's concerns ranked in order from most concerned (1) to least concerned (8): 1) Financial Solvency 2) Liability and Labor 4) Environmental Regulations 5) Health/Age/Physical Abilities 6) Estate/Trusts/Wills and Zoning/Planning and 8) Odor Nuisance Complaints. Financial Solvency far outweighed any of the other farm concerns.

Environmental Regulations, Labor, Liability, Health/Age/Physical Abilities, Estate/Trusts/Wills and Zoning/Planning were very similar in their rankings. Odor Nuisance Complaints were found to be the least concerning among all of the respondents.

It was expected that many of the producers in these two watersheds had participated before in cost share conservation programs. As anticipated, a large percentage (58.6%) of the respondents chose “yes” with regards to participating in cost share programs. However, the remaining 41% that answered “no” is a rather surprising discovery.

The BMP that was most willing to be adopted was Improved Pasture with a 72% responding. The next BMP that was most willing to be adopted was Soil Testing at 55% followed by Fencing that was ranked at 52%. Protected Heavy-Use Area(s), Cattle Crossings, Nutrient Management Plan, Alternative Water Source and Integrated Pest Management were all BMPs that the producers ranked as feeling neutral towards adoption. Producers were unwilling to adopt Manure Composting. It was assumed that producers in Oostanaula Creek would be against Manure Composting because they are beef cattle farmers and Manure Composting is typically a BMP associated with dairy cattle.

Manure Testing and Manure Composting were the two BMPs requiring the highest average cost-share, at 90% (Table 4). Buffer Strips, Cattle Crossings and a Nutrient Management Plan were the next highest with cost-share averaging near 80%. Slightly below these three were Alternative Water Source, Protected Heavy-Use Area(s) and Integrated Pest Management at 70% cost-share. Fencing and Soil Testing Programs required an average of 70% cost-share. Improved Pasture required the lowest cost share with an average of 50% cost-share.

Determining what producers like and don't like about using improved pasture practices can assist in the development of recommendations that will promote BMP adoption within the watershed. The following benefits listed from using improved pasture practices are ranked in order from most beneficial (1) to least beneficial (5): 1) Increased Carrying Capacity 2) Higher Weaning Weights 3) Increase in Property Value 4) Lower Death Rate 5) Greater Value of Cull Stock. Rankings 4 & 5, Lower Death Rate and Greater Value of Cull Stock had very similar results. The following disadvantages listed from using improved pasture practices are ranked in order from most harmful (1) to least harmful (5): 1) Initial Costs 2) Regular Maintenance Costs 3) Increased Maintenance Planning 4) Selective Grazing by Stock 5) Ecological Disruption. Initial costs far outweighed the other disadvantages with 74% choosing it as the most harmful disadvantage of using improved pasture practices. On the other spectrum, Ecological Disruption was chosen as the least harmful disadvantage by 61% of the respondents.

## 4.2 Results of Statistical Analysis

### 4.2.1 Comparison of Means Tests

#### 4.2.1.1 t – test

Because only two of the explanatory variables were continuous variables, Age and Conservation Knowledge were the only variables tested using a t-test. Both variables came back non-significant meaning that the means of the two variables were not statistically different from one another. These were expected results and reiterate the descriptive results found earlier in section 4.1.

#### 4.2.1.2 Chi square test

The Chi square test compared the means for ten variables. These ten variables were: Farm Improvements are more important than, equally important to or less important than Water Quality; Government Information Sources; Good Pasture; Soil Testing – Improves Decision Making; Soil Testing – Improves Profitability; Soil Testing – Takes too much time; Net Farm Income – Increase, Decrease or No Change; Conservation Program Participation; Crop; and Animal. Three out of the ten variables were to found have significantly different means between the two watersheds. The three variables were: Government Information Sources; Net Farm Income – Increase, Decrease or No Change; and Crops. It was anticipated that Government Information Sources would be statistically different between the two watersheds. This could be a result due to the Pond Creek watershed having its very own watershed coordinator, Lena Beth Carmichael, who travels the watershed and interacts with the producers to try and convince them to adopt BMPs. Differences in the other two variables were expected as well. In Pond Creek, where there are currently only 10 dairy operations in business, it was expected that we see a high percentage of producers with a decrease in net farm income compared to Oostanaula Creek producers who raised only beef cattle and were expected to have a high percentage with an increase in net farm income. The Crop variable is significant because many in Pond Creek grow their own crops for their livestock (especially dairy) while many in Oostanaula Creek use pasture as the main source of the cattle's (beef) diet.

#### 4.2.1.3 Multiple Analyses Of Variance (MANOVA) test

Fourteen explanatory variables were tested using the MANOVA test. These fourteen variables were: Financial Solvency; Environmental Regulations; Zoning/Planning; Labor; Odor Nuisance Complaints; Liability; Estate/Trusts/Wills; Health/Age/Physical Abilities; Pastureland; Beef; Dairy; Acres Owned; Acres Rented; and Off Farm Income. Seven of these variables were found to have significantly different means between the two watersheds. The seven were: (1) Financial Solvency; (2) Environmental Regulations; (3) Pastureland; (4) Dairy; (5) Acres Owned; (6) Acres Rented; and (7) Off Farm Income. Variables (1) and (4) were expected and can be examined together. Because of the high amount of dairy producers in the Pond Creek watershed and the falling milk prices nationwide, many in the Pond Creek watershed are struggling to keep their farms solvent. Environmental Regulations was an unexpected result. Producers in the Oostanaula Creek watershed were less concerned about environmental regulations than producers in the Pond Creek watershed. This could be due to the fact that many in the Oostanaula Creek watershed are hobby farmers and are not large enough to be looked at as significant polluters like many Confined Animal Feeding Operations (CAFOs). Also, none were dairy producers and so do not have any of the rules and regulations that go along with dairy farming. It was expected that variables (3), (5) and (6) would be fairly similar for both watersheds. However, producers in the Pond Creek watershed had more pasture land, owned more acres and rented more acres of land than producers in the Oostanaula Creek watershed. Again, this could be explained by the fact that many of the Pond Creek producers are full time farmers compared to the hobby farmers that mainly make up Oostanaula Creek. Because of this it was expected

that Off Farm Income would be statistically different between the two watersheds. By looking at the descriptive results, producers in the Oostanaula Creek watershed received more of their income from off farm employment than producers in the Pond Creek watershed. These results again back the statements that the majority of Oostanaula Creek producers are not farming as a full time profession but rather working mainly away from the farm for financial support.

### 4.2.2 Results of the Conditional Logistic Regression Model

Results from the logistic models suggests that off farm income, crop production, livestock production, producers with a high level of conservation knowledge, producers who deem their pasture as good (quality), producers concerned with environmental regulations and liability, and producers who thought soil testing improved decision making and profitability were associated with significant increases in producers willingness to adopt in 8 to 11 BMPs. It makes sense that off farm income would help increase the adoption of BMPs. This is because producers have a second source of income and are not relying totally on their farming income which in most cases is very small. Those involved in crop production and livestock production were expected to be positive. If one were not in either of these two businesses than there would be no need to adopt many of these BMPs. Those who already deem their pasture's quality as good are expected to want to keep it that way and so will take the steps needed to ensure it stays in good quality. If one were not concerned about environmental regulations or liability than it would be expected that they would not adopt many of these BMPs. Fear of legal troubles can be very strong motivation for farmers to

adopt BMPs. It was also expected that those who see the benefits of soil testing would also see the benefits of other BMPs and be more willing to voluntarily adopt them.

Factors that had negative impacts on producer's willingness to adopt a given BMP include: acres owned; acres rented; producers concerned with financial solvency, zoning/planning and labor issues; producers who relied upon government information sources; pastureland; producers who thought that soil testing takes too much time; and producers that experienced a decrease in their net farm income in the last five years. These negative factors impacted 5 to 9 BMPs. It was anticipated that acres owned, acres rented and pastureland would have a negative impact on adoption. The larger one's farm is typically the more responsibility and costs there are associated with running that farm. Therefore, the larger the farm grows, the less willing producers are to take the extra time needed to install and maintain many of these needed BMPs. Also, producers installing BMPs on rental property may not be able to recover whatever practice it is that they installed when they stop renting that piece of land. Thus, losing whatever investment they had made. Concerns over financial solvency, zoning/planning and labor issues were expected to have negative impacts as well. Concern about any of these three variables can cause a producer to become unsure of future production plans and unwilling to adopt BMPs on land that might soon be out of production. Producers who relied on government information sources were not expected to have a negative impact. While interviewing the producers, many spoke of poor relationships in the past with government agencies and their lack of trust in these government organizations. Many specifically discussed their dislike for the application process in these voluntary programs. It was expected that those who felt as though soil testing took too much

time would not be willing to spend time to adopt other BMPs as well. If producers are unwilling to do the simple tasks of collecting soil samples than they are probably unwilling to do the more time consuming tasks that are associated with adopting other BMPs. Producers who have seen a decrease in income in the past five years were expected to be less willing to adopt. If a producer does not have the money to adopt a given BMP then it does not matter whether they are willing to adopt or not.

Variables with mixed (i.e., positive and negative) results were: increase in net farm income in the past five years; dairy production; Pond Creek producers; previous conservation program participation; health, age, physical abilities; and estate, wills, trusts. It was unexpected and unknown why those who saw an increase in income in the last five years would be less willing to adopt. The mixed results for dairy production can be explained by the reasoning that certain BMPs are specifically for dairy production and some are specifically for beef production. Those not associated with dairy farming would likely never be adopted due to the low profit margins associated with dairy farming. The mixed results for Pond Creek producers go along with the dairy production results. There were no dairy producers surveyed in Oostanaula Creek while there were a large number surveyed in Pond Creek. Certain BMPs would be more or less applicable to the producer depending on the type of production that the producer is involved in. Those who had used conservation programs previously were initially expected to have only a positive outlook on adopting BMPs. The conflict in the past with government agencies spoken about earlier can be a reason for the mixed results. Tables 5, 6 and 7 report results from the logistic models at the

50%, 70% and 90% cost-share levels, respectively. Variables beef production, age and odor nuisance complaints were not found to be significant in any of the cost share models.

#### 4.2.2.1 Fifty Percent Cost Share Rate

Seventeen variables were found to be significant at the 50% cost-share level. Variables off farm income, producers with a high level of conservation knowledge, producers who deem their pasture as good (quality), producers concerned with environmental regulations and liability, and producers who thought soil testing improved decision making all positively influenced a producer's willingness to adopt. Variables acres owned, acres rented, pastureland, producers from the Pond Creek watershed, producers concerned with financial solvency, estate/wills/trusts, and labor issues, producers who relied upon government information sources and producers that experienced a decrease in their net farm income in the last five years all negatively influenced a producer's willingness to adopt. The variables dairy cattle and producers who experienced an increase in net farm income in the last five years received mixed (i.e.; positive and negative) results regarding producer's willingness to adopt. The following are the individual results of the producer's willingness to adopt the eleven chosen BMPs:

Alternative Water Source: Three variables were found significant for the voluntary adoption of an alternative water source. Producers concerned about estate/trusts/wills and labor issues had a negative impact on the adoption process. It was unsure at first what effect labor would have on the adoption of an alternative water source. The adoption of an alternative water source does require labor needs such as digging a well and the maintenance and upkeep of the water source. This added labor may negatively effect the way farmers

view installing an alternative water source. It was expected that estate/trusts/wills have a negative impact because farmers are more concerned about the future of their business and do not have the money to invest in an alternative water source. The variable acre rented was also found to be negative. This was expected because farmers who rent land are already paying higher costs (i.e., rental payments) and may not be able to bare the extra costs associated with this practice. Also, once they stop renting the land they may lose the installed practice to the landlord.

Buffer Strips: Three variables were found significant for the voluntary adoption of buffer strips. Producers who had a high level of knowledge about conservation programs were more likely to adopt. Those producers who deemed their pasture as good (quality) also were more likely to adopt buffer strips. The variable pastureland was found to have a negative effect on the adoption process. This can be explained by the fact that when producers install buffer strips, they lose a portion of their land. This in turn means lower profits for producers.

Improved Pasture: Five variables were found to be significant for the voluntary adoption of improved pasture. Dairy producers as well as producers concerned about labor issues and financial solvency were less likely to adopt. The negative effects on adoption were expected by these three variables. Dairy producers are under pressure to even stay in business because of the low net returns associated with dairy farming which goes hand in hand with concerns over financial solvency and labor issues. Also, the main food source in a dairy cow's diet is not pasture like it is for beef cattle. Because of this, dairy producers do not receive the same benefits from having an improved like beef producers do and so are

less willing to spend the additional money to keep their pastureland in good quality. Producers who deemed their pasture as good (quality) and those concerned about liability were more likely to adopt improved pasture. Producers who already have good pasture were expected to be more willing to keep it that way. Producers concerned about liability were also expected to have a positive effect on adoption because farmers fear that they may soon be held responsible for the pollution that comes from their individual farming operation.

Cattle Crossings: Only one variable was found significant for the adoption of cattle crossings. An increase in net farm income in the last five years had a positive effect on adoption. This was expected because the more money a producer has earned, the more able they are to adopt practices that may not necessarily see a direct return on their investment.

Fencing: Three variables were found significant for the voluntary adoption of fencing. Producers from the Pond Creek watershed were found to have a negative impact on the adoption process. This was expected by looking at Table 4 where only 14% of Pond Creek producers were willing to adopt compared to 59% of Oostanaula Creek producers willing to adopt. Unlike Oostanaula Creek producers, the majority of Pond Creek producers had water flowing through their pastureland. If producers were to fence out the cattle from the water then they would lose a large portion of their pastureland due to the zig zagging shape of the water. This loss of land would mean less income for the producers. Also, Pond Creek is on a flood plain and therefore more prone to flooding than Oostanaula Creek. Every time it floods, sections of fencing get torn out of the ground and need to be replaced. This repair can become very costly especially when it floods multiple times a year. Producers who believed soil testing improved decision making were more likely to adopt fencing. This

may be explained by producers who see the environmental value of soil testing also see the environmental value of fencing. Producers who received the majority of their income from off farm employment were also more likely to adopt. This was expected because farmers were not solely relying on their farm income and so they could implement a practice that might reduce their farm income some percent.

Manure Testing: Three variables were found significant for the voluntary adoption of manure testing. Producers who received information from government sources had a negative effect on adoption. This was an unexpected outcome and can be explained by those respondents who spoke of bad experiences in the past when working with government agencies. Dairy producers and producers who had a high level of knowledge of conservation programs were more likely to adopt. These were anticipated results. Manure testing is a BMP that is heavily associated with dairy farming. Government agencies want dairy producers to know the content of the stored manure so when they spread it on their fields they do not over apply any nutrients. Those with a high level of knowledge of conservation programs would have heard of manure testing and would know of the benefits associated with it. Manure testing is a practice that is currently not being used by the majority of Tennessee dairy producers.

Nutrient Management Plan: Four variables were found to be significant for the voluntary adoption of a nutrient management plan. Producers who deemed their pasture as good (quality) and those concerned about environmental regulations were more likely to adopt. Both were expected outcomes. Producers concerned about environmental regulations were expected to voluntarily adopt because they will want to adopt and receive cost share

assistance before it is mandated and they are forced to do so without any assistance. Producers who have seen increases in income in the last five years were found to have a negative impact on adoption. It was not expected that those who saw an increase in net farm income in the last five years to have a negative effect. One would think that an increase in income would have the opposite effect. Acres owned also had a negative impact on adoption. The more acres a producer owned the less likely they were to adopt a nutrient management plan. This was an expected result. The more land that is owned requires more time from the producer to prepare and implement a nutrient management plan. Time is something that is not always on a farmer's side.

<u>Manure Composting</u>: Only one variable was found to be significant for the voluntary adoption of manure composting. Producers who received information from government sources were found to have a negative impact on adopting manure composting. This was not expected because it was assumed that government sources would have a positive effect on adoption of all BMPs. Past relationships that have not gone well between producers and government agencies along with the cost of manure composting may be the reason that those who receive their information from government sources are unwilling to adopt manure composting. If a producer does not trust the government agency that is trying to push for the voluntary adoption of manure composting, then there is little chance of adoption of any BMP let alone manure composting.

<u>Protected Heavy-Use Area(s)</u>: Only one variable was found to be significant for the voluntary adoption of protected heavy-use area(s). Producers concerned about environmental regulations had a positive effect on the adoption process. Environmental

regulations were expected to have a positive impact on adoption of all BMPs. Feeding areas normally become very overrun and muddy and allow much runoff. By adopting this practice, much of that runoff can be decreased and the producers fear of mandated regulations can be put at ease.

Integrated Pest Management: Three variables were found to be significant for the voluntary adoption of integrated pest management. Producers who received more of their income from off farm employment had a positive effect on adoption. As stated before, those that receive more income from off farm work do not rely as heavily on their farm income as others and so may adopt practices that do not necessarily have such a high return on their investment. Producers who had both an increase and decrease in net farm income in the last five years had a negative effect on adoption. Those that had an increase in net farm income were not expected to have a negative impact. It was assumed that those who saw an increase in net farm income would be more willing to adopt all BMPs.

Soil Testing: Three variables were found to be significant for the voluntary adoption of soil testing. Dairy producers had a negative impact on adoption. This was expected because soil testing is not associated with dairy production. Also, those concerned with financial solvency and those that had an increase in income were less likely to adopt. It makes sense that if a producer is concerned about financial solvency than they will be less willing to adopt almost any BMP. It was unexpected that those who had seen an increase in income in the last five years would be less willing to adopt. This is a result that can not be fully explained.

#### 4.2.2.2 Seventy Percent Cost Share Rate

Twenty two variables were found to be significant at the 70% cost-share level. Variables off farm income, livestock production, crop production, producers with a high level of conservation knowledge, producers who deem their pasture as good (quality), producers concerned with liability and estate/trusts/wills, producers who were from the Pond Creek watershed, producers who viewed farm improvements as both more important and less important than water quality and producers who thought soil testing improved decision making all positively influenced a producer’s willingness to adopt. Variables dairy cattle, acres rented, producers concerned with financial solvency, zoning/planning, and labor issues, producers who relied upon government information sources, producers who thought soil testing took too much time, producers who had participated previously in a conservation program and producers that experienced a decrease in their net farm income in the last five years all negatively influenced a producer’s willingness to adopt. Producers who were concerned about health/age/physical abilities received mixed (i.e.; positive and negative) results regarding producer’s willingness to adopt. The following are the individual results of the producer’s willingness to adopt the eleven chosen BMPs:

<u>Alternative Water Source</u>: Three variables were found to be significant for the voluntary adoption of an alternative water source. Producers who deemed their pasture as good (quality) had a positive effect on adoption. Dairy producers and producers who were concerned of labor issues had a negative effect on adoption.

<u>Buffer Strips</u>: Three variables were found to be significant for the voluntary adoption of buffer strips. Producers who deemed their pasture as good (quality) and those

who received the majority of their income from off farm work had a positive impact on adoption. Both were expected. If a producer has a good quality pasture, than losing production land to buffer strips is not as overwhelming of a loss as if the producer's pasture was not in good shape. Along with this assumption, if the producer receives the majority of their income from off farm work, than they are not as reliant upon income from their farm so they may choose to adopt practices that do not have high returns. Producers concerned about health/age /physical abilities had a negative impact on adoption. These producers were predominately older farmers and so may not be physically able to implement this practice.

Improved Pasture: Three variables were found to be significant for the voluntary adoption of improved pasture. Livestock producers and producers who deemed their pasture as good (quality) had a positive effect on adoption. It was expected that livestock producers would have a positive effect. This is due to the fact that the majority of feed for livestock producers comes from their pasture. If the pasture is not in good quality then the livestock will suffer and not reach their desired weights, thus, losing possible income. Producers concerned of labor issues had a negative effect on adoption. This is hard to explain because improving one's pasture is not the most labor intensive practice.

Cattle Crossings: Nine variables were found to be significant for the voluntary adoption of cattle crossings. Crop producers, producers concerned with health/age/physical abilities, producers who deem their pasture as good (quality) and producers who receive the majority of their income from off farm employment had a positive effect on adoption. Crop producers were not expected to have a positive effect on cattle crossings. Producers who rent land, believe soil testing take too much time, have previously participated in conservation

programs, have seen a decrease in net farm income in the last five years and are concerned about zoning/planning were less likely to adopt. It was expected that if the producer had seen a decrease in income in the last five years, then they would be less willing to adopt not only cattle crossings, but any BMP.

Fencing: Four variables were found to be significant for the voluntary adoption of fencing. Producers concerned about liability and estate/trusts/wills, producers who believed that soil testing improved decision making and producers who received the majority of their income from off farm employment had a positive effect on adoption. It was expected that producers concerned about liability be more willing to adopt because they are scared that they will soon be mandated to adopt. A positive effect was also expected for those producers who receive the majority of their income from off farm employment. This is because fencing is an expensive practice to install and maintain and it causes loss of productive land. Those who do not rely as heavily on their farm's income are more able to adopt such a practice.

Manure Testing: Five variables were found to be significant for the voluntary adoption of manure testing. Producers from the Pond Creek watershed, producers who have a high level of knowledge of conservation programs, producers who deem their pasture as good (quality) and producers who are concerned about liability had a positive effect on adoption. It was expected that producers from Pond Creek be willing to adopt. Manure testing is a practice that many producers, especially dairy, have already adopted and put into practice in the watershed. It was also expected that producers concerned about liability would be more willing to adopt. Producers who received information from government sources were found to have a negative impact on adoption. This was unexpected because our

original hypothesis was that the use of government sources for information would lead to the adoption of all BMPs.

Nutrient Management Plan: Two variables were found to be significant for the voluntary adoption of a nutrient management plan. Producers who deemed their pasture as good (quality) had a positive effect on adoption. The amount of acres owned had a negative effect on adoption. This meaning, the larger the amount of land that the producer owned, the less likely they were to adopt. This was an unexpected result but was consistent with findings throughout the model.

Manure Composting: Two variables were found to be significant for the voluntary adoption of manure composting. Producers who received the majority of their family income from off farm employment had a positive effect on adoption. Because manure composting is not a highly profitable practice to implement, off farm income is needed to help offset the costs. Producers concerned about financial solvency had a negative effect on adoption. This goes together with the positive effect of off farm income. Producers who are struggling to keep their farm in business can not afford to implement such practices that require more money and time without seeing a financial return.

Protected Heavy-Use Area(s): Only one variable was found significant for the voluntary adoption of a protected heavy-use area(s). Those producers who deemed their pasture as good (quality) had a positive effect on adoption. This was expected because those producers who already have a “good” pasture will be more willing to keep their pasture in that condition.

Integrated Pest Management: Three variables were found to be significant for the voluntary adoption of integrated pest management. Producers who were concerned about liability and received the majority of their income from off farm employment had a positive effect on adoption. The third variable found significant were the producers' view of farm improvements compared to water quality. Findings stated that both producers who viewed farm improvements as more important than water quality and producers who viewed farm improvements as less important than water quality had a positive effect on adoption. It was unexpected to have the same result for these two opposite responses.

Soil Testing: Four variables were found to be significant for the voluntary adoption of soil testing. Producers who deemed their pasture as good (quality) and those producers who grew crops had a positive effect on adoption. It was expected that crop producers be more likely to adopt. Soil testing is a practice that is heavily associated with growing crops. Dairy producers and producers who were concerned about financial solvency had a negative effect on adoption. The negative effect of dairy producers on adoption goes along with the positive effect on adoption of crop producers. It was unexpected that financial solvency had a negative effect. Soil testing is a very inexpensive practice that has the possibility to save dramatically on input costs.

#### 4.2.2.3 Ninety Percent Cost Share Rate

Thirteen variables were found to be significant at the 90% cost-share level. Variables off farm income, dairy cattle, producers with a high level of conservation knowledge, producers who deem their pasture as good (quality), producers concerned with liability, producers who have previously participated in a conservation program and producers who

thought soil testing improved decision making and profitability all positively influenced a producer's willingness to adopt. Variables acres owned, producers from the Pond Creek watershed, producers concerned with financial solvency, producers who thought soil testing took too much time and producers that experienced a decrease in their net farm income in the last five years all negatively influenced a producer's willingness to adopt. There were no variables that received mixed (i.e.; positive and negative) results regarding producer's willingness to adopt. The following are the individual results of the producer's willingness to adopt the eleven chosen BMPs:

Alternative Water Source: Only one variable was found to be significant for the voluntary adoption of an alternative water source. Producers who had previously participated in a conservation program had a positive effect on adoption. Having already gone through the application process, these producers know what to expect and so are not "scared" of filling out the paper work. Those producers who had not participated before stated that they had not done so because of a lack of trust they had with the government. This meaning, they were hesitant to even let the government on their land.

Buffer Strips: Three variables were found to be significant for the voluntary adoption of buffer strips. Producers with a high level of knowledge of conservation programs and those who believe soil testing improves decision making had a positive effect on adoption. It was expected that those who had a higher level of knowledge be more willing to adopt all BMPs, not just buffer strips. The more acres a producer owned had a negative effect on adoption. This was an unexpected result. It was hypothesized that the more land a producer had, the more willing they would adopt buffer strips.

Improved Pasture: There were no variables found to be significant for the voluntary adoption of improved pasture.

Cattle Crossings: Three variables were found to be significant for the voluntary adoption of cattle crossings. Producers that deemed their pasture as good (quality), believed that soil testing improved decision making and received the majority of their income from off farm employment had a positive effect on adoption. All three variables were expected to have a positive influence on adoption.

Fencing: Two variables were found to be significant for the voluntary adoption of fencing. Producers who felt soil testing improved decision making had a positive influence on adoption. Those who see the benefits of soil testing were expected to be more conservation minded and be more willing to adopt any given BMP. Producers from the Pond Creek watershed had a negative impact on adoption. This was expected even before the analysis was run. Many producers from Pond Creek said during the survey interview that no matter what the cost share was, they would never adopt fencing.

Manure Testing: Two variables were found to be significant for the voluntary adoption of manure testing. Producers who deemed their pasture as good (quality) and dairy producers had a positive effect on adoption. For many dairy producers, this practice is already in place on their farm.

Nutrient Management Plan: Two variables were found to be significant for the voluntary adoption of a nutrient management plan. Producers who deemed their pasture as good (quality) and those who were concerned about liability had a positive effect on adoption. Producers who are concerned about liability would rather adopt the practice now

while they can receive cost share assistance than wait until the government imposes restrictions on them and forces them to adopt on their own.

Manure Composting: No variables were found to be significant for the voluntary adoption of manure composting.

Protected Heavy-Use Area(s): Three variables were found to be significant for the voluntary adoption of a protected heavy-use area(s). Producers who deemed their pasture as good (quality) and received the majority of their income from off farm employment had a positive effect on adoption. These were both expected outcomes. Most producers will do what it takes to keep their pasture in good condition and if they are receiving the majority of their income from off farm employment, they may be able to adopt practices on their farm that do not necessarily have high returns on the dollar amount spent. Producers who believed that soil testing took too much time had a negative effect on adoption. It was expected that if producers do not see the benefit of soil testing, than they will probably not see the benefit of other conservation practices.

Integrated Pest Management: Three variables were found to be significant for the voluntary adoption of integrated pest management. Producers who deemed their pasture as good (quality) and received the majority of their income from off farm employment had a positive effect on adoption.

Soil Testing: Four variables were found to be significant for the voluntary adoption of soil testing. Producers who thought that soil testing improved decision making and profitability had a positive affect on adoption. Both of these variables were expected to have a positive influence. It makes sense that anyone who believes that soil testing improves

decision making and profitability would want to adopt the practice. Producers who were concerned about financial solvency had a negative effect on adoption. This was unexpected due to the low costs of implementing soil testing. Also, the more land that a producer owned had a negative effect on adoption. This was unexpected as well.

### 4.3 Results of TDA and NRCS Data

The following are the results from the TDA and NRCS data sets.

#### 4.3.1 TDA Data

In 1996, 2,305 practices were installed and cost shared statewide. Out of these 2,305 practices, there were 48 different practices installed. However, only 4 practices were predominately chosen. Building a Pond, Pasture and Hayland Planting, Heavy Use Protection Area, and Watering Facility accounted for 1,533 or approximately 66.5% of the 2,305 practices installed. Pasture and Hayland Planting was the most common with 639 installations. Fencing was installed just 44 times accounting for 1.9% of installations. The ten counties with most installed practices were Clay, Coffee, Hamblen, Hawkins, Jackson, Lawrence, Maury, Tipton, Warren and White. These ten counties combined had 582 practices installed which accounts for just over 25%. Tipton County had the most installations with 133. Every county in the state except Carter, Lake and Unicoi installed practices in 1996. The maximum cost share spent on any practice was $143,729.20. A total of $2,621,735.20 was cost shared out with an average of each practice cost sharing $1,137.41. Overall, 72,888 acres were impacted due to the practices that were installed. The average practice impacted just over 34 acres. From this data, we can tell that it cost TDA an average of $35.97 to have an impact on one acre of farmland.

From first glance, 1999 is very similar to 1996. In 1999, 2,306 practices were installed and cost shared statewide. Out of these 2,306 practices, there were 47 different practices installed. Again however, only 4 practices were predominately chosen. Building a Pond, Pasture and Hayland Planting, Heavy Use Protection Area, and Watering Facility accounted for 1,529 or approximately 66.3%of the 2,306 practices installed. Strikingly similar to 1996, Pasture and Hayland Planting was the most common with 639 installations and Fencing was installed just 44 times accounting for 1.9% of installations. The ten counties with most installed practices were Clay, Coffee, Grainger, Hamblen, Hawkins, Lawrence, Maury, Tipton, Warren and White. These ten counties combined had 595 practices installed which accounts for nearly 26%. Tipton County again had the most installations with 133. Every county in the state except Carter, Lake and Unicoi installed practices in 1999. The maximum cost share spent on any practice was $143,729.20. A total of $2,892,705.80 was cost shared out with an average of each practice cost sharing $1,254.43. Overall, 74,633 acres were impacted due to the practices that were installed. The average practice impacted just less than 35 acres. From this data, we can tell that it cost TDA an average of $38.76 to have an impact on one acre of farmland.

In 2000, 2,307 practices were installed and cost shared statewide. Out of these 2,307 practices, there were 48 different practices installed. This year, 6 practices were predominately chosen. Building a Pond, Pasture and Hayland Planting, Heavy Use Protection Area, Terrace, Watering Facility and Water & Sediment Control Basin accounted for 1,678 or approximately 73% of the 2,307 practices installed. Pasture and Hayland Planting was the most common with 500 installations followed closely by Heavy Use

Protection Area with 453 installations. Fencing was installed just 50 times accounting for 2.2% of installations. The ten counties with most installed practices were Claiborne, Crocket, Grainger, Hamblen, Hawkins, Henderson, Jefferson, Lawrence, Sevier and Tipton. These ten counties combined had 532 practices installed which accounts for 23% of the installations. Crockett County had the most installations with 74. Every county in the state except Carter and Lake installed practices in 2000. The maximum cost share spent on any practice was $150,000.00. A total of $4,025,010.50 was cost shared out with an average of each practice cost sharing $1,746.21. Overall, 78,438 acres were impacted due to the practices that were installed. The average practice impacted just over 34 acres. From this data, we can tell that it cost TDA an average of $35.97 to have an impact on one acre of farmland.

In 2001, 2,308 practices were installed and cost shared statewide. Out of these 2,308 practices, there were 52 different practices installed. Again however, only 4 practices were predominately chosen. Building a Pond, Pasture and Hayland Planting, Heavy Use Protection Area, and Watering Facility accounted for 1,491 or approximately 64.6% of the 2,308 practices installed. Pasture and Hayland Planting was the most common with 587 installations. Fencing was installed 59 times accounting for 2.6% of installations. The ten counties with most installed practices were Claiborne, Crockett, Decatur, Grainger, Hamblen, Hawkins, Jefferson, Lawrence, Loudon, and Union. These ten counties combined had 542 practices installed which accounts for 23.5%. Crockett County had the most installations with 67. Every county in the state except Carter and Lake installed practices in 2001. The maximum cost share spent on any practice was $150,000.00. A total of

$3,927,866.40 was cost shared out with an average of each practice cost sharing $1,703.32. Overall, 76,140 acres were impacted due to the practices that were installed. The average practice impacted just less than 34 acres. From this data, we can tell that it cost TDA an average of $51.59 to have an impact on one acre of farmland.

In 2002, 2,309 practices were installed and cost shared statewide. Out of these 2,309 practices, there were 56 different practices installed. Again however, only 4 practices were predominately chosen. Building a Fence, Pasture and Hayland Planting, Heavy Use Protection Area, and Watering Facility accounted for 1,256 or approximately 54% of the 2,309 practices installed. Pasture and Hayland Planting was again the most common with 503 installations. Fencing was installed 197 times accounting for 8.5% of installations. The ten counties with most installed practices were Claiborne, Clay, Coffee, Crockett, Fentress, Hamblen, Jefferson, Loudon, Rhea and Tipton. These ten counties combined had 504 practices installed which accounts for 22%. Rhea County had the most installations with 70. Every county in the state except Carter County installed practices in 2002. The maximum cost share spent on any practice was $143,729.20. A total of $4,008,001.00 was cost shared out with an average of each practice cost sharing $1,739.58. Overall, 90,261 acres were impacted due to the practices that were installed. The average practice impacted just less than 40 acres. From this data, we can tell that it cost TDA an average of $44.40 to have an impact on one acre of farmland.

In 2003, 2,246 practices were installed and cost shared statewide. Out of these 2,246 practices, there were 51 different practices installed. This year 5 practices were predominately chosen. Building a Fence, Pasture and Hayland Planting, Pipeline, Heavy Use

Protection Area, and Watering Facility accounted for 1,552 or approximately 69% of the 2,246 practices installed. Pasture and Hayland Planting was again the most common with 485 installations. Fencing increased again this year and was installed 197 times accounting for 12.6% of installations. The ten counties with most installed practices were Clay, Cocke, Grainger, Hamblen, Jackson, Lawrence, Loudon, Macon, Overton and Warren. These ten counties combined had 591 practices installed which accounts for 26.3%. Overton County had the most installations with 77. Every county in the state except Carter and Sequatchie installed practices in 2003. The maximum cost share spent on any practice was $996,036.00. A total of $4,345,009.3 was cost shared out with an average of each practice cost sharing $2,612.75. Overall, 97,421 acres were impacted due to the practices that were installed. The average practice impacted just less than 44 acres. From this data, we can tell that it cost TDA an average of $44.60 to have an impact on one acre of farmland.

In 2004, only 1,163 practices were installed and cost shared statewide. Out of these 1,163 practices, there were 49 different practices installed. Only 2 practices were predominately chosen this year. They were the installation of Heavy Use Protection Areas and Watering Facilities. These 2 practices accounted for 558 or approximately 51% of the 1,163 practices installed. Heavy Use Protection Area was the most common with 319 installations. No Fencing installations occurred this year. The ten counties with most installed practices were Blount, Carroll, Clay, Crockett, Grainger, Henderson, Loudon, McMinn, Monroe and Robertson. These ten counties combined had 518 practices installed which accounts for 44.5%. Henderson County had the most installations with 118. Every county in the state except Carter, Dickson, Humphreys, Lake, Lewis, Lincoln, Marion,

Moore, Obion, Pickett, Rutherford and Stewart installed practices in 2004. The maximum cost share spent on any practice was $136,154.90. A total of $2,570,857.70 was cost shared out with an average of each practice cost sharing $3,418.69. Overall, 52,476 acres were impacted due to the practices that were installed. The average practice impacted just less than 51 acres. From this data, we can tell that it cost TDA an average of $48.99 to have an impact on one acre of farmland.

In 2005, 1,164 practices were installed and cost shared statewide. Out of these 1,164 practices, there were 47 different practices installed. This year 5 practices were predominately chosen. Building a Fence, Pasture and Hayland Planting, Pipeline, Heavy Use Protection Area, and Watering Facility accounted for 817 or approximately 70% of the 1,164 practices installed. Heavy Use Protection Area was the most common with 205 installations. Fencing this year overtook Pasture and Hayland Planting with 164 installations accounting for 14.1%. The ten counties with most installed practices were Blount, Clay, Grainger, Hamblen, Henderson, Knox, Loudon, Marshall, Monroe, and Union. These ten counties combined had 492 practices installed which accounts for 42%. Grainger County had the most installations with 78. Every county in the state except Carter, Davidson, Decatur, Dyer, Haywood, Humphreys, Lake, Lewis, Marion, Moore, Obion, Polk, Sequatchie, Stewart, Van Buren and Warren installed practices in 2005. The maximum cost share spent on any practice was $56,250.00. A total of $2,401,971.30 was cost shared out with an average of each practice cost sharing $3,002.46. Overall, 52,043 acres were impacted due to the practices that were installed. The average practice impacted just less

than 47 acres. From this data, we can tell that it cost TDA an average of $46.15 to have an impact on one acre of farmland.

### 4.3.2 NRCS Data

In 1997, 295 practices were installed and cost shared statewide. Out of these 295 practices, there were 35 different practices installed. However, only 4 practices were predominately chosen. Nutrient Management, Pasture and Hayland Planting, Pest Management and Prescribed Grazing accounted for 133 or approximately 45% of the 295 practices installed. Pasture and Hayland Planting was the most common with 46 installations. Heavy Use Protection Area was installed just 22 times accounting for 7.5% of installations. Only 4 counties had more than 10 contracts during the year. These 4 counties were Giles, Hardeman, Lauderdale and McMinn. These 4 counties combined had 65 contracts which accounts for 33.5% of the contracts this year. Lauderdale County had the most contracts with 23. Forty counties in the state signed no contracts. The most cost share spent on any practice was $99,522 for Grade Stabilization Structures. A total of $943,757.00 was obligated between 194 different contracts with the average contract receiving $4,864.72 of cost share funds. Overall, 27,487.9 acres were under contract for the year. From this data, we can tell that it cost NRCS an average of $34.33 per acre under contract.

In 1998, 1,014 practices were installed and cost shared statewide. Out of these 1,014 practices, there were 38 different practices installed. Similar to 1997, only 4 practices were predominately chosen. Nutrient Management, Pasture and Hayland Planting, Pest Management and Prescribed Grazing accounted for 549 or approximately 54% of the 1,014 practices installed. This year Pest Management was the most common with 147 installations.

Fencing was installed 41 times and covered 10,367 ft. Only 8 counties had more than 10 contracts during the year. These 8 counties were Bradley, Cumberland, Giles, Henry, Lauderdale, Lincoln, Overton and Tipton. These 8 counties combined had 139 contracts which accounts for 61.5% of the contracts this year. Overton County had the most contracts with 24. Fifty-one counties in the state signed no contracts. The most cost share spent on any practice was $148,880 for Waste Management Systems. A total of $988,346.00 was obligated between 226 different contracts with the average contract receiving $4,373.21 of cost share funds. Overall, 30,491.3 acres were under contract for the year. From this data, we can tell that it cost NRCS an average of $32.41 per acre under contract.

In 1999, 1,201 practices were installed and cost shared statewide. Out of these 1,201 practices, there were 37 different practices installed. As in 1997 and 1998, only 4 practices were predominately chosen. Nutrient Management, Pasture and Hayland Planting, Pest Management and Prescribed Grazing accounted for 652 or approximately 54% of the 1,201 practices installed. This year Nutrient Management was the most common with 203 installations. Fencing again was installed 41 times but now covered 12,769 ft. Only 5 counties had more than 10 contracts during the year. These 5 counties were Fentress, Hawkins, Lauderdale, McMinn and Overton. These 5 counties combined had 99 contracts which accounts for 44.4% of the contracts this year. Overton County had the most contracts (31). Forty-six counties in the state signed no contracts. The most cost share spent on any practice was $233,010 for Waste Management Systems. A total of $1,239,825.00 was obligated between 223 different contracts with the average contract receiving $5,559.75 of

cost share funds. Overall, 35,250.9 acres were under contract for the year. From this data, we can tell that it cost NRCS an average of $35.17 per acre under contract.

In 2000, 1,623 practices were installed and cost shared statewide. Out of these 1,623 practices, there were 44 different practices installed. Again only 4 practices were predominately chosen. Nutrient Management, Pasture and Hayland Planting, Pest Management and Prescribed Grazing accounted for 958 or approximately 59% of the 1,623 practices installed. This comes out to 59%. This year Nutrient Management was the most common with 303 installations. Fencing this year was installed 58 times and covered 59,857 ft. Only 7 counties had more than 10 contracts during the year. These 7 counties were Fentress, Henry, Lauderdale, Obion, Overton, Scott and Warren. These 7 counties combined had 155 contracts which accounts for 60.5% of the contracts this year. Fentress County had the most contracts again with 38. Fifty-four counties in the state signed no contracts. The most cost share spent on any practice was $225,559 for Grade Stabilization Structures. A total of $1,469,845.00 was obligated between 256 different contracts with the average contract receiving $5,741.58 of cost share funds. Overall, 41,660.7 acres were under contract for the year. From this data, we can tell that it cost NRCS an average of $35.28 per acre under contract.

In 2001, 2,185 practices were installed and cost shared statewide. Out of these 2,185 practices, there were 42 different practices installed. This year, Upland Wildlife Habitat Management was among the predominant practices chosen along with the 4 practices Nutrient Management, Pasture and Hayland Planting, Pest Management and Prescribed Grazing. These 5 different practices accounted for 1,442 or approximately 66% of the 2,185

practices installed. Again this year Nutrient Management was the most common with 447 installations followed by Pest Management with 417 installations. Heavy Use Area Protection this year was installed 82 times and covered 825.5 acres. Only 10 counties had more than 10 contracts during the year. These 10 counties were Clay, Crockett, Cumberland, Dekalb, Hamilton, Lauderdale, McMinn, Obion, Rhea and Warren. These 10 counties combined had 175 contracts which accounts for 65.8% of the contracts this year. Cumberland County had the most contracts with 28. Forty-nine counties in the state signed no contracts. The most cost share spent on any practice was $147,341.00 for Pasture and Hay Planting. A total of $1,664,460.00 was obligated between 266 different contracts with the average contract receiving $6,257.37 of cost share funds. Overall, 37,891.7 acres were under contract for the year. From this data, we can tell that it cost NRCS an average of $43.93 per acre under contract.

In 2002, 2,088 practices were installed and cost shared statewide. Out of these 2,088 practices, there were 43 different practices installed. Again this year, Upland Wildlife Habitat Management was among the predominant practices chosen along with the 4 practices Nutrient Management, Pasture and Hayland Planting, Pest Management and Prescribed Grazing. These 5 practices accounted for 1,390 or approximately 66.6% of the 2,088 practices installed. Nutrient Management was the most common again this year with 418 installations. Fencing this year was installed 81 times and covered 218,189.9 ft. Only 12 counties had more than 10 contracts during the year. These 12 counties were Clay, Crockett, Dekalb, Fentress, Giles, Henry, Lauderdale, Lawrence, Marshall, Obion, Rhea and Warren. These 12 counties combined had 244 contracts which accounts for 57% of the contracts this

year. Lauderdale County had the most contracts again with 71. Twenty-nine counties in the state signed no contracts. The most cost share spent on any practice was $179.641.00 for Grade Stabilization Structures. A total of $4,253,187.00 was obligated between 428 different contracts with the average contract receiving $9,937.35 of cost share funds. Overall, 77,676.7 acres were under contract for the year. From this data, we can tell that it cost NRCS an average of $54.75 per acre under contract.

# CHAPTER 5. SUMMARY AND CONCLUSIONS

## 5.1 Summary and Conclusions

Relatively little is known about the factors that motivate or hinder producers' willingness to adopt BMPs. This study seeks to add to the understanding of BMP adoption decision-making by examining the positive and negative factors that effect the adoption of a given BMP. The findings of this study are based upon analysis of survey data. "Today's conservation practices and BMPs must be good for business (i.e., on-farm economics), good for relations with other stakeholders and interests, and good for the environment" (Christensen and Loser, 2002). In order for this country to accomplish the water quality goals that are desired of it, cooperation between both producers and the government must take place.

### 5.1.1 Previous Literature

Feather and Cooper (1995) conclude that some conservation practices will require greater incentives to adopt than others. "For conservation practices and structures that do not pay for themselves in reduced costs or increased yields, some form of incentive (positive or negative) would be necessary to encourage adoption" (Lambert et al., 2006). Lambert et al. concluded that the initial investment for implementing different conservation practices is a major deterrent to adopting, even though there are long run benefits to be gained. The availability of expert advice was thought by Lambert et al. to help encourage the adoption of conservation practices. Rahelizatovo and Gillespie (2004) concluded that older farmers were less likely to adopt, due to their short planning horizons and the long term benefits associated with many BMPs. Along with this, they found a positive relationship between

farm size of dairy producers and the adoption of BMPs. Napier and Bridges discovered, against their own initial theory, that education and knowledge about conservation practices to improve water quality was not a significant factor in adopting BMPs between two Ohio watersheds. Factors such as cost share were said to be needed along with education and knowledge to encourage the adoption of conservation practices.

### 5.1.2 Findings of the Thesis

The models developed through logistic regression identified 16 variables that predicted the decision to adopt 8 to 11 BMPs and 15 variables that predicted the decision not to adopt 5 to 9 BMPs. This study establishes that a variety of economic, institutional, organizational and social factors interact in dynamic ways to influence farmer resource management decisions in the Pond Creek and Oostanaula Creek watersheds. Results of the analysis emphasized: (i) the positive influence of environmental regulations and liability issues on the adoption of six BMPs, reflecting producers understanding that they may be held liable and responsible for on-farm agricultural activities directly causing environmental damage off-farm (i.e., water and air pollution); (ii) the negative effect of financial solvency concerns and decreases in net farm income in the past five years on the adoption of five BMPs considered costly or non-profit maximizing, consistent with the theory that producers are profit maximizers; (iii) that prior participation in conservation programs did not necessarily guarantee adoption of two BMPs, suggesting that BMP adoption criteria is based upon more than past program participation and current cost-share incentives thereby reflecting producers understanding of the financial investment and maintenance cost impact of a given BMP on their operations; (iv) the negative influence of farm size (owned and

rented property) on the adoption of BMPs that are considered time-consuming, costly to maintain, or non-equity based investments (e.g., paying for the installation and maintenance of a BMP on rented property), stressing the importance producers place on BMP monetary benefits; and (v) that no single BMP or set of BMPs is best for all agricultural polluted watersheds, emphasizing the need to establish and develop conservation programs that assess and target individual watershed adoption criteria that motivates producers decision making. Water quality is a critical issue facing all livestock producers. When proposing best management practices, it is important to evaluate the entire farm operation.

When it came to distinguishing between the two watershed responses, there were not very many significant differences between the two. Producers in the Oostanaula Creek watershed were less concerned about both financial solvency and environmental regulations. This can be attributed to the fact that these farmers were predominately hobby farmers. Another significant difference between the two watersheds was that Pond Creek producers received more information from government sources than did Oostanaula Creek producers. The reason for this is that Pond Creek has its own watershed coordinator funded by the UT Extension. All in all, the beef and dairy producers in Pond Creek and beef producers in Oostanaula Creek were found to be very similar. This goes against the assumption that beef and dairy producers act differently towards voluntarily adopting BMPs.

## 5.2 Limitations of the Thesis

Because this study is based upon analysis of survey data, variables included in this study were limited to those available in the survey and study area. The use of survey data also limits the operational definitions of the variables to what can be constructed from the

data. For example, in this case attempts to construct an index of BMP adoption impact on water quality improvement were not successful. It is possible that the study's results regarding willingness-to-adopt a given BMP or set of BMPs are related to a certain level of improved water quality. However, without a good measure of improvements in water quality under each BMP or set of BMPs within the two watersheds, this study could not identify how the adoption of BMPs would impact water quality improvement. Along with knowing the water improvements made, the ability to put a cost price on the adoption of a BMP or set of BMPs when asking about willingness-to-adopt would give a deeper picture on the producers' willingness. If able to do this, a benefit/cost analysis may be created and the BMP or set of BMPs with the largest reduction in pollutants per dollar spent may be chosen. Another limitation of this thesis is the possible bias of the Oostanaula Creek producers. Where Pond Creek producers were interviewed on their farming operation, Oostanaula Creek producers were interviewed at an Extension beef workshop. The fact that these producers were at a workshop to help better their farming operation could create some bias in the way they responded to the survey questions. The act of attending a workshop shows that the producers are aware and concerned of the current condition that farming is having on the environment.

### 5.3 Needs for Further Research

There is still much to learn about what it is that encourages producers to voluntarily adopt conservation practices. "BMP adoption rates differ both across practices and across geographic areas" (Feather and Cooper, 1995). If researchers are unable to determine the motivating factors that assist in the voluntary adoption of conservation practices in the near

future, a new approach may be taken by policy makers. This approach being enforced regulations on producers. This possible forced regulation would create additional financial stress on producers and have the potential to drive many producers out of business.

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**APPENDICES**

**APPENDIX 1. Producer Survey**

The University of Tennessee, Knoxville College of Agricultural Sciences and Natural Resources would like you to take part in the following survey to help evaluate the criteria that producers seek when deciding on whether or not to use the best management practices to improve water quality and reduce soil erosion. This study is part of a senior honors paper by a student at the University of Tennessee in the Department of Agricultural Economics.

1. What was your most recent farm improvement?

   A. Farm Equipment Upgrade/Repair
   B. Built New Barn
   C. Repair Barn
   D. Install/Upgrade Manure System
   E. Install Alternative Water Source
   F. Cattle Crossing
   G. Fencing
   H. Buffer Strips
   I. Improve Pasture
   J. Built New Pond
   K. Improved Pond
   L. Renovate Farm

2. How much money did you spend on this investment?
   $___________

3. If you could make a list of farm improvements that currently need to be made, what would they be and how much would they cost (estimate)? List important first.

   A. ______________ $______________
   B. ______________ $______________
   C. ______________ $______________
   D. ______________ $______________
   E. ______________ $______________
   F. ______________ $______________
   G. ______________ $______________
   H. ______________ $______________

4. When do you plan on making these improvements?
   A. Less than 1 year
   B. 1 - 2 years
   C. 3 - 5 years
   D. More than 5 years

5. How do these improvements rank with adding best management practices for water quality?

A. Farm improvements are more important than water quality
B. Farm improvements are equally important to water quality
C. Farm improvements are less important than water quality

6. How much knowledge do you have of the following conservation programs?

| | Level of Knowledge | | | |
|---|---|---|---|---|
| | High | Moderate | Low | None |
| A. Stewardship Incentive Program (SIP) | ____ | ____ | ____ | ____ |
| B. Environmental Quality Incentives Program (EQIP) | ____ | ____ | ____ | ____ |
| C. National Conservation Buffer Initiative (NCBI) | ____ | ____ | ____ | ____ |
| D. Grassland Reserve Program (GRP) | ____ | ____ | ____ | ____ |
| E. Conservation Reserve Program (CRP) | ____ | ____ | ____ | ____ |
| F. Conservation Reserve Enhancement Program (CREP) | ____ | ____ | ____ | ____ |
| G. Wetland Reserve Program (WRP) | ____ | ____ | ____ | ____ |

7. What source do you use to learn about conservation programs? Select all that apply.

A. Extension Agent
B. Neighbor
C. Family
D. Newspaper/Magazine
E. Farm Bureau Agent
F. NRCS Staff
G. Not Interested in Conservation Programs
H. Other - _________________

8. How would you classify the condition of your pasture?

A. Excellent
B. Good
C. Fair
D. Poor

| 9. How often do you take soil samples? | Pasture Land | Crop Land |
|---|---|---|
| A. Twice a year | _____ | _____ |
| B. Once a year | _____ | _____ |
| C. Once every 2 years | _____ | _____ |
| D. Once every 3 years | _____ | _____ |
| E. Never | _____ | _____ |

Which soil lab do you use?______________________________________________

Why?____________________________________________________________

10. How does soil testing impact you farm operation? Select all that apply.

    A. Improves decision making
    B. Improves profitability
    C. Takes up too much time
    D. No Benefit

11. When was the last time you planted new seed to improve your pasture land?

    A. 1 year ago
    B. 2 years ago
    C. 3 years ago
    D. 4 years ago
    E. 5+ years ago

12. When was the last time you fertilized and/or limed?

| | | Pasture Land | | Crop Land | |
|---|---|---|---|---|---|
| | | Fertilize | Lime | Fertilize | Lime |
| A. | 1 year ago | _____ | _____ | _____ | _____ |
| B. | 2 years ago | _____ | _____ | _____ | _____ |
| C. | 3 years ago | _____ | _____ | _____ | _____ |
| D. | 4 years ago | _____ | _____ | _____ | _____ |
| E. | 5+ years ago | _____ | _____ | _____ | _____ |

13. What type of fertilizer/lime do you use?

| | | Pasture Land | Crop Land |
|---|---|---|---|
| A. | Commercial | _____ | _____ |
| B. | Livestock Manure | _____ | _____ |
| C. | Lime | _____ | _____ |
| D. | Synagro | _____ | _____ |

14. What was the nitrogen, phosphorous and potassium content used (lbs./acre)?

    A. _____lbs./acre - Nitrogen
    B. _____lbs./acre - Phosphorous
    C. _____lbs./acre - Potassium
    D. Unknown

15. In the past 5 years, would you say that your farm net income has increased, decreased or had no change?

- A. Increase
- B. Decrease
- C. No Change

16. Rank, in order, the following concerns most often related with your farm operation.
8 = Most Concerned 1 = Least Concerned

- A. Financial Solvency ______
- B. Environmental Regulations ______
- C. Zoning/Planning ______
- D. Labor ______
- E. Odor Nuisance Complaints ______
- F. Liability ______
- G. Estate/Trusts/Wills ______
- H. Health/Age/Physical Abilities ______

17. Rank the following best management practices according to your willingness to adopt these practices to improve water quality.

Willingness to Adopt
1 = Least Willing 5 = Most Willing

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Alternative Water Source | | | | | |
| Buffer Strips | | | | | |
| Improved Pasture | | | | | |
| Cattle Crossings | | | | | |
| Fencing | | | | | |
| Manure Testing | | | | | |
| Nutrient Management Plan | | | | | |
| Manure Composting | | | | | |
| Protected Heavy-Use Area(s) | | | | | |
| Integrated Pest Management | | | | | |
| Soil Testing Program | | | | | |

18. Have you ever signed up for a conservation program with USDA, EPA, NRCS, etc. that uses cost share as an incentive to participate?

- A. Yes
- B. No

19. What level of cost share would it take for you to participate in the following best management practices?

Government Payment Required
Cost Share Percentage

| | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | Would NOT Participate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alternative Water Source | | | | | | | | | | | | |
| Buffer Strips | | | | | | | | | | | | |
| Improved Pasture | | | | | | | | | | | | |
| Cattle Crossings | | | | | | | | | | | | |
| Fencing | | | | | | | | | | | | |
| Manure Testing | | | | | | | | | | | | |
| Nutrient Management Plan | | | | | | | | | | | | |
| Manure Composting | | | | | | | | | | | | |
| Protected Heavy-Use Area(s) | | | | | | | | | | | | |
| Integrated Pest Management | | | | | | | | | | | | |
| Soil Testing Program | | | | | | | | | | | | |

20. How would you rank the following benefits of using Improved Pasture practice?

1 = Most beneficial 5 = Least beneficial

A. Increased carrying capacity ______
B. Lower death rate ______
C. Greater value of cull stock ______
D. Increase in property value ______
E. Higher weaning weights ______

21. How would you rank the following disadvantages of using Improved Pasture practice?

1 = Most harmful 5 = Least harmful

A. Initial costs ______
B. Regular maintenance costs ______
C. Ecological disruption ______
D. Selective grazing by stock ______
E. Increased maintenance planning ______

Demographic Information:

1. Age: ____

2. Crops produced/number of acres:

| | | | |
|---|---|---|---|
| A. Corn | ______ | E. Cotton | ______ |
| B. Soybeans | ______ | F. Vegetables | ______ |
| C. Wheat | ______ | G. Hay/pasture | ______ |
| D. Tobacco | ______ | H. Other | ______ |

3. Livestock owned or produced/number of head:

| | Own | Sold 2003 |
|---|---|---|
| A. Beef Cattle | ______ | ______ |
| B. Dairy Cattle | ______ | ______ |
| C. Sheep | ______ | ______ |
| D. Swine | ______ | ______ |
| E. Poultry | ______ | ______ |
| F. Goats | ______ | ______ |
| G. Horses | ______ | ______ |
| H. Other | ______ | ______ |

4. Number of acres owned:

A. <50 B. 50 – 99 C. 100 – 299 D. 300 – 499 E. 500 – 749 F. 750 – 999 G. >1000

5. Number of acres rented/leased:

A. <50 B. 50 – 99 C. 100 – 299 D. 300 – 499 E. 500 – 749 F. 750 – 999 G. >1000

6. How long have you been in business?

_______________________________________________________________

7. What percentage of off-farm income makes up your total family income?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90%

## APPENDIX 2. TABLES

**Table 1. Major Land Use Classes in Pond Creek and Oostanaula Creek.**

| | Pond Creek | | Oostanaula Creek | |
|---|---|---|---|---|
| **Land Use Class** | **Acres** | **% of Watershed** | **Acres** | **% of Watershed** |
| Residential | 938 | 4.0% | 5,297 | 11.8% |
| Commercial / Industrial | 922 | 3.9% | 1,129 | 2.5% |
| Agriculture | 14,520 | 61.7% | 16,419 | 36.6% |
| Forest | 6,987 | 29.6% | 21,417 | 47.7% |
| Wetland | 0 | 0.0% | 226 | 0.5% |
| Mining | 0 | 0.0% | 150 | 0.3% |
| Open Water | 192 | 0.8% | 226 | 0.5% |
| **Total** | **23,559** | **100%** | **44,864** | **100%** |

**Table 2. Agricultural Land Use Classes in Pond Creek and Oostanaula Creek.**

| | Pond Creek | | Oostanaula Creek | |
|---|---|---|---|---|
| **Land Use Class** | **Acres** | **% of Ag Land** | **Acres** | **% of Ag Land** |
| High Residue Crops | 649 | 4.5% | 492 | 3.0% |
| Medium Residue Crops | 542 | 3.7% | 147 | 0.9% |
| Low Residue Crops | 367 | 2.5% | 352 | 2.1% |
| Strip Crops | 0 | 0.0% | 1,409 | 8.6% |
| Good Pasture | 3,362 | 23.2% | 20 | 0.1% |
| Fair Pasture | 5,898 | 40.6% | 11,727 | 71.4% |
| Heavily Overgrazed Pasture | 3,512 | 24.2% | 2,062 | 12.6% |
| Poor Pasture | 107 | 0.7% | 0 | 0.0% |
| Woodland Pasture | 0 | 0.0% | 118 | 0.7% |
| Feedlot Loafing Area | 83 | 0.6% | 92 | 0.6% |
| **Total** | **14,520** | **100%** | **16,419** | **100%** |

**Table 3. Characteristics of Study Respondents: Pond Creek (N=29) and Oostanaula Creek (N=29) Watersheds.**

| | Pond Creek | Oostanaula Creek |
|---|---|---|
| | **Age in years** | |
| Mean | 48.7 | 51.1 |
| SD[a] | 13.8 | 12.4 |
| | **Do you grow crops (%)** | |
| Yes | 96.5 | 68.9 |
| No | 3.5 | 31.1 |
| | **Do you raise livestock (%)** | |
| Yes | 96.5 | 96.5 |
| No | 3.5 | 3.5 |
| | **Beef cattle owned (%)** | |
| ≥ 300 | 10.3 | 3.5 |
| 100 - 299 | 13.8 | 72.3 |
| < 100 | 41.4 | 20.7 |
| 0 | 34.5 | 3.5 |
| | **Dairy cattle owned (%)** | |
| ≥ 300 | 0.0 | 13.8 |
| 100 - 299 | 0.0 | 34.5 |
| < 100 | 0.0 | 10.3 |
| 0 | 100.0 | 41.4 |
| | **Acres owned (%)** | |
| ≥ 1000 | 20.6 | 3.6 |
| 750 - 999 | 0.0 | 0.0 |
| 500 - 749 | 13.8 | 7.0 |
| 300 - 499 | 24.1 | 20.6 |
| 100 - 299 | 31.0 | 24.1 |
| 50 - 99 | 3.5 | 20.6 |
| <50 | 7.0 | 24.1 |
| 0 | 0.0 | 0.0 |
| | **Number of acres rented (%)** | |
| ≥ 750 | 0.0 | 0.0 |
| 500 - 749 | 7.0 | 0.0 |
| 300 - 499 | 10.3 | 3.5 |
| 100 - 299 | 34.4 | 17.2 |
| 50 - 99 | 6.9 | 6.9 |
| <50 | 6.9 | 41.4 |
| 0 | 34.5 | 31.0 |
| | **Percentage of total income from off-farm job (%)** | |
| 90% | 6.9 | 37.9 |
| 80% | 3.5 | 6.9 |
| 70% | 6.9 | 6.9 |
| 60% | 3.5 | 10.3 |
| 50% | 13.7 | 3.5 |
| 40% | 3.5 | 6.9 |
| 30% | 3.5 | 6.9 |
| 20% | 3.5 | 13.7 |
| 10% | 6.9 | 3.5 |
| 0% | 48.1 | 3.5 |

**[a]SD = standard deviation**

**Table 4. Percent of Survey Respondents Willing to Participate in a Specific BMP at the 50%, 70% and 90% Cost-Share Levels.**

| Best Management Practice | Cost Share Percent Level 50% | 70% | 90% |
|---|---|---|---|
| | Percent Willing to Participate | | |
| Alternative Water Source | | | |
| Pond Creek | 31.03 | 44.82 | 79.31 |
| Oostanaula Creek | 41.38 | 62.07 | 82.76 |
| Buffer Strips | | | |
| Pond Creek | 24.14 | 27.59 | 44.83 |
| Oostanaula Creek | 24.14 | 37.93 | 55.17 |
| Improved Pasture | | | |
| Pond Creek | 72.41 | 82.76 | 100.0 |
| Oostanaula Creek | 68.97 | 72.41 | 82.76 |
| Cattle Crossings | | | |
| Pond Creek | 34.48 | 44.83 | 51.72 |
| Oostanaula Creek | 31.03 | 37.93 | 72.41 |
| Fencing | | | |
| Pond Creek | 13.79 | 24.14 | 27.59 |
| Oostanaula Creek | 58.62 | 62.07 | 82.76 |
| Manure Testing | | | |
| Pond Creek | 34.48 | 37.93 | 65.52 |
| Oostanaula Creek | 13.79 | 17.24 | 31.03 |
| Nutrient Management Plan | | | |
| Pond Creek | 27.59 | 31.03 | 75.86 |
| Oostanaula Creek | 31.03 | 44.83 | 55.17 |
| Manure Composting | | | |
| Pond Creek | 13.79 | 20.69 | 37.93 |
| Oostanaula Creek | 10.34 | 17.24 | 31.03 |
| Protected Heavy-Use Area(s) | | | |
| Pond Creek | 34.48 | 51.72 | 62.07 |
| Oostanaula Creek | 27.59 | 48.28 | 75.86 |
| Integrated Pest Management | | | |
| Pond Creek | 24.14 | 37.93 | 65.52 |
| Oostanaula Creek | 37.93 | 48.28 | 55.17 |

**Table 4. Continued**

| Best Management Practice | Cost Share Percent Level | | |
|---|---|---|---|
| | 50% | 70% | 90% |
| | Percent Willing to Participate | | |
| Soil Testing | | | |
| Pond Creek | 75.86 | 82.76 | 89.66 |
| Oostanaula Creek | 58.62 | 65.52 | 79.31 |

**Table 5. Summary of the Expected Signs of Explanatory Variables for the Conditional Logistic Mode.**

| Variable | units | Alternative Water Source | Buffer Strips | Improved Pasture | Cattle Crossings | Fencing | Manure Testing | Nutrient Management Plan | Manure Composting | Protected Heavy-Use Area(s) | Integrated Pest Management | Soil Testing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Age** | years | ? | ? | + | - | - | - | - | - | ? | - | ? |
| **Crop** | 0 - 1 (dummy) | - | ? | - | - | - | - | - | - | - | + | + |
| **Animal** | 0 - 1 (dummy) | + | ? | + | ? | - | + | + | + | + | - | ? |
| **Pastureland** | 1 - 7 scale | + | + | + | ? | + | ? | + | ? | + | - | + |
| **Beef** | 1 -3 scale | + | ? | + | ? | ? | - | + | - | + | - | + |
| **Dairy** | 1 - 3 scale | + | - | + | ? | ? | + | + | + | + | - | + |
| **Acres Owned** | 1 - 7 scale | + | + | + | ? | ? | ? | + | ? | + | ? | + |
| **Acres Rented** | 1 - 7 scale | - | + | + | ? | ? | ? | ? | ? | + | ? | + |
| **Off-Farm Income** | 1 - 9 scale | + | + | + | + | + | ? | + | + | + | + | + |
| **Pond Creek** | 0 - 1 (dummy) | + | - | + | - | - | + | ? | + | + | ? | + |
| **Net Farm Income** | 1 - 3 scale | + | + | + | + | ? | + | + | + | + | + | + |
| **Conservation Knowledge** | 1 - 4 (scale) | + | + | + | + | + | + | + | + | + | + | + |
| **Government Information Source** | 0 - 1 (dummy) | + | + | + | + | + | + | + | + | + | + | + |
| **Good Pasture** | 0 - 1 (dummy) | + | + | + | ? | + | ? | ? | ? | + | ? | + |
| **ST[a] - Improves Decision Making** | 0 - 1 (dummy) | + | + | + | + | + | ? | ? | ? | + | + | + |
| **ST - Improves Profitability** | 0 - 1 (dummy) | + | + | + | + | + | ? | ? | ? | + | + | + |
| **ST - Takes too much time** | 0 - 1 (dummy) | - | - | - | - | - | - | - | - | - | - | - |
| **Conservation Program Participation** | 0 - 1 (dummy) | + | + | + | + | + | + | + | + | + | + | + |
| **Financial Solvency** | 1 - 8 (ranking) | - | - | + | - | - | - | - | - | - | + | + |
| **Environmental Regulations** | 1 - 8 (ranking) | + | + | + | + | + | + | + | + | + | + | + |
| **Zoning / Planning** | 1 - 8 (ranking) | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| **Labor** | 1 - 8 (ranking) | ? | - | + | - | - | - | - | - | ? | - | ? |
| **Odor Nuisance Complaints** | 1 - 8 (ranking) | ? | ? | ? | ? | ? | ? | ? | + | ? | ? | ? |
| **Liability** | 1 - 8 (ranking) | + | + | + | + | + | + | + | + | + | + | + |
| **Estate / Trusts / Wills** | 1 - 8 (ranking) | ? | ? | + | ? | ? | ? | ? | ? | + | ? | + |
| **Health / Age / Physical Abilities** | 1 - 8 (ranking) | ? | ? | + | - | - | - | - | - | ? | - | ? |

[a] ST refers to Soil Testing

## Table 6. Conditional Logistic Regression Analysis Results at the 50% Cost-Share Level.

| BMP | Variable | B | S.E. | Wald | df | Sig. | Exp(B) | -2Log Likelihood | Cox & Snell R Square | Nagelkerke R Square |
|---|---|---|---|---|---|---|---|---|---|---|
| **Alternative Water Source** | Labor | -0.402 | 0.189 | 4.549 | 1 | 0.033** | 0.669 | 59.402 | 0.248 | 0.340 |
| | Estate/Trusts/Wills | -0.416 | 0.178 | 5.486 | 1 | 0.019** | 0.660 | | | |
| | Acres Rented | -0.517 | 0.228 | 5.149 | 1 | 0.023** | 0.596 | | | |
| | Constant | 3.613 | 1.369 | 6.969 | 1 | 0.008*** | 37.065 | | | |
| **Buffer Strips** | Conservation Knowledge | 1.247 | 0.638 | 3.825 | 1 | 0.051** | 3.482 | 51.302 | 0.198 | 0.296 |
| | Good Pasture | 1.522 | 0.764 | 3.968 | 1 | 0.046** | 4.581 | | | |
| | Pastureland | -1.257 | 0.463 | 7.377 | 1 | 0.007*** | 0.284 | | | |
| | Constant | -2.480 | 1.247 | 3.955 | 1 | 0.047** | 0.084 | | | |
| **Improved Pasture** | Good Pasture | 3.393 | 1.256 | 7.303 | 1 | 0.007*** | 29.765 | 32.762 | 0.475 | 0.677 |
| | Financial Solvency | -0.784 | 0.316 | 6.156 | 1 | 0.013*** | 0.457 | | | |
| | Labor | -0.655 | 0.287 | 5.193 | 1 | 0.023** | 0.520 | | | |
| | Liability | 0.747 | 0.348 | 4.606 | 1 | 0.032** | 2.110 | | | |
| | Dairy | -2.606 | 1.020 | 6.527 | 1 | 0.011*** | 0.074 | | | |
| | Constant | 5.164 | 2.880 | 3.215 | 1 | 0.073* | 174.942 | | | |
| **Cattle Crossings** | NFI[a] - No Change | | | 6.312 | 2 | 0.043** | | 66.769 | 0.107 | 0.150 |
| | NFI - Increase | 1.686 | 0.730 | 5.332 | 1 | 0.021** | 5.400 | | | |
| | Constant | -1.099 | 0.516 | 4.526 | 1 | 0.033** | 0.333 | | | |
| **Fencing** | Pond Creek | -1.783 | 0.734 | 5.895 | 1 | 0.015** | 0.168 | 53.854 | 0.317 | 0.434 |
| | ST[b] - Improves Decision Making | 1.990 | 0.995 | 4.001 | 1 | 0.045** | 7.317 | | | |
| | Off Farm Income | 0.256 | 0.113 | 5.086 | 1 | 0.024** | 1.291 | | | |
| | Constant | -2.720 | 1.227 | 4.916 | 1 | 0.027** | 0.066 | | | |
| **Manure Testing** | Conservation Knowledge | 2.399 | 0.887 | 7.319 | 1 | 0.007*** | 11.016 | 42.577 | 0.310 | 0.464 |
| | Government Information Sources | -2.369 | 1.263 | 3.520 | 1 | 0.061* | 0.940 | | | |
| | Dairy | 0.904 | 0.395 | 5.226 | 1 | 0.022** | 2.468 | | | |
| | Constant | -4.930 | 1.743 | 7.997 | 1 | 0.005*** | 0.007 | | | |
| **Nutrient Management Plan** | Good Pasture | 1.767 | 0.831 | 4.521 | 1 | 0.033** | 5.854 | 41.266 | 0.392 | 0.559 |
| | NFI - No Change | | | 6.784 | 2 | 0.034** | | | | |
| | NFI - Increase | -3.416 | 1.316 | 6.733 | 1 | 0.009*** | 0.033 | | | |
| | Environmental Regulations | 0.776 | 0.280 | 7.679 | 1 | 0.006*** | 2.172 | | | |
| | Acres Owned | -0.730 | 0.325 | 5.054 | 1 | 0.025** | 0.482 | | | |
| | Constant | -2.967 | 1.770 | 2.811 | 1 | 0.094* | 0.051 | | | |
| **Manure Composting** | Government Information Sources | -1.932 | 0.897 | 4.634 | 1 | 0.031** | 0.145 | 38.462 | 0.071 | 0.136 |
| | Constant | -0.511 | 0.730 | 0.489 | 1 | 0.484 | 0.600 | | | |
| **Protected Heavy-Use Area(s)** | Environmental Regulations | 0.510 | 0.189 | 7.285 | 1 | 0.007*** | 1.666 | 63.095 | 0.140 | 0.197 |
| | Constant | -3.494 | 1.092 | 10.233 | 1 | 0.001*** | 0.030 | | | |
| **Integrated Pest Management** | NFI - No Change | | | 6.237 | 2 | 0.044** | | 58.578 | 0.204 | 0.288 |
| | NFI - Increase | -2.406 | 1.004 | 5.748 | 1 | 0.017** | 0.090 | | | |
| | NFI - Decrease | -1.470 | 0.811 | 3.284 | 1 | 0.07* | 0.230 | | | |
| | Off Farm Income | 0.338 | 0.121 | 7.746 | 1 | 0.005*** | 1.402 | | | |
| | Constant | -1.406 | 0.624 | 5.083 | 1 | 0.024** | 0.245 | | | |
| **Soil Testing** | NFI - No Change | | | 6.337 | 2 | 0.042** | | 56.257 | 0.255 | 0.356 |
| | NFI - Increase | -2.289 | 0.968 | 5.596 | 1 | 0.018** | 0.101 | | | |
| | Financial Solvency | -0.491 | 0.169 | 8.428 | 1 | 0.004*** | 0.612 | | | |
| | Dairy | -1.191 | 0.489 | 5.937 | 1 | 0.015** | 0.304 | | | |
| | Constant | 4.396 | 1.257 | 12.230 | 1 | 0.001*** | 81.091 | | | |

[a] NFI refers to Net Farm Income.

[b] ST refers to Soil Testing.

* Significant at 10%: ** significant at 5%; and *** significant at 1%

## Table 7. Conditional Logistic Regression Analysis Results at the 70% Cost-Share Level.

| BMP | Variable | B | S.E. | Wald | df | Sig. | Exp(B) | -2Log Likelihood | Cox & Snell R Square | Nagelkerke R Square |
|---|---|---|---|---|---|---|---|---|---|---|
| **Alternative Water Source** | Good Pasture | 2.680 | 0.807 | 11.028 | 1 | 0.001*** | 14.592 | 48.958 | 0.416 | 0.555 |
| | Labor | -0.483 | 0.201 | 5.777 | 1 | 0.016** | 0.617 | | | |
| | Dairy | -1.098 | 0.444 | 6.110 | 1 | 0.013** | 0.334 | | | |
| | Constant | -21.064 | 27953 | 0.000 | 1 | 0.044** | 7.613 | | | |
| **Buffer Strips** | Good Pasture | 2.242 | 0.794 | 7.983 | 1 | 0.005*** | 9.415 | 55.794 | 0.261 | 0.364 |
| | Health/Age/Physical Abilities | -0.352 | 0.183 | 3.687 | 1 | 0.055* | 0.703 | | | |
| | Off Farm Income | 0.282 | 0.112 | 6.297 | 1 | 0.012** | 1.326 | | | |
| | Constant | -1.890 | 0.933 | 4.106 | 1 | 0.043** | 0.151 | | | |
| **Improved Pasture** | Good Pasture | 2.999 | 1.136 | 6.967 | 1 | 0.008*** | 20.057 | 44.347 | 0.259 | 0.395 |
| | Labor | -0.533 | 0.236 | 5.094 | 1 | 0.024** | 0.587 | | | |
| | Livestock | 3.140 | 1.794 | 3.062 | 1 | 0.080*** | 23.106 | | | |
| | Constant | 0.201 | 2.192 | 0.008 | 1 | 0.927 | 1.223 | | | |
| **Cattle Crossings** | Good Pasture | 9.846 | 3.973 | 6.140 | 1 | 0.013** | 18877.363 | 11.363 | 0.687 | 0.925 |
| | ST[a] - Takes too much time | -9.328 | 4.642 | 4.037 | 1 | 0.045** | 0.000 | | | |
| | NFI[b] - No Change | | | 5.246 | 2 | 0.073* | | | | |
| | NFI - Decrease | -10.734 | 4.716 | 5.181 | 1 | 0.023 | 0.000 | | | |
| | Zoning/Planning | -1.131 | 0.635 | 3.170 | 1 | 0.075* | 0.323 | | | |
| | Health/Age/Physical Abilities | 2.365 | 1.231 | 3.690 | 1 | 0.055* | 10.641 | | | |
| | Conservation Program Participation | -4.268 | 2.389 | 3.192 | 1 | 0.074* | 0.014 | | | |
| | Crop | 26.906 | 10.776 | 6.235 | 1 | 0.013** | 5E+011 | | | |
| | Acres Rented | -1.696 | 0.953 | 3.169 | 1 | 0.075* | 0.183 | | | |
| | Off Farm Income | 0.850 | 0.366 | 5.387 | 1 | 0.020** | 2.339 | | | |
| | Constant | -23.974 | 11.787 | 4.137 | 1 | 0.042** | 0.000 | | | |
| **Fencing** | ST - Improves Decision Making | 2.680 | 1.062 | 6.366 | 1 | 0.012** | 14.589 | 53.113 | 0.363 | 0.488 |
| | Liability | 0.603 | 0.270 | 4.981 | 1 | 0.026** | 1.828 | | | |
| | Estate/Trusts/Wills | 0.367 | 0.182 | 4.093 | 1 | 0.043** | 1.444 | | | |
| | Off Farm Income | 0.395 | 0.119 | 11.065 | 1 | 0.001*** | 1.485 | | | |
| | Constant | -8.708 | 2.454 | 12.595 | 1 | 0*** | 0.000 | | | |
| **Manure Testing** | Pond Creek | 3.298 | 1.289 | 6.542 | 1 | 0.011*** | 27.059 | 34.966 | 0.437 | 0.632 |
| | Conservation Knowledge | 4.371 | 1.323 | 10.910 | 1 | 0.001*** | 79.146 | | | |
| | Government Information Sources | -5.751 | 2.135 | 7.253 | 1 | 0.007*** | 0.003 | | | |
| | Good Pasture | 1.982 | 1.079 | 3.370 | 1 | 0.066* | 7.255 | | | |
| | Liability | 0.769 | 0.334 | 5.316 | 1 | 0.021** | 2.158 | | | |
| | Constant | -12.094 | 3.656 | 10.942 | 1 | 0.001*** | 0.000 | | | |
| **Nutrient Management Plan** | Good Pasture | 1.880 | 0.663 | 8.052 | 1 | 0.005*** | 6.557 | 59.222 | 0.264 | 0.359 |
| | Acres Owned | -0.585 | 0.224 | 6.824 | 1 | 0.009*** | 0.557 | | | |
| | Constant | 0.370 | 0.765 | 0.234 | 1 | 0.628 | 1.448 | | | |
| **Manure Composting** | Off Farm Income | 0.301 | 0.129 | 5.454 | 1 | 0.02** | 1.351 | 47.983 | 0.134 | 0.216 |
| | Financial Solvency | -0.272 | 0.145 | 3.509 | 1 | 0.061* | 0.762 | | | |
| | Constant | -1.914 | 0.782 | 5.992 | 1 | 0.014** | 0.147 | | | |
| **Protected Heavy-Use Area(s)** | Good Pasture | 1.764 | 0.578 | 9.320 | 1 | 0.002*** | 5.833 | 70.155 | 0.162 | 0.216 |
| | Constant | -0.847 | 0.398 | 4.523 | 1 | 0.033** | 0.429 | | | |
| **Integrated Pest Management** | Farm Improvements = Water Quality | | | 5.603 | 2 | 0.061* | | 60.249 | 0.280 | 0.376 |
| | Farm Improvements < Water Quality | 1.490 | 0.820 | 3.304 | 1 | 0.069* | 4.437 | | | |
| | Farm Improvements > Water Quality | 2.812 | 1.235 | 5.183 | 1 | 0.023** | 16.645 | | | |
| | Liability | 0.563 | 0.223 | 6.357 | 1 | 0.012** | 1.755 | | | |
| | Off Farm Income | 0.260 | 0.100 | 6.759 | 1 | 0.009*** | 1.297 | | | |
| | Constant | -5.660 | 1.647 | 11.808 | 1 | 0.001*** | 0.003 | | | |
| **Soil Testing** | Good Pasture | 2.022 | 0.959 | 4.445 | 1 | 0.035** | 7.556 | 42.886 | 0.332 | 0.488 |
| | Financial Solvency | -0.544 | 0.235 | 5.370 | 1 | 0.020** | 0.581 | | | |
| | Crop | 2.438 | 1.059 | 5.300 | 1 | 0.021** | 11.447 | | | |
| | Dairy | -1.529 | 0.705 | 4.709 | 1 | 0.03** | 0.217 | | | |
| | Constant | 2.284 | 1.589 | 20.660 | 1 | 0.151 | 9.814 | | | |

[a] ST refers to Soil Testing.

[b] NFI refers to Net Farm Income.

* Significant at 10%: ** significant at 5%; and *** significant at 1%

## Table 8. Conditional Logistic Regression Analysis Results at the 90% Cost-Share Level.

| BMP | Variable | B | S.E. | Wald | df | Sig. | Exp(B) | -2Log Likelihood | Cox & Snell R Square | Nagelkerke R Square |
|---|---|---|---|---|---|---|---|---|---|---|
| Alternative Water Source | Conservation Program Participation | 1.942 | 0.751 | 6.681 | 1 | 0.010*** | 6.974 | 48.734 | 0.123 | 0.198 |
| | Constant | 0.486 | 0.449 | 1.167 | 1 | 0.280 | 1.625 | | | |
| Buffer Strips | Conservation Knowledge | 2.113 | 0.641 | 10.860 | 1 | 0.001*** | 8.272 | 55.481 | 0.349 | 0.466 |
| | ST[a] - Improves Decision Making | 2.588 | 0.999 | 6.711 | 1 | 0.010*** | 13.298 | | | |
| | Acres Owned | -0.552 | 0.231 | 5.698 | 1 | 0.017** | 0.576 | | | |
| | Constant | -4.337 | 1.488 | 8.497 | 1 | 0.004*** | 0.013 | | | |
| Improved Pasture[b] | | | | | | | | | | |
| Cattle Crossings | Good Pasture | 1.782 | 0.739 | 5.818 | 1 | 0.016** | 5.939 | 49.731 | 0.375 | 0.510 |
| | ST - Improves Decision Making | 1.848 | 0.959 | 3.714 | 1 | 0.054*** | 6.346 | | | |
| | Off Farm Income | 0.431 | 0.119 | 13.127 | 1 | 0.000*** | 1.539 | | | |
| | Constant | -3.410 | 1.140 | 8.955 | 1 | 0.003*** | 0.033 | | | |
| Fencing | Pond Creek | -3.180 | 0.837 | 14.426 | 1 | 0.000*** | 0.042 | 52.869 | 0.371 | 0.497 |
| | ST - Improves Decision Making | 2.572 | 1.022 | 6.329 | 1 | 0.012*** | 13.091 | | | |
| | Constant | -0.119 | 0.779 | 0.023 | 1 | 0.879 | 0.888 | | | |
| Manure Testing | Good Pasture | 1.927 | 0.685 | 7.908 | 1 | 0.005*** | 6.871 | 61.746 | 0.274 | 0.366 |
| | Dairy | 1.176 | 0.385 | 9.338 | 1 | 0.002*** | 3.242 | | | |
| | Constant | -1.698 | 0.578 | 8.635 | 1 | 0.003*** | 0.183 | | | |
| Nutrient Management Plan | Good Pasture | 1.591 | 0.676 | 5.537 | 1 | 0.019** | 4.908 | 62.607 | 0.189 | 0.260 |
| | Liability | 0.598 | 0.237 | 6.378 | 1 | 0.012*** | 1.818 | | | |
| | Constant | -3.004 | 1.301 | 5.327 | 1 | 0.021** | 0.050 | | | |
| Manure Composting[b] | | | | | | | | | | |
| Protected Heavy-Use Area(s) | Good Pasture | 2.576 | 0.888 | 8.425 | 1 | 0.004*** | 13.146 | 48.214 | 0.335 | 0.471 |
| | ST - Takes too much time | -4.948 | 1.594 | 9.629 | 1 | 0.002*** | 0.007 | | | |
| | Off Farm Income | 0.327 | 0.121 | 7.337 | 1 | 0.007*** | 1.386 | | | |
| | Constant | -1.018 | 0.587 | 3.012 | 1 | 0.083* | 0.361 | | | |
| Integrated Pest Management | Good Pasture | 1.784 | 0.755 | 5.580 | 1 | 0.018 | 5.951 | 57.207 | 0.300 | 0.406 |
| | NFI[c] - No Change | | | 8.369 | 2 | 0.015** | | | | |
| | NFI - Decrease | -2.476 | 0.922 | 7.217 | 1 | 0.007*** | 11.898 | | | |
| | Off Farm Income | 0.248 | 0.108 | 5.313 | 1 | 0.021** | 1.282 | | | |
| | Constant | -0.384 | 0.606 | 0.401 | 1 | 0.005*** | 0.681 | | | |
| Soil Testing | ST - Improves Decision Making | 4.314 | 2.103 | 4.207 | 1 | 0.040** | 74.728 | 19.956 | 0.405 | 0.863 |
| | ST - Improves Profitability | 4.343 | 1.863 | 5.433 | 1 | 0.020** | 76.952 | | | |
| | Financial Sovency | -1.027 | 0.452 | 5.175 | 1 | 0.023** | 0.358 | | | |
| | Acres Owned | -1.559 | 0.677 | 5.303 | 1 | 0.021** | 0.210 | | | |
| | Constant | 8.779 | 3.772 | 5.417 | 1 | 0.020** | 6496 | | | |

[a] ST refers to Soil Testing.

[b] No significant variables present.

[c] NFI refers to Net Farm Income.

* Significant at 10%: ** significant at 5%; and *** significant at 1%

**Table 9. Marginal Effects of Conditional Logistic Regression Analysis Results from the 50% Cost Share Model.**

| BMP | Variable | Marginal Effect | Significance |
|---|---|---|---|
| **Alternative Water Source** | Labor | -0.092 | 0.033 |
| | Estate/Trusts/Wills | -0.096 | 0.019 |
| | Acres Rented | -0.119 | 0.023 |
| **Buffer Strips** | Conservation Knowledge | 0.228 | 0.051 |
| | Good Pasture | N/A | N/A |
| | Pastureland | -0.230 | 0.007 |
| **Improved Pasture** | Good Pasture | N/A | N/A |
| | Financial Solvency | -0.162 | 0.013 |
| | Labor | -0.136 | 0.023 |
| | Liability | 0.155 | 0.032 |
| | Dairy | N/A | N/A |
| **Cattle Crossings** | NFI[a] - Increase | N/A | N/A |
| **Fencing** | Pond Creek | N/A | N/A |
| | ST[b] - Improves Decision Making | N/A | N/A |
| | Off Farm Income | 0.059 | 0.024 |
| **Manure Testing** | Conservation Knowledge | 0.439 | 0.007 |
| | Government Information Sources | N/A | N/A |
| | Dairy | N/A | N/A |
| **Nutrient Mangement Plan** | Good Pasture | N/A | N/A |
| | NFI - Increase | -0.708 | 0.009 |
| | Environmental Regulations | 0.161 | 0.006 |
| | Acres Owned | -0.151 | 0.025 |
| **Manure Composting** | Government Information Sources | N/A | N/A |
| **Protected Heavy-Use Area(s)** | Environmental Regulations | 0.109 | 0.007 |
| **Integrated Pest Management** | NFI - Increase | N/A | N/A |
| | NFI - Decrease | N/A | N/A |
| | Off Farm Income | 0.072 | 0.005 |
| **Soil Testing** | NFI - Increase | N/A | N/A |
| | Financial Solvency | -0.108 | 0.004 |
| | Dairy | N/A | N/A |

[a]NFI refers to Net Farm Income

[b]ST refers to Soil Testing

**Table 10. Marginal Effects of Conditional Logistic Regression Analysis Results from the 70% Cost Share Model.**

| BMP | Variable | Marginal Effect | Significance |
|---|---|---|---|
| **Alternative Water Source** | Good Pasture | 0.667 | 0.001 |
| | Labor | -0.120 | 0.016 |
| | Dairy | -0.273 | 0.013 |
| **Buffer Strips** | Good Pasture | 0.494 | 0.005 |
| | Health/Age/Physical Abilities | -0.078 | 0.055 |
| | Off Farm Income | 0.062 | 0.012 |
| **Improved Pasture** | Good Pasture | 0.521 | 0.008 |
| | Labor | -0.093 | 0.024 |
| | Livestock | 0.546 | 0.080 |
| **Cattle Crossings** | Good Pasture | 2.389 | 0.013 |
| | ST[a] - Takes too much time | -2.263 | 0.045 |
| | NFI[b] - Decrease | -2.604 | 0.023 |
| | Zoning/Planning | -0.274 | 0.075 |
| | Health/Age/Physical Abilities | 0.574 | 0.055 |
| | Conservation Program Participation | -1.035 | 0.074 |
| | Crop | 6.528 | 0.013 |
| | Acres Rented | 0.411 | 0.075 |
| | Off Farm Income | 0.206 | 0.020 |
| **Fencing** | ST - Improves Decision Making | 0.657 | 0.012 |
| | Liability | 0.148 | 0.026 |
| | Estate/Trusts/Wills | 0.090 | 0.043 |
| | Off Farm Income | 0.097 | 0.001 |
| **Manure Testing** | Pond Creek | 0.659 | 0.011 |
| | Conservation Knowledge | 0.873 | 0.001 |
| | Government Information Sources | -1.149 | 0.007 |
| | Good Pasture | 0.396 | 0.066 |
| | Liability | 0.154 | 0.021 |
| **Nutrient Mangement Plan** | Good Pasture | 0.442 | 0.005 |
| | Acres Owned | 0.138 | 0.009 |
| **Manure Composting** | Off Farm Income | 0.046 | 0.002 |
| | Financial Solvency | -0.041 | 0.061 |
| **Protected Heavy-Use Area(s)** | Good Pasture | 0.441 | 0.002 |
| **Integrated Pest Management** | Farm Improvements < Water Quality | 0.365 | 0.069 |
| | Farm Improvements > Water Quality | 0.690 | 0.023 |
| | Liability | 0.138 | 0.012 |
| | Off Farm Income | 0.064 | 0.009 |
| **Soil Testing** | Good Pasture | 0.388 | 0.035 |
| | Financial Solvency | -0.104 | 0.020 |
| | Crop | 0.468 | 0.021 |
| | Dairy | -0.293 | 0.030 |

[a]ST refers to Soil Testing

[b]NFI refers to Net Farm Income

**Table 11. Marginal Effects of Conditional Logistic Regression Analysis Results from the 90% Cost Share Model.**

| BMP | Variable | Marginal Effect | Significance |
|---|---|---|---|
| **Alternative Water Source** | Conservation Program Participation | 0.299 | 0.100 |
| **Buffer Strips** | Conservation Knowledge | 0.528 | 0.001 |
| | ST[a] - Improves Decision Making | 0.647 | 0.017 |
| | Acres Owned | -0.138 | 0.004 |
| **Improved Pasture[b]** | | | |
| **Cattle Crossings** | Good Pasture | 0.419 | 0.016 |
| | ST - Improves Decision Making | 0.435 | 0.054 |
| | Off Farm Income | 0.101 | 0.000 |
| **Fencing** | Pond Creek | -0.786 | 0.000 |
| | ST - Improves Decision Making | 0.636 | 0.012 |
| **Manure Testing** | Good Pasture | 0.481 | 0.005 |
| | Dairy | 0.294 | 0.002 |
| **Nutrient Management Plan** | Good Pasture | 0.360 | 0.019 |
| | Liability | 0.135 | 0.012 |
| **Manure Composting[b]** | | | |
| **Protected Heavy-Use Area(s)** | Good Pasture | 0.551 | 0.004 |
| | ST - Takes too much time | -1.058 | 0.002 |
| | Off Farm Income | 0.070 | 0.007 |
| **Integrated Pest Management** | Good Pasture | 0.427 | 0.018 |
| | NFI[c] - Decrease | -0.593 | 0.007 |
| | Off Farm Income | 0.059 | 0.021 |
| **Soil Testing** | ST - Improves Decision Making | 0.565 | 0.040 |
| | ST - Improves Profitability | 0.569 | 0.020 |
| | Financial Solvency | -0.135 | 0.023 |
| | Acres Owned | -0.204 | 0.021 |

[a]ST refers to Soil Testing

[b]No significant variables present

[c]NFI refers to Net Farm Income

**Table 12. t-test of Explanatory Variables.**

| Variable | Watershed | N | Mean | Standard Deviation | Sig. (2-tailed) |
|---|---|---|---|---|---|
| **Conservation Knowledge** | Pond Creek | 29 | 1.85 | 0.715 | 0.692 |
| | Oostanaula Creek | 29 | 1.919 | 0.624 | |
| **Age** | Pond Creek | 29 | 48.69 | 13.779 | 0.486 |
| | Oostanaula Creek | 29 | 51.1 | 12.379 | |

**Table 13. Multiple Analysis Of Variance (MANOVA) test of Explanatory Variables.**

| Variable | Watershed | Mean | Standard Error | Sig. |
|---|---|---|---|---|
| **Financial Solvency** | Pond Creek | 2.357 | 0.430 | 0.000 |
| | Oostanaula Creek | 6.571 | | |
| **Environmental Regulations** | Pond Creek | 5.321 | 0.336 | 0.090 |
| | Oostanaula Creek | 4.500 | | |
| **Zoning/Planning** | Pond Creek | 3.714 | 0.452 | 0.579 |
| | Oostanaula Creek | 4.071 | | |
| **Labor** | Pond Creek | 5.071 | 0.376 | 0.894 |
| | Oostanaula Creek | 5.143 | | |
| **Odor Nuisance Complaints** | Pond Creek | 3.036 | 0.379 | 0.188 |
| | Oostanaula Creek | 2.321 | | |
| **Liability** | Pond Creek | 5.179 | 0.298 | 0.800 |
| | Oostanaula Creek | 5.071 | | |
| **Estate/Trusts/Wills** | Pond Creek | 3.286 | 0.386 | 0.197 |
| | Oostanaula Creek | 4.000 | | |
| **Health/Age/Physical Abilities** | Pond Creek | 3.893 | 0.379 | 0.427 |
| | Oostanaula Creek | 4.321 | | |
| **Pastureland** | Pond Creek | 1.964 | 0.167 | 0.054 |
| | Oostanaula Creek | 1.500 | | |
| **Beef** | Pond Creek | 1.036 | 0.150 | 0.318 |
| | Oostanaula Creek | 1.250 | | |
| **Dairy** | Pond Creek | 1.250 | 0.153 | 0.000 |
| | Oostanaula Creek | 0.000 | | |
| **Acres Owned** | Pond Creek | 4.214 | 0.302 | 0.000 |
| | Oostanaula Creek | 2.536 | | |
| **Acres Rented** | Pond Creek | 2.071 | 0.276 | 0.040 |
| | Oostanaula Creek | 1.250 | | |
| **Off Farm Income** | Pond Creek | 2.607 | 0.596 | 0.000 |
| | Oostanaula Creek | 5.929 | | |

**Table 14. Pearson Chi square test of Explanatory Variables.**

| Variable | Pearson Chi-Square Value | df | Aymp. Sig. (2-sided) |
|---|---|---|---|
| **Farm Improvements** | 2.161 | 2 | 0.339 |
| **Government Information Sources** | 4.975 | 1 | 0.026 |
| **Good Pasture** | 0.827 | 1 | 0.363 |
| **ST[1] - Improves Decision Making** | 0.074 | 1 | 0.786 |
| **ST - Improves Profitability** | 1.454 | 1 | 0.228 |
| **ST - Takes too much time** | 0.001 | 1 | 0.972 |
| **Net Farm Income** | 7.431 | 2 | 0.024 |
| **Conservation Program Participation** | 0.517 | 1 | 0.472 |
| **Crop** | 7.733 | 1 | 0.005 |
| **Animal** | 0.000 | 1 | 1.000 |

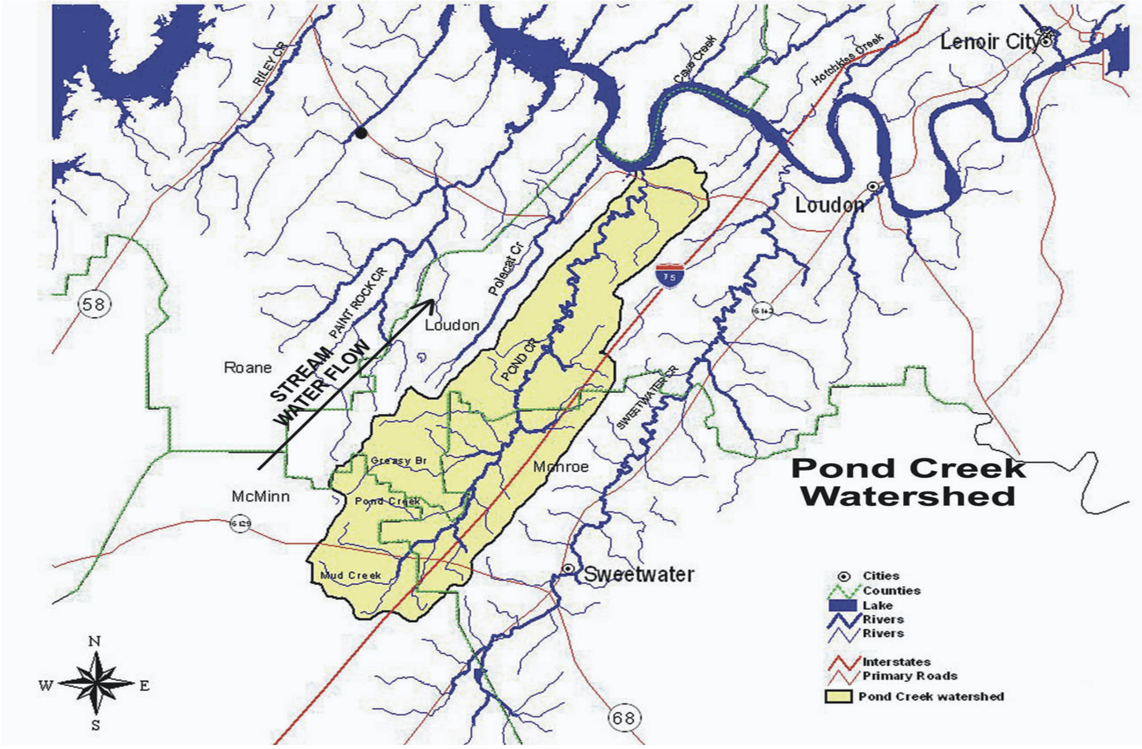


**Figure 1. Pond Creek Watershed**

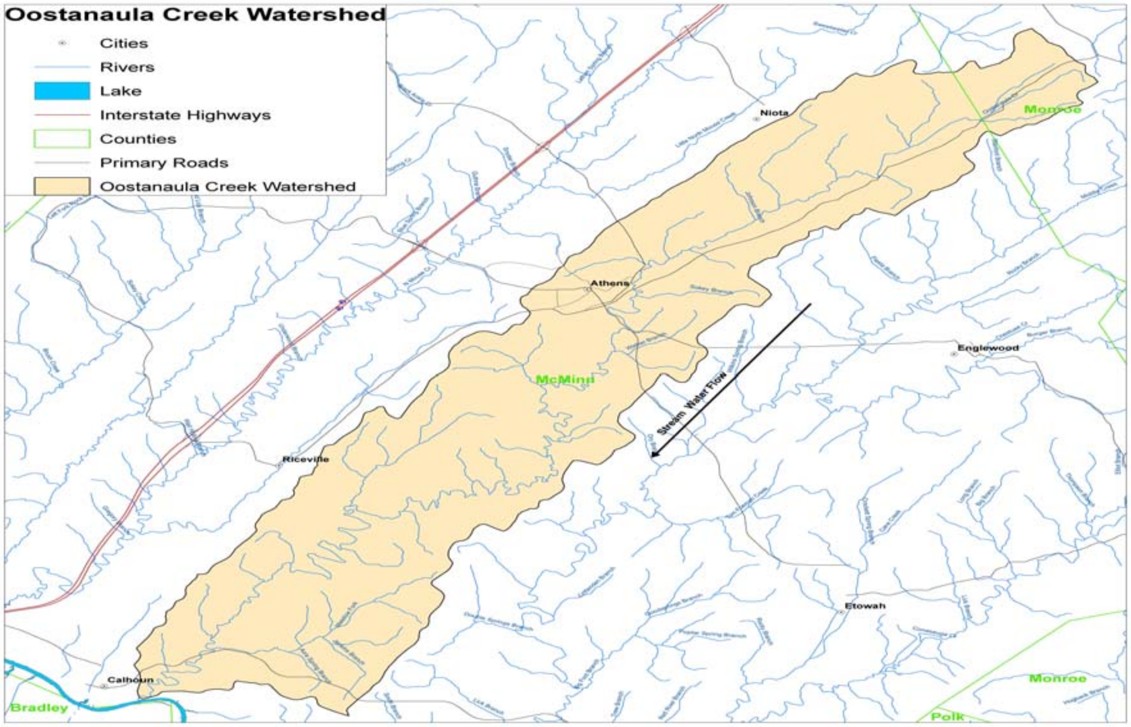


**Figure 2. Oostanaula Creek Watershed**

## VITA

Michael John Barrowclough was born in Winston Salem, North Carolina on April 14, 1982 to Dr. John and Ann Barrowclough. He has three brothers and two sisters, Matthew, Lauren, David, Eric and Megan. Michael graduated from Science Hill High School in Johnson City, Tennessee.

Michael began his college career in August 2000 at the University of Tennessee, Knoxville. He graduated from UTK with a Bachelor of Science in Agriculture, with a major in Agricultural Economics in May 2004. In August 2004, he enrolled in the Agricultural Economics Master's Program at the University of Tennessee, Knoxville. He graduated from the Master's program in December 2006.

Michael plans on one day to have his own farm.