The Economics of Water and Land Resource Use

by

Oluwagbemiga Abiodun Ojumu

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Approved by

Diane Hite, Co-Chair, Professor of Agricultural and Resource Economics
Deacue Fields, Co-Chair, Associate Professor of Agricultural Economics
Asheber Abebe, Associate Professor of Mathematics and Statistics
Valentina Hartarska, Associate Professor of Agricultural Economics

Abstract

Natural resource economics deals with the supply, demand, and the management of the earth's natural resources. It brings together different broad areas in human economics, earth science, and natural ecosystems to create better understanding of the natural resources in order o develop sustainable ways of managing them to ensure their availability to future generations. Natural resources provide services that respond to market forces, but the right mix of these resources have to be employed in order to optimize the value that they provide. This dissertation focuses on the economics of water and land resources, using economic and biophysical models to show how these resources can be better used to optimize the services that they provide.

To do this, this dissertation uses three essays. The first essay uses survey responses from randomly selected anglers in the 2006/2007 recreational fishing season in Alabama in a travel cost model to estimate their consumer surpluses and total willingness to pay for this type of recreation. With some contingent valuation questions in the survey, used with the travel cost model, the study shows that anglers' willingness to pay for recreational visits will increase if the quality of the recreational fishing sites are improved. This result infers that the owners and managers of recreational fishing sites could improve their possible profits by improving recreational fishing sites.

The second essay does an impact analysis of new monies that is brought into the economically depressed Black-Belt region of Alabama and Alabama State by anglers that come to the recreational fishing sites in the State. Using IMPLAN for this analysis, the

multiplier effects of the new income shows that new jobs are created; and more could still be created if the quality of the sites are improved. Policies could be used to support the greater use of water resource that is in abundance in the State, particularly in the Black-Belt, as a key to the economic problems in these regions.

In the third essay, the economic and environmental impact of land-use change is examined. This study assumes that the demand for bio-ethanol and bio-diesel will continue to increase in United States. Using Kelly Creek watershed in Dale County, Alabama, biophysical and bio-economic models in APEX and GAMS are used to estimate the change of traditional agricultural use of the land to the cultivation of bio-energy crops. The modeling is done using 32 year soil and weather data from 1979 to 2010, under the different ENSO phases to determine the best cropping mix to adopt. The study shows that it is possible to optimize the farmers' profits using the ideal cropping mix while the agricultural nonpoint source pollutants are greatly reduced or kept minimal.

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BACKGROUND

1. Introduction

The subject of economics deals with the management of scarce resources, and natural resource economics is an interdisciplinary field of economics that deals with the management of the earth's natural resources. One of the main objectives of this specialized field of economics is to create a better understanding of natural resources in order to develop sustainable ways of managing them to ensure their availability to future generations. To do this, natural resource economics brings together different broad areas in human economics, earth science, and natural ecosystems. The traditional areas of natural resource economics, which emphasized fisheries models, forestry models, mineral extraction models, and welfare theory, have been extended to include other notable resources like air, water, the global climate, environmental economics, pollution control, resource extraction and exhaustibility and non-market valuation.

In examining the value of nature, Daily et al. (2000) explained that natural resources like forests and fisheries, and environmental systems like the air and watersheds are great assets that produce flows of valuable services that are not really appreciated until they are lost. Complex natural resources have been identified to produce four direct services to people. They include: 1) the supply of material inputs such as fossil fuels, wood products, minerals, water, and fish; 2) provision of life support services like breathable atmosphere and livable climates; 3) provision of amenities that include recreation, wildlife watching, scenic views, and 4) other passive services, and naturally dispersing, transforming, and storing waste products of economic activities

(Freeman 1994; Daily et al., 2000). The services provided by natural resources are valued through various non-market valuation methods. These values respond to market forces, but the right mix of these resources have to be employed in order to optimize the value that they provide.

Bhattarai (2006) reports that studies in natural resource economics employ several models in an attempt to understand and manage natural resources ranging from simple linear regression models, to very complex models that require skills in statistics, Geographic Information Systems, and computer programming. These models help understand the best ways to achieve optimal outputs from natural resources and to ensure that they are not destroyed to stop the flow of services they provide to the current and future generations.

There are many potential uses for water could which are associated with different values and tradeoffs. These uses include drinking and other domestic uses; industrial uses, power generation, agricultural irrigation, and recreational uses like boating, fishing, and swimming. Land resources are similarly affected by competing uses, particularly as expanding human population and related activities like housing; waste disposal and agricultural activities which all result in increasing chemical, microbial, and sediment loads, that affect bodies of surface water. These activities have consequences such as lost habitat (to plants and animals that live in water), depleted fisheries, and degraded water quality for drinking and other uses.

Recreational use of water is considered non-consumptive and is often tied to lakes and reservoirs used for whitewater boating, swimming, water skiing, and fishing. The State of Alabama is rich in water resources, which are currently being harnessed for profits by the private individuals from organized recreational fishing purposes and by the government for recreational purposes, particularly in regards to tourism.

Agricultural land is a second natural resource important to Alabama. The current uses of agricultural land are aimed at maximizing profits, but many cultural practices result in nonpoint source pollution of water resources. The Energy Information Administration, EIA, (2009) projects that the use of bio-fuels will increase, while the use of fossil fuel will flatten out beyond 2010. Given this projection, it is expected that prices of most bio-fuel crops will increase as the need for ethanol and bio-diesel increases. Agricultural land could be used to produce more bio-fuel crops, such as sugarcane, switch-grass and soybeans, which require little or no fertilizer, and produce minimal nonpoint source pollutants.

Therefore, an understanding of the value of water and land resources to different users, the methods of evaluating their economics, and the social tradeoffs associated with allocating water and land resources among their competing uses would be vital in devising appropriate and effective policies in using them. This study focuses on the natural resource in Alabama and especially the Alabama Black-Belt; I focus on use of water as a recreational resource and land as an input to agricultural production, specifically its use to meet a national objective in bio-energy production while simultaneously improving water quality by reducing nonpoint source pollution.

2. Dissertation Outline

This dissertation is made up of three stand-alone essays. Each essay focuses on specific objectives that are analyzed using different assumptions and modeling techniques. The first two essays involve the recreational use of water, using the primary data collected through a direct mail survey. The third essay involves the optimization of agricultural land. These three essays demonstrate the use of different models in areas of natural resource and environmental economics.

The first essay estimates the demand for recreational fishing in Alabama using a Travel Cost Model (TCM). This is part of a larger effort to assess the total economic benefits of recreational fishing to individual anglers, fishing site managers and private owners; and the regions where the fishing sites are located. Data for this essay are obtained from responses by 708 anglers to a direct mail survey. This survey also contains elements of contingent valuation by allowing anglers to choose elements of an 'ideal' hypothetical site by asking what the anglers would be willing to pay for such a site. Using the survey data, welfare analysis is done to derive the consumer surplus and total willingness to pay for recreational fishing in Alabama. The results from this essay could help owners of recreational fishing sites and the government officials that manage recreational fishing sites to improve the qualities of the sites, thereby increasing consumer surplus and total willingness to pay. The essay also estimates the elasticities of the variables that affect the demand for recreational fishing trips. The results from this essay could provide guidance to owners and operators of recreational fishing operations to increase return on investment.

In the second essay, the anglers' direct mail survey data are used with IMPLAN (Impact Analysis for Planning), input-output system, to estimate the economic impact of recreational fishing in Alabama and the Alabama Black-Belt. Separate economic impacts are analyzed for the Black-Belt and the State; and direct, indirect, and induced economic impacts are estimated for government revenues, income, and employment. Possible increases in these impacts are also estimated if the recreational fishing sites were improved, using the 'ideal' hypothetical site characteristics. It is hoped that the results of this analysis would encourage the development of recreational water resources in the Black-Belt, a region of the State that is economically depressed, but rich in water resources. It is also expected that the results would positively influence public and private recreational fishing management decisions.

The third essay estimates the environmental and economic impacts of land-use change in a three stage bio-economic model. Using soil and climate data in a biophysical model of the Kelly Creek watershed in Dale County, Alabama, impacts of changing from traditional crops in the watershed to a scenario in which only bio-energy crops are produced. The traditional crops are replaced with switch-grass, corn, soybeans, and cotton; these are the closest to energy crops suitable for the climate of the Kelly Creek in Dale County. The yields, profits, nutrients in sediments, and run-offs are examined for these crops. The weather data for this essay cover a 32 year period during which annual and inter-annual climate changes are possible. The Climate Impacts Group (2009) explains that El Nino Southern Oscillation (ENSO) is the major source of climate variation in the Pacific Northwest. The warm phase of the variation is referred to as the El Nino while the cold phase of the variation is referred to as the La Nina phase. The same bio-physical modeling is done under these ENSO phases to determine optimal cropping under these different weather scenarios when climate variation occurs. It is assumed that farmers may not be willing to adopt the energy crops even when they produce less sediments and runoffs than the traditional crops if their profits are negatively impacted the third stage of the modeling then assumes a social planners' position. By using an optimization model, the social planner maximizes potential profits, while constraining the pollution level to the minimum levels of nitrogen, phosphorus, and sediments (nonpoint source pollutant) associated with each of the crops. The minimum pollution level refers to the crop that generates the lowest quantity of nitrogen, phosphorus and sediments as nonpoint source pollutants when planted on the soil. The land in the watershed is then allocated to the crops that will maximize the farmers profit with minimum levels of nonpoint source pollution in the form of runoff to the surface water bodies in the region; thereby increasing water quality for domestic and recreational uses. The model developed in this essay, although specific to one watershed, may be extrapolated to applications throughout Alabama and to areas in the southern seaboard region with similar weather and physical characteristics.

Using different models in the field of natural resource economics, these essays show the benefits of water and land resource uses to individuals as well as to the regions where the resources are located. It also demonstrates how natural resources can be harnessed for the economic benefits of a local economy by creating additional jobs and increasing tax revenues. This study also demonstrates how some attributes of natural resources could be improved to increase willingness to pay (WTP) for their use. The increased WTP is an indication of possible increase in profits to managers of such resources. In an economically depressed region like the Alabama Black-Belt, where there are few options for economic development, locally available natural resources could be employed to attract new income, create more jobs, and lead to increased tax revenues that could be used to improve the quality of life for residents in the region. The essays also demonstrate possibilities for using natural resources in a way that will complement one another without compromising gains from their uses.

I. ESTIMATING DEMAND FOR RECREATIONAL FISHING IN ALABAMA

1.1 Introduction

Individuals and households pay to enjoy natural resources that the environment can provide. Recreational fishing is provided by water, a natural resource; it is modern and involves fishing for pleasure. It has conventions, rules, licensing restrictions and laws that limit the way in which fish may be caught to ensure sustainable practices amongst anglers. The state of Alabama and the Black-Belt has tremendous recreational fishing resources. The public waterways of the state cover more than one million surface acres with additional 150,000 acres of private bodies of water. The state's Division of Wildlife and Freshwater Fisheries manages 23 lakes, 77 miles of perennial rivers, streams and deltas, the Department of Conservation and Natural Resources manages 38 lakes, and the State Park Division has four large reservoirs and 14 lakes (Outdoor Alabama 2007). The state also supports 11 million angler fishing days with resident anglers estimated to be about 628,000 in 2008 (Outdoor Alabama 2008). The quality of the state's water resources could be improved by the government and/or private parties in order to enhance their recreational values. For this intervention to be considered, current demand for recreational fishing and the potential for increasing demand needs to be estimated.

Alabama's Black-Belt region is one of the most economically depressed regions in the United States. It is characterized by persistent poverty, high unemployment, low incomes, low education, poor health, high infant mortality, and high adult dependence on welfare and/or on their parents (Wimberley et al 1997; Baharanyi et al. 1993).

Economic development solutions for Alabama's Black-Belt counties have been elusive, and natural fisheries and private sport fishing opportunities have the potential to represent an important natural and economic asset in the region. In the existing reservoirs and other public fishing venues, such as county lakes, in the region, current fish populations can be enhanced via aquacultural management practices and sites can be improved via infrastructural improvements in order to attract more recreational fishing activities. Also, plans to improve US Rt. 80 between Cuba and Montgomery, and I-85 through the Western Black-Belt, from Montgomery, Alabama to the east of Mississippi state line, would open the region to further development. Better access to the area's natural resource base will increase opportunities to develop tourism and recreational outlets in this socially depressed area. As a result, the infrastructure for sport fishing that already exists in the regions' many ponds, lakes, reservoirs and rivers represents prospects for developing the Black-Belt as a recreation destination in the state.

A number of statistics regarding the value of recreational fishing exist at the state and national levels. These statistics are fairly confounded, as specific destinations are not represented, and reported expenditures represent only a fraction of economic value from a societal viewpoint. Thus, this paper covers a full economic analysis using a recreation demand model, particularly the Travel Cost Model (TCM). This model has long been in use by environmental and resource economists to measure not just the expenditures associated with fishing trips, but to estimate demand curves for fishing. By estimating demand, economists can incorporate opportunity costs as well as estimate consumer surplus associated with fishing activities.

1.2 Literature Review

Curtis (2002) uses a count data travel cost model to estimate the demand and economic value of salmon angling in Donegal County, Ireland. Using the truncated negative binomial model and allowing for endogenous stratification, he finds that angling quality, age, and nationality affect recreational fishing demand. For this study, the estimate of consumer surplus per angler per day was 138 Irish pounds (175.22 Euro) on the average. Using 2009 rate, this is approximately $262.83 United States dollars.

Tay and McCarthy (1994) investigate fresh water anglers' responses to improved water quality. Using a multinomial logit model of destination choice, 1985 data on Indiana anglers, and multiple-sites, the model computes the benefits of alternative water quality improvements. Their results indicate that anglers are sensitive to changes in water quality and anglers' per-trip welfare gains from a 1% reduction in various pollutants range from 4.9 to 25.3 cents and a similar reduction in all pollutants increases per-trip welfare by 64.5 cents. These values are higher in 2009 dollars on adjustment.

Bannear et al. (2004) use revealed preferences to infer the environmental benefits evidenced from recreational fishing. The study uses panel data on prices of state fishing licenses in the continental United States over a fifteen year period, combined with substitute prices and demographic variables. A license demand function is estimated with an instrumental variable procedure to allow for endogeniety of administered prices. The study reveals that there is variation in the value of recreational fishing across United States and the use of benefits estimates may result in substantial bias in regional analysis.

Ditton et al. 2002, emphasize that sport fishing is a recreation activity for residents in each state, and it is also a form of tourist activity that makes anglers cross to other states. Using data from 1996 National Survey of Fishing, Hunting, and Wildlife associated recreation; they reported that the states are promoting tourism, which includes recreational fishing, in the name of economic development. The study reveals several stakeholders' diverse perspectives with respect to fishing as a tourism issue. The study concluded that fishing site managers need to acquire greater awareness of fishing tourism and develop effective partnerships with state and local tourism promotion organizations.

Lupi et al. (1997) estimate the demand for recreational angling in Michigan using the travel-cost model. Using a four level nested logit on one season of angler data, they show that the travel cost method establishes a relationship between the recreational use and the cost and characteristics of the sites, but the method is only as good as the statistical link between the site quality characteristics and the travel cost method demand for trips to the site.

Feather and Shaw (1999) propose a method of estimating the cost of leisure time for recreation demand models. They explain that the decision to participate in recreational activity is affected by constraints on time and money. In their estimation of a shadow wage, the natural log of annual income was regressed on some demographic characteristics of respondents in their survey and the shadow wage equation parameters are used to predict the opportunity cost of time as the shadow wage.

Randall (1994) emphasizes the potential differences between observed travel cost and the actual unobserved cost which is subjective. He explains that the measurable travel costs are ordinal indicators of the actual travel cost. He suggests that Travel Cost Models only produce ordinal measures of recreators' welfare.

Bowker et al. (1996) use count data to examine the consumer surplus associated with guided whitewater rafting in two southern rivers for every trip. The study employs a truncated count travel cost regression model that is based on individual travel cost and alternative price specification data. By varying the assumptions of the opportunity cost of time and river quality, their findings show average consumer surplus that range between $89 and $286.

O'Neill and Davis (1991) estimate an angling demand function in Northern Ireland using an Ordinary Least Square (OLS) estimator. The OLS estimator infers an own price elasticity of 0.7 and consumer benefits of 9.1 million pounds. The estimate of the own price elasticity was positive, which is an indication that the OLS may result in a biased estimate when used with count data.

Nicolau (2008), in characterizing tourist sensitivity to distance traveled observes the real choices made by 2,127 tourists. Using regression analysis, the study finds that the important factors that affect individual sensitivity are income, number of children in the household, size of the city of residence, transport mode, interests in discovering new places, variety seeking behavior, and motivations. The study concludes that sensitivity to distance follows a random coefficient logit model and the effect of distance on destination choice could be positive or negative.

Frederick and Vernon (1990) analyze the demand for beach resources by tourists that come from long distances. By collecting on-site survey data, they use travel cost model to estimate the demand curve of tourists to Florida State beaches. The study finds daily consumer surplus of $34.00 for the long distance tourists.

Fix et al. (2000) examine the possible over-estimation of consumer surplus from endogenously chosen travel cost. They apply a Travel Cost Model to mountain biking at Moab in Utah using data of endogenously chosen travel cost by the bikers. They also provide empirical test of the presence of endogeniety and estimate possible error if endogeniety is ignored in travel costs. Their results show that consumer surplus is overstated by 12% if endogeniety is ignored.

Englin and Shonkwiler estimate social welfare as applied to long-run recreation demand under the conditions of endogenous stratification and truncation. Using data from hikers in the Cascade Mountains of Washington, the negative binomial model is used to estimate recreational demand. This approach gives the estimated latent demand associated with the population sample and the consumer surplus associated with the trips. The model corrects for endogenous stratification that is associated with the data and provides an estimate of the population willingness to pay for hiking in the Cascade Mountain Range.

This paper estimates the demand for recreational fishing in Alabama using a negative binomial econometric model. Count data obtained from a direct mail survey of individuals who held Alabama fishing licenses between 2006 and 2007 are used to estimate the model. Burt and Brewer (1971) report that direct interviews are about the most accurate way to obtain data necessary for the estimation of demand equations. This study is however constrained by financial and time resources and thus a direct mail survey to holders of Alabama fishing licenses was use for data colletion.

Recreational demand is special because the consumer is transported to the recreation site and the cost incurred on transportation is part of the surrogate price of recreational services. It is expected that the results of the analysis of this data will be useful to fishery managers in identifying the factors that drive recreational fishing in the state. The welfare estimates obtained from this study could also reveal the value to anglers of the trips to their fishing sites by providing the approximate values of their willingness to pay.

1.3 Methodology

1.31 *Area of Study*

The study area includes fresh water bodies in the state of Alabama and the survey was conducted for anglers that have visited Alabama fresh water for recreational purposes. This is because the state has tremendous recreational fishing resources and supports recreational activities with about $0.75 billion annually (Outdoor Alabama, 2007). The public waters of the state covers more than one million surface acres with an additional 150,000 acres of private bodies of water. Public waterways include 23 public lakes in 20 counties and an estimated 50,000 ponds across the state. These water bodies are stocked with largemouth bass, spotted bass, striped bass, bluegill (bream), red-ear sunfish (shell cracker), channel fish, white crappie, black crappie, and catfish. Recreational fishing takes place all year round in the state, with more anglers fishing in the Spring and Summer periods. The Division of Wildlife and Freshwater Fisheries manages 23 lakes, 77 miles of perennial rivers, streams and delta in Mobile, the Department of Conservation and Natural Resources manages 38 lakes, and the State Park Division has four large reservoirs and 14 lakes (Outdoor Alabama, 2007).

1.4 Data

The sample frame consists of names and addresses of 6,250 randomly selected from 80,000 anglers licenses sold in Alabama during the 2006/7 fishing season. The data needed to assess economic activity are collected by direct mail surveys sent to the randomly selected 6,250 sample of anglers licensed to fish in Alabama. A pilot test of the survey was conducted in late September of 2006 in the Auburn and Tuskegee area to anglers without concern as to whether they had fishing licenses or not, to verify the survey contents. The final surveys were then mailed between November 28th and December 13th of 2006. The survey response was plagued by a large number of undeliverable addresses, resulting in 347 usable responses and 858 undeliverable surveys by January 18th of 2007. Reminders were then sent to the remaining 5,145 respondents by the first week in February 2007. This generated additional 104 usable surveys by March 6th of 2007 and another 641 undeliverable surveys. In March of 2007, a total of 4400 surveys and reminder notes were sent to the respondents generating 257 additional usable responses and 1,033 undeliverable addresses. Overall, 708 respondents from the randomly selected sample responded. With 2,632 bad addresses, the total sample size is reduced to 3,618 anglers (respondents). This results in an effective response rate of 19.5 percent.

The survey was used to collect data on individual angler characteristics, expenditures on fishing equipment, and destinations and expenditures on time and travel for each trip taken. In addition, the kinds and quantities of fish that anglers sought on each trip were also obtained (see appendix 2). The data thus collected are used to generate a demand curve for fishing statewide. A one year period is used in order to avoid memory loss and double counting by the respondents on questions related to frequency to fishing sites within the year.

Haab et al. (2002) explain that sample selection problems could arise from the systematic effects of excluding some of the population from the sampling list. Greene (1997) shows that the econometric issues that arise from sample selection stems from the biases that are possible when estimates from non-randomly sampled population are used to make inferences about the entire population. Bockstael et al. (1990) in estimating recreation demand of sport fishing explain that sample selection problems arises and makes it difficult to estimate the recreational demand when a large portion of those sampled are non-participants in the recreation activity. The sample selection problems are thus avoided in this study by restricting the study population to include all anglers that have fishing licenses, and as such, they are likely to all be participants in recreational fishing in at least one of the Alabama water bodies.

1.5 Theoretical and Econometric Models of Estimation

1.51 Travel Cost Method (TCM)

For this study, the TCM is used to estimate economic values associated with recreational sites in Alabama. It estimates demand based on anglers' fishing decisions and their willingness to pay for fishing and reveals how much an individual is willing to pay for access to the outdoor recreational site. It involves detailed analysis of the number of times the anglers fish during the period, where they fish and the cost of getting to the sites using variables that explain their choice of sites and some demographic characteristics. The basic assumption of the TCM is that the number of trips varies with the distance traveled by the angler, that is, it assumes that as the distance to the site increases, the out of pocket cost to the site increases as well. The survey for this study shows that visitors come to Alabama fishing sites from all over the United States and this provides great variations in travel time, travel distance and out of pocket costs. Survey data are used for this study which allows the TCM to incorporate the actual behavior of the anglers when estimating the benefits and the results of the estimates from this study will not be based on hypothetical situations.

The following steps are then taken in order to use the TCM: 1) data are collected over the 2006/2007 period, which is one fishing season for this study, 2) regression method is used to estimate an equation that predicts anglers latent demand for fishing based on travel costs, site characteristics, income, and others demographics 3) the predicted dependent variable is then expressed as an exponential function of the explanatory variables in several negative binomial models 4) The net economic benefits (consumer surplus) are then estimated in each of the equations in step 3. 5) The willingness to pay is also estimated by including information on how much more the respondents will pay to visit hypothetic sport fishing sites that are yet to be in existence.

The fishing sites of Alabama are assumed to be the same and as such, a single site model is used in this paper. This because the demand being estimated is the demand for recreational fishing in Alabama as a whole. This is done by observing through survey response the purchases of travel which were made to gain access to the fishing sites. The relationships between the travel costs and access to these sites vary for different individuals because they face different implicit prices and it is expected that the travel and time cost will increase with distance. This information is reported by the anglers in the survey and the number of visits to fishing sites at different travel costs "prices" vary for each respondent. This is then used to construct the demand equation for fishing sites as shown in equation 1. The theoretical TCM model takes the form:

$$Q_d = f(t_c, y, z, x, \beta) + \varepsilon_i \qquad (1)$$

Where Q_d is the number of fishing trips which is also the quantity demanded. The price of recreation, t_c, is also the trip cost which includes all transit expenses (travel cost, access fees, equipment cost and time cost) and is expected to have a negative relationship with the quantity demanded. The price paid to fish varies as far as the traveling distances to the sites and also varies for different angler. The variable, y, is the income of the angler and is expected to have positive relationship with the quantity demanded of recreational fishing. The variable z is a vector of several demographic variables that could affect the demand for recreational fishing, such as age, gender, experience in fishing, activities at the site, education, occupation, fishing boat ownership, distance to fishing sites etc. The variable x, is a vector of the site characteristics. β is a vector of unknown parameters, and ε is the random error of the model, which is implicit the travel cost model.

1.52 Econometric Model

The recreation demand is a function of factors like price paid by the angler (travel cost and time cost), site distance, angler's characteristics (demographics), and site characteristics. This specification in equation 1 is similar to the one specified by Lupi et al. (1997), in estimating demand for recreational fishing and showed the relationship between travel cost and the characteristics of fishing sites. Parsons (2003) shows that recreation demand depends on travel cost, demographics, site characteristics and proximities of sites to other substitute sites. However, for the purpose of this study, the sites in the state are assumed to have similar characteristics and the distance and travel cost to the sites is the differentiating factor.

The sample selection for this study is a convenience sampling which targets actively fishing anglers. In contrast, on-site samples involve anglers that are actively fishing, which presents two problems that are relevant to sampling anglers with fishing licenses. The first is that the anglers have current fishing license and are assumed to be actively fishing to have incurred the cost of a fishing license and will embark on a minimum of one fishing trip for the season. This implies that the trip demand as observed is non negative and truncated at positive trips, since license holders will have positive trips. Thus, the sample choice for this study is truncated at 1, because the survey sample for this study is targeted at anglers with fishing license who go on fishing trips at least once during the fishing season.

The second problem is that of endogenous stratification, which occurs when the systematic variation in sampling is dependent on the characteristics of individuals in the sample. This problem is common to on-site sampling, where the probability of being sampled is higher for frequent site users or the period when the sampling is done (Haab and McConnell, 2002). Although endogenous stratification is associated with on-site sampling, there may be some similarities between endogenous stratification and sample selection problem caused by target sampling from the use of a sample of fishing licenses holders as used in this study. These similarities are as follows: 1) the likelihood of being included in the sample is that the angler purchases an Alabama fresh water fishing license, 2) the possibilities that those who purchase Alabama fishing license and fish

Alabama fresh water bodies could have similar characteristics that attract them to fish in Alabama, and 3) those who responded to the mail survey could possess certain similar characteristics, such as being highly educated. The ownership of Alabama fishing license infers that all the respondents to the survey are anglers that participate in fishing in at least one of the state of Alabama water bodies. These may cause a systematic variation in the sampling proportion to be dependent on the characteristics of the anglers in the survey sample, because the sample size of this study is of those with fishing license. In this study, Alabama water bodies are modeled as a single site, Nicolau (2008); Sirakaya et al. (1996); and Kim and Lee (2002) show in different studies that the motivation of individuals and the characteristics of the recreation destinations are factors that push or pull recreators to recreation sites. The model choice for this study deals with these two important problems of truncation and sample selection problems, that could arise given the similarities to on-site sampling.

The dependent variable is an individual recreational behavior where each respondent in the survey reports a discrete number of fishing trips of at least one or greater since they all have fishing license. In the specification of the model in equation 1, the model's dependent variable is thus an integer value that is a count variable (data) since the number of trips varies from 1 to infinity and exhibits a form of dispersion. The count data travel cost model is widely used in the estimation of recreation demand. Loomis et al. (2000) use it to estimate the demand for whale watching, while Shaw and Jakus (1996) estimate the demand for rock climbing using travel cost model.

Count data models are often estimated using the Poisson regression, in which the mean and variance are assumed to be equal. Booth et al. (2003) explain that the Poisson model suffers from lack of flexibility in modeling variances. The resulting over-dispersion from it results in biased estimates of the other parameters and leads to difficulties in interpreting the results. In addition, over-dispersion in the count data results in deflated standard errors of the parameters in the Poisson model, resulting in inflated t-statistics.

Greene (1997) suggests different tests of over-dispersion. The dispersion parameter in the negative binomial method of analyzing count data is one of the ways to determine and correct for over-dispersion. Whenever the dispersion parameter in the negative binomial estimation is statistically different from zero, the implication is that the mean and variance are not equal and that over-dispersion is present. When the dispersion assumption is violated, the negative binomial model is used. The negative binomial model addresses the issue of over-dispersion by including a dispersion parameter in the model to accommodate the unobserved heterogeneity in the count data.

Equation 1 is estimated using a Poisson model where the expected number of trips is stated as the exponential function of the dependent variables, stated as

$$E(Qi | t_c, x, y, z) = \lambda_i = \exp(t_c, x, y, z, \beta) \tag{2}$$

Lamda (λ_i), the expected number of trips, is both the mean and the variance of the count model. The value of the dispersion parameter makes the negative binomial is a more appropriate model to estimate the data for this study. The negative binomial leads to a meaningful parameter estimates and inferences because it eliminates over-dispersion in the dependent variable. Gourieroux et al. (1984) explains that the negative binomial model provides a consistent estimator even when the dependent variable exhibits over dispersion, which is a form of heteroscedasticity.

The negative binomial model is stated as

$$\ln Q = f(t_c, x, y, z, \beta) + \varepsilon_i \qquad (3)$$

Where epsilon (ε_i) is the unobserved heterogeneity, it is same as the implicit error term expressed in equation 1, and has an expected value of 1if normally distributed. The density of epsilon, ε_i, is given as

$$(\varepsilon_i) = \frac{\alpha^{\alpha}}{r(\alpha)} \exp(-\alpha\varepsilon)\varepsilon^{\partial-1} \qquad (4)$$

Where α is the dispersion parameter

Shaw (1988) also identifies non-negative integers, truncation, and endogenous stratification as problems in on-site samples. To correct for endogenous stratification using the travel cost model, it is extended to show that if Q_i, is the number of trips demanded by person i (i = 1,..N), the negative binomial log-likelihood function for trip demand is given by

$$\ln L = \sum_{i=1}^{N} [\ln q_i + \ln(\delta(qi+1/a)) - \ln(\delta(qi+1)) - \ln(\delta(1/a)) + qi\ln a + (qi-1)\ln\lambda_i - (q_i+1/a)\ln(1+a\lambda_i)] \qquad (4)$$

Where α and λ_i are parameters of the negative binomial distribution. λ_i is the expected latent demand and is defined as a function of variables that affect demand.

δ(.) is the negative binomial density function of the sample size, which is

$$\delta(Q_i | t_c, x, y, z) = Q_i\tau\{Q_i + 1/\alpha_i\}\, \alpha_i^{Qi}\, \lambda_i^{Qi-1}(1+\alpha_i\lambda i)^{-(Qi+1/\alpha i)} / \tau\{Q_i+1\}\, \tau\{1/\alpha_i\} \qquad (5)$$

The conditional mean and variance are respectively given as

$$E(Qi | t_c, x, y, z) = \lambda_i(1 + \alpha\lambda_i)\text{and} \qquad (6)$$

$$\mathrm{Var}(Qi | t_c, x, y, z) = \lambda_i(1 + \alpha + \alpha\lambda_i + \alpha^2\lambda_i) \qquad (7)$$

From equations 6 and 7, if the dispersion parameter, α, is not statistically different from zero, the negative binomial model is same as the Poisson, where the mean and variance are equal. If the dispersion parameter, α, is statistically greater than or less than zero, the existence of over-dispersion is confirmed. The latent demand of each respondent to the survey, λ_i, is then expressed as a semi logarithm function of all the dependent variables in equation 2.

$$\text{Ln } \lambda_i = f(t_c, x, y, z) \tag{8}$$

Ln λ_i =

$$\beta_0 + \beta_1 AV\_TRV\_COST_{1i} + \beta_2 FSH\_EXP_i + \beta_3 AV\_SITEDIST_i + \beta_4 INC + \beta_5 STATE_i + \beta_6 AGE1_i + \beta_7 EDU \tag{9a}$$

OR

$$\lambda_i = \exp(\beta_0 + \beta_1 AV\_TRV\_COST_{1i} + \beta_2 FSH\_EXP_i + \beta_3 AV\_SITEDIST_i + \beta_4 INC + \beta_5 STATE_i + \beta_6 AGE1_i + \beta_7 EDU) \tag{9b}$$

where

AV_TRV_COST = Average Travel Cost to fishing site in dollars

FSH_EXP = Fishing Experience in years

AV_SITEDIST = Average Site Distance in miles

STATE = Anglers Resident State (Dummy)

INC = Income of the Angler($)

AGE = Age of Respondent in years

EDU = Level of Education (also separated into 3 classes using dummy)

ε = Error Term (unobserved individual differences /heterogeneity)

Equations 9a or 9b represent a typical travel cost model, where the actual behavior of the respondents is used to estimate their welfare. The equations do not include any of the characteristics of the hypothetical site and results from the estimation are not based on any hypothetic scenario, but observed behavior of the respondents.

1.6 Variables

The dependent variable is the number of fishing trips that the angler undertakes annually the number of days fished during the 2006/2007 fishing season. This is taken as reported by the angler and in order to avoid trip recall problem, anglers were asked to report the past seasons' fishing trips and also to report the number of trips for every month in the season. Where the reported trips for the season differ from those summed up by the months, an average (from question 2 and 6 of the questionnaire) is taken as the angler's fishing trip for the season. It is assumed that this will lessen any error that could be caused by the angler's recall of past trips.

The explanatory variables include travel costs to the fishing site. This is a sum of all the costs that the angler incurs in making the trip which includes the cost of gasoline, access fees, food cost, equipment cost, camping or lodging cost etc, and time cost. To use this variable, all the costs reported by the anglers on the survey are summed. To determine the monetary value of time for this study, it is assumed that every worker works 8 hours daily, 40 hours weekly, and 50 weeks yearly, totaling 2,000 hours for the year. Each angler's reported annual income is then divided by 2,000 hours to obtain individual hourly wage. It is also assumed that the angler cannot work and go on a fishing trip on the same day, so the angler-reported number of fishing days is multiplied by 8 hours and then multiplied by the hourly wage to finally obtain each angler's monetary value of time. In several studies, the time cost ranges from 25 percent to about 60 percent of annual wages. Cesario (1976) reports that the value of time should range between one-fourth and half of the anglers' reported wage rate. McConnell and Strand (1981) estimate time value to be worth 61 percent of the angler's reported income. However, the methods of estimation in this study show the angler's time value to be about one third of their reported annual income.

The income variable could be perceived as an individual budget restriction which sets the spending capacity or the anglers' propensity to consume recreational fishing. Income has been shown to be an important demographic variable that explains the behavior of tourists. Individuals that belong to different income groups and categories have been found to participate in tourism and recreation activities (Mergoupis and Steuer 2003; Hay and McConnell 1979. For this study, income is reported by the respondents in different ranges from those under $10,000 annually to those earning over $100, 000 annually (appendix 2). The estimated income used here is the midpoint of the income range reported by each respondent.

Fishing experience refers to the number of years that the angler has been fishing. This is taken as reported by anglers on the survey in number of years. It is expected that the longer the angler has been fishing, the less responsive they will be to the travel cost, and will be more responsive to the site quality characteristics. The average catch per trip refers to the number of fish caught by the angler on a fishing trip. It is expected that this will have a positive relationship with the demand for fishing days since the primary aim of the angler is to catch fishes.

The average site distance refers to the average distance the angler travels to get to his or her most visited fishing site in Alabama. To get this variable, the anglers are asked to list the two sites they frequent the most and the distances to these sites, an average of the distance is then taken as the anglers average site distance. The state variable represents the state the anglers come from and it is denoted by a dummy. Zero is for in-state anglers and one is for out of state anglers.

Age is an important demographic variable that influences recreation demand. For the age variable, ten age groups were created, from 16 to 65 and above, in the survey and the anglers checked the group that they belonged. The midpoint of each of the groups is then used in determining the age of the respondents and the actual age used where the respondent reports it. Age is also used in the analysis to determine how age affects the number of fishing days demanded. The broad group is divided into 3 groups using dummies, group 1 is from 16 to 35 yrs, group 2 is from 36 to 50 yrs, and group 3 is above age 50. These groups are important because the predisposition of individuals to participate in any recreation activity could be critical when age difference is as much as 10 or 20 years.

The education variable is also created using dummies. The three dummy classifications are respondents who 1) have less than 9th grade to high school diplomas, 2) those with associate degrees and those with some college, but did not complete college, and 3) those with bachelors, graduate or professional degrees. The classification that the respondent chooses is one while zero represents the class(es) not chosen. Income and education variables are positively correlated and only one of these variables will be used in the model in order to avoid the problem of multicollinearity.

1.7 Hypothetic Ideal Site Characteristics (Variables)

A hypothetical ideal fishing site that would enhance fishing experience is created in the survey and the anglers are asked under eight different price scenarios how much they would pay to visit such a site. The prices the anglers were asked to pay to visit the ideal fishing site range from $2.50 to $30.00 that are indicated in different questionnaires randomly mailed to the respondents. It is assumed that the anglers are equidistance to the hypothetical site and that the proposed improvement will be to the sites they normally visit. The hypothetical site characteristics are all assumed to be desirable and are all expected to have positive relationship with the demand for recreation trips.

The response to this provides a scenario for comparison with changes in demand to be expected from enhanced fishing experiences. The responses are also used to assess the changes in consumer welfare if the fishing sites are improved. The ideal site characteristics and the prices the anglers report that they would be willing to pay to access the site is then included in the negative binomial model to estimate the changes in the prices, consumer surplus, and total willingness to pay (WTP). This enables comparison of the welfare measures from the revealed and stated preferences of the anglers.

The site characteristics are grouped into four and include natural features (NF), convenient features (CF), man-made or physical features (PF), and recreation features (RF). The natural features include variety of fish, size of fish, number of fish (stock), peace and quiet, shade/shelter near water body, and scenery at the site. The respondents were asked to rank these characteristics from one through six, with one being the most important. The convenience features of the ideal site includes, close to home, close to restaurants, close to shopping area, good restroom facilities, good parking area, and tourist activities. These are also ranked from one to six with one being the most important. The physical characteristics include picnic features, camping facilities, lodging facilities, boating facilities, marine facilities, and vending facilities (bait and drinks). The anglers ranked these features from one to six as the previous. The recreation facilities refer to facilities that allow the anglers participate in other fun activities apart from fishing. These include swimming, wildlife watching, shopping and antiquing, meditating, and relaxing. These are also ranked from one to six with one being the most important to the angler.

The means and standard deviations of the variables used in this dissertation is presented in table 1.1 below. The distribution of the count data for this dissertation shows that the variance of the mean fishing days is greater than the mean, the data shows mean fishing days of 33.09days per year with a standard deviation of 40.47 days. This finding is supported by Haab and McConnell, 2002, who reported that, for recreational trip data, the variance is always greater than the mean, which verifies the over dispersion of the count data. The mean fishing days and the variance from this data is one of the justifications for the use of the negative binomial which does not assume that the conditional mean and variance are equal.

Table 1.1: Descriptive Statistics of Variables

Variable	Label	Mean	Std Dev
Number of Fishing Trips	**AN_FSH_TRP**	33.08616	40.4736411
Fishing Experience in Years	**FSH_EXP**	33.03602	14.2853488
Average Catch Per Trip	**AV_CATCH**	11.75141	17.9912067
State	**STCode**	0.200565	0.4007062
Willing to Pay for Site Question	**WTP_ASK**	14.60805	9.5271876
Amount willing to Pay for Site Improvement	**PRICE_WTP**	7.91702	8.0454365
Annual Amount willing to Pay for Site Improvement	**AN_PRICE_WTP**	245.3316	497.641317
Average Site Distance	**AV_SITE_DIST**	81.2589	99.5076976
Average Trip Cost	**AV_TRV_COST1**	216.3467	477.496164
Average Trip Cost + Amount willing to Pay	**AV_TRV_COST2 WTP**	277.6782	491.148392
AGE	**AGE1**	45.43644	13.8681475
AGE (16 - 35)	**AGE_D1**	0.266949	0.4426783
AGE (36-50)	**AGE_D2**	0.331921	0.4712357
AGE (over 50)	**AGE_D3**	0.40113	0.4904737
High School Diploma or Less	**EDU_D1**	0.413842	0.492869
Assoc. Degree But Less Than College	**EDU_D2**	0.368644	0.4827782
BSc. Degree and Above	**EDU_D3**	0.217514	0.4128468
Income	**INC**	57806.5	28821.66
Hypothetic Site Characteristics			
Fish Size (NF1)	**NF1**	0.275424	0.447043
Fish Number(NF2)	**NF2**	0.225989	0.418527
Shade (NF3)	**NF3**	0.504237	0.500336
Peace (NF4)	**NF4**	0.323446	0.468122
Scenery (NF5)	**NF5**	0.30226	0.459562
Fish Variety (NF6)	**NF6**	0.45904	0.498672
Near Home (CF1)	**CF1**	0.148305	0.355653
Near Shopping (CF2)	**CF2**	0.686441	0.464268
Near Restaurant (CF3)	**CF3**	0.577684	0.494278
Restroom Facility (CF4)	**CF4**	0.340396	0.474177
Parking (CF5)	**CF5**	0.152542	0.3598
Tourist Activities (CF6)	**CF6**	0.685028	0.464833
Picnic Facilities (PF1)	**PF1**	0.419492	0.493825
Camping Facilities (PF2)	**PF2**	0.430791	0.495537
Lodging Facilities (PF3)	**PF3**	0.473164	0.499632
Boat Launch Facilities (PF4)	**PF4**	0.142655	0.349968
Marina (PF5)	**PF5**	0.330509	0.470729
Vending Facilities (PF6)	**PF6**	0.543785	0.498431
Swimming (RF1)	**RF1**	0.440678	0.496819
Boating (RF2)	**RF2**	0.230226	0.421275
Antiquing (RF3)	**RF3**	0.694915	0.460769
Relaxing (RF4)	**RF4**	0.620057	0.485716
Meditation (RF5)	**RF5**	0.117232	0.321924
Wildlife Watching (RF6)	**RF6**	0.481638	0.500016

Just like price and quantity relationship of a rational consumer, it is expected that the demand for recreation will decrease with increasing travel cost per trip. The relationship of fishing experience with demand for recreational fishing cannot be predicted since experience may be related to fishing as a profession and not as recreation activity. Average site distance is expected to have a negative relationship with demand for recreation, because distance could result in higher fishing cost from gas that needs to be put in the anglers' vehicle or from other distance related costs. Longer distance could also just discourage the angler from going to fishing sites.

The relationship between the amount anglers are willing to pay and the demand for fishing days cannot be predicted. This is because those willing to pay for site improvements could be frequent visitors who are not satisfied with the conditions of the sites which they have visited. These could also be one time visitors that are not satisfied with the site conditions and want the site improved before further visits. Thus, this variable's relationship with the number of fishing trip(s) cannot be predicted. The demand relationship with age and level of education cannot be predicted. Higher income is expected to have a negative relationship with recreation demand. This is because higher income earners may lose more income by taking time out for a recreational activity like sport fishing and may also have greater varieties in terms of recreational choices.

1.8 Welfare Measures

The benefits of the TVC model using the negative binomial specification are calculated using the estimated parameter on the average trip cost, which represents the price of recreation. The marginal effect of each coefficient on the mean or expected fishing days is given by

$$\partial E(Q_i \mid (Tc, x, y, z) \big/ \partial (tc, x, y, z)_j = (1+\alpha)\lambda_i \beta_j \tag{10}$$

It is the derivative of the expected number of trips with respect to each of the explanatory variables used in the model. The elasticity of each explanatory variable is then obtained by multiplying the value of each marginal effect with the ratio of the mean of the explanatory variable and the expected number of fishing days. The value of access is the area under the expected demand curve.

The consumer surplus, CS, is then obtained by integrating the demand function in equation 8 over the relevant price range from P_0 to P_1, the [1]choke price (the price where the number of fishing days demanded (Q) is zero), using a simple integral. This is done between the mean travel cost, P_0, and the price where the number of fishing days demanded (Q) is zero, P_1. For the negative binomial model, it is estimated as follows.

If Ln λ_i (t_c, x, y, z) =

$$\beta_0 + \beta_1 AV\_TRV\_COST_{1i} + \beta_2 FSH\_EXP_i + \beta_3 AV\_SITEDIST_i + \beta_4 STATE_i + \beta_5 AGE1_i + \beta_6 EDU + \beta_7 INC \tag{11}$$

Then the ith consumer surplus is given as

$$CS_i = \int_{p^0}^{p^1} \lambda(t_{ci}, x_i, y_i, z_i) dP_i =$$

$$\int_{p^0}^{p^1} \exp\{\beta_0 + \beta_1 AV\_TRV\_COST_{1i} + \beta_2 FSH\_EXP_i + \beta_3 AV\_SITEDIST_i + \beta_4 STATE_i + \beta_5 AGE1_i + \beta_6 EDU + \beta_7 INC\} dP_i \tag{11a}$$

[1] This is the price at which all demand is choked off. At any price below the choke, a good is demanded. At any price equal to or above the choke price, quantity demanded is zero. Typically, these prices are associated with natural resources.

$$=\exp\{\beta_0+\beta_2 FSH\_EXP_i+\beta_3 AV\_SITEDIST_i+\beta_4 STATE_i+\beta_5 AGE1_i+\beta_6 EDU+\beta_7 INC\}$$

$$\int_{p^0}^{p^1}\exp\{\beta_1 t_{ci}\}dP_i \tag{11b}$$

$$=\exp\{\beta_0+\beta_2 FSH\_EXP_i+\beta_3 AV\_SITEDIST_i+\beta_4 STATE_i+\beta_5 AGE1_i+\beta_6 EDU\}$$

$$\left[\frac{\exp\{\beta_1 AV\_TRV\_COST_i\}}{\beta_1}\right]_{p_0}^{p_1} \tag{11c}$$

$$=\exp\{\beta_0+\beta_2 FSH\_EXP_i+\beta_3 AV\_SITEDIST_i+\beta_4 STATE_i+\beta_5 AGE1_i+\beta_6 EDU\}$$

$$\left[\frac{\exp\{\beta_1 P_1\}-\exp\{\beta_1 P_0\}}{\beta_1}\right] \tag{11d}$$

$$CS_i=\left[\frac{\lambda\{P_1,x_i,y_i,z_i\}-\lambda\{P_0,x_i,y_i,z_i\}}{\beta_1}\right] \tag{11f}$$

The consumer surplus (CS) at the mean and is given as

$$\overline{CS}=\left[\frac{\hat{\lambda}\{P_1,\bar{x}_i,\bar{y}_i,\bar{z}_i\}-\hat{\lambda}\{P_0,\bar{x}_i,\bar{y}_i,\bar{z}_i\}}{\hat{\beta}_1}\right] \tag{11g}$$

For the hypothetic site characteristics, the change in consumer surplus is estimated by adding the additional price the anglers are willing to pay for the ideal site and then integrating from P_0 to $P_1^{'}$, where $P_1^{'}$ is the travel cost plus the addition price the anglers are willing to pay to access the ideal site. CS_i and CS_{hi} are consumer surplus of the observed behavior of the *i*th angler and that of their planned behavior if the hypothetic characteristics are present at the recreational fishing site.

$$CS_{hi}=\int_{p0}^{p1^{1}}\lambda_i dP=\left[\frac{\lambda\{P_1^{'},x_i,y_i,z_i\}-\lambda\{P_0,x_i,y_i,z_i\}}{\beta_1}\right] \tag{12}$$

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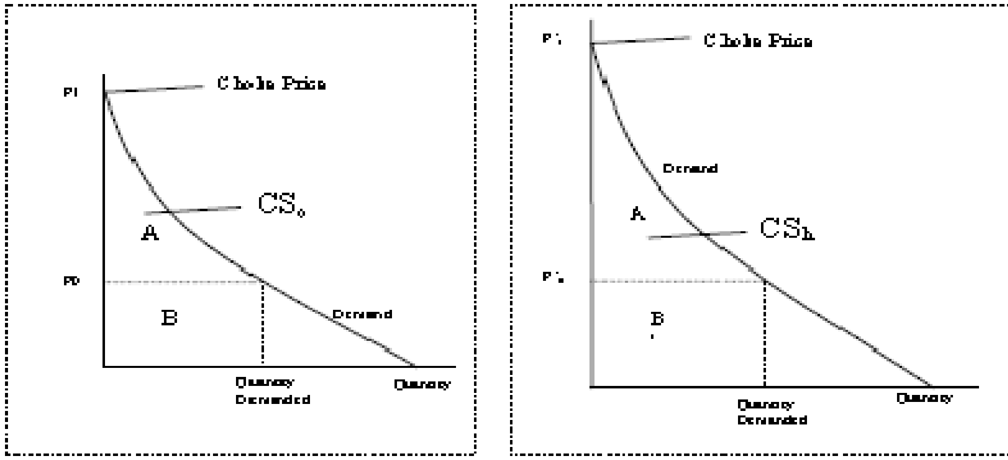

Fig. 1.1: Graphs showing Consumer Surpluses

Since the goal of this travel cost model is to estimate consumer surpluses and the compensating variations, where possible, that would stand for welfare measures, the following assumptions about the model are made in order to be certain about the welfare measures. Similar assumptions are made by Haab and McConnell (2002). The first assumption is that travel and time costs are proxies for the price of recreational trips and these costs do not provide utility on their own. Second, travel time is assumed neutral in providing utility or disutility. The third assumption is that the trips are single purpose trips taken to the recreation site for the sole purpose of recreation. Finally, the quantity of fishing days consumed relates to Alabama fishing sites, with similar characteristics, for all consumers. Fishing trips to recreation sites outside the State of Alabama as reported by some anglers in this study are not included in this study.

The two different model specifications are estimated using a negative binomial model that controls for endogenous stratification and truncation using likelihood ratio test. The specifications are as follows

Model 1:

Ln λ_i =

$$\beta_0 + \beta_1 AV\_TRV\_Cost_{1i} + \beta_2 FSH\_EXP_i + \beta_3 AV\_SiteDist_i + \beta_4 STATE_i + \beta_5 AGE_i + \beta_6 AGE_i^2 + \beta_7 EDU\_D1_i + \beta_8 EDU\_D2 \tag{13}$$

Model 2:

Ln λ_i =

$$\beta_0 + \beta_1 AV\_TRV\_COST_{1i} + \beta_2 FSH\_EXP_i + \beta_3 AV\_SITEDIST_i + \beta_4 STATE_i + \beta_5 AGE_i + \beta_6 AGE_i^2 + \beta_7 EDU\_D1_i + \beta_8 EDU\_D2 + \beta_9 HYP \tag{14}$$

Where, HPY represents the hypothetic site characteristics which are classified into four categories of hypothetic site characteristics.

Model 1 is a pure Travel Cost Model, which uses actual behaviors of the anglers to estimate the economic benefits of recreation while model 2 has elements the of Contingent Valuation Model (CVM), which uses behavioral intentions of the anglers to estimate economic benefits. The model estimated in equation 2 includes the site characteristics of the ideal hypothetical site and how much the anglers will pay for the site.

The purpose of the model estimated in equation 2 is to observe the marginal effects of these hypothetic site characteristics on the demand for recreation trips and help in managerial decisions concerning future development of the fishing sites. The 24 hypothetic site characteristics are included in the initial estimation equation. The characteristics that are statistically significant are then reported. The travel cost model in equation 2 includes the extra cost that the anglers report that they are willing to pay for the hypothetically improved site. This also shows the difference in consumer surplus from the observed behavior of the angler and possible increase or decrease in consumer surplus due to the new travel cost.

Given the change in price P^0 to P'^0 in figure 1.1 and the average travel costs in equations 13 and 14, when the anglers agree to pay for the hypothetic site, the method developed by Hausman (1981); Curtis (2002); and Englin and Shonkwiler (1995), in estimating the welfare of consumers in recreation demand, the negative binomial and Poisson models can be used in calculating the compensating variation (CV) or equivalent variation (EV) for equation 8. Given an angler's willingness to pay extra amount for the ideal hypothetical site, it is assumed that each angler is a rational consumer and would want to maximize his or her utility, u, subject to the available fixed income, y.

$$max\ u(\lambda) \text{ subject to } \sum_{i=1}^{n} p_i \lambda_i = p\lambda \leq y \qquad (15)$$

where pi is the average travel cost, y is the anglers reported income, and λ is the number of trips demanded. A dual approach to the anglers' rational behavior is to attempt to minimize the average travel cost, p, and this defines the expenditure function.

$$e(p, \bar{u}) = \min p\lambda \text{ subject to } u(\lambda) \geq \bar{u} \qquad (16)$$

The partial derivative of equation 16 with respect to price gives the compensated demand (Hicksian demand) for recreational fishing.

$$\delta e(p, \bar{u})\ )/\delta p_i = h_i\ (p, \bar{u}\ ) \qquad (17)$$

An indirect utility function solves the optimization problem facing the anglers in equation 15 and 16. The indirect utility function equates the anglers' utility maximization solution and expenditure minimization solution that each angler faces, that is the point where the maximum utility is equal to the minimum travel cost if travel cost (price) changes. The CV expresses how much each angler would be willing to pay due to the change in travel cost to keep them at the same level of utility as before the change and it helps to give a monetary value to the utility change.

$$h(p, u^*) = \lambda(p, y) \quad (18)$$

$$v\,(p, y) = \max\{u(\lambda): p\,\lambda \leq y\} \quad (19)$$

$\lambda(p, y)$, $h_i\,(p, \bar{u}\,)$, and u^* are the uncompensated demand, compensated demand, and the maximum utility that each angler faces. Equation 19 is the indirect utility function and when it is partially differentiated with respect to the travel cost, P, and anglers' income, y, using Roy's identity, it yields the observed demand curves of the anglers.

When the travel cost changes as a result of the anglers' willingness to pay to access an ideal fishing site while income is constant, the compensating variation (CV) expresses the minimum number of fishing trips that will keep the angler at the same level of satisfaction before and after the change in travel cost, that is (p^0, y^0) and $(p^1, y^0 + CV)$ respectively. Expressing CV in terms of the expenditure function,

$$CV(P^0, P^1, y^0) = e(P^1, u^0) - e(p^0, u^0) = e(p^1, u^0) - y^0 \quad (20)$$

solved as

$$CV = \frac{1}{\beta_y}\ln\left[1 + \frac{\lambda\beta_y}{\beta_p}\right] \quad (21)$$

and equivalent variation uses utility after the travel cost has changed

$$EV(P^0, P^1, y^0) = e(P^1, u^1) - e(p^0, u^1) \quad (22)$$

and solved as

$$EV = -\frac{1}{\beta_y}\ln\left[1 - \frac{\lambda\beta_y}{\beta_p}\right] \quad (23)$$

where $CV(P^0, P^1, y^0)$ is the minimum quantity of trips that will keep the angler as well off as he was before any increase in the travel cost at (P^0, y^0), β_p is the coefficient of the travel cost (price) variable, β_y is the coefficient of the income variable and λ is the number of fishing days demanded when price changes.

1.9 Results and Discussion

The descriptive statistics from the dataset used in this study are presented in table 1.1. The distribution of the count data for this paper, the number of fishing trips, shows that the mean fishing days is 33.09 with a standard deviation of 40.47 days. Several specifications of the recreational fishing demand models are estimated and the results presented in table 1.2 represent the models that best fit the data for this study. These specifications included explanatory variables like income, average catch per trip, marital status, type of fishing license, ownership of a fishing boat, and other hypothetic site characteristics.

The variables that do not significantly enter into the final model reported in this study are dropped from the model and analysis. Multicollinearity between the income and education variables was tested using the Variance Inflation Factor (VIF) statistic. The value of the VIF is 1.24 for both variables. The VIF values are less than 10 and shows that multicollinearity does not exist and that neither variable introduce multicollinearity into the model. An alternative specification was also estimated using the Poisson model, but was rejected in favor of the negative binomial models using the [2]likelihood ratio (LR) test. The LR statistic for the tests in model 1 and 2 presented are 19,256.77 and 18,284.37 respectively. Both values of the LR statistics are statistically significant at 1% level.

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[2] *Likelihood ratio Test = -2(LL (Poisson) – LL (Negative binomial)) ~ χ^2 (Result of Poisson estimation is presented in appendix 1)*

Table 1.2: Parameter Estimates

Variable Description	Variable	Model Estimates 1	2
Intercept		3.6551***	3.4773***
Average Trip Cost	**AV_TRV_COST**	-0.0016** (-0.0007)	-0.0042*** (-0.0001)
Fishing Experience in Years	**FSH_EXP**	0.0152*** (0.0037)	0.0133*** (0.0037)
Average Site Distance	**AV_SITE_DIST**	-0.0012** (0.0005)	-0.0016*** (0.0005)
State	**ST**	-0.5207*** (0.1032)	-0.5616*** (0.1019)
Income	**INC**	-0.0032** (0.0016)	-0.0031** (0.0015)
Age	**AGE**	-0.0327* (0.0188)	-0.0285*** (0.0085)
Age*Age	**AGE^2**	-0.0002*** (0.0000)	-0.0002*** (0.0001)
High School Diploma or Less	**EDU_DUMMY**	0.6753*** (0.1033)	0.6632*** (0.1028)
Assoc. Degree But Less Than College)	**EDU_DUMMY**	0.6227*** (0.1047)	0.6582*** (0.1041)
Fish Variety (NF6)	**NF6**		0.1274** (00599)
Near Shopping (CF2)	**CF2**		-0.2899** (0.1245)
Near Restaurant (CF3)	**CF3**		0.2252** (0.0990)
Restroom Facility (CF4)	**CF4**		0.1499* (0.0867)
Parking (CF5)	**CF5**		-0.1421 (0.1089)
Picnic Facilities (PF1)	**PF1**		0.3366*** (0.0873)
Vending Facilities (PF6)	**PF6**		0.1188** (0.0604)
Swimming (RF1)	**RF1**		-0.1429* (0.0851)
Wildlife Watching (RF3)	**RF3**		-0.1271 (0.1188)
Dispersion Parameter	**Alpha**	0.9972***	0.9471***
Criteria for Assessing Goodness of Fit			
Deviance		1.1431	1.1539
Pearson X^2		1.5138	1.4028
Log-Likelihood		69,900.75	69,921.23
BIC		6,333.7	6,285.3

***, **, * - Significance at 1%, 5%, and 10%

Table 1.2 presents the parameters of the estimated models. Models 1 and 2 are presented in table1.2 because they are both full models that represent the observed and intended behavior of the anglers. The deviance and the Pearson Chi-square (χ^2) have values slightly greater than 1, which indicates over-dispersion that has been corrected by the negative binomial specification. These values are usually much greater if a Poisson[2] model was used in the estimation.

Another indication of the over-dispersion is the value of the dispersion parameter, alpha, in both models. These values are positive and statistically significant at the 1 percent level. If this parameter was statistically insignificant, the appropriate model would have been the Poisson count travel cost model. The predicted mean fishing days demanded by the anglers is 33.13 days in model 1 and 35.17 days in model 2, which is approximately the same as the actual mean fishing days of 33.09 in table 1.1. This satisfies the property of the negative binomial that the sample mean of the predicted number of trips demanded equals the sample mean of the observed value of trips demanded (Haab and McConnell, 2002).

The log likelihood values of the models presented are 69,900.73 and 69,921.23 in model 1 and 2 respectively. These values exceed the tabulated chi-square and indicate that the parameter and the dispersion parameter are not zero. This rejects the null hypothesis of $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \alpha = 0$ in model 1 and $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = \beta_{13} = \beta_{14} = \beta_{15} = \beta_{16} = \beta_{17} = \beta_{18} = \alpha = 0$ in model 2. All these show that the models are correctly specified and adequate.

The parameter estimates of the models presented represent a change in the log of the expected count of the number of fishing days or the percentage change in the number of fishing days, dependent variable, for every unit change in the explanatory variable. The regression coefficients can be interpreted as follows; if other explanatory variables are held constant, for every unit change in the explanatory variable that is allowed to vary, the difference in the logs of the expected count of the number of fishing trip days demanded is expected to change by the varying explanatory variables' regression coefficient. The dummy variables enter the model dichotomously and the derivative of the dependent variable with respect to the dummies do not exist (Halvorsen and Palmquist, 1980). The coefficients of the dummy variables in this study measure the discontinuous effect of the explanatory variables they represent on the dependent variable, the number of fishing days demanded. Thus, an alternative, the percentage impact of the dummy variable on the number of fishing trip days demanded is used. This measure is given by

$$\beta_i' = 100(\exp(\beta_i - V(\beta_i)/2 - 1) \quad (24)$$

Where β_i' is an estimate of the percentage impact of the dummies of the site characteristic variables on the number of fishing trips that is demanded and $V(\beta_i)$ is the variance of variance of β_i.

The estimated coefficients on average trip cost in models 1 and 2 are negative and statistically significant at 5% and 1% levels in models 1 and 2 respectively. For model 1, if the travel cost increases by $1, this would cause the log of the expected (count) number of fishing trips demanded to decrease by 0.1053 units as shown by the marginal effect in table 1.3, or that the number of fishing days demanded will decrease by 0.16% if the travel cost increases by $1. This supports what theory would predict; for demand, as the price of the fishing trips increases with other variables held constant, the number of days demanded would decrease. Table 1.3 also shows that the trip cost in model 1 is price inelastic at -0.75, meaning that an increase in travel cost will result in less change in number of trips demanded and would not affect the revenues to the recreation site. For model 2, the inclusion of hypothetical site characteristics causes the coefficient of the travel cost to change to -0.0042. This implies that if the travel cost increases by $1, the log of the expected (count) number of fishing trips demanded would decrease by 0.0042 units. This shows that anglers would respond more to changes in the travel cost since the travel cost would increase with the inclusion of the additional features to the ideal site. This is supported by the marginal effect of -0.29 and an elasticity of -1.93 in table 1.3. This shows that the price effect moves from being inelastic to being elastic due to the price increase.

For this study, this change from being inelastic to becoming elastic could be a result of the 21.16 percent of the respondents not willing to pay any extra amount for the fishing site improvement, while another 11.86 percent are willing to pay less than $2.50, the lowest suggested payment for site improvement in this study. The implication of this is that consumers of recreational fishing will respond to price increases at some point. The coefficients for anglers fishing experience in models 1 and 2 are 0.0152 and 0.0133 respectively, and are statistically significant at the 1 percent level. This variable has marginal effect of 1.00 in model 1 and an elasticity of 0.99, while it has a marginal effect of 0.91 in model 2 and an elasticity of 0.86. The elasticity in both models could be rounded to unit elasticity. This shows that the fishing experience of the angler has positive effect on the number of fishing days demanded and actually increases the days demanded by about 1 day for every extra year of the anglers' years of experience fishing.

Table1.3: Marginal effects and Elasticity

Description	Variable	MODELS 1 M.E	ELAS	2 M.E	ELAS
Average Trip Cost	**AV_TRV_COST**	-0.1053	-0.7513	-0.2878	-1.934
Fishing Experience in Years	**FSH_EXP**	1.0001	0.9978	0.9111	0.8559
Average Site Distance	**AV_SITE_DIST**	-0.0724	-0.1776	-0.1096	-0.2533
State	**ST**	-34.2739	-0.2075	-38.5698	-0.2199
Income	**INC**	-0.2094	-0.3653	-0.2081	-0.3631
Age	**AGE**	-1.1524	-0.013	-1.9525	-2.5226
Age*Age	**AGE^2**	-0.0133	-0.9026	-0.0137	-0.8791
High School Diploma or Less	**EDU_D1**	44.7454	0.5589	45.4343	0.5346
Assoc. Degree But Less Than College)	**EDU_D2**	41.2601	0.4591	45.0917	0.4726
Fish Variety (NF6)	**NF6**			8.7279	0.1139
Near Shopping (CF2)	**CF2**			-19.8604	-0.3876
Near Restaurant (CF3)	**CF3**			15.4279	0.2534
Restroom Facility (CF4)	**CF4**			10.2693	0.0994
Parking (CF5)	**CF5**			-9.7349	-0.04221
Picnic Facilities (PF1)	**PF1**			23.0597	0.2751
Vending Facilities (PF6)	**PF6**			8.1387	0.1258
Swimming (RF1)	**RF1**			-9.7418	-0.1221
Wildlife Watching (RF6)	**RF3**			8.7073	0.1720
Predicted mean fishing days		33.14days		35.17days	
WTP		$249.52		$310.71	
CS		$33.09		$32.82	

M.E. – Marginal Effect, ELAS. - Elasticity

The length of the average site distance is inversely related to the number of fishing days demanded as expected. The coefficient for this variable is -0.0012 and -0.0016 in models 1 and 2 respectively. The implication of this variable is that the number of fishing trips demanded by each angler would reduce by 0.12 percent and 0.16 percent respectively for every extra mile the fishing site is farther from the angler. The marginal effect is smaller in model 1 than in model 2 implying that respondents will less likely change their demand for recreation trips in model 1 since the travel cost is not as much as the travel cost in model 2 where respondents pay more for each trip. This variable is relatively inelastic in both models and suggests that anglers would likely travel to their fishing sites if they so choose to, irrespective of the distance.

In this study, 552 anglers are residents of Alabama; this represents 77.97 percent of the respondents while 22.03 percent visit from other states in the country. The coefficient of the State dummy variable in models 1 and 2 are -0.5207 and -0.5616 (Table 1.2) respectively and are statistically significant at the 1 percent level. The coefficients represent the difference between in state and out of state residents. The difference in the log of the expected count is will reduce by 0.52 and 0.56 for anglers that reside outside of Alabama in models 1 and 2 respectively. These coefficients support the average site distance traveled by the anglers, because, it is expected that the anglers that are residents of other states would travel longer distances on average to be able to fish in Alabama waters. The variable is also quite inelastic at -0.2 in both models and suggests that the anglers' response with respect to their resident state would hardly change their demand for number of fishing days.

The coefficients of income variables are -0.0032 and -0.0031 in models 1 and 2. They are inversely related to the expected number of fishing days and statistically significant at the 5 percent levels. These coefficients show that as the anglers' income increases, the log of the expected count (the number of fishing days demanded) would be expected to decrease. The marginal effects are -0.209 and -0.208 in both models ad they are both inelastic. The income elasticity of demand for recreational fishing is quite inelastic in both models. This shows that when income increases by one percent, the percentage reduction in the number of fishing days demanded are 0.21 and 0.36 in the two models respectively. The negative relationship with of the dependent variable with income does not imply that recreational fishing is an inferior activity; rather it could be accounted for from two perspectives. The first one is that, as individual income increases, there are more varieties of recreational activities for the consumer. The second one is that as income increases, individuals are less willing to create time for recreation that could require mote time off work.

The age variable shows an inverse relationship with the number of fishing days demanded. This suggests that as the anglers get older, the number of fishing days demanded will be reduced. The coefficient of the age and age squared variables are all statistically significant at the 1 percent level except in model 1 where age is statistically significant at 10 percent level. Age is elastic at -0.013 and -2.5 respectively both models and relatively inelastic at -0.9 with age squared variable. The overall implication of this is that age as a variable that could become elastic particularly as the travel cost increases from model 1 to model 2.

The demand for recreational fishing is differentiated by the levels of education into those with high school diploma or less associate degrees but less that college degree, and those with Bachelor degrees and higher. The estimation is done with the bachelor degree and more education group as the base. The estimates show positive relationship with the number of day demanded and all the estimates are statistically significant at 1 percent level. The group with the high school diploma or less has the larger coefficient, marginal effect and elasticity values. This suggests that as the level of education increases, their demand for fishing days reduce minutely. The elasticity values for these variables indicate that all the categories are inelastic.

The hypothetical site characteristic variables are only applicable to model 2, because it estimates what the anglers would be willing to pay for the hypothetical characteristics. These characteristics are represented with dummies and their coefficients measure the percentage change in the number of fishing trips demanded with the presence of these characteristics on the fishing site. For the natural features, only the fish variety enters into this model significantly. The coefficient of the fish variety dummy is 0.1274 and it is statistically significant at the 5 percent level. This implies that if the variety of fish at the fishing site increases, the number of fishing trips demanded by will increase 11 percent as shown by the elasticity.

The convenient characteristic features are expected to improve the comfort of the anglers on a recreational fishing trip. Four of these characteristics fit into the model, near shopping (CF2), near restaurants (CF3), restroom facilities (CF4), and parking facilities (CF5). The coefficient of the near shopping dummy (CF2) is –0.2899 and it is statistically significant at 5 percent level. This shows that when shopping area is close to a fishing site, it reduces the anglers demand for fishing trip days by 38.76 percent. This negative relationship with fishing trip demand is because most anglers prefer fishing sites away from heavy traffic areas that could be created by shopping places or areas. The coefficient of the near restaurant dummy (CF3) is 0.2253, with positive effect on the dependent variable. This variable is statistically significant at 5 percent and increases each angler's visits to recreational fishing sites by 25.34 percent. The restroom facility dummy (CF4) coefficient is 0.1499, it shows a positive relationship with the dependent variable which mean that the presence of restroom facilities will increase angler's visit to recreation sites. Its presence will increase fishing trips by 9 percent as shown by the elasticity.

The two physical facilities that fit in this model, the picnic facilities (PF1) and vending facilities (PF6) are statistically significant at 1 percent and 5 percent levels respectively. The coefficient of the picnic facility variable is 0.3366 and it is positively related to the dependent variable. When these facilities are present at a fishing site, the number of trips to fishing site increases by 27.51 percent. The coefficient of the vending facility dummy is 0.1188 suggesting it can increase trips to fishing sites by 12.58 percent when it is available.

For other recreation activities, swimming (RF1) is negatively related to the dependent variable. The coefficient of the dummy is -0.1422 and is statistically significant at the 10 percent level. The negative relationship is due to the fact that anglers would rarely want to go to the recreational fishing site to swim or have swimmers interfere with their fishing.

For these models, the mean willingness to pay for access to fishing sites changes to the extent that the coefficient of the average travel cost (own-travel cost) changes. The consumer surplus is calculated for the mean trip value, using the estimate of the travel cost parameter. That is, per trip consumer surplus is given by $(33.14/(1+ ß_i))$ on average for the model specifications; where $ß_i$ is the coefficient of the travel cost in each of the models. The mean total willingness to pay (TWTP) for recreational fishing in Alabama is the consumer surplus plus the mean travel cost for the 2006/2007 fishing season.

In model 1, which estimates the observed behavior of the anglers, the average consumer surplus is $33.09 per recreational trip per person and the total willingness to pay for recreational fishing is \$249.52 per person for the 2006/2007 fishing season. The minimum and maximum CS in model 1 are \$2.31 and \$69.04 with a standard deviation of \$12.61. In model 2, where the planned behavior of the angler is estimated, the average consumer surplus is \$32.82 per recreational trip per person and the total willingness to pay for recreational fishing with all the hypothetical facilities in place is \$310.71 per person, using the 2006/2007 survey data. The minimum and maximum CS in model 1 are \$1.80 and \$99.74 with a standard deviation of \$15.22. The CS estimated in this study is not too different from the consumer surplus estimate of Layman et al. (1996) who estimated a CS of \$51 per day for Alaskan Pacific salmon recreational fisheries. Bell and Vernon (1990) also found a daily CS of \$34.00 when they estimated the demand curve for tourists that visit Florida's beaches, and Englin and Shonkwiler (1995) \$24.42 for a single day hiking trip.

The compensating variation (CV) estimated at the mean for the anglers in this study using equation 21, is \$3.13. This value is small because the estimate of the income variable is small suggesting a small income effect in the model, but similar to the finding by Englin and Shonkwiler (1995) who estimate a CV of \$3.01 for recreational hiking in Cascade Mountain range. The distributions of these welfare measures are shown in figures 1.2, 1.3, and 1.4. The graphs show that these distributions are non-normal.

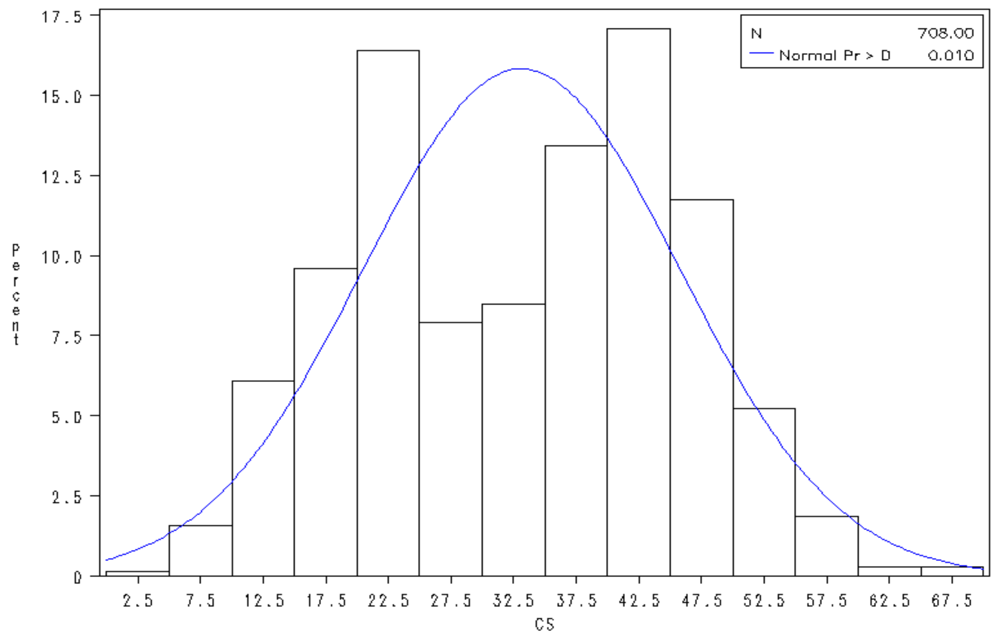

Fig. 1.2: Graph showing the distribution of the Consumer Surplus in Model 1

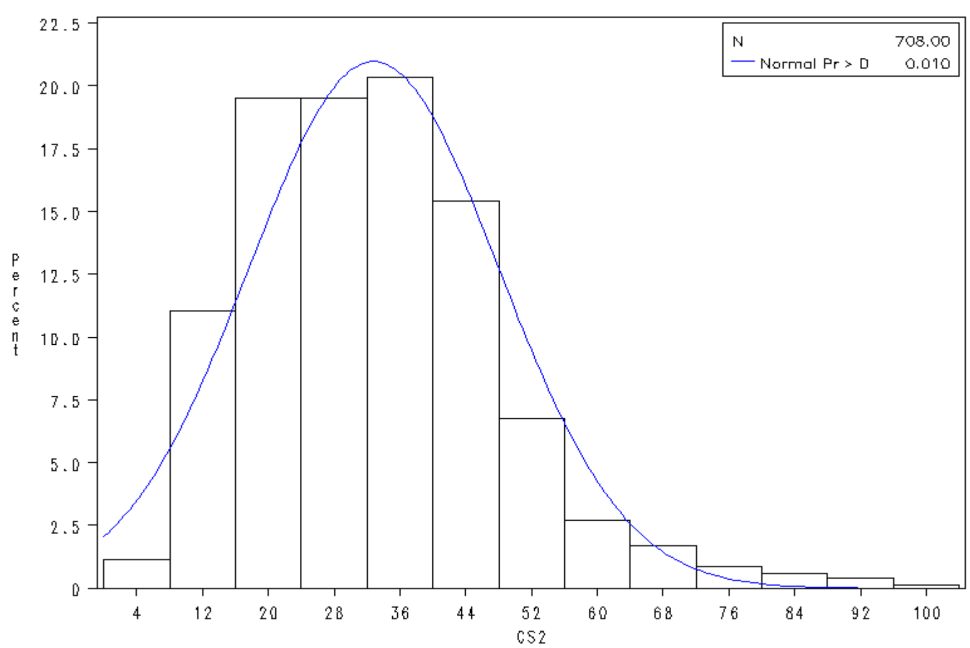

Fig. 1.3: Graph showing the distribution of the Consumer Surplus in Model 2

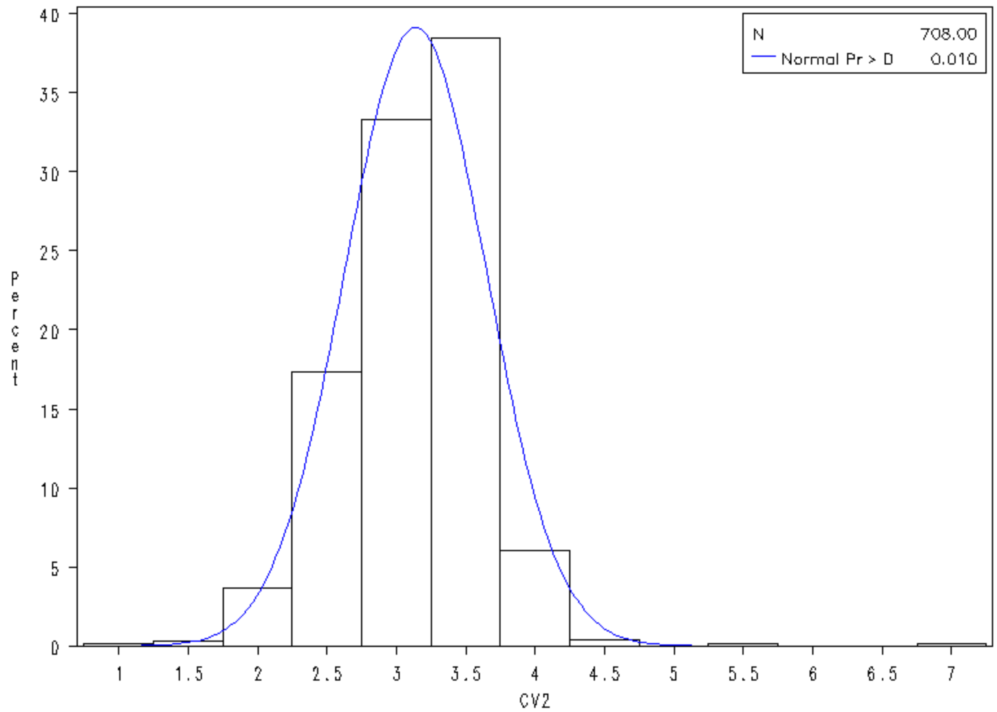

Fig. 1.4: Graph showing the Distribution of the Compensating Variation after TC Increase

1.10 Conclusion and Policy Implications

This study has found that the angler mean willingness to pay for recreational fishing in Alabama is $249.52 and the consumer surplus is about 13% of this amount. However, if the site characteristics are improved, the total willingness to pay for recreational fishing could increase to $310.71. This is a 24.52 percent increase in anglers' willingness to pay. The implication for fishery managers and private fishing site owners is that there is opportunity for them to increase fishing revenues by enhancing site characteristics and by using target marketing.

To capture this surplus, the owners and managers of recreation fishing sites need to target their market to segments of the public that have higher willingness to pay for fishing trips. Table 1.3 of this paper shows age to be elastic to the demand for fishing trips. The coefficient of the age variable is also negative and implies that as anglers get older; their demand for fishing trips will be reduced. As such, marketing could be done in a way to encourage anglers older than 45.44 years (average age for this study) to fish more. All the other variables included in this study are inelastic; this is a good indication that more revenues are still possible from recreational fishing trips.

This study shows that by improving the natural characteristics of fishing sites like increasing the number and variety of fish, improving the convenient characteristics like good restaurants, good and neat restroom facilities, and parking facilities will help to increase patronage at recreational fishing sites. Picnic and vending facilities are other characteristics that could increase recreational fishing trips, while allowing swimming in fishing ponds and locating recreational fishing sites near shopping areas could decrease the number of trips to recreational fishing sites. Including picnic and vending facilities would likely be very cost effective ways to increase revenues as they require little in the way of capital investment.

To improve the results from this study, more similar studies should be done in order to include a time series dimension to the analysis. This could help show the effects of improvements in recreational fishing sites characteristics over time. The time series will also help to create a rich consumer database and information that fishery managers and private fishing site owners can tap into in order to keep abreast of fishing site features that are desired by recreators. The elasticities reported in this study are short-run elasticities and long term elasticities can be calculated with more frequent studies. The frequency of this type of study will also allow good projections that could enhance adequate planning for recreational fishing seasons in the state.

II. ECONOMIC IMPACT OF RECREATIONAL FISHING IN ALABAMA AND THE BLACK BELT

2.1 Introduction

The purpose of this paper is to examine the potential economic impacts that natural fisheries and private sport fishing opportunities have in the economically depressed Black-Belt region of Alabama. For this study, the Black-Belt is taken as described by Raper (1936) as a region historically home to the richest soil and the poorest people in the United States. Particularly, the Southern Black-Belt is one of the most economically depressed regions in the United States and it is characterized by persistent poverty, poor employment, low incomes, low education, poor health, high infant mortality, and adult dependence (Wimberley et al 1997; Baharanyi et al. 1993).

Economic development in the Black-Belt region has been a primary focus of policy makers at both national and local levels; development of recreational opportunities, as part of a goal of promoting ecotourism in the area has been under particular consideration. In Alabama's Black-Belt, there are a number of existing reservoirs and other public fishing venues, such as county lakes in which current fish populations can be enhanced via aquacultural management practices in order to attract more recreational fishermen. Additionally, many farm ponds are currently either under or unemployed for terrestrial livestock production, suggesting they could be converted to recreational fishing venues. Following the states' tourism department demarcation, the

Black-belt is within the River Heritage and the Gulf Coast regions where water resources are readily available for recreational fishing activities.

To examine the possible value of these fishing opportunities, it was necessary to conduct a baseline study of angling expenditures in Alabama, from which we could estimate the spillover, or multiplier, economic impact. A direct mail survey was thus conducted of resident and non-resident anglers, from which we were able to obtain 2007 expenditures of fishing in the state.

In order to examine the economic impact of recreational fishing in Alabama and its Black-Belt, this paper covers a full economic analysis based on anglers' expenditures, combined with a model of regional economic impacts from IMPLAN. The results from this study aims at providing economic information that is pertinent to formulating policy decisions that would help maximize the existing water bodies in the economically depressed Alabama Black-Belt.

2.2 Literature Review

Bannear et al. (2004) use revealed preferences to infer the environmental benefits evidenced from recreational fishing. Their study use panel data on prices of state fishing licenses in the continental United States over a fifteen year period, combined with substitute prices and demographic variables. A license demand function was estimated with an instrumental variable procedure to allow for endogeniety of administered prices. It was revealed that there is variation in the value of recreational fishing across United States and the use of benefit estimates may result in substantial bias in regional analysis.

A study on coastal Alabama recreational live bait by Hanson et al (2004) reports recreational fishing as a major industry, which as sport complements a wide array of activities associated with the expansion of U.S. tourism. They identify recreational saltwater fishing as an integral part of coastal Alabama economy as evidenced by the increase in the sale of fishing licenses in 1995 and crucial to this was the supply of life baits. Their survey also revealed that businesses involved in life baits had annual sales of approximately $2.3 million between 1997 and 1998.

Ditton et al. 2002, writing on recreational fishing as tourism, explain that apart from fishing being a recreation activity for residents in each state, it is also a form of tourism that entices anglers to cross over to other states. Using data from the 1996 National Survey of Fishing, Hunting, and Wildlife Associated Recreation, they report that the states are pushing to promote tourism, including recreational fishing, in the name of economic development. The study reveals several stakeholders diverse perspectives with respect to fishing as a tourism issue. They conclude that fishing site managers need to acquire greater awareness of fishing tourism and develop effective partnerships with state and local tourism promotion organizations.

Clonts, et al. (1998) examine recreational fishing in Alabama's public waters. Using 403 surveys, an input-output simulation analysis was used to estimate the economic impact of recreational fishing in Alabama. Their study shows that the recreational fishing industry in the state contributed to direct spending of $1.3 billion by licensed anglers in the economy, and also created jobs in the state. Angler expenditures sustained about 36,539 workers with annual income of $600 million. In 2007 dollars using the Bureau of Labor Statistics 2009 Consumer Price Index inflation calculator, the spending is 1.65 billion and sustained 36,539 workers with annual income of $763 million

Lupi et al. (1997) estimate the demand for recreational angling in Michigan using the travel-cost model. Using a four level nested logit model on one season of angler data, they show that travel cost method establishes relationship between the recreational use and the cost and characteristics of the sites and the method is only as good as the statistical link between the between the site quality characteristics and the travel cost method demand for trips to the site.

Gardner and Mendelsohn (1984) apply the hedonic travel cost method to value the steelhead fish density in Washington State streams. The model reveals how users are willing to pay for site characteristics of recreation sites. Using a regression analysis, they estimate the prices of recreation attributes by regressing travel costs on characteristics of the recreation sites. The demand for the site characteristics is revealed by comparing site selection of the users when faced with different prices.

Hite (2005) examines the potential economic impact of developing national grassland, Black-Belt Prairie National Grassland (BPNG), as ecotourism destination in the Alabama Black-Belt. She explains that the project would directly and indirectly increase economic activities in the Black-Belt and also attract other tourism infrastructures, which among others would include private recreational fishing areas. Using existing studies and reports, the study showed that developing the grassland would increase jobs in the retail and service areas of the Black-Belt region, which would in turn impact other sectors in this economically depressed region.

Hodges et al. (2005) measure the impacts of Florida citrus industries in 2003-2004 seasons. Using the IMPLAN software, they show how the expenditures invested in the citrus industry cuts through several sectors of the Florida economy to increase economic activity in the state.

While several studies have used travel cost models or willingness to pay methods to assess demand and consumer surplus to recreation sites, this study uses IMPLAN, an acronym for "Impact Analysis for Planning". IMPLAN is an economic impact and social accounting software package. It is an input-output modeling system that focuses on the economic impacts of angler spending or expenses on the economy of their recreation sites. There are also other studies that have looked at economic impacts of other activities in different economies in Alabama; this study focuses on the current impact of recreational fishing and the potential to have an increased economic impact using IMPLAN.

2.3 Methods

The study area covers the whole state of Alabama. This is because the state has tremendous recreational fishing resources. The public water of the state covers more than one million surface acres with additional 150,000 acres of private bodies of water. The Division of Wildlife and Freshwater Fisheries manages 23 lakes, 77 miles of perennial rivers, streams and delta in Mobile, the Department of Conservation and Natural Resources manages 38 lakes, and the State Park Division has four large reservoirs and 14 lakes (Outdoor Alabama 2007).

Table 2.1 shows the demographics of Alabama and the Alabama Black-Belt using IMPLAN, 2006 data. It shows the ratio of the Black-Belt in Alabama to Alabama State and expresses it as a percentage of the State for total area (square miles), population, number of industries, employment, number of households, income per household, and total personal income. The table shows that there is a big disparity in the HH income and the personal income ratios. This huge disparity supports the finding of Wimberly et al., 1997; and Baharanyi et al., 1993 of the high adult dependency in the Black-Belt.

Table 2.1: Demographics of Alabama and the Black-Belt

	Black-Belt	State	Ratio BB/State (%)
Area (sq. Miles)	18,419.00	50,752.00	36.29
Population('000)	689,924.00	4,503,726.00	15.32
Number of Industries	306.00	464.00	65.95
Employment ('000)	345,727.00	2,345,653.00	14.74
House Hold (HH)('000)	318,891.00	2,035,107.00	15.67
Income per HH ($'000)	52,321.00	58,657.00	89.2
Total Personal Income ($ '000)	16,684,710,000.00	119,373,000,000.00	13.98

The bodies of fishing water in the Black-Belt region of the state are of particular interest as the study's purpose is to compare the revenues of the region as compared to the entire state. This will allow policy makers to address possible ways to enhance the bodies of water currently being used for better economic gains in the economically depressed region. It will also encourage them to harness idle bodies of water for new economic gains for the Black-Belt of the State.

Figure 2.1 shows three maps of Alabama, where the counties highlighted in red or yellow in A and B are traditional Black-Belt counties (Center for Business and Economic

Research, 2008). It also shows that a large part of the Black-Belt is in the river heritage of the state.

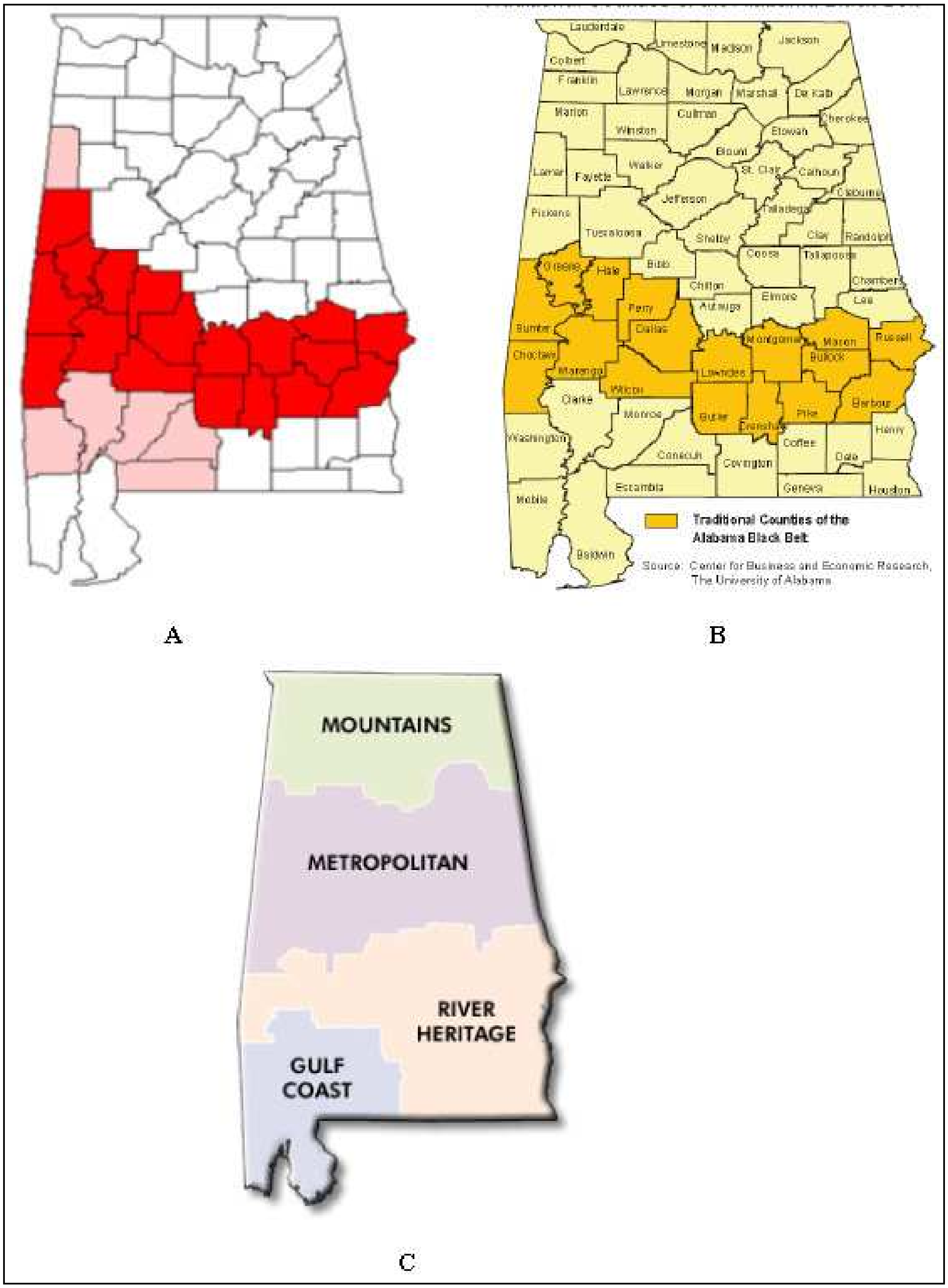

Fig. 2.1: Maps of Alabama's Black Belt region.

2.4 Economic Impact (IMPLAN – Impact Analysis for Planning)

While Travel Cost models reflect the value of fishing to the individuals doing the fishing, IMPLAN models reflect the amount of additional regional economic values that can be expected from a given activity. These values are reflected by revenues that are brought into the area and which filter through the local economy. IMPLAN is an input-output (I-O) model that uses economic multipliers to estimate the effects of changes in final demand for one or more industries in the region of interest. These multipliers measure the direct, indirect and induced effects of new expenditures on changes in output, income, and employment. The direct effect is the initial change in the sector of interest and involves the initial purchase made by the angler. The indirect effect refer to changes in inter-industry transactions, such as when supporting industries like hotels respond to increased influx of recreation anglers in the directly affected sector in Alabama. The induced effect refers to the changes in local economy due to spending that may result from income changes of the industry employee households and create a continued cycle of indirect and induced effects.

For this study, IMPLAN measures the consequences of the expenditures on recreational fishing on considerations such as the local employment, wage levels, and other business activities that results from directly, indirectly or is induced by the new income into the local economy.

The IMPLAN database provides information on employment, industry or sector output, value added, institutional demands, and inter-institutional transfers. Each industry that produces goods and services generates demands for other goods and services. IMPLAN captures these effects and the model determines multipliers that describe these interactions within a specified region. The total multiplier for an industry is the sum of the direct, indirect, and induced effects. In the case considered here, the industry is recreational fishing, and the economies in question are those of the state of Alabama and the Black-Belt. The question being addressed by this study is what the effect of recreational spending is currently doing and would do to the economies of interest if the spending increases would occur as a result of expanded recreational fishing activities.

Practices for ponds, lakes and reservoirs can include optimizing combinations of fish species to promote growth of valued species, as well as fertilizing to enhance plant growth and dissolved oxygen content of water bodies. On the other hand, streams and rivers present more of a challenge, though crop management practices such as buffer strips would help improve water quality and fish habitat. It is also believed that efforts that improve fishing quality of the recreational fishing experience would likely have positive external effects in the form of improved hunting, wildlife and bird watching, and overall enhancement of the state's environment and natural resource base.

2.5 Data

The data needed to assess economic activity and economic impact was gathered by direct mail surveys sent to a randomly selected 6,250 sample of licensed anglers in Alabama. The mails were sent out between November 28th and December 13th of 2006. The survey response was plagued by lots of bad and undeliverable addresses and we only had 347 good responses and 858 undeliverable surveys by January 18th of 2007. Reminders were then sent to the remaining 5145 respondents by the first week in

February 2007. This generated only 104 good surveys by March 6th of 2007 and 641 undeliverable surveys. In March of 2007, a total of 4400 surveys and reminder notes were sent to the respondents and this only generated 257 good responses and 1033 undeliverable addresses. Overall 708 respondents from the randomly selected sample responded. With 2,632 bad addresses, the total sample size is reduced to 3,618 anglers (respondents). This gives an overall response rate of 19.5 percent.

The survey is used to collect data on individual angler characteristics, expenditures on fishing equipment, and destinations and expenditures on time and travel for each trip taken. In addition, the kinds and quantities of fish that anglers sought on each trip is also be obtained. The data thus collected is used to generate a demand curve for fishing statewide. Because destinations are also identified, the differences in trip demand for the Black-Belt vs. the rest of Alabama's counties are also ascertained. The sample frame consists of names and addresses of 6,250 randomly selected from anglers licenses sold in Alabama during the 2006/7 fishing season. A one year period is used in order to avoid memory loss and double counting by the respondents on questions related to frequency to fishing sites within the year.

An ideal fishing site that would enhance fishing experience is created in the survey and the anglers are asked under eight different price scenarios how much they would pay to visit such site. The assumption here is that the anglers are equidistance to the hypothetical site. The response to this provides a baseline, or status quo, scenario for comparison with changes in demand to be expected from enhanced fishing experiences.

Economic impacts of current expenditures by the anglers are then generated using the IMPLAN model. The total willingness to pay amount by each angler is then added to their total cost per trip and the IMPLAN is used to generate another economic impact to the state. The new impact is then compared to the baseline to determine the potential increase in economic impact to the state if the fishing sites are improved through good aquaculture practices.

2.6 The Impact Analysis

Economic impact analysis predict the economic effects on a regional or economy of a new business location, a new project venture, or new injections into the region or economy of interest. It is a counterfactual policy tool that that shows a condition contrary to the present situation. For the purpose of this paper, the impact analysis shows the effect that tourism as induced by recreational fishing could have on Alabama state and the poor economy of the Black-Belt region of state.

In the application of a final demand change to a predictive economic input-output model and then analyzing the resulting changes in the economy, the IMPLAN software uses producer prices while the data collected are those of final purchase prices, thus these prices are separated by the use of margins, the difference between the producer and final consumer price. This margin is further fine-tuned by the use of the regional purchasing coefficient (RPC). The RPC defines the trade flow in a region and it differs for regions and for states. The RPC determines the percentage of the final consumer price that remains in the local economy where the final spending takes place.

Table 2.2: Alabama Expenditures for Recreational Fishing (2006/7)

Category	708 State Anglers Expenditures	Av. Exp. $ (708 Anglers)	Total Exp. for (80,000 ANG) $.	Increase in Total Exp. From WTP $	*RPC (%)
Gas	688,456.44	972.4	77,791,688.05	77,791,688.05	32.8
Food and Drinks	452,354.49	638.92	51,113,501.52	51,113,501.52	90
Bait & Tackle	297,810.61	420.64	33,650,916.40	33,650,916.40	77.6
License	269,097.01	380.08	30,406,441.65	30,406,441.65	77.6
Fishing Gears	319,398.83	451.13	36,090,263.43	36,090,263.43	77.6
Hotels & Lodgings	431,395.45	609.32	48,745,248.49	48,745,248.49	40.5
Camping	82,088.82	115.94	9,275,573.11	9,275,573.11	22.5
Boat Rentals	46,049.63	65.04	5,203,348.18	5,203,348.18	100
Entrance Fees	85,193.02	120.33	9,626,330.08	29,252,855.50	100
Misc	428,375.47	605.05	48,404,008.19	48,404,008.19	75
Total	**3,100,219.77**	**4,378.84**	**350,307,319.10**	**369,933,844.53**	

The anglers' expenditures are carefully distributed in the IMPLAN sectoring scheme. Based on this scheme, nine industry sectors in IMPLAN are used to analyze the Alabama recreation fishing sector for the 2006/2007 season. The sectors include petroleum refineries, food services and drinking places, miscellaneous store retailers, sporting goods and hobby stores, recreational sport centers, hotels and motels, travel trailers and campers' manufacturers, water transportation, and the non-store retailers' sector. These industries are defined based on their primary output or service as defined by the North American Industry Classification System (NAIC) and Bureau of Economic Analysis (BEA). The output value of each type of product is specified as an impact event in the respective industry.

Table 2.3: Alabama Black-Belt Expenditures for Recreational Fishing Season (2006/7)

Category	236 BB Anglers Expenditures ($)	Av. Exp. $ (236 Ang)	Total Exp. for (26,667 ANG) $.	Increase in Total Exp. From WTP $	*RPC (%)
Gas	54,484.76	230.87	6,156,547.34	6,156,547.34	5.6
Food and Drinks	119,595.89	506.76	13,513,828.79	13,513,828.79	83.9
Bait & Tackle	86,933.62	368.36	9,823,130.54	9,823,130.54	75.3
License	92,249.10	390.89	10,423,757.24	10,423,757.24	75.3
Fishing Gears	82,100.05	347.88	9,276,957.96	9,276,957.96	47.8
Hotels & Lodgings	151,953.36	643.87	17,170,085.35	17,170,085.35	29.2
Camping	22,555.58	95.57	2,548,684.54	2,548,684.54	8.5
Boat Rentals	9,994.40	42.35	1,129,324.66	1,129,324.66	100
Entrance Fees	13,523.72	57.3	1,528,123.09	**8,004,644.73**	100
Misc	91,778.42	388.89	10,370,572.03	10,370,572.03	57.3
Total	**725,168.89**	**1,024.25**	**81,939,987.30**	**88,417,533.18**	

*RPC is the Regional Purchasing Coefficient that shows the percentage of expenditure that remains in the economy to create an impact.

Table 2.2 shows the inputs purchased by the recreation sector like the food, drinks, bait and tackle, fishing licenses, hotels and lodging, camping equipments, boat rentals, and other gears, constitute the production function, that drives the estimates if indirect and induced impacts. The direct impacts are the ones for local consumption as they do not represent a change in the overall economic activity for the region. These are allocated to the sectors that are represented in the local economy from which the recreation fishing sector got their inputs. The industry information on value added, employee compensation, proprietor income, other property income, and indirect business taxes are all left as default in the IMPLAN model.

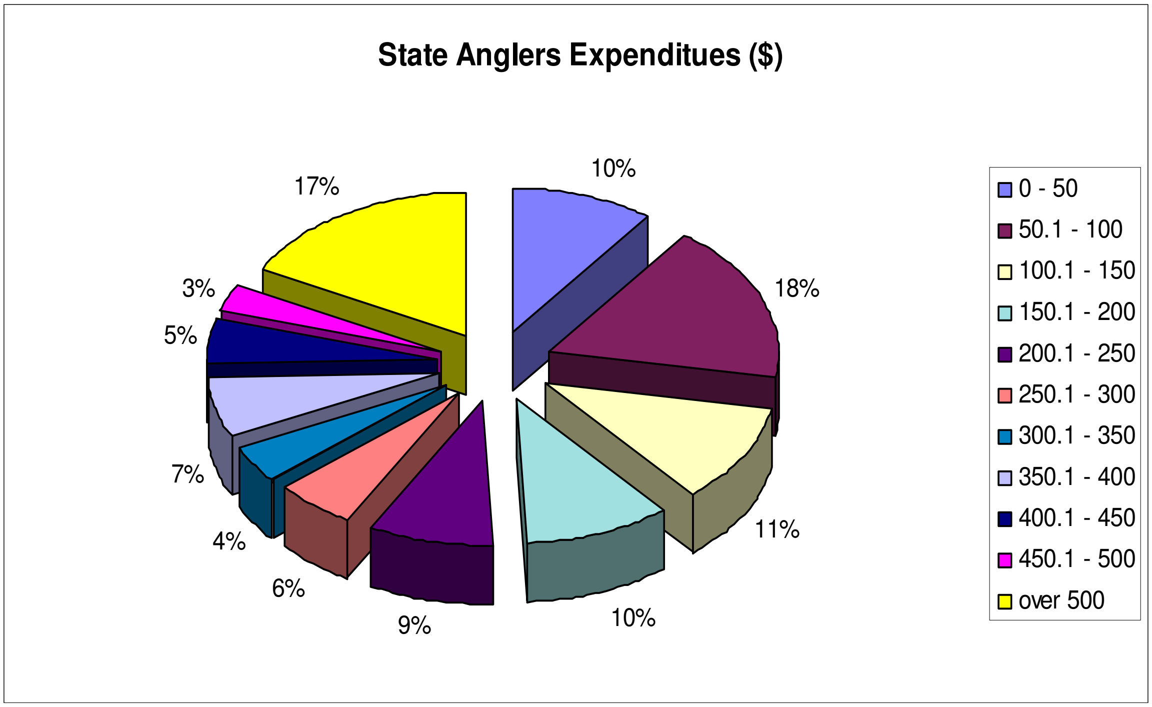

Figure 2.2: Distribution of Angling Expenditures ($) in the state

Figures 2.2 and 2.3 show the distribution of the expenditures of the anglers that responded to the questionnaire for those who fished in the State and those who fished in the Black-Belt respectively. It shows that 22 percent of the anglers that fished in the Black-Belt spend $500.00 or more compared to the 17 percent that spend equal amount in the state. For those who spend $200.00 and above in the Black-Belt and the State are 53 percent and 51 percent respectively. This shows that the Water bodies in the Black-Belt have the potential to attract a few higher spenders, which could be a good source of new income to the region.

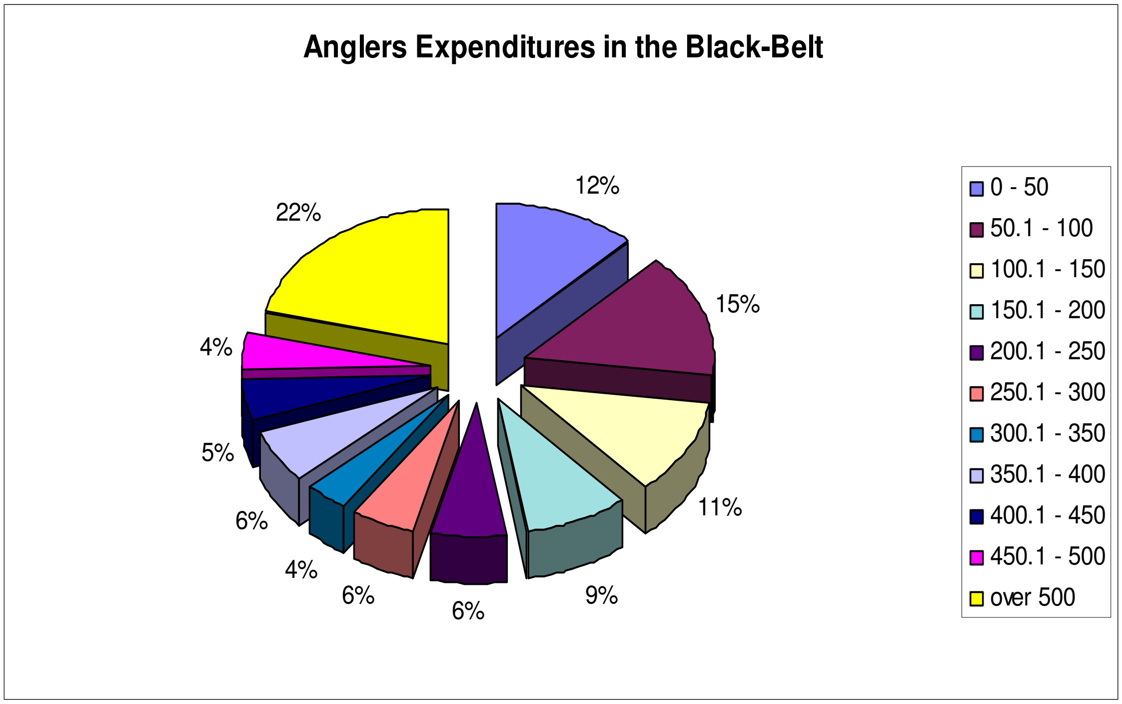

Figure 2.3: Distribution of Angling Expenditures ($) in the Black-Belt

2.7 Results and Discussion

Of the available expenditure data from the 708 survey respondents for the state, 236 fished the Black-Belt waters. A total for the 80,000 anglers was reported by the department of fisheries for the state and 26,667 of the reported anglers are estimated to fish the Black-Belt waters. Table 2.2 shows estimated amounts spent by the 80,000 anglers during the 2006/2007 fishing season on recreation fishing inputs of gas, food and drinks, bait and tackle, fishing license, fishing gears, hotels and lodgings, camping, boat rentals, entrance fees, and other miscellaneous spending related to recreation angling as $77.8m, $51.1m, $33.6m, $30.4m, $36.1m, $48.7m, $9.2m, $5.2m, $9.6m, and 48.4m respectively. The table also shows the increase in expenditure by virtue of extra amount the respondents are willing to pay for an ideal fishing site if presented with all the features that the angler wants. The WTP amount is added only to the site fee expenditure. As a result of this willingness to pay for ideal site, the total expenditure increased from $350.5m to $369.9m for the fishing season. This represents a about 6 percent increase in total expenditures by the anglers.

Table 1.3 shows the expenditures by the 26,667 anglers that fished the Black-Belt waters and the increase in expenditures if they are presented with an ideal fishing site just like the anglers that fish in other parts of the state. The total expenditure is shown to be $81.9m and it increases to $88.4m with an ideal site improvement which includes better aquaculture management to improve fish quality. This increase represents an 8 percent increase in total expenditures of anglers to the Black-Belt. Tables 2.2 and 2.3 also show the RPC of the state and the Black-Belt Region. All the RPCs of the state are higher than those of the Black-Belt and this are attributed to the fact that there are more economic activities at the state level than within the economically poor Black-Belt.

Table 2.4 shows the direct, indirect, and induced impacts as a result of recreation expenditures of the 80,000 anglers in the state and those for the 26,667 anglers in the Black-Belt for the 2005/06 fishing season. For the state, the table shows a direct total value added impact of $102.5m, and indirect impact of $24.7m, and an induced impact of $8.3m which all add up to a total impact of $135.5m in total value added to the state. This total impact can potentially increases to $142.2m, a 5 percent increase, with an increase in total expenditure if the fishing sites were improved to ideal state. The total labor impact for the state is 4,442 jobs that are created as a result of the expenditures. This employment impact could potentially increase to 4,682 jobs, a 5.4 percent potential increase in jobs if the sites are improved. The table also shows the potential increase in the impacts when the anglers are willing to pay for improved site characteristics.

The total value added in the Black-Belt is $38.3m which could potentially increase to $43.4m with an improvement to the fishing sites in the region. This potentially represents 13.3 percent increase in the Black-Belt and 4.9 percent for the state. This lower potential impact for the state could be improved and the Black-Belt has more potential for improvement if the conditions of the fishing sites are improved. For the Black-Belt, this value added culminates into 1,345 direct jobs, 95 indirect jobs, and 42 induced jobs. Thus, the total jobs created are 1,481 and this could potentially increase to 1,686 jobs, 13.8 percent increase, if the fishing sites are improved to ideal state.

Table 2.4: Alabama and the Black-Belt - Social Account Matrix (SAM) IMPACTS of Anglers - 2006/07

STATEWIDE	Direct*		Indirect*		Induced*		Total*		Multiplier
	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	
Employee compensation	57,534,949.00	59,417,010.00	11,500,631.00	12,117,283.00	4,076,824.00	4,237,343.00	73,112,405.00	75,771,635.00	1.27
Indirect Business tax Income	17,559,197.00	18,989,604.00	2,260,218.00	2,356,557.00	892,254.00	927,386.00	20,711,668.00	22,273,547.00	1.18
Property Income	19,516,547.00	20,800,432.00	8,696,166.00	9,094,067.00	2,794,970.00	2,905,019.00	31,007,684.00	32,799,518.00	1.59
Proprietors Income	7,358,052.00	8,373,779.00	2,246,429.00	2,339,843.00	570,027.00	592,471.00	10,174,508.00	11,306,093.00	1.36
Total Value Added	**102,468,752.00**	**107,580,833.00**	**24,703,444.00**	**25,907,750.00**	**8,334,076.00**	**8,662,219.00**	**135,506,272.00**	142,150,805.00	1.32
Labor Income	65,593,003.00	67,790,791.00	13,747,059.00	14,457,125.00	4,646,852.00	4,829,814.00	83,786,914.00	87,077,730.00	1.28
Output	280,915,315.00	288,435,268.00	45,494,541.00	47,447,295.00	13,335,214.00	13,863,259.00	339,745,063.00	349,742,827.00	1.21
Employment(# of Jobs)	3,940.70	4,155.70	354.30	373.50	146.60	152.40	4,441.70	4,681.60	1.13
Black-Belt	Direct*		Indirect*		Induced*		Total*		Multiplier
	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	
Employee compensation	17,495,010.00	19,006,465.00	2,708,158.00	3,135,224.00	1,117,990.00	1,230,323.00	21,321,158.00	23,372,009.00	1.22
Indirect Business tax Income	5,390,765.00	6,553,690.00	413,567.00	471,889.00	239,677.00	263,760.00	6,044,009.00	7,289,339.00	1.12
Property Income	4,240,941.00	5,284,007.00	1,676,494.00	1,933,051.00	767,001.00	844,073.00	6,684,436.00	8,061,131.00	1.58
Proprietors Income	3,677,331.00	4,113,327.00	395,599.00	453,959.00	130,174.00	143,254.00	4,203,104.00	4,710,540.00	1.14
Total Value Added	**30,804,045.00**	**34,957,488.00**	**5,193,818.00**	**5,994,122.00**	**2,254,842.00**	**2,481,409.00**	**38,252,706.00**	43,433,019.00	1.24
Labor Income	21,172,340.00	23,119,791.00	3,103,757.00	3,589,183.00	1,248,164.00	1,373,577.00	25,524,261.00	28,082,551.00	1.21
Output	77,561,399.00	83,773,459.00	9,408,989.00	10,732,076.00	3,557,017.00	3,914,427.00	90,527,407.00	98,419,963.00	1.17
Employment(# of Jobs)	1,344.70	1,532.00	93.50	107.50	42.30	46.60	1,480.50	1,686.20	1.10

2.8 Conclusion

The maps of Alabama displayed in fig. 2.2 show that there are lots of water bodies in the state and particularly in the Black-Belt regions of the state. These water bodies have potential to be improved for recreational uses by anglers and others who may love their aesthetic values. The number of anglers reported by the state for the 2006/2007 fishing season is a testament to the potential that lies in improving these water bodies. The possible impacts that could be generated from the incomes anglers bring into the regions where they fish points to a possible bottom-up solution to the economically depressed Black-Belt region of Alabama which has unused water resources.

Figures 5a&b and figures 6a&b show the distribution of expenditures by the anglers to the state and to the Black-Belt region. The charts show that in the event that the expected numbers of anglers don't visit the state or the Black-Belt water bodies, the anglers that spend $350 and above constitute 32 percent and 38 percent for the state and Black-Belt respectively. This could be a planning tool for the state or regional planners who manage these sites to target the high spending anglers in marketing the attributes of the fishing sites.

Given the results of this impact analysis, it is evident that an improvement in site quality by site owners or improvement in the quality of the public fishing sites by the government would generate extra willingness to pay for these sites by the current pool of anglers in the state. These improvements could also make more people to be interested in fishing, picnicking, and watching nature, or just to come in and enjoy the fishing facilities of the state and in the Black-Belt. The results also show that there is room for improvement in terms of bringing the impacts generated by the state to the Black-Belt.

These economic impacts are based on the responses from the survey sent to anglers in the state for the 2006/7 fishing season. It is important that in order to get a more accurate result, similar study would have to be done over consistent period of years in order to be sure that the estimates in this study are consistent and actually obtainable in the state.

III. ECONOMIC AND ENVIRONMENTAL IMPACT OF AGRICULTURAL LAND-USE CHANGE

3.1 Introduction

Humans modify and use land in various ways, extents and intensities. These modifications are either directly or indirectly used to obtain food, water, and other essentials resources. Land use can be broadly defined to include social and economic purposes with differing contexts in terms of the usage and could be taken as an overall functional entity in which human activities interact with natural processes. These activities cause changes in environmental processes, ecosystems, and land topography; they also cause water, soil and air pollution. Ellis (2007) explains that industrialization has encouraged the concentration of human population in urban regions and depopulation of rural areas. This has lead to intensive agriculture, with consequences, on the most productive lands. Kerilenko (2004) explains that urbanization modifies a lot of natural processes including runoffs, pollution, erosion, and most global climate changes.

Hsu and Mills (2000) explain land-use as an interdisciplinary study that is related to ecology, geography, economics, and sociology, and studying land-use helps in understanding how to relate the social process with the natural environment. The main objective of this study is to examine the impact of energy crop cultivation by way of changing the traditional agricultural use of the watershed to planting energy crops. Agricultural production generally has negative environmental consequences by moving agrochemicals, especially nitrogen (N), phosphorus (P), pesticides, and sediments from the farms to other habitats. These chemicals are transported by leaching and other surface flows like runoffs to other places or water bodies causing loss of biodiversity and non-source point pollution, and when they flow into water bodies, they increased nitrate and phosphate concentrations in such water bodies.

Watershed is a term that is used to describe a water drainage basin. It refers to a divide that separates one drainage area from the other and water flows across it to the lowest points that could be a creek, stream, wetland, pond, lake or river. Watersheds function to provide drinking water, recreation, irrigation, farming, and transport paths for sediment, soil nutrients, and other chemicals. Human activities on the watershed can greatly impact the watershed functions. A high sediment yield from watersheds is an indication of watershed that is degrading (Blaszczynski 2003). Sediments are usually transported in form of runoffs and these runoffs contain nutrients like nitrogen, phosphorus, and other nutrients that could be deposited in lakes, rivers, wetlands, and groundwater as non- source point pollution.

Energy security is an important concern in the United States, in addition to the ramifications of a petroleum based economy, global climate change, and national security. In 1978, U.S. Department of Energy (DOE) established the Bio-energy Feedstock Development Program (BFDP) to develop new crops and cropping systems that could be used as bio-energy feed-stocks. Further development of bio-fuels is a goal of the current administration. However, plans to increase the development of energy crops as part of bio-fuels development may have localized consequences for water quality in the form of agricultural non-point source pollution, which should be addressed through local watershed level policies.

The United States produced 3.4 billion barrels of crude oil and imported 1.2 billion barrels in 1973. By 2004, this position had shifted, with the United States importing 3.7 billion barrels of crude oil while producing only 2 billion barrels of crude oil (U.S. Department of Energy, 2006). This dependence on crude oil imports and the recent jumps in crude oil prices has prompted policy makers to assess the economics of renewable sources of fuel and also explore how to be less dependent on imported oil. Bush (2007) states in the state of the union address, that, ethanol and other alternative energy sources could replace 75 percent of oil imports to the country.

Slater (2007) reports some of the driving forces for ethanol production, which include the 2007 President's Advanced Energy Initiative, which has a 2012 goal of increasing research funds in cutting edge research on ethanol production and a 2030 goal to replace 30 percent of gasoline consumption in the United States with ethanol. The 2007 USDA farm bill provides $210 million to support an estimated $2.17 billion in loan guarantees for cellulosic ethanol projects in rural areas. The 2007 farm bill concept includes pilot and demonstration programs to help growers identify and grow the most suitable crops for cellulosic ethanol feedstock. In 2009, the current United States administration also plans to cut greenhouse gas emissions from cars by 5 percent in 2015 and 10 percent in 2020. This plan counts on new limits to stimulate increased production of renewable bio-fuels, such as corn and cellulosic ethanol, which naturally have lower emissions. These plans are backed by 2009 proposed a bill in the Senate that would raise fuel efficiency standards and would cut about 583 million tons of greenhouse gases in 2020 (Energy and Natural Resources Committee, 2009).

To produce agro-fuels, one could grow crops that have high sugar contents like sugarcane, sweet sorghum, corn etc, or one could grow crops that contain high amounts of vegetable oils like soybean, cotton, peanuts, etc. Cellulosic ethanol could also be produced from the non-edible plants or residues of the crops grown solely for energy, like switch-grass. Crop residues act as cover that protect soil from direct impacts of rainfall, sunshine, and wind and help to improve soil structure, reduce runoffs and sediment loss from erosion. The use of crop residue for bio-fuels could pose a problem by exposing the soil to runoffs and sediment loss.

The Natural Resource Conservation Service (2009) reports that crop residue is managed using reduced tillage practices like no-till, strip till, ridge till etc. on farmlands. Lindstorm (1986) finds that under no-till practice, runoff and soil loss decreased while residue on the soil reduced. He then suggested that a 30% residue removal will not significantly damage the soil. Biomass is derived from recently dead plants and animals or their by-products like manure, garden waste, and crop residues. When biomass is converted into fuel, it is referred to as bio-fuel and the most common source is photosynthetic plant. Continuous advances in biomass conversion technology has renewed interest in using crop residue as bio-fuel to complement energy need and this is borne from the concern about the security and continuous availability of fossil fuel (Glassner et al., 1999).

Alabama's water bodies are of particular interest in this study since they provide resources for economic activities in the state, particularly recreational fishing as tourist activity in the state and as economic activities providing new source of revenues for the economically depressed Black-Belt. Agriculture is also an important activity in the state of Alabama and it should be practiced such that non-source point pollution is reduced to maintain the water quality in the state without impairing the farmers' profits. To keep profits high, the farmers have to cultivate crops that are in high demand or crops that meet the national interest, such as meeting the ethanol demand as required.

Several studies have been done to measure the yields and energy potentials of crops like corn, perennial switch grass, perennial soybeans, and cotton, the main crops considered in this study (McLaughlin et al., 1999; Coelho and Dale, 1980; DiPardo, 2000; Glassner et al., 1999). There are however few studies that examine their environmental impacts, particularly with regard to water quality. The objectives of this paper includes the following; 1) to determine how to increase agricultural land that is dedicated to energy crop production, 2) determine how farmers' profit will be affected and maximized, 3) estimate the environmental effect of land-use change with regards to water quality, and 4) determine the best crop-mix to adopt during the ENSO phases, to optimize farmers profits without compromising water quality.

3.2 Limitations

The models and results presented in this study are from simulations and are therefore exploratory in nature. Much is unknown about how the potential evolution of production technology in the near future, and how the market would develop and react to the suggested changes. The models and results presented in this essay have not been fully tested in the study area for the chosen energy crops. The results should be seen as one of the initial steps in the analysis of the benefits and costs of large scale bio-ethanol and bio-diesel production without compromising the states' water resource. Although, this study makes use of actual farm output data from USDA, the simulated results may differ from situations on farmers' fields due to the following assumptions; 1) that the farmer adopts the best management practices and 2) the simulations are done under [3]conventional tillage.

3.3 Literature Review

Using ethanol to run automobiles dates as far back as 1908 in United States and was used until the 1920s and 1930s. This interest was renewed in the 1970s when crude oil supply became a national security issue and the United States started phasing out lead as an octane booster in gasoline. Another force driving the interest in ethanol has been the increasing price of crude oil and the fluctuating and volatile prices of farm commodities. United States ethanol production has been growing at the rate of 12 percent annually since 1980 (U.S. Department of Energy,2009). United States Renewable Fuel Association (RFA) (2008) also reports that the U.S. ethanol production is expected to grow in years ahead and the amount of land required to meet this demand will continue to be small compared to the world agricultural land use. Informa Economics also projected that the land required to produce 15 billion gallons of grain ethanol in U.S. in 2015 would be less than 1 percent of world cropland. A very good understanding of the changes in land use such as deforestation, crop choice and agricultural expansion are required to confront challenges in climate change, natural resource utilization, and energy production and consumption especially as it concerns indirect land use changes for bio-fuel expansion.

Coltrain (2004) reports that there are currently 56 ethanol producing plants in the United States, producing about two billion gallons of ethanol annually; the profitability of

[3] Conservational tillage is practiced in most part of Alabama (information confirmed from Professor Charlie Mitchell, Agronomy & Soils Extension specialist, Auburn University).

ethanol has been the driving force in this expansion. He explains that the return on investment in an ethanol plant was about 50 percent with ethanol priced at $1.77 per gallon in 2001. The current plan to eliminate methyl tertiary butyl ether (MTBE) from gasoline with the 1990 passage of the Clean Air Act Amendment by the congress will make ethanol more valuable as an octane booster in gasoline as it replaces the lost MTBE volume, because ethanol contains higher oxygen content than MTBE. The United States Department of Energy (DOE) also plans to reduce the currently high production cost of ethanol to 60 cents per gallon by 2015. All these factors should result in low cost biomass that will make ethanol competitive with gasoline and will better penetrate the market than it is currently doing.

DiPardo (2008) explains that the ability to produce ethanol from low-cost biomass will be important in making ethanol competitive with gasoline. Energy independence, Green House Gas (GHG) reduction, and clean air from vehicle emission are the three main drivers for increased ethanol production. This could call for an increased demand for dedicated crops to provide additional contributions to the United States' energy use mix. This increase in demand for energy crops would make them economically competitive with the traditional crops.

Duffy and Nanhou (2001) estimate the average annual cost of producing switch-grass in a watershed in Iowa. Their estimates show that it will cost about $187 per acre to produce 4 tons per acre of land while 6 tons per acre increases the production cost to $241. The break-even revenue for the switch-grass enterprise stands at about $110 per ton and this reduces to $82 per ton due to the increase in production cost. They speculated that switch-grass yield could substantially increase above these 2001 estimates with major breakthroughs in research.

Tembo et al. (2003) explain that the public policies that subsidize ethanol as a fuel substitute coupled with the use of additives that contain oxygen molecules that could improve the atmosphere. The 1990 Clean Air Act Amendments pushed for the use of alternative fuels or oxygenated fuels in cities with high carbon monoxide (CO). The U.S. Department of Energy (USDOE) made a discovery that methyl tertiary butyl ether (MTBE), one of the primary oxygenates contaminates ground water. This contaminated groundwater could end up in water bodies, reducing their qualities for recreation.

Ogg et al. (1983) evaluate the economic impact of alternative control of reaching a target quantity of phosphorus from nonpoint source phosphorus from croplands into the Greenlane reservoir near Philadelphia. They use a linear programming model to assess three different methods of control while maximizing the farmers' net return subject to resource constraints and the lower phosphorus level. They found 70 and 50 percent phosphorus reduction loads to be \$7 per kg and \$5 per kg respectively.

Intarapapong et al. (2005) compare nonpoint source pollution of different crop rotation practices for different tillage practices. They used Environmental Policy-Integrated Climate Model (EPIC) to predict the nonpoint source pollution and use the estimates in a farm level model of optimal profitability. Sensitivity analysis of reducing the pollutants at 15, 25, and 35 percent for net return optimization are conducted. Their study revealed that the marginal costs of sediment reduction range from \$1.61 to \$9.63 per ton, nitrate reduction range from \$1.21 to \$7.08, while phosphate reductions range from \$0.09 to \$31.91.

3.31 Energy Crops

Ugarte (2003) reports that agriculture is well positioned to become an important component in the strategy to develop and use alternative energy sources. Energy crops are crops that are specifically grown for their fuel value. They include food crops such as corn, soybeans, coconut, and sugarcane; and non-food crops like switch grass, cotton (cotton seed), and some woody crops like hybrid willow trees and hybrid poplar trees (Cottonwood). The prices of some food crops that have the potential to be used for bio-ethanol or bio-diesel crops have been reported as follows in $/lb units; corn oil was $0.232, peanut oil was $0.38, poppy seed oil was$1.39, tung oil was $0.65, linseed oil was $0.33, coconut oil was $0.275, cottonseed oil was $0.265, soybean oil was $0.21 (Duke, 1983). However, when compared to gasoline in the last decade, at about $2.00 per gallon, gasoline is roughly $0.25/lb. The energy crops considered in this study are corn, switch grass, soybeans, and cotton. These crops are more suited to the climate of Alabama and the study area in particular. Also, corn, cotton, and soy are among the first four crops that were successfully genetically modified, suggesting that they can be mass produced for alternative energy source.

3.32 Corn (*Zea Mays*)

Corn is grown extensively and used in very diverse ways. In the United States as in other parts of the world, it is used as grain or fodder for animal feeding, for human consumption as a vegetable such as corn-on-the-cob, fresh, canned or frozen and several forms of corn meals. It can also be converted into various substances which have a wide range of uses. Corn is essentially a subtropical plant, but will grow where summers are long enough to produce good vegetative growth. It is known to grow from 58°N to 40° S latitude and from altitudes below sea level to 4,000m and on a great variety of soil types. The average yield of sweet corn for the fresh market is about 8.75 MT/ha, ranging from 3.6 MT/ha to 10.75 MT/ha, depending on crop variety (cv) and area. It is the leading crop in the US, grown in every state on more than 40 million hectares, with a total production of approximately 1.3 billion pounds of fresh sweet corn, and billions of tons of grain corn and silage corn (Dibb, 1983).

Palz and Chartier, (1980) explain that a ton of dried corn would yield about 370 kg of ethanol with a residue coefficient of 1,300 kg/ha of corn stover after the ton of corn is harvested. They estimate that corn ethanol has an energy content of 28 [4]MJ/kg and an energy density of 28,000 MJ/m^3 leaving ethanol as one of the most attractive synthetic fuels compared with petrol which with 44 MJ/kg, 32,000 MJ/m^3. Shapouri et al. (2004, 2004) proved that the studies showing benefits of ethanol from corn are incomplete because some energy inputs in the ethanol production system are omitted. Apart from the air and water pollution caused by ethanol producing plants, U.S. corn production causes more soil erosion than other crops because it uses more herbicides and insecticides to achieve an expected high yield (Pimentel and Patzek, 1995: National Academy of Science (NAS), 2003). According to Hitzhusen and Abdallah (1980), the economic feasibility of utilizing corn stover as a coal supplement in small to medium-sized, coal-burning steam-electric plants appears promising, particularly when the low sulphur emission value of corn stover is considered.

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[4] MJ= Megajoules. Joules is measure of energy and 1 joule is equivalent to 0.2388 calories or 0.0009481 Btu.

3.33 Switch Grass (*Panicum virgatum*)

This is a perennial-warm season grass that is genetically diverse with lowland and upland varieties. It has the highest potential for ethanol production due to its ability to adapt to a wide range of growing conditions (Walsh et al., 2009). Duffy and Nanhou (2002) report that switch grass is normally grown on marginal lands that are not well suited for conventional row crops, but is now being recognized as a potential energy crop and an alternative cash crop. It also grows well with moderate inputs and is known to reduce and sometimes prevent adverse soil erosion. The wide acceptance choice of switch grass will really depend on its profitability when compared to other crops in terms of land allocation. Samson et al. (2004) estimated that the average energy per hectare of switch grass production is about 3.8 million kcal annually and suggested that each kcal of fossil energy invested returns about 11 kcal as switch grass bio-fuel. If the fuel is pelletized, and used as fuel in stoves, each kcal invested returns 14.6 kcal.

Walsh et al., (2003, 2009) examined the economic impacts of bio-energy crops in the United States. Using POLYSIS, an agricultural policy simulation model, they found that at a farm gate price less than $44/dry MG (switch grass), nearly 17 million hectares of agricultural cropland in U.S. could produce bio-energy crops at a profit greater than the existing agricultural use. The energy crop stands to increase farm income by about $6 billion over a 5 year period. For all the crops included in their analysis that includes corn, grain sorghum, wheat, soybeans, and cotton; switch grass was found to be the most profitable bio-energy crop.

3.34 Soybeans (*Glycine Max*)

The soybean is a subtropical plant, with cultivation that extends from the tropics to 52°N. Soybeans can be grown on marginal land that is not very suitable for row crops; it grows better than many crops on soils that are low in fertility, droughty or poorly drained. The seeds serve as one of the world's most important sources of oil and protein and yield edible, semi-drying oil, used as salad oil and for manufacture of margarine and shortening. Soybean oil is used industrially in the manufacture of paints, linoleum, oilcloth, printing inks, soap, insecticides, and disinfectants. In the United States, it has its greatest development in the Corn-Belt and does not usually survive excessive heat or severe winters (Duke, 1993).

Soybeans are known to contain the proper nitrogen-fixing bacteria and its yields increase yearly when grown on the same land for 2–3 successive years. Pimentel and Patzek (2005) reports that soybeans can be grown with zero nitrogen fertilizer, one of the most energy costly inputs in crop production. Their report shows that on average, one hectare of land yields 2,668kg of soy, which requires about 3.7 million kcal energy input to produce oil with total energy output of 11.2 million kcal. Bio-diesel costs $1.21 per kg, making it about 2.8 times as expensive as diesel fuel, but it has less green house gas (GHG) effect than fuel diesel. The perennial nature of the crop also makes it an environmentally good, leaving the soil undisturbed for a longer period, thereby reducing runoffs and soil erosion. Lipinsky et al. (1981) report that "Soybean oil, due to its availability and low cost relative to the other seed oils, is viewed as having the most potential as an emergency diesel fuel substitute in the near term."

3.35 Cotton (*Gossypium hirsutum*)

Cotton is believed to have originated in Central America and introduced into the United States in the 1700s. Pryde and Doty (1981) and Parnell (1981) estimate the average oil yield from cotton seed at only 140 kg/ha while the average annual yields of cottonseed in U.S. vary from 800–950 kg/ha. It is tolerant of a wide variety of soils, but thrives best on deep, friable, moisture-holding soils with good humus supply. Cotton is cultivated primarily for its vegetable seed fiber; the raw material for a large volume of textile products, this species is considered the most important of the cotton-yielding plants, providing the bulk of commercial cottons. Cottonseed oil is a vegetable oil extracted from the seeds of the cotton plant after the cotton lint has been removed. Cottonseed oil is semi-drying and edible oil, used in shortening, margarine, salad and cooking oils, and for protective coverings (Duke, 1993).

3.4 Data and Methods

The software packages used in this essay are APEX, EPIC, GAMS/SAS. The soil and weather data for this study are obtained from black-land research center. The weather data covers a 32 year period from 1979 to 2010. Agricultural input cost and output price data for the four crops considered in this study are obtained from the Economic Research Service (ERS), USDA; and the 2007 subsidy data are obtained from the Environmental Working groups' farm subsidy data.

Following Ho et al (2007) Kelly Creeks' watershed divided into 77 sub-watersheds based on land use and soil type using SWAT. Their study identified the four major crops suitable for the watersheds as cotton, corn, peanut, and soybeans and examined the outcome of 6-8 months climate forecast on the farmers' profits. Kelly

Creek watershed is in Dale County, Alabama. Kelly is a community located substantially outside the boundaries of any incorporated place in Dale County, Alabama, centered at latitude 31.324 and longitude 85.655. The whole water shed covers an area of 4,146.4 hectares within a larger Choctawhatchee watershed. The elevation is 167 feet above sea level and it is characterized by several narrow streams that divide the entire community into several watersheds. A map of the Kelly Creek watershed, showing its location and coverage is shown in Figures 3.1 and 3.2.

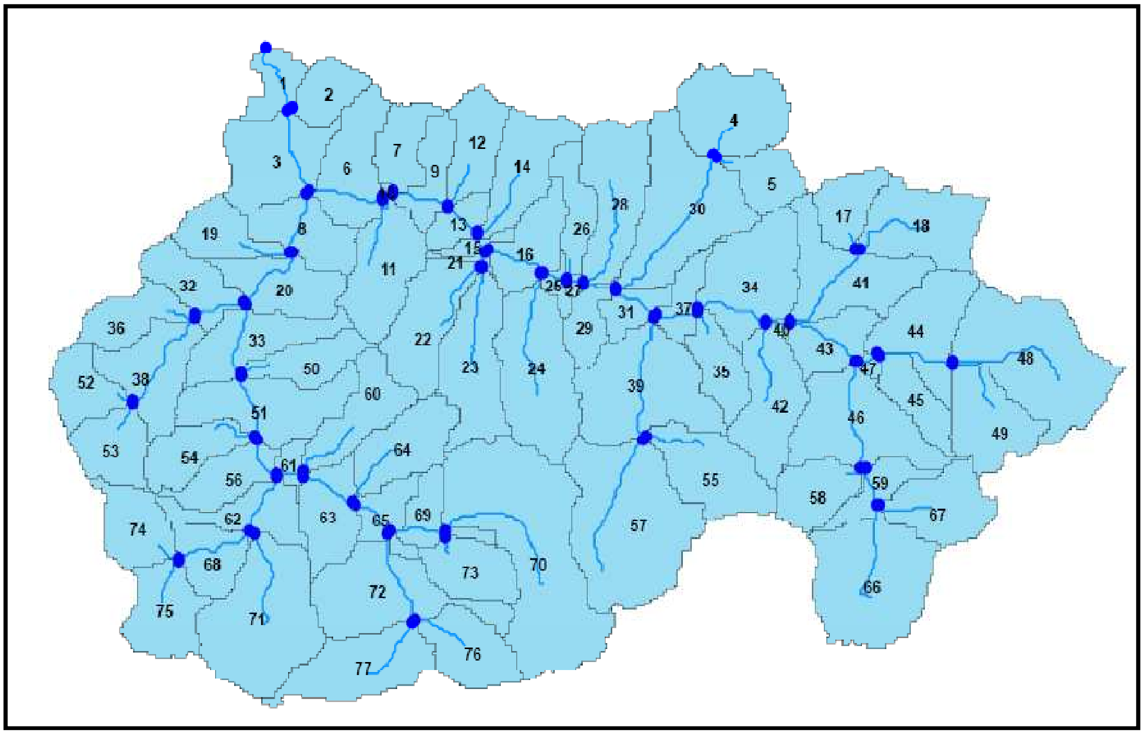

Figure 3.1: Map of Kelly Creek showing the 77 sub-watersheds

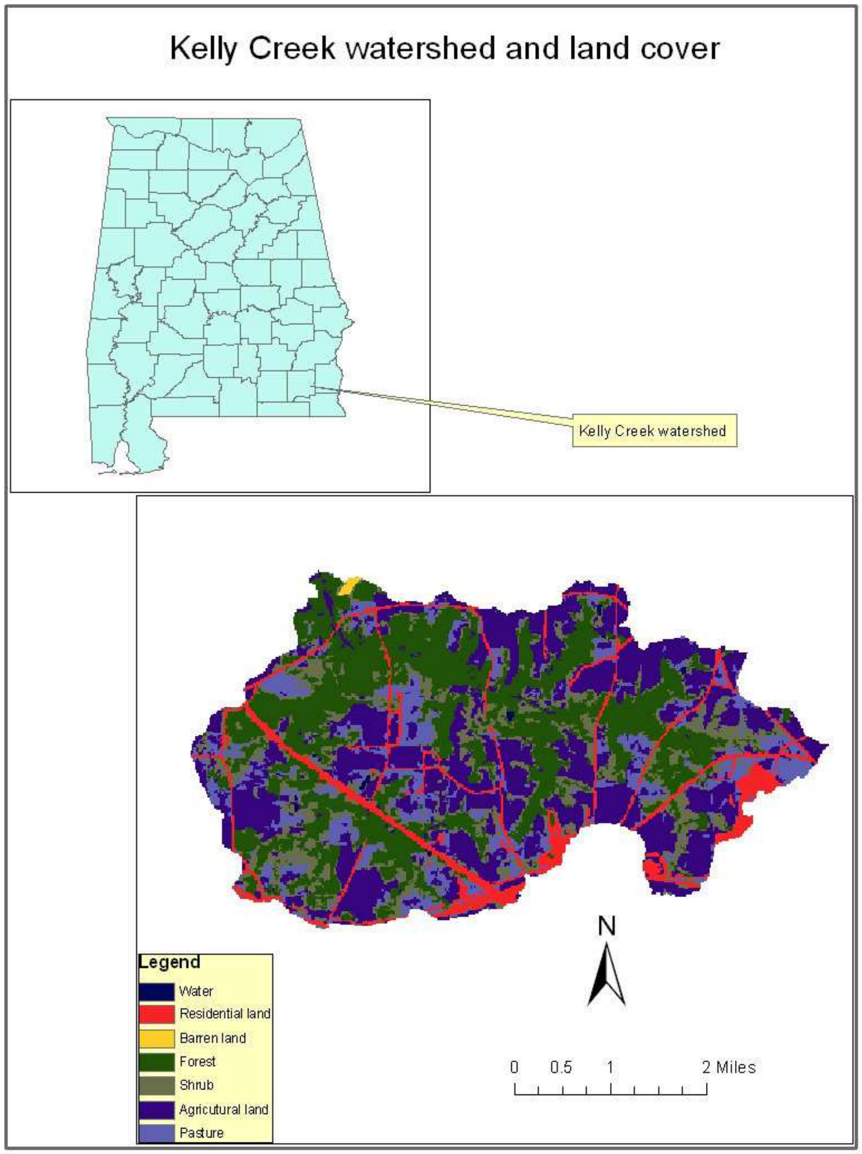

Figure 3.2: Map of Kelly Creek watershed and land cover (courtesy: Ho et al., 2006)

This study is extended by changing the baseline, historical agricultural use of each sub-watershed in the Kelly Creek into a monoculture of energy crop production. The baseline refers to the current conditions in the watershed based on the current cropping mix and land-use in Kelly Creek. Sediment loss and nutrient loss for the baseline are then compared to those associated with planting energy crops in the agricultural sub-basins. The environmental impacts of these activities are examined by changes in runoffs of nitrogen, phosphorus, and total sediments loss under the different cropping regimes.

To achieve the objectives of this study, a three stage modeling approach is adopted for the study area. The first two stages are biophysical models, and the third stage is an economic model.

3.5 Biophysical Model

First, a bio-physical simulation model of traditional crops in Kelly Creek, the study area, is done with Agricultural Policy Environmental Extender (APEX), to get crop yields, soil nutrients (nitrogen and phosphorus) losses, and sediments losses through runoffs and erosion. The APEX model is developed for use in whole farm/small watershed management and it evaluates the various land management strategies considering sustainability, erosion, economics, water supply and quality, soil quality, plant competition, weather and pests. This model thus assumes the best management practices for the crops used in this study. The model uses daily weather variables like temperature, rainfall, wind speed, solar radiation, and humidity over the 32 year period from 1979 to 2010. The 77 watershed sub-division by Ho et al. (2007) is followed and the model uses the soil types, drainage, and landscape positions in the watershed to assign the crops that best fit each sub-watershed. The bio-physical model (APEX) estimates the crop yields and the environmental effects determined by the nutrients, nitrogen and phosphorus, run-offs; and sediments that are lost from the soil and end up in ground water and other surrounding water bodies as non-point pollution source.

The modeling is first done for the traditional crops, cotton, peanut, and soybeans in the watershed. The traditional crops are then removed and the watershed is cropped with energy crops, corn, cotton, soybeans, and switch-grass. These crops are traditional to the study area and the newly introduced crop, switch-grass, is known to grow well on marginal soils and can easily be adapted to the study area. The crop yields and nutrient and sediment losses are compared under these scenarios. Using the input cost and price data for the crops in the study, the profits for these crops are calculated for the traditional crops and the energy crops.

The second stage involves the investigation of how climate change affects crop yields. To do this, a similar type of bio-physical simulation is carried out using four weather scenarios; normal weather, neutral weather, and under the ENSO phases of El Nino and La Nina. Normal weather refers to a scenario that includes both El Nino and La Nina events over the simulation period. The El Nino event is characterized by higher than average sea surface temperatures in the central and eastern equatorial Pacific Ocean, and an eastward shift in intense tropical rainfall. When these occur, the average minimum temperatures are higher. La Nina events are the exact opposite, cooler than average sea surface temperatures, stronger easterly trade winds, and a westward shift in tropical rainfall. These create the cool phase of the ENSO, resulting in cooler minimum temperatures. Neutral periods, usually referred to as the ENSO-neutral periods, are years when the deviations from the equator are not statistically significant from the average conditions. Each of the ENSO phases usually last between 6 to 18 months (Climate Impact Group, 2007).

3.6 Economic Model

Bio-energy crops compete for fixed resources, and land area, not only with traditional crops, but with each other as well, with greater allocation to the most profitable crop given the profit and pollution constraints. This competition brings about the third stage of this analysis which involves the use of a linear programming to optimize the possible profits while constraining the agricultural nutrients and sediments that could pollute or reduce the quality of the water bodies that serve for domestic uses and recreation. The optimization model helps to efficiently allocate the land use to the crops based on their profitability and pollution levels. It is assumed that farmers will not be willing to switch from traditional land uses if the resulting outputs will impair their economic profits. The optimization model combines the outputs from the biophysical model from APEX, crop yields, nutrients and sediments from runoffs and erosion with the cost, and market price data to determine the optimal use of the watershed with regards to energy crop production.

For effective optimization, the third stage uses the General Algebraic Modeling System (GAMS), which is a high-level modeling system for mathematical programming and optimization (Rosenthal, 2008). It is used to maximize the profit of the farmer subject to constraints like land area in each watershed, costs, and sediment loss, nitrate loss, and phosphate loss from the area when crops that can be used to produce ethanol are planted in place of the traditional crops in this watershed. The model then determines the margin of production for each energy crop and then allocates the optimal area for their production.

Given that the land available in the watershed is fixed, the optimization is likened to a social planner who wants to maximize the social welfare of the farmers for producing bio-energy crops. The social planner will attempt to achieve a Pareto optimal outcome where the farmers' (social benefit) profits are not impaired while the nutrient runoff into groundwater and other water bodies from the application of nitrate and phosphate fertilizer application is reduced. In addition to the assumption that the farmers' profits depend on bio-energy crops, the weather scenario during each planting season also dictates the crop level activity.

Thus, the objective function of the social planner is to optimize the profit of the farmer given the crop combination, their prices, the operating cost, each crop's activity (land coverage) level and current subsidy available to the crops.

The optimization model is then set as follows

(1) $$max\_\Pi = \sum_{w}\sum_{c}\left[\left(P_c Y_{w,c} - (OC_c - SS_c\right)\right] \cdot X_{w,c}$$

Subject to:

(2) $$\sum_{w}\sum_{c} X_{w,c} \leq Total\_Land$$

(3) $$\sum_{w}\sum_{c} Sediment_{w,c} \leq Threshold\_Value_{switchgrass}$$

(4) $$\sum_{w}\sum_{c} Nutrient_{w,c} \leq Threshold\_Value_{switchgrass}$$

(5) $$\sum_{w}\sum_{c} Runoff_{w,c} \leq Threshold\_Value_{soybean}$$

$$X_{w,c} \geq 0$$

where Π is a vector of profits when the all the agricultural lands in all the watershed are each planted with the bio-energy crop in dollars ($), Y is a vector of crop yields in tons per hectares, P is a vector of crop prices in dollars ($), OC is a vector of operating cost in the production of each crop in dollars ($), X is a choice variable that represent the crop activity levels in hectares (Ha), SS represent the subsidies for each crop to make them profitable in dollars ($). The operating cost and price data are those of the Southern Seaboard, which particularly have similar operating cost as the Kelly Creek.

Sediments are particulate materials that are transported by flowing water during runoffs. The quantities transported differ depending on the type of crop that is planted and the ability of the crop to keep the soil bonded. The sediments and nutrients are the most common nonpoint-source pollutants of water bodies. They are transported by runoff during rainfall or irrigation and contaminate drinking water or spawning water for fish. Sediments and nutrients are measured in tons per hectare (T/Ha). Sediments that are transported end up as suspended particles in water bodies or as layer(s) of solid particles on the bottom of a body of water. Nutrients refer to soil/crop nutrients that are applied during crop cultivation. The most common are from nitrate and phosphate fertilizers that are not completely used up by the plants. The subscript, w, refers to the 66 sub-watershed that are planted, while c, refers to the crop that is/are planted on the sub-watershed.

For this study, farmers' profits are optimized while constraining the nitrogen, phosphorus, and sediments to that of the energy crop that produces the least level of these non-point source pollutants. The aim is to examine the possible profits to the farmers while minimizing environmental damages when the traditional use of the land is changed, specifically focusing on energy crops and taking into consideration the impacts of ENSO phases. This focus on energy crops and aspect of the impacts of the ENSO phases make this study different from other similar studies that have investigated the non-point source pollution reduction and farmers profitability with alternative practices, using experimental data or simulation models.

3.7 Bio-physical Simulation Results

Kelly Creek watershed is divided into 77 sub-watersheds, but traditionally, only 34 of the sub-watersheds are used for the cultivation of crops while others are dedicated to forest and shrubs. The agricultural land in the 34 sub-watersheds covers a total of 2,472 hectares, which is about 59 percent of the total watershed. The result of the crop yields from the traditional land-use is presented in table 3.1. The table shows the results from the first stage of the bio-physical simulation with APEX. The simulation reveals that peanuts, cotton, and soybeans are the three crops that are in the baseline crop-mix, their yields, sediments, and nutrient loss.

The aim is to be able to compare these outputs with those of the biophysical simulation, when the sub-watersheds are stripped and then mono-cropped with each of the energy crops in this study. All the results presented are averages for 32 years, the study period from 1979 to 2010.

Table 3.1: Details of Sub-watersheds in the baseline

Sub Area ID	CROP	CROP Yield (T/HA)	Area (HA)	Runoff (mm)	Sediments (T/HA)	P transported (T/HA)	N transported (T/HA)
4	PNUT	3.4	76.03	320	8.691	0.011058	0.007281
5	SOYB	2	31.86	172	9.036	0.002024	0.007292
14	SOYB	2	60.14	71	1.463	0.000549	0.003395
17	PNUT	3.4	34.48	320	10.325	0.01208	0.00757
18	PNUT	3.4	75.16	311	5.802	0.009258	0.006605
23	PNUT	3.4	77.35	327	11.031	0.01278	0.007818
24	SOYB	2	101.11	184	14.938	0.002947	0.009057
26	SOYB	2	32.73	182	13.142	0.00268	0.00851
28	SOYB	2	77.13	64	0.736	0.000375	0.002252
30	SOYB	2	117.08	72	1.166	0.000515	0.003397
34	SOYB	2	85.8	186	14.307	0.00285	0.009207
35	PNUT	3.4	36.23	330	14.808	0.014572	0.008248
39	PNUT	3.4	113.72	326	10.05	0.012061	0.008355
41	SOYB	2	83.11	182	12.713	0.002661	0.009724
42	PNUT	3.4	70.57	326	11.115	0.012591	0.00785
48	PNUT	3.5	131.58	337	12.781	0.014083	0.009124
50	SOYB	2	36.96	71	1.603	0.000581	0.003453
51	SOYB	2	78	69	1.216	0.000514	0.002944
52	PNUT	3.4	36.89	324	11.703	0.012613	0.007808
53	PNUT	3.4	44.18	315	7.541	0.010149	0.006948
54	SOYB	1.9	40.97	63	1.005	0.000289	0.001906
55	PNUT	3.4	69.04	318	6.679	0.009976	0.006896
57	COTP	0.9	157.46	434	21.563	0.01248	0.012074
58	PNUT	3.5	40.09	338	16.15	0.015398	0.009305
59	PNUT	3.5	25.95	346	20.251	0.017807	0.009984
60	SOYB	2	53	169	7.245	0.001808	0.006792
64	PNUT	3.4	56.35	329	9.999	0.012075	0.007665
66	PNUT	3.4	116.2	311	4.264	0.008238	0.006116
67	PNUT	3.5	55.99	335	12.792	0.013587	0.008965
70	PNUT	3.4	196.76	314	4.807	0.008859	0.006399
72	SOYB	2	97.47	67	0.941	0.000443	0.00302
73	PNUT	3.4	44.83	327	10.557	0.012192	0.00773
74	PNUT	3.4	44.98	318	7.212	0.010141	0.007035
77	PNUT	3.4	73.19	320	7.327	0.010382	0.007167
Total		**95.2**	**2472.39**	**8478**	**304.959**	**0.270616**	**0.237892**

Table 3.2: Total Output for the Watershed (Normal weather)

	Total yield (tons)	Sediments (tons)	N in Runoff (tons)	P in Runoff (tons)	N in Sediments Transported (tons)	P in sediments Transported (tons)
Base	6780.2360	29.4286	5.0645	7.6946	13.0859	12.1272
Corn	20590.4390	61.2619	5.8773	48.1457	25.6497	16.2919
Cotton	3030.8390	50.6849	4.8509	7.4037	21.6707	21.1542
Soy	7200.7830	19.0556	1.9170	0.9764	18.4475	4.1709
Switch grass	5550.2160	14.5129	3.3272	3.8782	9.4763	3.8437

Table 3.3: Average Output per sub-watershed (SW) or sub-area (SA)

	Average yield (t/SA)	Sediments (t/SA)	N in Runoff (t/SA)	P in Runoff (t/SA)	N in Sediments Transported (t/SA)	P in sediments Transported (t/SA)
Base	199.4187	0.8655	0.0767	0.1166	0.1983	0.1837
Corn	311.9763	0.9282	0.0890	0.7295	0.3886	0.2468
Cotton	45.9218	0.7680	0.0735	0.1122	0.3283	0.3205
Soy	109.1028	0.2887	0.0290	0.0148	0.2795	0.0632
Switch grass	84.0942	0.2199	0.0504	0.0588	0.1436	0.0582

Table 3.4: Profit scenarios in Normal Weather

CROP	Total Profit ($)	PROFIT/SW ($)	PROFIT/Ha ($)
Base	3,576,775.17	105,199.27	1,446.69
Corn	6,700,334.75	101,520.22	1,872.84
Cotton	439,471.66	6,658.66	122.84
Soybeans	2,545,188.76	38,563.47	711.42
Switch Grass	421,816.42	6,391.16	117.90

Using the soil information from USDAs' Natural Resource Conservation Service, a total of 66 sub-watersheds in the area could be planted with these energy crops. The 66 sub-watershed covers a total are of 3,577.63 hectares, which is 86.3 percent of the total watershed. The results of the crop yields, nutrient losses, sediments, runoffs, and possible profits under the normal weather conditions are presented in table 3.2 and table 3.3 for the total watershed and average per watershed respectively.

The results in tables 3.2 and 3.3 represent outputs under the normal weather conditions for the 32 year period, it includes La Nino phases, La Nina phases, and ENSO neutral phases, occurring at different times over the entire period.

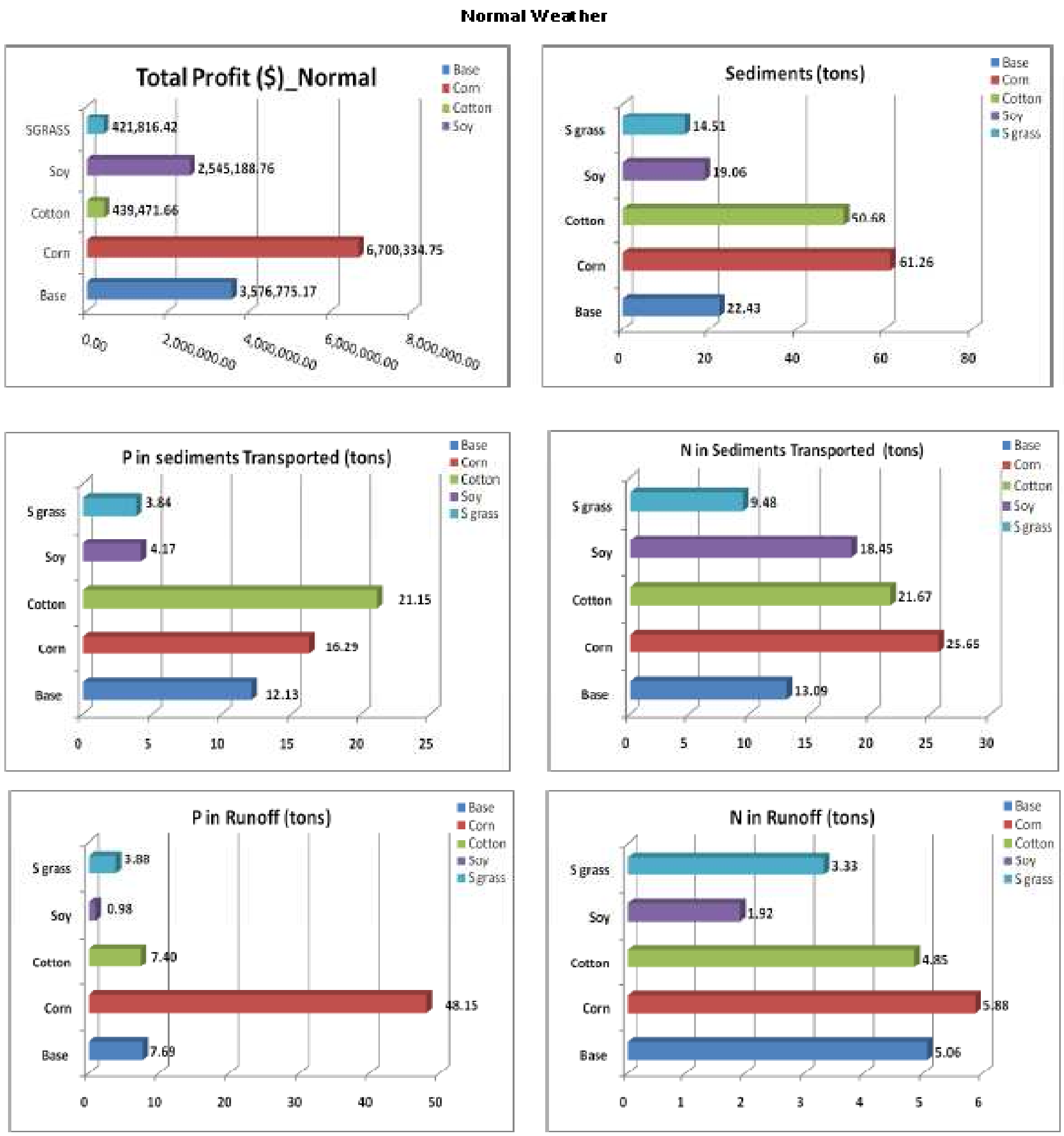

Figure 3.3: Graphs Showing the Outputs and Profits under Normal Weather

The results show that corn gives the highest yield in tons and also as the most profitable in table 3.4, using the 2008 prices. Corn is also shown to pollute the most with respect to the nonpoint source pollutants. Switch Grass is the least profitable and the least pollutant. The base shows the current level of output, pollution, and profits, with a crop mix that includes cotton, soybeans and peanuts. These results are shown in the graphs in figure 3.3.

Given that farmers will plant crops under different weather conditions during the ENSO phases, the simulation is also done under the assumption of El Nino, La Nina, or ENSO neutral conditions, with each being the only phase for the entire 32 year period. To do this, EPIC crop weather analyzer is used to change the weather variables under these different conditions and the crop yields, nonpoint source pollutants, and profits are simulated using APEX. The results are presented in tables 3.5, 3.6, and 3.7, and in graphs 3.4, 3.5, and 3.6 below.

Table 3.5: Total Output for the Watershed in Different ENSO Phases

EL NINO	**Total yield (tons)**	**Sediments (tons)**	**N in Runoff (tons)**	**P in Runoff (tons)**	**N in Sediments Transported (tons)**	**P in sediments Transported (tons)**
Corn	24921.8150	37.0579	3.3718	28.1306	14.0618	6.3469
Cotton	2697.5990	41.6511	3.7122	6.3008	14.0210	21.5354
Soy	11382.0640	5.0183	1.1343	0.6527	11.7953	1.8554
Switch grass	5020.1410	7.3904	1.6897	2.3594	0.0247	3.1271
LA NINA	**Total yield (tons)**	**Sediments (tons)**	**N in Runoff (tons)**	**P in Runoff (tons)**	**N in Sediments Transported (tons)**	**P in sediments Transported (tons)**
Corn	26701.6580	13.7588	1.8906	12.5779	8.1407	3.3893
Cotton	3614.6350	20.7762	1.5275	3.3109	12.4949	6.5986
Soy	8827.0020	2.2201	0.6023	0.2932	6.7700	1.9411
Switch grass	5617.4970	3.5984	0.9754	1.4310	0.0167	1.7721
NEUTRAL	**Total yield (tons)**	**Sediments (tons)**	**N in Runoff (tons)**	**P in Runoff (tons)**	**N in Sediments Transported (tons)**	**P in sediments Transported (tons)**
Corn	22609.8410	33.5531	3.9106	22.8144	18.2777	12.4999
Cotton	2473.3000	35.1595	3.9741	5.1497	13.8923	15.1680
Soy	8728.5860	4.9421	0.9894	0.5329	2.9461	1.8443
Switch grass	5184.6330	6.7197	1.7194	2.2616	0.0222	2.8958

Table 3.6: Average Output for the Watershed in Different ENSO Phases

EL NINO	Average yield (t/SA)	Sediments (t/SA)	N in Runoff (t/SA)	P in Runoff (t/SA)	N in Sediments Transported (t/SA)	P in sediments Transported (t/SA)
Corn	377.6033	0.5615	0.0511	0.4262	0.2131	0.0962
Cotton	40.8727	0.6311	0.0562	0.0955	0.2125	0.3263
Soy	172.4555	0.0760	0.0172	0.0099	0.1787	0.0281
Switch grass	76.0627	0.1120	0.0256	0.0357	0.0004	0.0474
LA NINA	**Average yield (t/SA)**	**Sediments (t/SA)**	**N in Runoff (t/SA)**	**P in Runoff (t/SA)**	**N in Sediments Transported (t/SA)**	**P in sediments Transported (t/SA)**
Corn	404.5706	0.2085	0.0286	0.1906	0.1233	0.0514
Cotton	54.7672	0.1633	0.0231	0.0502	0.1984	0.0999
Soy	133.7425	0.0336	0.0091	0.0044	0.1026	0.0243
Switch grass	85.1136	0.0545	0.0148	0.0217	0.0003	0.0269
NEUTRAL	**Average yield (t/SA)**	**Sediments (t/SA)**	**N in Runoff (t/SA)**	**P in Runoff (t/SA)**	**N in Sediments Transported (t/SA)**	**P in sediments Transported (t/SA)**
Corn	342.5733	0.5084	0.0593	0.3457	0.2769	0.2348
Cotton	37.4742	0.5327	0.0602	0.0780	0.2014	0.2299
Soy	132.2513	0.0749	0.0150	0.0081	0.0446	0.0279
Switch grass	78.5550	0.1018	0.0261	0.0343	0.0003	0.0439

Simulations under the different weather scenarios also show corn to be the most profitable and the highest nonpoint source pollutant. Switch grass is the most environmentally friendly, based on the content of nitrogen and phosphorus in the sediments and runoffs, but it is the least profitable. It also shows that when soybean is cultivated, the watershed experiences the least runoffs and it is the next profitable next to corn, using the 2008 crop prices. These results are presented in table 3.7, and are shown the graphs in figure 3.4, 3.5, and 3.6, under the different ENSO phases.

The low levels of sediment removal and runoff with switch grass and soybean is because they are perennial crops and the soil has little or no disturbance when they are planted. Corn and cotton on the other hand are annual crops which encourage soil disturbance that result in higher sediments and increased runoffs. Corn and cotton also need high levels of nitrate and phosphate fertilizers. The fertilizers leave residues that are transported as nonpoint source pollutions to water bodies or get leached into ground water causing contamination.

Table 3.7: Profits for the Watershed in Different ENSO Phases

CROP (El Nino)	Total Profit ($)	PROFIT/WS ($)	PROFIT/Ha ($)
corn	8,109,558.60	122,872.10	2,266.74
Cotton	393,040.17	5,955.15	109.86
Soy	4,023,104.34	60,956.13	1,124.52
SGRASS	381,530.72	5,780.77	106.64
CROP (La Nina)	**Total Profit ($)**	**PROFIT/WS ($)**	**PROFIT/Ha ($)**
corn	8,688,719.51	131,647.27	2,428.62
Cotton	526,652.32	7,979.58	147.21
Soy	3,119,992.13	47,272.61	872.08
SGRASS	426,929.77	6,468.63	119.33
CROP (Neutral)	**Total Profit ($)**	**PROFIT/WS ($)**	**PROFIT/Ha ($)**
Corn	7,357,242.26	111,473.37	2,056.46
Cotton	360,359.81	5,460.00	100.73
Soy	3,085,206.01	46,745.55	862.36
S grass	394,032.11	5,970.18	110.14

3.8 Bio-economic Simulation Result

For the final stage of the simulation, the profit of the farmer is optimized subject to the size of agricultural land in the watershed. The sediment is constrained to the least level, produced by planting switch grass; the least level of nutrients (nitrogen and phosphorus), also produced by planting switch grass; and the least level of runoff, which is achieved by planting soybeans. The optimization allocates the watershed to the crops based on their profits and pollution levels. The optimization is done under the different ENSO phases as the profitability and pollution levels differ under these phases. This allows the farmer to determine the best crop mix to adopt depending on the ENSO phase that presents itself.

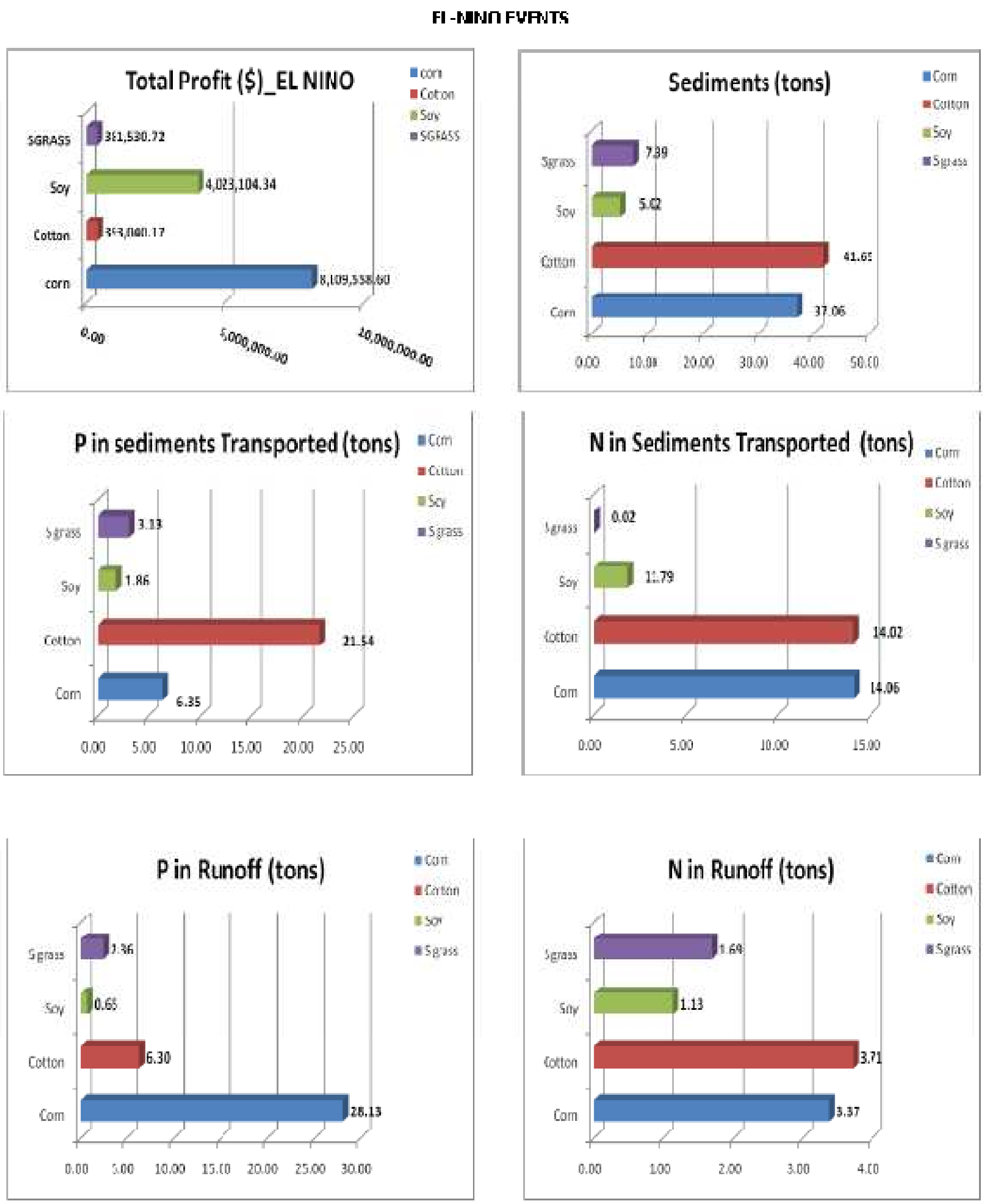

Figure 3.4: Graphs Showing the Outputs and Profits under El Nino Weather

LA-NINA EVENTS

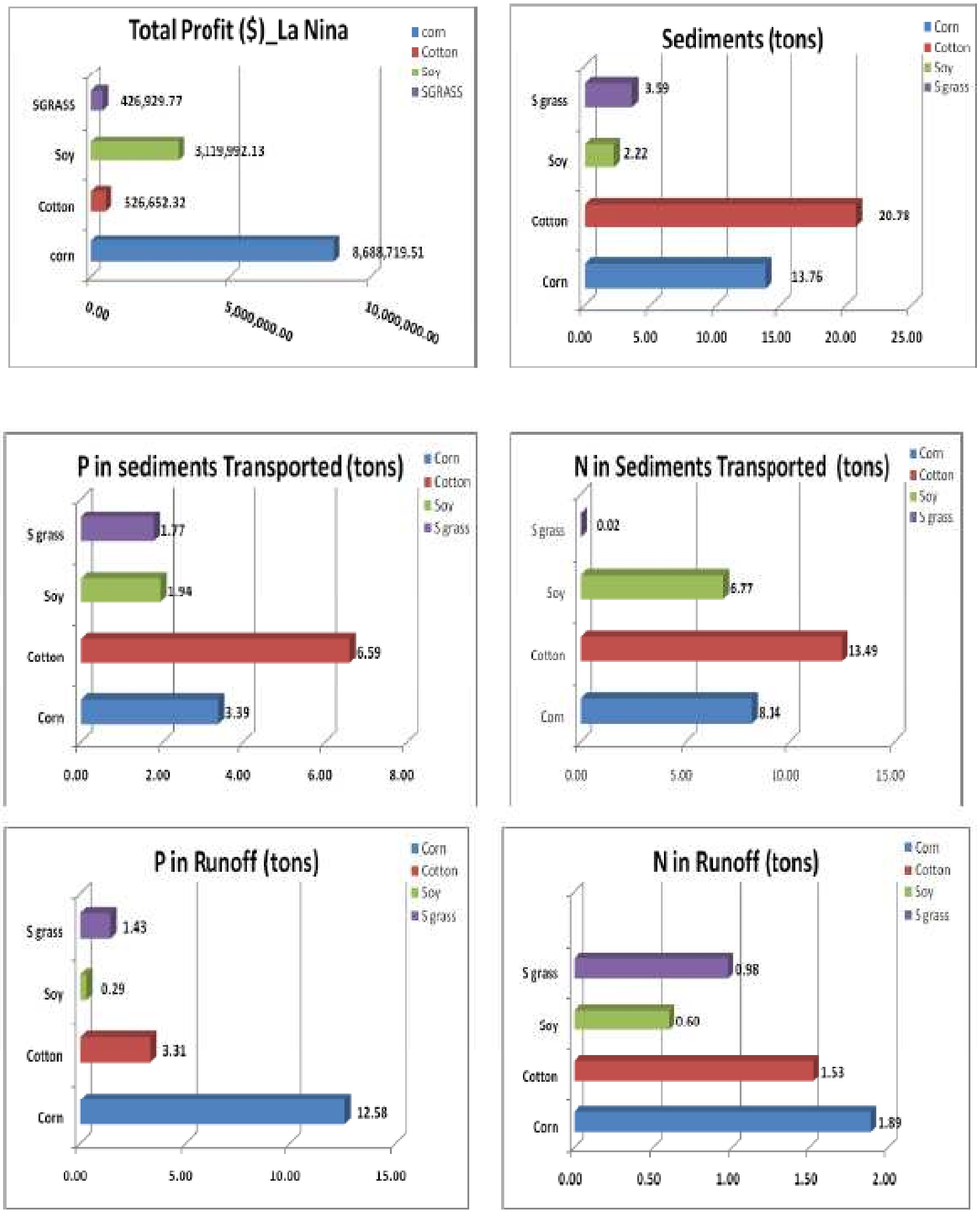

Figure 3.5: Graphs Showing the Outputs and Profits under La Nina Weather

NEUTRAL EVENTS

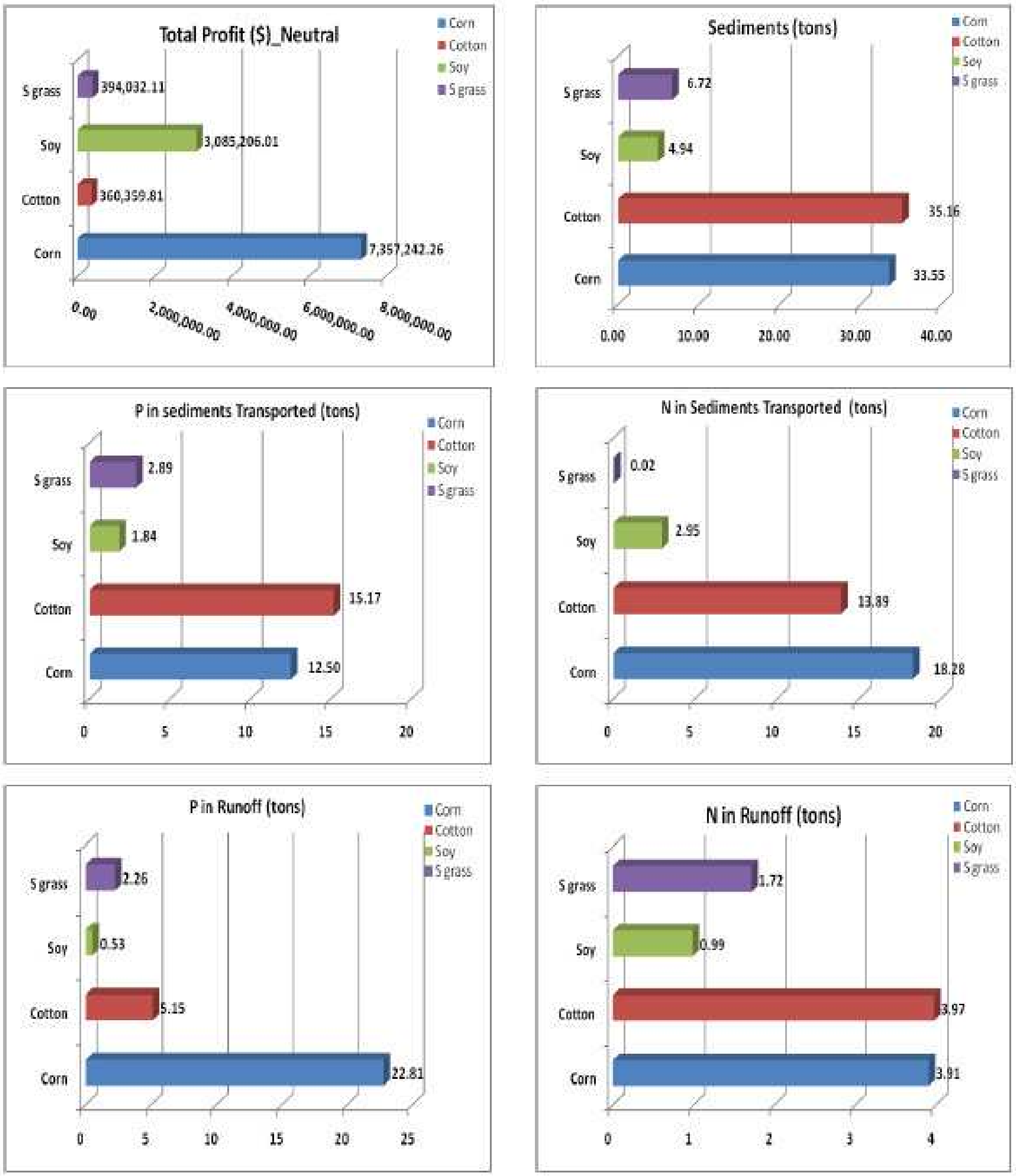

Figure 3.6: Graphs Showing the Outputs and Profits under Neutral Weather

The optimization model in this study differs from other studies that constrain nonpoint source pollutants to different percentages of the observed levels at the baselines. Hite et al. (2005) reduce the nitrogen and sediment runoffs to 20 and 80 percent levels and found that the profit increase by 6 and 40 percent respectively for the nitrogen and sediment constraints. Intarapapong et al. (2005) constrain the sediment and nitrate levels to 15, 25, and 35 percent to find that the nitrate reduction policy is less costly than sediment reduction policy. The optimization in this study constrains the nonpoint source pollutants to the minimal levels of each crop that is currently being cultivated and allows the model to allocate each crop's activity in the watershed based on their profitability and pollution levels.

The possible profits and land allocation under the different weather scenarios are presented below in Figures 3.7 and 3.8 respectively.

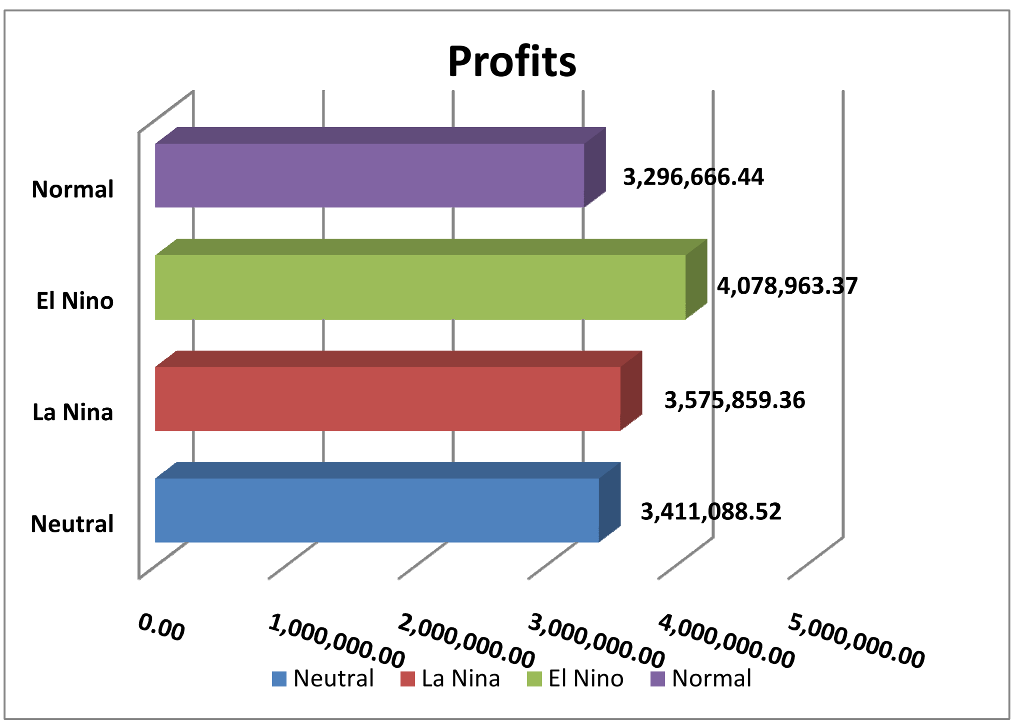

Figure 3.7: Graphs Showing Possible Profits under Different Weather scenarios

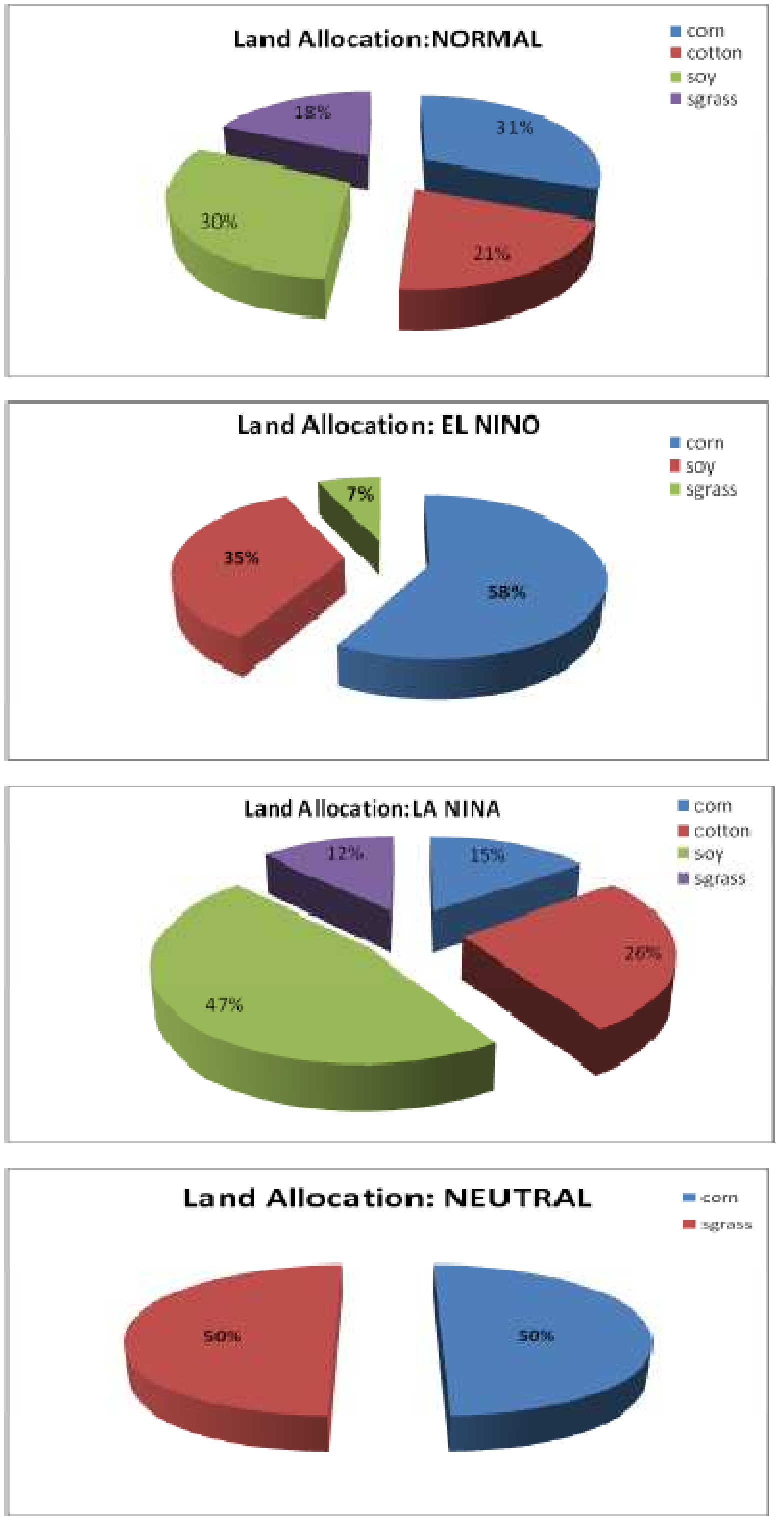

Figure 3.8: Possible Watershed Land Allocations in Different ENSO Phases

The optimized results for the 32 year study period show that it is possible to constrain the annual nonpoint source pollution in the watershed to the level of sediments by switch grass, the level of nitrate and phosphate (nutrients) pollution caused by switch grass, and the level of runoffs allowed by soybean. To achieve this minimal level of pollution, the crop mix and land allocation are as shown in figure 3.8. Under the normal weather, which comprises all the ENSO phases, the average annual profit is reduced from $3,576,775.17 to $3,296,666.44 if the watershed is allocated to 31 percent corn, 30 percent soybean, 21 percent cotton and, 18 percent switch grass. This crop mix causes the profit to be reduced by $280,108.73, a 7.80 percent reduction. In terms of the nonpoint source pollution reduction, the minimum sediment loss by switch grass is 14.51 tons compared to unconstrained 29.43 tons, when the optimized crop mix is not adopted. This translates to a 50.69 percent reduction in sediment pollution. The nitrogen and phosphorus in the sediments when constrained are 9.46 tons and 3.84 tons compared to 13.09 tons and 12.13 tons respectively when unconstrained. These translate in to 27.57 percent and 68.34 percent reductions in nitrogen and phosphorus respectively. The reduction in nonpoint source pollution is a big gain when compared to the 7.80 percent in reduced profit.

For the El Niño periods, the watershed should be allocated to 58 percent corn, 35 percent soybean, and 7 percent switch grass, to achieve a profit level of $4,078,963.37. Under the La Niña scenario, the watershed is allocated to 47 percent soybean, 26 percent cotton, 15 percent corn, and 12 percent switch grass, to achieve a profit of $3,575,859.36. In ENSO neutral weather scenarios, the watershed is allocated to 50 percent corn and 50 percent switch grass, which gives a profit level of $3,411,088.52. These profit levels are higher than what is possible with the current crop mix in the watershed and they all result in the reduction in the nonpoint source pollution in the watershed. However, for the 32 year period in which the simulation is formed, the normal scenario and the ENSO neutral scenarios had the highest recorded occurrence, while the El Niño or La Niña had fewer recorded occurrence during the 32 years. The results presented in this study provide insights to the best ways to plan and mix crops with specific focus on energy crops for the farmers without any adverse effects on their incomes.

3.9 Conclusion

This study examined the economic and environmental impact of agricultural land use change with respect to maximizing the farmers' profits while reducing the agricultural nonpoint source pollution caused by agricultural practices. Using the linear programming algorithm in GAMS, the study shows that by dedicating more agricultural land to energy crops, particularly switch grass and corn for bio-ethanol production, and soybeans for bio-diesel production, the non-point source pollution could be reduced without adverse impact on the farmers' profits. With the agricultural prices of 2008, these crops command market prices that enhance profit maximization. Also, when they are combined in the best cropping-mix as determined by the weather scenario, these crops reduce the nonpoint source pollutants while preserving water quality for domestic and recreational uses.

The results here show that rather than imposing pollution tax on agricultural practices, the farmers could be encouraged to produce energy crops that preserve the soil and reduce nonpoint source pollutants without any adverse effect on farmers' profits.

Subsidies to crops that pollute more could also be reduced while increased for crops that pollute less as this will help guide farmers towards the best cropping decisions. It also shows that in optimizing the agricultural outputs, the national objective of increasing bio-fuels and reducing dependence on foreign fossil fuels can also be met.

The results of this research are specific to the Kelly Creek watershed and possibly the southern seaboard region, since they have similar-type weather and soil. For the study to be applied to other regions, it should be done with soil and weather data for the biophysical modeling of the region in question before combining the biophysical output with the economic model. This will greatly enhance every region in implementing policies that will allow optimal resource allocation for optimal economic returns, while the environment is preserved or the current environmental degradation is greatly slowed down.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

This dissertation examines the economics of water and land resource use with different econometric models applicable in natural resource and environmental economics. The essays presented in this dissertation are interconnected by way of showing the economics of natural resource use; water resource for recreation and land resource for agricultural purposes and how the use of one affects the other. It also shows how the use of land for agricultural purposes can be profitable without compromising water quality through the externality problems of nonpoint source pollution from agricultural practices.

The first essay uses the travel cost model to estimate the demand for recreational fishing in Alabama, using a random survey data of anglers who recreated in Alabama waters in the 2006/07 fishing season. Specifically, a negative binomial model was used due to the count nature of the number of trips by the anglers, the dependent variable in this study. Another support for this model is because the number of trips by the anglers is truncated at one. Two TCM models are estimated in this essay; one is a traditional travel cost model that used the observed behavior of the anglers while the second has an element of contingent valuation with the behavioral intentions of the anglers. The demand curves for recreational fishing trips in both models are used to estimate the total willingness to pay (total benefit enjoyed by the anglers) and the consumer surplus. The result show that the total willingness to pay for recreational fishing trips in Alabama water bodies are $249.52 and $310.71 respectively for the two models. The consumer surpluses in the two models are $33.09 and $33.03 respectively for the pure travel cost model and the travel cost model that has an element of contingent valuation. The own price elasticities in model 1 of this essay is inelastic while it is slightly elastic in model 2. The policy implication of this is that, while facilities that will improve recreators quality of trips are good and could increase the site managers or owners profits, the return on their investments may not necessary be realized, as least not in the near future.

In the second essay, the economic impact of recreational fishing in Alabama and the Black-Belt is estimated using the same survey data from anglers in the state for the 2006/07 recreational fishing season. Using IMPLAN's input-output model to measure the consequences of the expenditures on recreational fishing on considerations such as the local employment, wage levels, and other business activities that results directly, indirectly or is induced by the new income into the local economy. The new incomes are used with the IMPLAN sectors they affect to estimate the direct, indirect, and induced economic impacts for income and employment. The sectors include petroleum refineries, food services and drinking places, miscellaneous store retailers, sporting goods and hobby stores, recreational sport centers, hotels and motels, travel trailers and campers' manufacturers, water transportation, and the non-store retailers' sectors. For the State, the results show a total impact of $135.5m which could be increased to $142.2m if the sites are improved, total labor impact for the state is 4,442 jobs that are created and could be potentially increased to 4,682 jobs. For the Black-Belt, the impact is $38.3m which could potentially increase to $43.4m with an improvement to the fishing sites in the region and the total jobs created are 1,481 which could potentially increase to 1,686 jobs. It is also shown that anglers that spend $350 and above constitute 32 percent for the state and 38 percent for the Black-Belt. The policy implication is that the recreational fishing sites in the Black-Belt could be used to jumpstart lasting economic activities in the economically depressed Black-Belt regions of Alabama State.

In the third paper, the economic and environmental impacts of land-use change are examined. Using the 32 year soil and weather data from Kelly Creek watershed in Dale County, Alabama, combined with three stage bio-economic model, the production of bio-energy crops in place of the traditional crops in the watershed is simulated. The simulations show that for the farmers' profits to be optimized with minimal agricultural nonpoint source pollution to the groundwater and other water bodies in the area, the watershed should be allocated differently in different ENSO phases. Under the normal weather, the watershed should be allocated to 31 percent corn, 30 percent soybean, 21 percent cotton, and 18 percent switch grass. In ENSO neutral weather scenarios, the watershed should be allocated to 50 percent corn and 50 percent switch grass. For the El Niño periods, the watershed should be allocated to 58 percent corn, 35 percent soybean, and 7 percent switch grass; and under the La Niña scenario, the watershed is allocated to 47 percent soybean, 26 percent cotton, 15 percent corn, and 12 percent switch grass to achieve optimal profits with minimal agricultural nonpoint source pollutant.

The third paper also suggests a 'no-loss' land-use change that focuses on energy crops to produce bio-ethanol and biodiesel, which naturally have lower GHG emissions. This would be a paradigm shift for the farmers, producing bio-energy crops that will support increased research and investments in cleaner fuels and flexible-fuel vehicles and equipments. The increase in energy crop production would also support the current administration's plan to invest in clean energy, clean technology workforce, and develop key technology to develop the next generation of bio-fuels. All these will create more jobs in these areas and could increase the prices of these energy crops.

Obama (2008) stated that the increased production of ethanol from crops could help stop the transfer of national wealth to oil-producing regimes and reduce the US trade deficits. To support and encourage the production of energy crops, subsidies could be used as a policy tool to encourage the farmers that produce energy crops. The subsidy policy could be implemented in ways that compensate energy crop producers while producers of crops that pollute are penalized. The current subsidies to crops that pollute could also be reduced or withdrawn.

Overall, the essays here show that agricultural practices could be practiced in a way that profits to the farmers are maximized by adopting the right cropping-mix that will yield minimal nonpoint source pollutants that compromise the quality of water for use as domestic or recreational purposes.

4.2 Recommendations for Future Research

The results in this dissertation are of great interest to different groups. The first chapter provides insight for the private owners of recreational fishing sites and state managers of recreational fishing sites of the consumers' total willingness to pay to visit these sites. It also shows them the change in total willingness to pay if they would improve the condition on these sites. The elasticities in this essay provide tools that could assist in planning how to manage these sites. The second essay on the other hand provides insight into the regional and statewide economic impacts of recreational fishing. This could be a decision making tool for policies that will promote and enhance recreational fishing at the regional and State levels, especially in the economically depressed Black-Belt where existing water bodies could be developed and used to enhance economic activities. These results provide a base for further similar research in other regions of the State and other sectors in the State. However, for this research to provide basis for stronger policy support for recreational fishing, more of this kind of studies have to be done to provide an ample database for forecasts and planning purposes.

The third essay is of interest to the farmers and extension agents that disseminate agricultural information. It must however be noted that the essay is a simulation that uses Kelly Creek as a study area. The results may only be applicable to regions with similar type weather and soil situations. The weather data used is a 32 year data of the closest weather station to the watershed from 1979 to 2010. Since weather is known to change at an average of 25 years, current weather data should be use for similar simulations. The watershed is assumed to be under the control of a single social planner. Thus, for similar results to be possible, the different farmers have to practice cooperative farming as suggested by Hite et al. (2005). The model here is practically possible and could be adopted for optimal results using the suggested crop-mix that maximize profits while yielding the minimal non-point source pollutants.

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APPENDICES

Appendix 1: Maps of Alabama

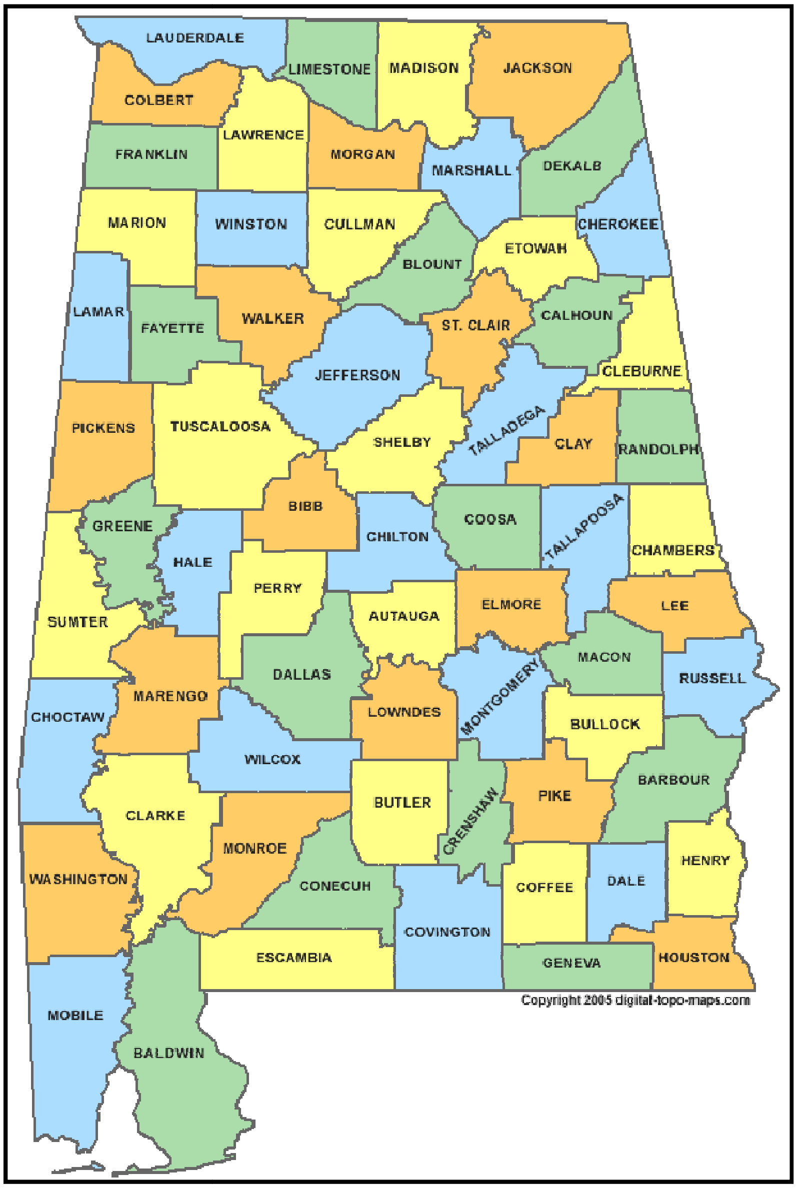

Figure 1A: Map of Alabama Showing all the sixty-seven Counties

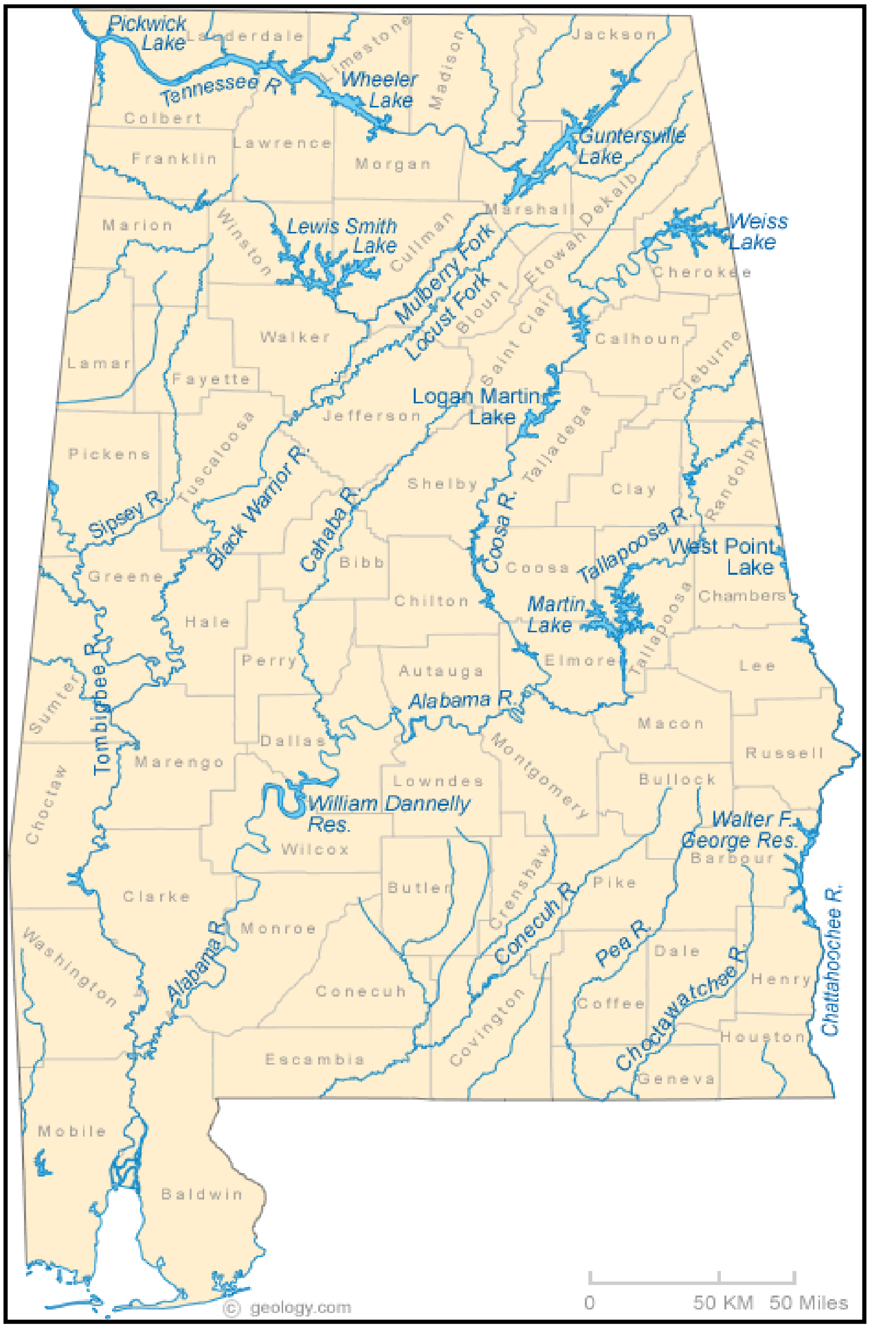

Figure 1B: Some Alabama Rivers and Lakes (courtesy: Google Earth)

Appendix 2: Survey Instrument

In this first set of questions, we would like to ask you questions related to your typical fishing experiences. Please check the boxes or fill in the answers where indicated. Please include as a fishing trip any time you go fishing, except when it is on your own property.

1. Do you regularly take fishing trips outside your county of residence? ☐ Often ☐ Sometimes ☐ Never

2. How often do you fish in Alabama? ________ times per year

3. If you reside outside of Alabama, have you traveled to Alabama in the last year *primarily* for a fish trip? ☐ Yes ☐ No

4. If you reside in Alabama, how often do you fish in other states? _________ times per year

5. How many years have you been fishing? __________(Years).

6. In a typical year, how many fishing trips do you take in each of the given months?

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

7. On an average trip, how many fishing sites (ponds, lakes, etc.) do you visit per trip? ______________________________

8. Do other people usually go with you on a fishing trip? ☐ Yes ☐ No
   8a. If yes, how many_________ (Number besides yourself).
   8b. Do all the members of your party participate in fishing? ☐ Often ☐ Sometimes ☐ Never

9. Do you and/or other members of your fishing party participate in activities other than fishing during these trips?
   ☐ Yes ☐ No
   9a. If yes, please check all that apply below.
   ☐ Swimming ☐ Boating ☐ Skiing ☐ Shopping ☐ Antiquing in surrounding area
   ☐ Relaxing ☐ Meditating ☐ Wildlife watching ☐ Other (Please state) ______________________

10. Please list, in order of frequency of your visits, the names of the five places where you most often fish and their estimated average distance from your home. If you don't know the name of the place, please check if it is a lake, pond or river/stream.

	County	Lake Name	Pond Name	River/stream Name	Distance from your Home	Public or Private	Entrance Fee ($)
a)							
b)							
c)							
d)							
e)							

11. How long do you stay on the fishing trip? ________Number of Hours _________Number of Days

12. Is your catch per trip very important? ☐ Yes ☐ No

13. What is/are your reason (s) for fishing? Please check all that apply.
    ☐ Relaxation ☐ Spend time with family ☐ Competition ☐ Economic (Extra Income) ☐ Interact with Nature
    ☐ Supplement family diet

14. What is your average catch per trip? (Please State) ______

15. What is your most preferred catch? ☐ Bass ☐ Trout ☐ Catfish ☐ Crappie ☐ Blue gill ☐ Others

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16. What factors decide your choice of fishing sites?

1 = Strongly Disagree 2 = Disagree 3 = Neither Disagree or Agree 4 = Agree 5 = Strongly Agree

		SD	D	N	A	SA
i.	Public access.	1	2	3	4	5
ii.	Avoiding congestion (i.e. too many people).	1	2	3	4	5
iii.	Nearby facilities (i.e. restrooms, parking).	1	2	3	4	5
iv.	Natural beauty/scenery	1	2	3	4	5
v.	Chances of catching fish	1	2	3	4	5
vi.	Size of catch	1	2	3	4	5
vii.	Species of fish	1	2	3	4	5
viii.	Proximity to my home	1	2	3	4	5
ix.	Safety	1	2	3	4	5

17. Do you ever fish at private or fee fishing facilities? ☐ Yes ☐ No

17a. If yes, how much do you pay to use the site?

i. Flat fee of $_______ per hour/day (please circle one)

ii. Price per number or pounds of fish caught _______ per fish/per pound (please circle one)

18. Do you prefer the private fishing site to the public fishing site? ☐ Yes ☐ No

19. Please estimate your average cost per trip to the two sites you visit to fish most often. Please estimate the cost for your entire fishing party.

Type of Expense	Site 1	Site 2
Gas	$	$
Groceries (food and drinks)	$	$
Bait/Tackle	$	$
Fishing licenses	$	$
Other fishing gear	$	$
Hotel/Restaurants	$	$
Camping	$	$
Boat Rental	$	$
Entrance Fee (if applicable)	$	$
Others (Please Specify) ________________ ________________	$	$

20. Do you own a fishing boat? ☐ Yes ☐ No

20a. If yes, what was the approximate purchase price of the boat? (Please State) $___________

20b. What is the age of the boat _________(Years)

21. Where do you get your fishing information? Please circle the appropriate number corresponding to the frequency with which you get information from the various sources. (NO = Not Often, S = Sometimes, VO = Very Often)

		NO	S	VO
i.	Bait and Tackle Shops	1	2	3
ii.	Fishing Clubs/ Club Newsletters	1	2	3
iii.	Newspapers	1	2	3
iv.	Radio / Television	1	2	3
v.	Magazines	1	2	3
vi.	Friends / Family / Word of Mouth	1	2	3
vii.	Internet Web Site (s)	1	2	3

Please List Website (s) ____

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22. Have you purchased an Alabama fishing license in the past 3 years? ☐ Yes ☐ No

23. Do you have a current fishing license for Alabama ? ☐ Yes ☐ No

23a. If yes, what type of fishing license do you have? (Kindly check all that applies)

☐ Freshwater ☐ Saltwater ☐ Hunting & Freshwater ☐ Freshwater & Saltwater

☐ Spear Fishing ☐ Commercial ☐ Lifetime

24. The Alabama Wildlife and Freshwater Fisheries Division is considering a program in which they would automatically remind holders of licenses when they are up for renewal. Do you think such a program would be a good idea?

☐ Yes ☐ No

In questions 25 - 28 below, please think about the features that you have experienced at fishing sites you have visited over the past 5 years, and how much features add to the enjoyment of your fishing experience.

25. Consider all the places where you have fished in the last 5 years, please rank the importance of the types of **natural** features you would enjoy at the sites (i.e. 1=most impost important, 2=next most important, …7=least important)

☐ Size of fish ☐ Number of fish ☐ Shade/shelter near water ☐ Peace and quiet

☐ Variety of fish ☐ Scenery ☐ Other (please state) ____________

25a. If variety of fish is very important, please list the types of fish you value ________________________________

____

26. Consider all the places where you have fished in the last 5 years, please rank the importance of the types of **convenience** you enjoy at the sites (i.e. 1=most impost important, 2=next most important, …7=least important)

☐ Close to home ☐ Close to shopping ☐ Close to restaurants ☐ Good Restroom Facilities

☐ Parking ☐ tourist activities ☐ Other (Please state) ________________________

27. Consider all the places where you have fished in the last 5 years, please rank the importance of the types of **physical or man-made** features you would enjoy at the sites (i.e. 1=most impost important, 2=next most important, …6=least important)

☐ Picnic facilities ☐ Camping facilities ☐ Lodge or cabin ☐ Boat launch facility

☐ Marina ☐ Vending facilities ☐ Other (Please state) ______________________________

28. Consider all the places where you have fished in the last 5 years, please rank the following **recreation activities** in the order that you would enjoy them. (i.e. 1=most impost important, 2=next most important, …10=least important)

☐ Swimming ☐ Boating ☐ Shopping and Antiquing in surrounding area

☐ Relaxing ☐ Meditating ☐ Wildlife watching ☐ Other (Please state) __________________

29. Imagine that you had a site located 50 miles from your residence that had all of the features listed in questions 25-28 that you ranked first or second. If such a place existed, would you be willing to pay an entrance fee of $5 to access it?

☐ Yes ☐ No

29a. If no, please state the minimum amount you would be willing to pay, or zero if you would not pay $ __________

Now we would like to ask a few questions about you. These questions will be used for statistics only, and your personal information will not be shared with anyone.

30. Where do you reside? County ____________________ Zip __________ State ______________

31. What is your age in years?

☐ 18 - 25 ☐ 26 - 30 ☐ 31 - 35 ☐ 36 - 40 ☐ 41– 45 ☐ 45 - 50 ☐ 51 - 55
☐ 56- 60 ☐ 61 - 65 ☐ over 65

32. How much school have you completed?

☐ Less than 9th grade ☐ 9th to 12th grade, no diploma ☐ High School graduate
☐ Associates degree ☐ Some College, no degree ☐ Bachelors degree
☐ Graduate or professional degree

33. What is your employment status?

☐ Currently working full time ☐ Currently working part time ☐ Unemployed ☐ Retired

34. What is your gender? ☐ Male ☐ Female

35. What is your marital status? ☐ Single ☐ Married ☐ Divorced ☐ Widowed

36. What is your ethnic group? ☐ Caucasian ☐ African American ☐ Hispanic ☐ Other (Please Specify) _________

37. What is your total household income before tax?

☐ Under $10,000 per yr ☐ $10,000 - $19,000 per yr ☐ $20,000 - $29,000 per yr
☐ $30,000 - $39,000 per yr ☐ $40,000 -$49,000 Per yr ☐ $50,000 - $59,000 per yr
☐ $60,000 - $99,000 per yr ☐ $100,000 and above

38. Have you ever made a donation to an environmental or conservation organization in the past 5 years?

☐ Yes ☐ No

38a. If yes, which organizations? (Please list them) ____

____

Appendix 3

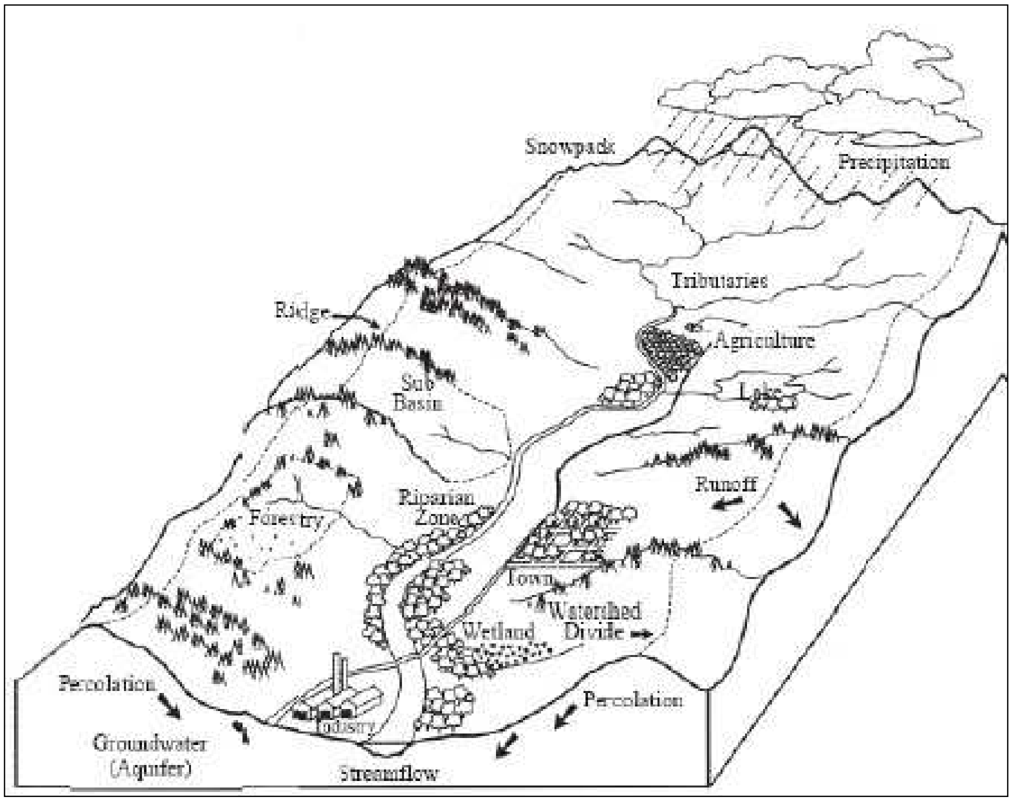

Figure 1C: Diagram of a typical watershed

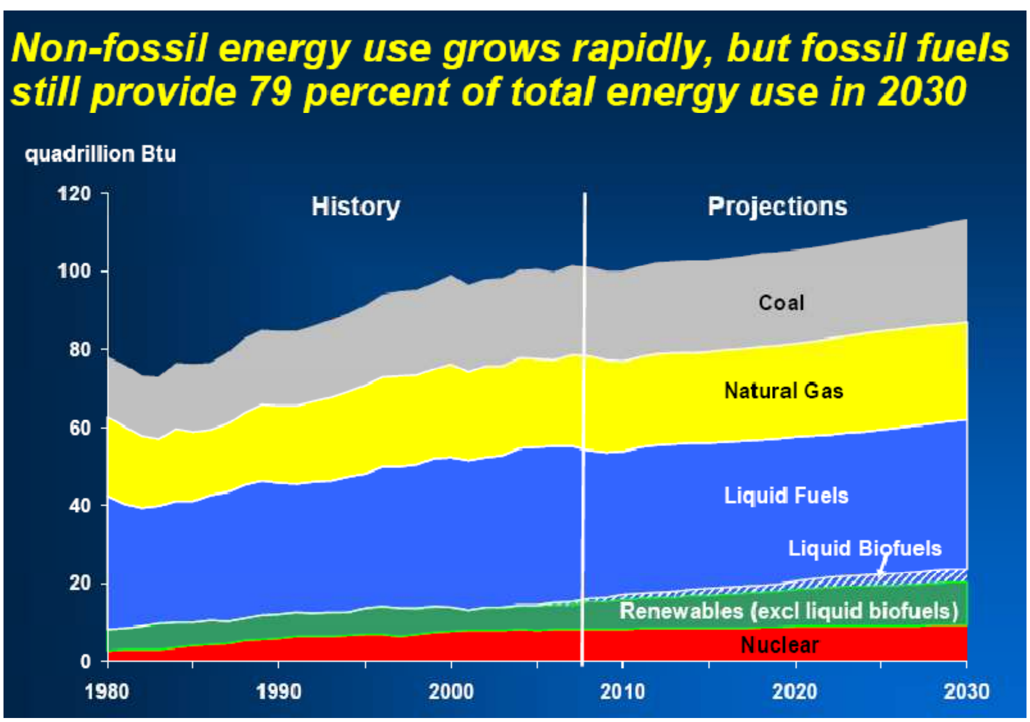

Figure 2C: 2009 Non-fossil fuel projection (EIA, 2009)

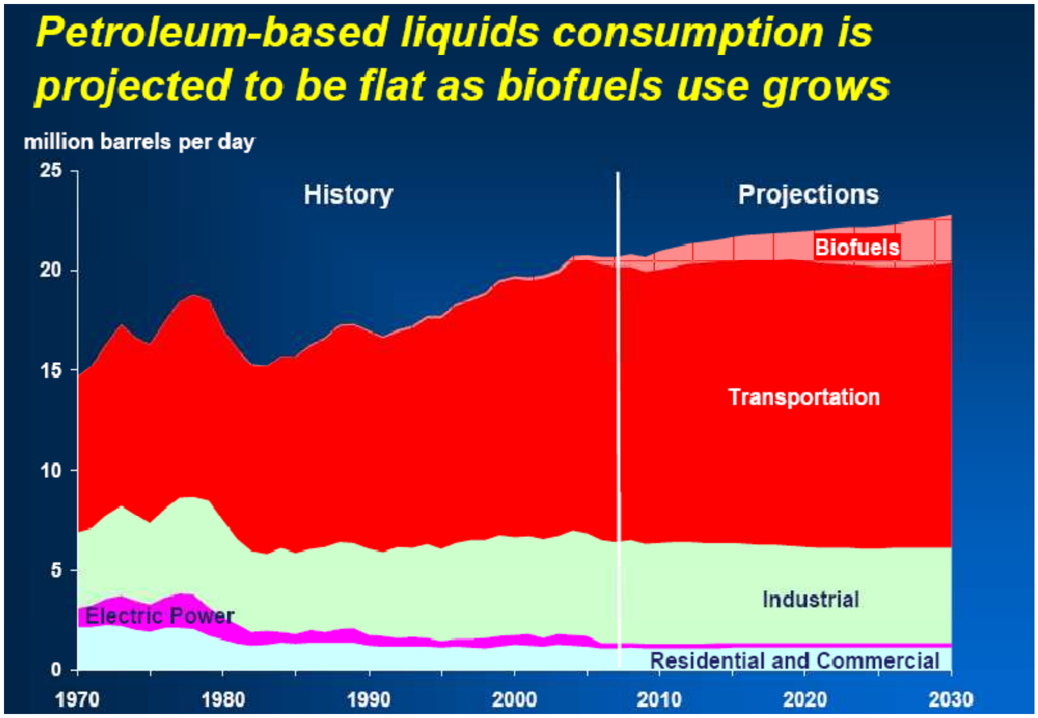

Figure 3C: 2009 Non-fossil fuel projection (EIA, 2009)

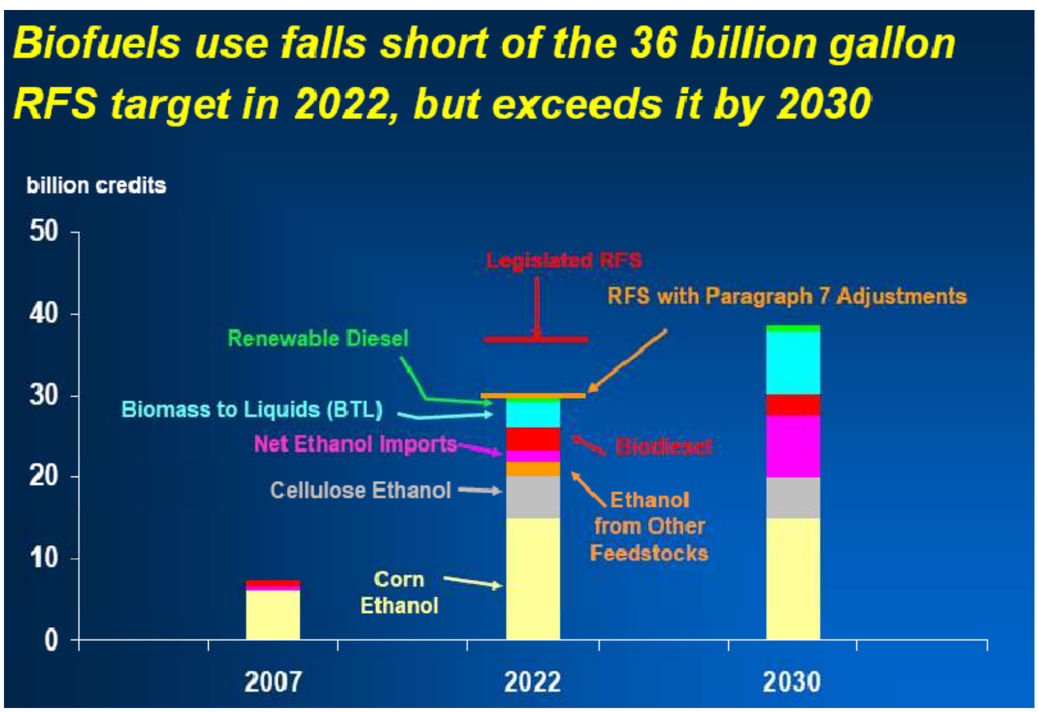

Figure 4C: 2009 Non-fossil fuel projection (EIA, 2009)

Appendix 4

Table showing the Poisson Parameter Estimates

Variable Description	Variable	Model Estimates	
		1	2
Intercept		3.6091***	3.5744***
Average Trip Cost	**AV_TRV_COST**	-0.0028*** (-0.0000)	-0.0042*** (-0.0000)
Fishing Experience in Years	**FSH_EXP**	0.0169*** (0.0000)	0.0143*** (0.0007)
Average Site Distance	**AV_SITE_DIST**	-0.0032*** (0.0001)	-0.0024*** (0.0001)
State	**ST**	-0.5884*** (0.0021)	-0.5343*** (0.0020)
Income	**INC**	-0.0352*** (0.0013)	-0.0341** (0.0011)
Age	**AGE**	-0.0563*** (0.0003)	-0.0469*** (0.0005)
Age*Age	**AGE^2**	-0.0299*** (0.0000)	-0.0262*** (0.0000)
High School Diploma or Less	**EDU_DUMMY**	0.6753*** (0.0023)	0.6593*** (0.0028)
Assoc. Degree But Less Than College)	**EDU_DUMMY**	0.6137*** (0.0024)	0.6192*** (0.0041)
Fish Variety (NF6)	**NF6**		0.1234*** (0.0014)
Near Shopping (CF2)	**CF2**		-0.3268*** (0.0213)
Near Restaurant (CF3)	**CF3**		0.2203*** (0.0181)
Restroom Facility (CF4)	**CF4**		0.1741*** (0.0154)
Parking (CF5)	**CF5**		-0.1791 (0.1089)
Picnic Facilities (PF1)	**PF1**		0.3351*** (0.0156)
Vending Facilities (PF6)	**PF6**		0.1769*** (0.0159)
Swimming (RF1)	**RF1**		-0.1631*** (0.0149)
Wildlife Watching (RF3)	**RF3**		-0.1911*** (0.0203)
Scale	**Scale**	1	1
Criteria for Assessing Goodness of Fit			
Deviance		31.8031	30.7492
Pearson X^2		45.2679	41.3329
Log-Likelihood		60272.37	60779.05

***, **, * - Significance at 1%, 5%, and 10%