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Factors Influencing Desire for Increased Wildlife Habitat among Tennessee Farmers and the Economics of Switchgrass Production

Janet Jones
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Janet Jones entitled "Factors Influencing Desire for Increased Wildlife Habitat among Tennessee Farmers and the Economics of Switchgrass Production." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Christopher D. Clark, Major Professor

We have read this thesis and recommend its acceptance:

William M. Park, Emmit L. Rawls

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

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A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Janet Jones

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Abstract

In order to keep up with a growing human population, wildlife habitat has had to be relinquished. Modern technology has furthered the abilities of commodity producers but caused a deterioration of the quality and quantity of habitat available for wild animals in many cases. Many species of wildlife have left areas of the state in order to meet their basic needs. In order to increase wildlife numbers, wildlife habitat will have to be reintroduced or managed differently. The first objective of this research is to identify and evaluate the factors associated with a demand for increased wildlife habitat among Tennessee farmers. The provision of habitat can not only benefit wildlife, but the public and private sectors as well.

An analysis was preformed in order to identify a more specific interested individual. These individuals can then be more exclusively targeted by administrators of governmental programs with information that will assist in targeting their programs to farmers in Tennessee. These programs offer a wide range of assistance for landowners who are interested in helping the environment.

The analysis revealed that individuals who are interested in providing more habitat on their land are younger, more educated, issue hunting leases, were members of environmentally related organizations, and attended agriculture events. Over half of the interested individuals also reported some amount of erosion on their land.

Another topic of this research contemplates the growth of switchgrass (*Panicum virgatum*) for energy production. Switchgrass possesses numerous benefits for both landowners and wildlife. The second goal of this study was to analyze the economics of

switchgrass production in order to assist landowners in considering growing this crop.

Switchgrass is an excellent source of biomass, which currently supplies over 3 percent of the total United States energy consumption. Switchgrass also comprises a very extensive root system, which provides a large area of storage for carbon that is removed by the plant from the atmosphere. Due to its broad root system, this warm-season grass also is proving to be a wonderful plant to be used for erosion control.

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CHAPTER I

Introduction

Wildlife habitat has had to be abandoned, and in many cases destroyed, in order for the human population to continue developing as it has. Technological advances in agriculture have led to an increase in yield on smaller portions of land. LaPierre suggested that surplus land, once heavily needed for production, is being developed for use by the human population instead of being put back into natural cover crops to benefit wildlife. Habitat is lost not only by housing development, but also with the introduction of more paved roads and the growth of industry, which can lead to pollution of what habitat is left in a surrounding area.

Wildlife habitat has both private and public good characteristics. Landowners capture some of the benefits of providing habitat through their land and associated access to the wildlife. They can also restrict the public and charge for access often through the issuance of hunting leases. However, a contribution to overall wildlife population also accrues to individuals other than the landowner. It is difficult to put a monetary value on the provision of habitat, especially in the case of the public since everyone perceives it differently. This provision enters into each individual's utility level by some amount, either positively or negatively. The amounts and varieties of wildlife that benefit from the habitat, as well as the financial gains from issuing hunting leases or charging for access to the land, can be physically observed, while experiencing wildlife can not be exactly measured.

The government can promote the provision of the public good by subsidizing the provision of habitat, through a variety of programs such as the Wildlife Habitat Incentives Program (WHIP), Conservation Reserve Program (CRP), and the Wetlands Reserve Program (WRP). Each of the programs offer some range of assistance to landowners, either financial, technical or both in some cases. Some reserve programs prohibit the amount or type of agricultural practices that can be performed on enrolled land. In most cases, recreational uses, such as fishing and hunting, on the land are permitted. Another positive feature of increased wildlife habitat is that it can increase the value of land it is found on.

Conversely, wildlife has proven to be a nuisance in many different aspects of human life. Due to overpopulation in many areas, there have been numerous wildlife-related incidents, mostly vehicular, causing large amounts of physical and financial damage. Wildlife feeding on or grazing in fields can also damage or even destroy agriculture crops.

Researchers at Clemson University stated that previous research had suggested that deer, or other wildlife, would more than likely only damage the edges of fields, primarily in the early stages of crop production. However, due to the increase in size of most deer herds, many producers are reporting that deer are feeding on their entire fields throughout the growing season. Total crop loss with no harvestable yield has become a common producer complaint in some areas. The Clemson University Extension publication suggested a few possible remedies for deer issues such as fencing, repellents, and scare devices. However, use of these various devices can be very pricey and leave the

farmer in worse shape financially than before. Other management practices mentioned in the publication was that of "shoot-to-kill" or depredation permits that are available to producers in some areas with severe crop damage.

Alternative revenue sources are another possibility for landowners who are experiencing crop loss. Many people are considering planting a portion of land into native warm season grasses, such as switchgrass (*Panicum virgatum*). Switchgrass can provide landowners, as well as the public, with many benefits. A large amount of research is currently being conducted on this grass for its possibilities as an energy feedstock.

Switchgrass has the ability to reduce soil erosion, the amount of chemical pollution in waterways, and the amount of atmospheric CO_2. Switchgrass also can provide wildlife habitat. This provision can lead to increased wildlife on private land, in which the landowner can charge for hunting, generating added income. The public also benefits from switchgrass production through cleaner air and water.

Even with the benefits that providing more wildlife can provide for the different sectors, the numbers of landowners that would be willing to provide more habitat on their land hasn't been closely evaluated. This research will gauge landowner interest in providing additional wildlife habitat or those who might be interested in participating in conservation programs like the ones mentioned earlier. It will also help to analyze the economics of switchgrass production through an analysis that will assist landowners in determining whether or not it would be profitable to take land out of crop-production and produce switchgrass for energy use. The switchgrass evaluation will also investigate the

growth and production of switchgrass as both a habitat provider and alternative income source.

Objectives

This research has two primary objectives. The first is to identify and evaluate the factors associated with a demand for increased wildlife habitat among Tennessee farmers. This information will provide administrators of programs, such as WHIP, with information that will assist in targeting their programs to farmers in Tennessee. The second objective is to analyze the economics of producing switchgrass by examining the potential costs and benefits to Tennessee producers as well as the public.

CHAPTER II

Introduction

Wildlife habitat has been slowly diminishing. With the introduction of paved roads, motorized vehicles, growth of industry, and the human population multiplying extensively, habitat has had to be abandoned in order for the human population to continue developing as it has. Technological advances in agriculture have also had a direct impact on wildlife. This progress has spurred an increase in yield on smaller portions of land. However, instead of taking the surplus land and putting it back into natural cover crops, most of the land is being developed into housing or industry (LaPierre).

Habitat can be destroyed or degraded in two basic ways: quantitative and qualitative losses. Quantitative losses involve a reduction in the amount of habitat area. For example, if a wetland is paved over, then there has been a quantitative loss of wetland. Qualitative changes involve a change or degradation in the structure, function, or composition of the habitat. For example, if a paper company is discharging chemicals into a waterway and polluting the water, then there has been a qualitative loss. Sometimes there is a combination of quantitative and qualitative, such as when a forest is fragmented or divided into many patches (from conversion to agricultural or residential land) providing fewer benefits to species than an intact forest (EPA). Like humans, animals need food, water and shelter to survive; development of land can cause a decrease in one or all of these needs. Game animals such as whitetail deer, turkey, etc.,

are becoming overpopulated in the few areas that they still have left to call their home. This is forcing wildlife to move or relocate in order to find food and shelter.

Due to the shift in wildlife, different areas of the state are dealing with larger or smaller amounts of wildlife, deer in particular. For better wildlife management, Tennessee is divided into three deer units. The three areas are shown in Figure 2. Unit L is basically where it needs to be in terms of deer numbers even though some areas of Unit L have a few too many deer. Unit A is below target and has potential for a little more deer growth. Unit B has a lot more room for deer numbers to grow, which is why this region has more restrictive hunting regulations. With larger amounts of wildlife, such as deer, in an area, there is a greater potential for crop loss or other potential damages caused by this move.

People need to be concerned with this decrease in habitat for several reasons. First, if habitat is decreased, the affected animal is forced to move to find substitutes for their needs. Second, if animals begin to leave an area this will decrease the diversity of

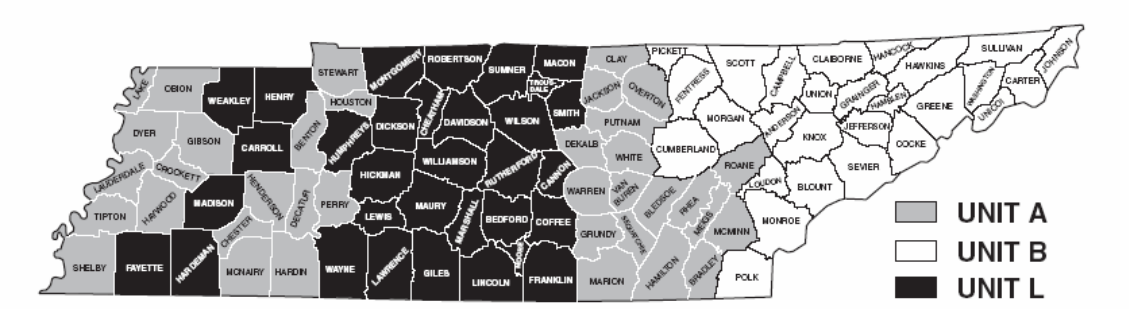

Figure 1. White-Tailed Deer Hunting Units.

Source: Tennessee Wildlife Resource Agency, Regional Office Information, 2006 Tennessee Hunting and Trapping Guide.

the wildlife population in a certain area. Third, animals leaving an area can have economic effects on a community. Recreational activities, such as hunting, fishing and camping, can become less enjoyable for the public. Many businesses, such as cabin- or boat- rentals, can suffer due to the lack of a diverse wildlife population, as well as dwindling numbers of game animals.

Wildlife habitat has both private and public good characteristics. Landowners capture some of the benefits of providing habitat through their land and associated access to the wildlife. They can restrict the public and charge for access often through the issuance of hunting leases. Landowners may have different preferences over the provision of wildlife habitat. These preferences may take the form of either use or non-use values. For instance, one individual may desire a larger amount of habitat just for the sake of knowing that additional habitat could support more wild animals; this is an example of non-use. On the other hand, a use value occurs when another individual might crave more habitat for wildlife for the purpose of viewing or hunting game associated with that habitat.

The provision of habitat by the landowner contributes to the cumulative habitat provided, which contributes to the support and maintenance of the general wildlife population. Both revenue and non-revenue benefits can be realized with this provision. By providing additional habitat, this affects the economic rent accruing to landowners, giving an example of a revenue benefit. Increasing habitat may also generate costs in the form of out-of-pocket expenses and opportunity costs associated with land use limitations. In many cases, fewer inputs will be needed for the new management

practices, which results in extra savings, or a reduction of input-costs, for the farmer. Non-revenue profits can include such things as the psychological benefits that are attained by the landowner knowing that with increased habitat provision they are helping the environment while also working towards a more abundant wildlife population.

However, a contribution to overall wildlife population also accrues to individuals other than the landowner. The public also gains utility from the provision of wildlife habitat. From nature-watchers to the avid hunters, individuals other then landowners benefit from an assorted wildlife. Since wildlife habitat has public good attributes, the market is likely to under-provide the amount available. As a result, the government intervenes in the market by providing subsidies in order to promote the growth and maintenance of habitat through programs or other possible measures. Similarly, hunting leases can provide a market incentive to encourage landowners to provide more habitat through individual market transactions. In both cases there are informational issues in identifying landowners interested in participating in government programs or in hunters and landowners finding each other.

The governmental programs that support wildlife habitat were devised in order to keep the projects more affordable for landowners and are geared to agricultural lands, forestlands, wetlands or specific wildlife practices. Many of the plans call for taking land out of production of crop farming, and urge the landowner to plant that land with habitat sustaining vegetation, such as warm or cool season grasses, like switchgrass. There is a wide range of governmental programs available, many of which address certain environmental issues. There is a wide enough range of programs so that virtually all

landowners in Tennessee can qualify for some type of assistance. The following are a few examples of programs that specifically deal with habitat-related matters on privately owned land.

The Tennessee Wildlife Resources Agency (TWRA) is tasked with improving wildlife in Tennessee through research, outreach and the creation of various wildlife-related programs. For categorical reasons, this agency has divided Tennessee into four regions categorized by roman numerals ranging from Region I, the western area of the state, to Region IV, the northeastern area of the state. Figure 3 shows these areas. In 1988, TWRA created the Upland Game Bird Habitat Program (UGBHP), in an attempt to increase the amount of suitable habitat available for wildlife populations. The program provides financial incentives for the development of habitat for certain species of small game. Those who enroll in the UGBHP receive full or partial reimbursement for the management of wildlife habitat on their land, depending on the management practice chosen (LaPierre).

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) offers two programs that are particularly relevant to the provision of wildlife habitat—the Environmental Quality Incentives Program (EQIP), and the Wildlife Habitat Incentives Program (WHIP). EQIP is a voluntary conservation program promoting agricultural production and environmental quality as compatible national goals. Under this program, producers are eligible for cost-share to establish native grasses and a management incentive payment for the first two years of the contract to compensate for forage loss during establishment (Gudlin 2007a). WHIP is a voluntary program for

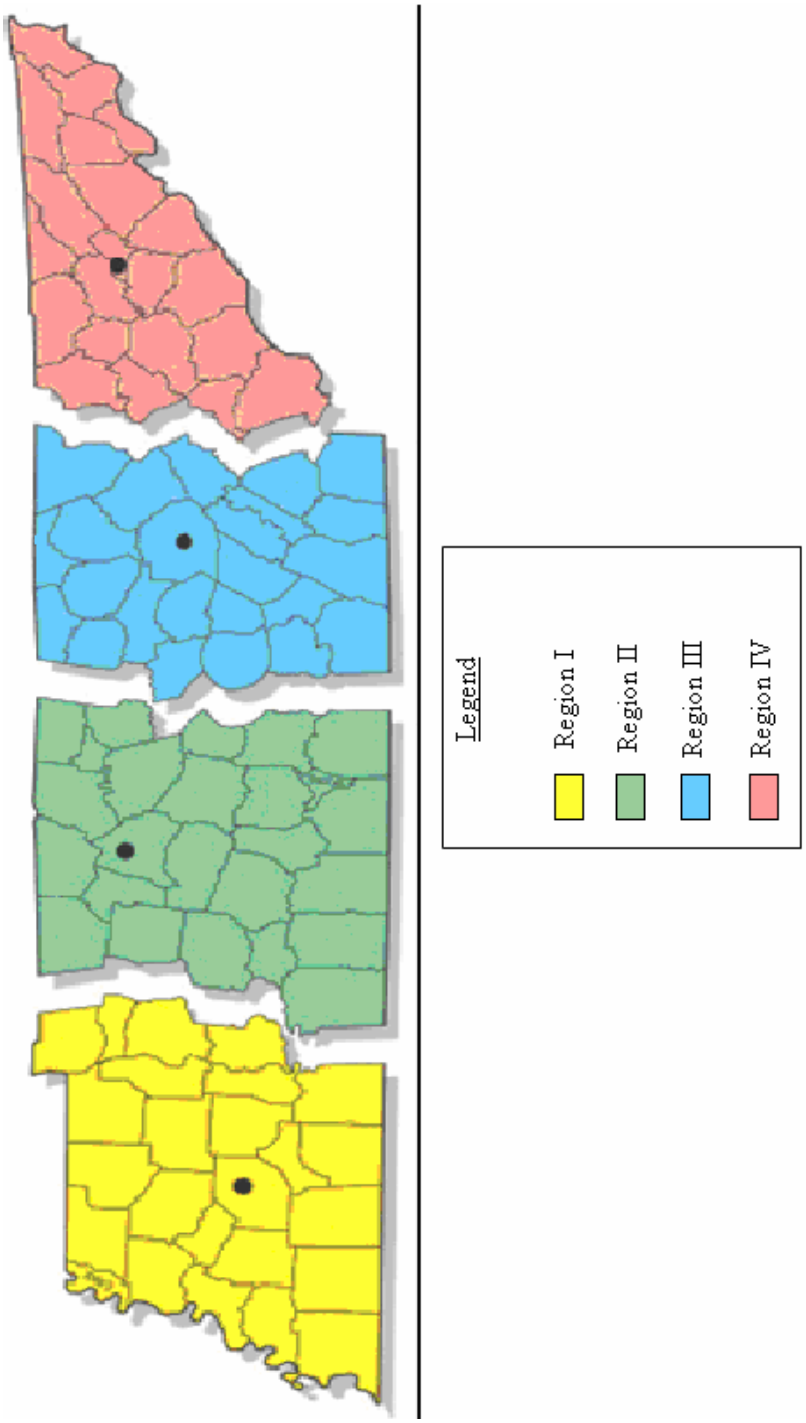

Figure 2. TWRA Regions.

Source: Tennessee Wildlife Resource Agency, Regional Office Information, 2006 Tennessee Hunting and Trapping Guide.

people who want to develop and improve wildlife habitat primarily on private land. Through WHIP, NRCS provides cost-share payments for the development and protection of upland, wetland, riparian, and aquatic habitat areas. WHIP agreements between NRCS and the participant generally last from 5 to 10 years. By targeting wildlife habitat projects on all lands and aquatic areas, this program provides assistance to conservation-minded landowners who are unable to meet the specific eligibility requirements of other USDA conservation programs (Rainford).

The USDA Farm Service Agency (FSA) offers several programs to help improve the agricultural community while enhancing wildlife habitat. The most widely known is the Conservation Reserve Program (CRP). The CRP is a voluntary program under which landowners receive annual rental payments and cost-share assistance to establish long-term, resource-conserving covers on eligible farmland. Landowners set aside acreage, particularly highly erodible land, and put the land into more resource-conserving vegetative covers, which makes the program a major contributor to increased wildlife populations in many parts of the country (U.S. Department of Agriculture 2006).

Not all land is suitable for wildlife; therefore, a landowner needs to begin the process by assessing their land. After this assessment, a landowner can then make the decision on whether or not pursuing the provision of habitat is a worthwhile investment. Many program provisions may call for very particular land management practices to be utilized. Therefore, the landowner should decide if they would be willing to follow through with specific changes that may be required.

Another possibility in the quest for increasing wildlife habitat is for the landowner to get involved with local hunt clubs and to possibly offer land up for lease. In most cases, members of clubs will work towards establishing and maintaining crops that are habitat friendly and inviting for wildlife on land that they have leased. Harper et al. provides detailed information for landowners and others interested in hunting leases.

Currently, more information is needed regarding the factors that affect farmers' interest in providing additional wildlife habitat on their land. The objectives of this research are to analyze these associated factors in order to: (1) assess the potential of governmental programs to increase wildlife habitat in Tennessee, and (2) provide program administrators with information that will assist in targeting their programs to specific landowners in Tennessee. The remainder of this chapter examines the relationship between various landowner characteristics and landowner interest in providing additional wildlife habitat. The next section describes the conceptual framework for this analysis. Afterwards, a discussion of the methods used in this analysis will be found. Test results are discussed subsequently.

Conceptual Framework

The economic model for this study assumes that landowners are attempting to maximize the following utility function:

$$(1) \qquad U_i = f(H_i, H, Y_i(H_i))$$

where,

- U_i is the utility of individual i ;

- H_i is the amount of habitat provided by individual i ;
- H is the aggregate amount of habitat provided in the study area, such that

  (2) $\quad H=\sum_{i=1}^{n} H_i$; and

- Y_i is the economic rent accruing to individual i by virtue of i's ownership of land.

The provision of wildlife habitat enters into an individual landowner's utility function in three different ways. First, habitat provision may enter directly to the extent that landowners have preferences over the provision of wildlife habitat. Second, the provision of habitat that landowner i contributes can directly effect a landowner's utility. Third, the economic rent accruing to the landowners by providing the additional habitat also can affect an individual's utility. For individual j who owns no land, the utility function reduces to $U_j = f(H)$. The public good nature of wildlife habitat is illustrated by the fact that the amount of habitat provided by i impacts j's utility.

The decision facing the landowner/farmer involves allocation of land between habitat and agriculture. There are implications for utility directly via preferences over H_i and indirectly through effects on land rents. Since wildlife habitat has public good attributes, the market is likely to under-provide the amount available. This research will attempt to address some of these issues by looking at results from a survey administered by the University of Tennessee Switchgrass Project called the "Switchgrass Production for Energy: Your Views" ("Switchgrass Survey").

Methods and Procedures

The Switchgrass Survey was created in order to gather information about farmers in Tennessee and their basic knowledge of, and interest in, growing switchgrass for energy production. This survey was conducted over the months of March and April in 2005. There were a total of 15,002 surveys sent out to a random sample of farmers statewide that were estimated to have sales of agricultural commodities of US $10,000 or more. The Tennessee Agriculture Statistics Service was responsible for the selection of this sample and for organizing the mailings. The survey began with a brief description of switchgrass and its potential benefits as well as its capability to be used for energy production. This description was followed by a series of 27 questions that covered the following general topics:

- Interest in growing switchgrass;
- Opinions on a variety of issues related to growing switchgrass (including interest in providing additional wildlife habitat);
- Attributes of the respondent's farming operations;
- Financial characteristics, such as the amounts and sources of income; and
- Demographics.

The initial mailing included a cover letter providing some background information on the survey, the survey, and a postage-paid return envelope. A week later, a reminder postcard was sent out. Three weeks later a follow-up mailing with another copy of the survey and another postage-paid envelope was sent to non-respondents.

Out of the 15,002 surveys that were mailed out, 3,499 were completed and returned; 282 were returned as undeliverable; and 102 came back with a note saying that the addressee was no longer capable of farming. Thus, there was a response rate of 23.9 percent after the removal of surveys that were returned as undeliverable or where the landowner was no longer farming.

The survey sample was generally representative of the State's population of rural citizens and agricultural producers. The age of the survey respondents ranged from 21 to 94 years of age, with a mean of 60 years old (N=3,237). According to the Tennessee State Fact Sheet on the ERS website, the average farm operator in Tennessee was 56 years old in 2002, showing that survey respondents were a bit older then the State average.

A large portion of the respondents, around 38.3 percent reported that high school was the highest level of education attained (N=3223). Around 20.0 percent of the respondents stated that they had attained some college education. In 2000, ERS reported that approximately 37.4 percent of the state rural residents finished high school only, while 19.8 percent reported to have completed some college. Therefore, educational attainment of the respondents was quite similar to that reported by ERS.

A majority (63.7 percent) of the respondents reported a net farm income in the $0 - $15,000 range (N=2971). Approximately 49.3 percent chose the $0 - $9,999 range. These responses seem to be generally in line with the state average of $10,500 in 2005, calculated by taking the ERS reported net farm income of $8.9 million and dividing it by the reported 85,000 farms. Approximately 78.3 percent of the respondents were full

owners (N=3227). The state average was 73.4 percent in 2002, as reported by ERS (N=64,279). Respondents farmed, on average, 198.2 acres (N=3,161). The state average farm size was 133 acres in 2002, as reported by ERS, showing that the survey respondents had a bit higher average in this case.

Some other interesting characteristics of the survey respondents include:

- Respondents reported an average of 39 years of farming experience (N=3,016);
- 52 percent of the household income came from off-farm sources (N=2,763);
- The majority, approximately 79.7 percent, reported a debt to asset ratio of zero (N=2,941);
- Almost half, 40 percent, reported attendance at one or more extension workshops or experiment station field days each year (N=2,832);
- 47.3 percent reported that they did not have a significant erosion problem on their land (N=2,950);
- A total of 18,349.4 acres were reported to be enrolled in CRP and planted to grass and/or trees; and
- Only 8.7 percent reported that they issued hunting leases (N=3229).

Table 1 provides a list of the variables that were expected to influence or be associated with landowners' willingness to provide more wildlife habitat on their land. Included in this table is a description of each variable along with its mean value, standard deviation and number of responses. Variables in the landowner group include information on age, education level, income-related statistics, and membership in organizations.

Table 1. Variable Definitions and Summary Statistics.

Variable	Description	Mean	Standard Deviation	*N*
Dependent Variable: HABITAT	Willing to provide more habitat for native wildlife: strongly agree = 1, agree = 2, no opinion = 3, disagree = 4, strongly disagree = 5.	2.38	0.98	1675
Explanatory Variables:				
EDUCATION	Some high school or less =1, high school graduate = 2, some college = 3, college graduate = 4, post graduate = 5.	2.79	1.23	3223
FULLOWNER	Full owner = 1, otherwise = 0.	0.78	0.41	3227
EXPERIENCE	Years of farming experience.	38.73	17.09	3016
NFIPERACRE	Net farm income per acre in 2004 after taxes. Mid-point of NFI / total acres farmed. (Midpoints: $0, $4000, $12,500, $20,000, $30,000, $42,500, $62,500, $87,500, and $125,000.)[1]	147.42	1309.56	2821
OFFFARM	Percent of income that came from off-farm sources in 2004.	52.19	39.29	2763
HUNTING	Member of this organization = 1, otherwise = 0.	0.10	0.30	3271
ENVIRONMENTAL	Member of this organization = 1, otherwise = 0.	0.04	0.21	3271
GROWER/ COMMODITY	Member of this organization = 1, otherwise = 0.	0.05	0.22	3271
COOPERATIVE	Member of this organization = 1, otherwise = 0.	0.50	0.50	3271
FARMBUREAU	Member of this organization = 1, otherwise = 0.	0.77	0.42	3271
HUNTINGLEASES	Issue hunting leases on land = 1, otherwise = 0.	0.09	0.28	3229
DEBTFREE	For every $100 of farm assets, how many dollars are financed with debt: debt free =1, otherwise = 0.	1.73	1.80	2941
COMPUTER	Owns a personal computer = 1, otherwise = 0.	0.61	0.49	3212
EXTENSION	Number of extension workshops or experiment station field days in a typical year.	0.80	1.37	2832
ACRESFARMED	Total acres farmed; including acres owned, rented/leased from others and acres used rent free, less acres rented to others.	198.18	248.86	3161
NOEROSION	No significant erosion problem on farm = 1, otherwise = 0.	0.47	0.50	2950
REGIONI	Respondents county is located in this TWRA region = 1, otherwise = 0.[2]	0.16	0.37	3357
REGIONIII	Respondents county is located in this TWRA region = 1, otherwise = 0.[Ibid.]	0.19	0.39	3357
REGIONIV	Respondents county is located in this TWRA region = 1, otherwise = 0.[Ibid.]	0.28	0.45	3357
RURAL	County is considered rural as reported by the 2003 Rural-urban Continuum Code.[3]	0.49	0.50	3357

[1] Net Farm Income in 2004 (after taxes). Choices on the survey were: 1=Negative, 2=$0-$9,999, 3=$10,000-$14,999, 4=$15,000-$24,999, 5=$25,000-$34,999, 6=$35,000-$49,999, 7=$50,000-$74,999, 8=$75,000-$99,999, 9=$100,000-$149,999, 10=Greater than or equal to $150,000.

[2] TWRA Regions are defined in Figure 2.

Table 1. Variable Definitions and Summary Statistics (cont.)

Variable	Description	Mean	Standard Deviation	*N*
BEEF	Has this type of operation = 1, otherwise = 0.	0.79	0.41	3273
DAIRY	Has this type of operation = 1, otherwise = 0.	0.02	0.13	3273
BACKGROUNDING	Has this type of operation = 1, otherwise = 0.	0.05	0.23	3273
EQUINE	Has this type of operation = 1, otherwise = 0.	0.04	0.20	3273
POULTRY	Has this type of operation = 1, otherwise = 0.	0.01	0.10	3273
SWINE	Has this type of operation = 1, otherwise = 0.	0.00	0.06	3273
CORN	Produces this crop = 1, otherwise = 0.	0.11	0.32	3357
COTTON	Produces this crop = 1, otherwise = 0.	0.01	0.11	3357
TOBACCO	Produces this crop = 1, otherwise = 0.	0.13	0.34	3357
SOYBEANS	Produces this crop = 1, otherwise = 0.	0.08	0.27	3357
WHEAT	Produces this crop = 1, otherwise = 0.	0.06	0.23	3357
FRUIT	Produces this crop = 1, otherwise = 0.	0.02	0.15	3357
VEGETABLES	Produces this crop = 1, otherwise = 0.	0.05	0.22	3357
HAY	Produces this crop = 1, otherwise = 0.	0.73	0.44	3357
FORESTLAND	Has forest = 1, otherwise = 0.	0.17	0.38	3357
IDLE	Has idle acres = 1, otherwise = 0.	0.02	0.16	3357
NOTILL	Practice no-till = 1, otherwise = 0.	0.44	0.50	3055
OFFFARM	Percent of income that came from off-farm sources in 2004.	52.19	39.29	2763
CRPGRASS	Amount of CRP-enrolled acres planted in grass.	23.21	67.40	553
CRPTREES	Amount of CRP-enrolled acres planted in trees.	9.98	60.99	553
AGE	Age of farmer in years.	59.99	12.35	3237

[3] 2003 Rural-Urban Continuum Code ranges from 1 – 9, 9 being most rural. For the purposes of this research, scores of 1 – 4 were considered to be urban while scores of 5 – 9 were classified as rural.

Management related variables cover such items as the type of livestock operation practiced and the commodities grown on the land. Other relevant variables in this category include the total number of acres farmed, the existence of erosion, and whether or not the practice of "no-till" is employed. Respondent willingness to provide wildlife habitat was probed by a question that asked respondents to rate their agreement with the statement: "I would like to provide more habitat for native wildlife species on my own land." The choices were Strongly Agree, Agree, No Opinion, Disagree, and Strongly Disagree. A comparison of the respondents who were and who were not interested in providing more wildlife habitat on their land was created by sorting the respondents into two groups on the basis of their responses to this question. The interested group encompasses those who agreed or strongly agreed that they were interested in providing more wildlife habitat, while the not interested group includes the rest of the responses, i.e. those who disagreed, strongly disagreed, or chose the no opinion option. Respondents who did not answer this question were omitted from this analysis. After these two groups were created, the data was entered into the statistical program STATA and differences between variable means for the two groups were tested for statistical difference using a *t*-test. These comparisons can be thought of as providing profiles of the farmers who were or were not interested in providing more wildlife habitat.

In order to determine how respondent characteristics affected their willingness to provide habitat, responses to this question also served as the dependent variable in an ordered probit regression. The ordered probit model is specified as:

$$(3) \qquad y_i^* = \beta' x + \varepsilon_i$$

Where, y^* is unobserved (Greene) and y is the underlying response variable (Maddala). From this, the following observations are made:

(4) $y = 1$ if $y^* \leq \mu_1$;

(5) $= 2$ if $0 < y^* \leq \mu_2$;

(6) $= 3$ if $\mu_2 < y^* \leq \mu_3$;

(7) $= 4$ if $\mu_3 < y^* \leq \mu_4$;

(8) $=5$ if $y^* > \mu_5$.

The $\mu's$ are unknown parameters. Since this is a probit, or normative, model, μ and β are measured together, not separately**.** Respondents had their own intensity of feelings with respect to their willingness to provide habitat, which feelings depend on certain measurable factors, x, and certain unobservable factors, ε. In principle, the respondents could have answered the question with their own y^* if they had been asked to do so (Greene). This model measures an individual's utility for providing habitat. Each person has his or her own scale making it impossible to measure an individual's personal utility. What can be measured is the extent to which the individual corresponds with the levels of agreement in the survey.

In order to correspond with the format of the probit model, responses to the interest in providing more habitat question were coded 1 through 5. Variable means, standard errors and number of observations (*N),* were defined in Table 1. The ordered probit model was:

$$(9)\quad \text{HABITAT}_i = \beta_0 + \beta_1 \text{EDUCATION}_i + \beta_2 \text{FULLOWNER}_i + \beta_3 \text{EXPERIENCE}_i + \beta_4 \text{NFIPERACRE}_i + \beta_5 \text{OFFFARM}_i + \beta_6 \text{HUNTING}_i + \beta_7 \text{ENVIRONMENTAL}_i + \beta_8 \text{GROWERCOMMODITY}_i + \beta_9 \text{COOPERATIVE}_i + \beta_{10} \text{FARMBUREAU}_i + \beta_{11} \text{HUNTINGLEASES}_i + \beta_{12} \text{DEBTFREE}_i + \beta_{13} \text{COMPUTER}_i + \beta_{14} \text{EXTENSION}_i + \beta_{15} \text{ACRESFARMED}_i + \beta_{16} \text{NOEROSION}_i + \beta_{17} \text{REGIONI}_i + \beta_{18} \text{REGIONIII}_i + \beta_{19} \text{REGIONIV}_i + \beta_{20} \text{RURAL}_i + \beta_{21} \text{BEEF}_i + \beta_{22} \text{DAIRY}_i + \beta_{23} \text{BACKGROUNDING}_i + \beta_{24} \text{EQUINE}_i + \beta_{25} \text{POULTRY}_i + \beta_{26} \text{SWINE}_i + \beta_{27} \text{CORN}_i + \beta_{28} \text{COTTON}_i + \beta_{29} \text{TOBACCO}_i + \beta_{30} \text{SOYBEANS}_i + \beta_{31} \text{WHEAT}_i + \beta_{32} \text{FRUIT}_i + \beta_{33} \text{VEGETABLES}_i + \beta_{34} \text{HAY}_i + \beta_{35} \text{FORESTLAND}_i + \beta_{36} \text{IDLE}_i + \beta_{37} \text{NOTILL}_i + \varepsilon_i.$$

Table 2 lists the *a-priori* hypothesized effects of these variables on landowner willingness to provide more habitat. For instance, it was hypothesized that landowners, who were members of hunting-related or environmentally associated organizations, would be more likely to be willing to provide more wildlife habitat. It is also hypothesized that livestock producers would be generally unwilling to increase habitat, as they would be opposed to the increase of wildlife in or around their animals. For example, poultry farmers would not want to increase the amount of wildfowl because of the possibility of disease associated with wild birds.

The relationship between interest in providing habitat and growing certain commodities is less clear. Soybean farmers, for example, have historically had issues

Table 2. Hypothesized Effects of Variables on Willingness to Provide Habitat.

Variable	Hypothesized Effect on Willingness to Provide Wildlife Habitat
EDUCATION	+
FULLOWNER	?
EXPERIENCE	+
NFIPERACRE	-
OFFFARM	+
HUNTING	+
ENVIRONMENTAL	+
GROWERCOMMODITY	?
COOPERATIVE	?
FARMBUREAU	?
HUNTINGLEASES	+
DEBTFREE	?
COMPUTER	+
EXTENSION	+
ACRESFARMED	+
NOEROSION	-
REGIONI	+
REGIONIII	+
REGIONIV	+
RURAL	+
BEEF	-
DAIRY	-
BACKGROUNDING	-
EQUINE	-
POULTRY	-
SWINE	+
CORN	+
COTTON	-
TOBACCO	?
SOYBEANS	-
WHEAT	-
FRUIT	-
VEGETABLES	-
HAY	+
FORESTLAND	+
IDLE	+
NOTILL	+
CRPGRASS	+
CRPTREES	+
Age	+

with deer damaging their crops. Clemson University reported that there has been severe deer pressure on soybeans due to the fact that this is a preferred food of deer. Crop producers reported that 70 percent of their 1991 soybean acreage was damaged to some extent by deer. Based on the reported acreage, it was estimated that deer damage cost soybean producers in that state more than $7.8 million in 1991 (Clemson University). Therefore, soybean growers would most likely be opposed to increasing habitat on their land due to the fact that an increase in habitat could bring about a larger crop loss.

Results

Interest in Providing Habitat

Table 3 summarizes the responses to the question regarding interest in providing additional habitat. The mean response of those responding to the question was 2.4 (N=1,675), signifying that those who responded were generally in agreement with this statement. There were 950 respondents who agreed or strongly agreed and 725 who disagreed at some level or who chose the no opinion option.

The results of the *t*-tests, which test the statistical significance between variables, are shown in Table 4. From the results of the means test, respondents who were interested

Table 3. Distribution of Agreement/Disagreement with the Statement "I would like to Provide more Habitat for Native Wildlife Species on my own Land."

Willingness to Provide Habitat	Percent	Count
Strongly Agree (1)	19.9	333
Agree (2)	36.8	617
No Opinion (3)	31.5	527
Disagree (4)	9.5	159
Strongly Disagree (5)	2.3	39
Total:	**100**	**1675**

Table 4. Test of Difference in Means of Variables among Respondents who were Interested or Not Interested in Providing More Wildlife Habitat.

Variable	Interested		Not Interested	
	Mean	N	Mean	N
Full Owner	0.79	947	0.78	711
Net Farm Income per Acre	152.34	843	223.42	627
Off-Farm Income	52.80*	871	49.50	602
Acres Farmed	214.03***	918	181.15	695
Hunting Leases	0.10***	937	0.07	718
Debt Free	1.98**	873	1.80	651
No Erosion	0.39***	874	0.54	652
CRP Grass	25.47	195	14.83	104
CRP Trees	7.55	195	10.45	104
Education	3.05***	940	2.73	700
Age	58.35*	946	59.71	708
Farming Experience	36.13***	905	39.08	666
Computer	0.70***	938	0.57	708
Extension	0.98***	846	0.71	637
Hunting Organization	0.17***	948	0.04	718
Environmental Organization	0.08***	948	0.03	718
Grower / Commodity Organization	0.08***	948	0.04	718
Cooperative	0.53**	948	0.49	718
Farm Bureau	0.76	948	0.74	718
Beef Cattle	0.75***	943	0.80	721
Dairy Cattle	0.01***	943	0.03	721
Backgrounding / Stockering	0.06	943	0.03	721
Equine	0.06***	943	0.03	721
Poultry	0.01*	943	0.01	721
Swine	0.00	943	0.00	721
Corn	0.13	950	0.12	725
Cotton	0.02	950	0.01	725
Tobacco	0.14	950	0.13	725
Soybeans	0.11**	950	0.08	725
Wheat	0.08***	950	0.05	725
Fruit	0.03	950	0.02	725
Vegetables	0.07*	950	0.06	725
Hay	0.77	950	0.74	725
Forest Land	0.19***	950	0.14	725
Idle Acres	0.04***	950	0.01	725
No-Till	0.50***	904	0.42	688
Region I	0.19***	950	0.13	725
Region III	0.18	950	0.17	725
Region IV	0.23***	950	0.34	725
Rural	0.49	950	0.48	725

*** Indicates statistical significance at $\alpha = 0.05$

** Indicates statistical significance at $\alpha = 0.10$

* Indicates statistical significance at $\alpha = 0.15$

in providing more wildlife habitat:

- Farmed more acres;
- Issued more hunting leases;
- Had more erosion on their land and were more likely to practice no-till;
- Had more education, and higher off-farm income, but a higher debt to asset ratio;
- Were younger;
- Had less farming experience and owned more computers; and,
- Attended more extension workshops or experiment station field days;
- Were more likely to be members of hunting, environmental, grower/commodity, or cooperative organizations;
- Owned less beef and dairy cattle, but more equine;
- Grew more soybeans, wheat, and vegetables;
- Had more forest land and idle acreage; and,
- Were more likely to be located in Region I and less likely to be located in Region IV.

The parameter estimates found from conducting the ordered probit regression, along with their associated standard errors, are presented in Table 5. There were 12 variables that were significant at the 85 percent confidence level or greater. Most of the significant variables conformed to expectations. The following conformed to prior expectations: growing soybeans; having a beef, dairy, or backgrounding / stockering operation; no significant

Table 5. Parameter estimates and summary statistics.

Variable	Estimate	Standard Error
Willingness to Provide More Habitat		
Landowner Information		
Education	0.00	0.03
Full Owner	0.11	0.08
Farming Experience	-0.00	0.00
Net Farm Income per Acre	-0.00	0.00
Percent Off-farm	-0.00	0.00
Hunting Organization	0.69***	0.11
Environmental Organization	0.28**	0.15
Grower / Commodity Organization	-0.04	0.14
Cooperative	-0.06	0.07
Farm Bureau	-0.02	0.08
Hunting Leases	0.02	0.12
Debt Free	0.00	0.02
Computer	0.19***	0.08
Extension	0.01	0.03
Characteristics of Farm Operation		
Acres Farmed	0.00	0.00
No Erosion	-0.20***	0.07
Region I	0.15	0.12
Region III	0.08	0.10
Region IV	-0.22***	0.09
Rural	-0.01	0.07
Beef Cattle	-0.32***	0.10
Dairy Cattle	-0.88***	0.26
Backgrounding / Stockering	-0.20*	0.14
Equine	0.10	0.17
Poultry	0.14	0.31
Swine	-0.28	0.45
Corn	0.06	0.11
Cotton	-0.31	0.28
Tobacco	0.12	0.11
Soybeans	-0.27***	0.14
Wheat	0.41***	0.15
Fruit	0.38**	0.23
Vegetables	0.15	0.14
Hay	0.05	0.09
Forest Land	0.06	0.09
Idle Acres	0.34	0.20
No-Till	0.03**	0.07
Pseudo R^2		0.05

*** Indicates statistical significance at $\alpha = 0.05$

** Indicates statistical significance at $\alpha = 0.10$

* Indicates statistical significance at $\alpha = 0.15$

erosion problem; no-till; membership in hunting and environmental organizations; and owning a computer.

The growing of soybeans did in fact have a negative impact on the farmer's willingness to provide more habitat. This finding appears to support the theory that soybean farmers would be opposed to increasing wildlife on their land since they incurred such a large amount of damage from wildlife that decrease harvestable yields. Additional variables that had predicted outcomes were that of the cattle operations: beef, dairy, and backgrounding / stockering. In order to maximize their land potential, producers would most likely not want to reduce the amount of pasture or hay producing land for their cattle. The results showed a negative influence.

Not having an erosion problem ended up having a negative impact on respondent interest in providing habitat, which is consistent with the original hypothesis. Landowners who do not have a significant erosion problem are less likely to want to take land out of production and enroll it in a government program or plant it in switchgrass. More than likely, they will be producing on as much of their land as possible to be efficient.

Farmers who practice no-till were expected to have a greater interest in assisting wildlife. No-till has wildlife benefits. Crop residues left intact help both natural precipitation and irrigation water infiltrate the soil where it can be used. By implementing no-till, land is less compacted, and the field generally keeps a higher count of certain insects and earthworms. This can also lead to winter habitat and food for certain birds and other animals.

Membership in hunting and environmental organizations was hypothesized to have a positive effect on interest in providing more habitat. Therefore, it was not surprising when the results showed that these two variables had a positive influence.

It was originally believed that wheat farmers would be opposed to growing certain habitat-friendly crops, such as switchgrass, due to the fact that the crop could be seen as a possible competitor to their existing operations, since switchgrass and wheat can be grown in the same areas in come cases. However the growing of wheat ended up having a positive and statistically significant influence. One possible explanation is that wheat farmers may be trying to find a less demanding crop to plant. Wheat can be a delicate crop to harvest. It must be harvested at a certain time during its growth period, more specifically, when the crop is drying up. During this fragile state, it takes little disturbance to cause the seeds to fall out of the plant, which causes them to not be recoverable. Wildlife wandering through wheat fields can cause a large amount of seed dispersion just by bumping into the plants. After considering the downfalls of growing and harvesting wheat, growers may decide that the production of switchgrass could be easier to handle and less worrisome.

Another interesting finding was that the variable for growing fruit had a positive and statistically significant effect. This result was unexpected since some species of wildlife are often attracted to fruits. One possible reason behind the positive effect is due to the sensitivity of these plants. In order to be successful, most fruits, such as grapes from vineyards, require particular weather conditions. Perhaps some fruit producers are

ready to depart from this particular type of farming and move towards something that has a few less specialized requirements.

TWRA Region IV has been consistently reported to have the lowest amounts of species of wildlife in the State. Figure 2 showed the distribution of hunting units in Tennessee that correspond to the numbers of wildlife in those areas. In order to increase numbers in a certain area, more habitat will need to be created and maintained. It was originally thought that landowners would be more willing to provide habitat in Region IV of the state in order to draw more wildlife back to this area of the state. Therefore, it is interesting that landowners in this area of the state were actually not interested. Perhaps a reason behind the small amount of interest falls upon lack of general knowledge of the dwindling wildlife in this region. Another possibility is that the lack of interest in providing habitat is what caused the numbers to lessen in the first place.

Conclusion

This research analyzed the associated factors of willingness to provide more habitat in order to assess the potential of governmental programs to increase wildlife habitat in Tennessee, and provide program administrators with information that will assist in targeting their programs to specific landowners in the state.

Data was obtained from a survey conducted by the University of Tennessee Switchgrass Project called the "Switchgrass Production for Energy: Your Views." Landowners were asked to rate their agreement with the statement "I would like to provide more habitat for native wildlife species on my own land." Of those who responded to this question, a majority (57 percent) agreed or strongly agreed. These

results indicate that there are a significant number of farmers who would at least consider adopting practices to improve habitat. This also suggests that programs could be successful in increasing wildlife habitat in Tennessee.

A *t*-test was conducted in order to check for statistical significance between the means of variables among respondents who were interested and those who were not interested in providing more wildlife habitat. The results of the means test provide a more specific picture of the interested landowner. Specifics about management practices of the interested individuals were also observed.

Information from the statistically significant variables found from the ordered probit analysis showed that the following characteristics of landowners have a positive effect on interest in providing habitat:

- Membership in hunting and environmental organizations; and,
- Ownership of a computer.

The farm management practices that had a positive influence on willingness to provide habitat were:

- Production of wheat, fruit; and,
- The practice of no-till.

Negative influences included statistically significant variables such as:

- No significant erosion problem;
- Location in TWRA Region IV;
- Beef cattle, dairy cattle and backgrounding / stockering operations; and,
- Production of soybeans.

TWRA Region IV, or basically Northeast Tennessee, seems to have the least interest in providing more habitat. This is rather interesting considering this region of the state already has the lowest numbers of many game animals in the state. In order to increase the numbers of some of these animals, the amount of habitat is going to have to be increased.

After reviewing the results of the regression analysis, as well as the means test, a group of interested individuals can be characterized. Overall, those who are interested in habitat provision are younger, more educated, issue hunting leases, were members of environmentally related organizations, and attended agriculture events.

Of those who expressed interest to provide additional habitat on their land, over half reported that they had an issue with erosion. Providing wildlife habitat has the ability to decrease erosion by changing the management practices of landowners. Some of the governmental programs call for the planting of certain native grasses, which can improve the soil composition with their root systems. No-till also can benefit both the land and associated wildlife. This practice results in less soil compaction and reduced amounts of erosion linked to tillage.

Only a small percentage of respondents issued hunting leases. Perhaps the low numbers are due to the perception that they must have large amounts of land to offer to the potential hunter. When, in fact, many hunters desire smaller tracks of land, and many prefer one landowner as opposed to several persons or hunting clubs. The amount of land leased by a hunter is also directly related to the type of game animals to be hunted.

Considering how membership in hunting and environmental organizations is higher for those interested in providing additional habitat, this is an excellent place for program administrators to begin educating about the possibilities offered from the various agendas. Other notable considerations are the ownership of computers and the attendance at extension workshops or field days within the interested group. These are very direct ways to contact landowners and to provide education about the available government programs. Therefore, setting up a more detailed description of an interested individual and means by which those landowners can be reached has completed the second objective of this research.

There are still a few gaps in the research. A specific survey could be produced to more specifically target potential program enrollees or those interested in providing more habitat. It remains to be seen how influential things such as location of the land, age of the farmer, and current program-enrollees, are on the possibility of following suggested farm management practices. Another issue that can be addressed by further investigation is that of the hunt lease. To date, there is not that much information concerning the issuance of and satisfaction received by both the landowner and the lessee. Something else to examine with future research is the impact that technology has on interest in proving habitat. Landowners who are up-to-date on technology and are profit-maximizers may be more likely to adopt a program that would provide financial gain than those who do not keep up with the latest advances. On the other hand, those landowners who can not afford the latest technology and are forced to implement mostly used machinery may be very willing to adopt a program that could help alleviate costs associated with production.

This information may be helpful for program administrators to know in the future. Future research can take these factors into consideration and further assist government officials in targeting landowners of their available programs that could lead to the increase of wildlife habitat.

CHAPTER III

Introduction

Power from biomass is proving to be a commercial electricity-generation option for the United States. Biomass is now the largest domestic source of renewable energy, currently supplying over 3 percent of the U.S. total energy consumption. An increasing number of power marketers are starting to offer environmentally friendly electricity, including biomass power, in response to consumer demand and regulatory requirements (DOE 2007c). Biomass is defined as all plant and plant-derived material, meaning that biomass is a fully renewable resource and that it's conversion to biomass-derived fuels, power, chemicals, materials, or other products, essentially generates no greenhouse gases. The process seeks to capture energy originally created through photosynthesis. The most important products are biomass-derived ethanol and bio-diesel, which provide the only renewable alternative liquid fuel for transportation (DOE 2007b). Energy production from biomass has the potential to strengthen rural economies, decrease America's dependence on imported oil, abolish the use of highly toxic fuel additives, and reduce environmental impacts such as, greenhouse gas emissions and water pollution (DOE 2007a).

There is interest in converting switchgrass (*Panicum virgatum*) biomass into ethanol for use as a bio-fuel or burning it to generate electricity (Comis 2007a). Switchgrass has been identified as a promising bio-energy crop because of the wide range of conditions under which it can grow. Switchgrass is a natural component of the tall-

grass prairie, which covered most of the Great Plains, but was also found on the prairie soils in the Black Belt of Alabama and Mississippi (Bransby).

As carbon accumulates, especially below the ground, it is known as carbon sequestration. Switchgrass, like all other plants, removes carbon dioxide (CO_2) from the atmosphere and incorporates it into plant tissue, both above and below the ground. Switchgrass is considered by some researchers to be one of the best crops for reducing atmospheric CO_2, which is a greenhouse gas that increases the risk of global climate change. In contrast, when fossil fuels are burned, carbon is removed from its below ground storage and released into the atmosphere as CO_2. Biomass that is used to produce energy will reduce the risk of global climate change by replacing fossil fuels (coal, natural gas and oil). When harvested switchgrass is burned for energy production, CO_2 is returned to the atmosphere, but the use of switchgrass will reduce dependency on fossil fuels. Figure 3 gives an illustration of how switchgrass cycles carbon dioxide. CO_2 is

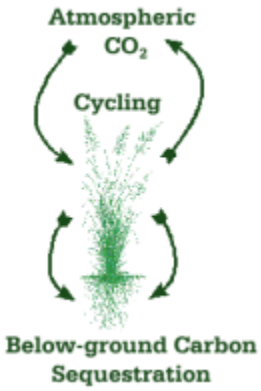

Figure 3. Switchgrass Cycling of Carbon Dioxide.

Source: David Bransby, Auburn University, Switchgrass Profile

being recycled which makes this process CO_2 – neutral, or actually CO_2 – negative if soil carbon sequestration is taken into consideration (Bransby).

Switchgrass has been produced as a forage crop and used for conservation purposes for many years, but its development as a potential energy crop didn't begin until 1991 as part of the U.S. Department of Energy's Biomass Feedstock Development Program at the Oak Ridge National Laboratory. Field trials were established at 18 sites in 13 states, including Tennessee (Walsh). Walsh suggests that energy production of switchgrass would require this crop to compete with existing uses of agricultural land.

Dave Bransby, a forage scientist at Auburn University, has been experimenting in southern Alabama with converting cotton fields into switchgrass producing fields. Bransby claims his site holds the one-year record at 15 dry tons per acre, but reports a six-year average of 11.5 dry tons per acre per year. One possible use for switchgrass is to convert into ethanol, which is an alcohol that can fuel vehicles. According to Bransby's research, approximately 1,500 gallons of ethanol can be obtained per acre of switchgrass. At a yield of 15 dry tons per acre, this translates into roughly 100 gallons of ethanol per dry ton. Another additional benefit is that the leftover parts of the crop that can't be converted into ethanol can be used to produce electricity (Oak Ridge National Laboratory). Many farmers already grow switchgrass, either as forage for livestock or as a ground cover, to control erosion. For the farmers, cultivating switchgrass as an energy crop instead would require only minor changes in how it's managed and when it's harvested. Switchgrass can be cut and baled with conventional mowers and balers. And it's a hardy, adaptable perennial, so once it's established in a field, it can be harvested as a

cash crop, either annually or semiannually, for 10 years or more before replanting is needed (Oak Ridge National Laboratory).

Switchgrass has excellent burn qualities, is easily managed, and can have satisfactory yields without the high rates of nitrogen fertilizer that some crops require. Since it is a native grass, it is relatively adaptable to a variety of soils and climatic conditions. There is also a range of possible planting times for switchgrass. Most of it is planted in mid-April to late-May. However, there has been some grower success with dormant planting in late November and December. Growers have also had some success with surface sowing or frost seeding in February and March (Teel et al).

There are several governmental programs available to assist farmers with a variety of agriculture-related tasks. Only a few of these programs presently address the growth of switchgrass on enrolled acreage; more specifically are that of the Conservation Reserve Program (CRP) and the Environmental Quality Incentives Program (EQIP). Both of these programs attempt to improve the environment in several different ways. They both encourage farmers to grow native grasses on enrolled land in order to both improve agricultural land and benefit the environment. Each of these programs will be examined a bit more in depth later in this chapter along with a discussion on the program's current positions on switchgrass production.

Attention has been recently been focused on switchgrass concerning land that is coming out of "retirement" from the CRP. Many CRP contracts are expiring soon and that land will be returned to production in the coming years. If returned to row crops, the perennial soil qualities from CRP grasses may be lost, causing the benefits, such as

increased soil fertility and erosion control due to lack of tillage, to be marginal at best. Switchgrass production for energy has the potential to partially maintain the benefits of CRP, while at the same time, allowing landowners to earn profits on land that sat idle for years (Caldwell).

This research is intended to provide farmers with an investigation on the economic possibilities of switchgrass production. The Chapter will be focused on providing a framework for examining the full range of potential costs and benefits to Tennessee producers from producing switchgrass for energy production. This Chapter begins with an economic analysis of switchgrass production. Included in this analysis are actual and opportunity costs of producing switchgrass as opposed to producing another crop. Also included are many of the benefits of switchgrass production, including both revenue and non-revenue benefits. There will also be a brief examination of the public benefits of producing this crop.

Economic Analysis

A profit-maximizing farmer is usually on the look out for a crop that generates the greatest revenues with the lowest possible input costs. This segment of the chapter will attempt to analyze financial issues relating to switchgrass production in order to assist farmers in analyzing the production of switchgrass as opposed to the crops being currently grown on their agricultural land. When considering a change in crop production, there are trade offs to consider. Producing a crop generates both benefits and costs and some of these costs are associated with the lost opportunities for using the land and other resources in other ways.

Associated costs of production consist of two categories: actual and opportunity. When considering production, most expenses fall under the heading of actual costs. This category generally refers to tangible goods being bought and utilized, for instance the cost of fertilizer or the depreciation of machinery used in producing switchgrass. Cost of production can be calculated on a per acre basis when making a comparison among alternative crops. Or a farmer can calculate costs on a whole-farm basis (Idaho Barley Commission). Land can require different amounts of input costs while in production, such as fertilizer, which depends on the land in question. Therefore, the best estimates on crop production probably should be done on a per-acre basis in order to capture the varying costs such as fertilizer application.

Opportunity costs are the values of the next best alternative. When a farmer decides a certain crop to plant, they cannot choose another separate crop for that same field for that production year, nor can they lease that land to anyone else. Thus, two factors to consider when calculating opportunity costs are agriculture land rents and the profits from the production of a different crop. A farmer cannot both rent land to someone else and grow a crop on it concurrently; therefore, the farmer should be familiar with the benefits and costs of both alternatives.

The production of switchgrass can generate benefits in the form of revenue. There is a developing market for growing switchgrass for energy needs. Governmental programs are available to assist farmers technically, as well as to possibly provide a potential source of revenue. Since switchgrass provides habitat for many birds and other small game, growing switchgrass can draw more wildlife to an area. With an increase in

wildlife, farmers could possibly charge for hunting leases on their land, providing another income source.

Switchgrass can also provide non-revenue benefits. As already mentioned, this crop can provide habitat for numerous animals. Another potentially important factor for farmers is the fact that switchgrass has the ability to be used for erosion control due to its extensive root system. When considering the massive roots of switchgrass, it is also relevant to speak of its ability to store carbon deep below the ground. Rice suggests that when carbon is part of the soil organic matter, the soil's capacity to hold basic organic matter increases, which improves the soil's fertility. Rice also mentions that the increased organic matter in the soil improves its water holding capacity, while the increased soil carbon improves the structure of the soil, resulting in improved drainage and aeration.

Actual Costs of Switchgrass Production

The University of Tennessee Extension has created a series of "Switchgrass Working Budgets" for the year 2007, which are located in Appendices 13 through 18. This is a good starting place for farmers when considering the change towards production of switchgrass. Included are many production-related costs to be considered by the farmer, such as fertilizer and machinery expenses, and labor estimates. The budgets are broken up into stages: establishment, reseeding, and annual production. Estimated labor, power and machinery inputs are also included in the Appendices.

Switchgrass harvesting can be done with regular hay-baling equipment, therefore not causing the farmer extra money in specialty equipment. The same goes for when considering chemical usage, switchgrass doesn't require special fertilizers, and in most

cases requires fewer chemicals than the crops already in production. Table 6 shows a comparison of fertilizer needs for switchgrass and competing crops.

Consideration of cultural practices, as they relate to production, is one of the initial steps in evaluating costs of producing another crop, such as switchgrass. Certain factors can be associated to particular practices as well: land type, skill of the farmer, available machinery, etc. These factors also have a direct impact on when seeding occurs and the land type used in production (Duffy). Once a seeding time has been decided, other things can be considered. Duffy also suggests that there are varying costs that are associated with the different seeding times, seed cost and the amount of seed needed for frost- and spring- seeding practices are an example. Chemical usage can also vary depending on when a farmer decides to plant switchgrass.

Harvesting activities involve mowing, raking, baling, staging, and loading. Depending on the equipment used, the estimates for the time and costs of harvesting can fluctuate. The harvesting of switchgrass is not the same as regular hay or alfalfa due to the difference in plant density and height difference of switchgrass. Another potential cost difference relates to the size of bale used, large round bale vs. large square bale. These differences influence the harvesting time and thus the cost. Harvesting costs are assumed to not be linear; that is, as the yield increases, the harvesting costs per acre increase, but the per-ton costs decrease (Duffy).

Table 6.Amount of Fertilizer Needed for Production of Various Crops.

Crop	Description	Unit	Quantity	Price	Amount
Corn					
Conventional and No Tillage (150 Bushel Yield)	N (Urea)	Lb.	170	$0.31	$52.70
	$P_2 0_5$	Lb.	70	$0.32	$22.40
	K_2O	Lb.	70	$0.22	$15.40
	Ag Limestone	Ton	0.5	$23.00	$11.50
				Total:	$102.00
Wheat					
(55 Bushel Yield)	N	Lb.	80	$0.42	$33.60
	$P_2 0_5$	Lb.	40	$0.32	$12.80
	K_2O	Lb.	20	$0.22	$4.40
	Lime	Ton	0.5	$23.00	$11.50
				Total:	$62.30
Soybeans					
Roundup Ready-No Tillage	$P_2 0_5$	Lb.	20	$0.32	$6.40
(40 Bushel Yield)	K_2O	Lb.	40	$0.22	$8.80
	Lime (2 tons every 4 years)	Ton	0.5	$23.00	$11.50
				Total:	$26.70
Cotton					
Roundup Ready-Conventional and No Tillage	N (Urea)	Lb.	80	$0.42	$33.60
BgRR-Conventional and No Tillage	$P_2 0_5$	Lb.	60	$0.32	$19.20
	K_2O	Lb.	90	$0.22	$19.80
	Boron	Lb.	0.5	$3.85	$1.93
	Lime	Ton	0.5	$23.00	$11.50
				Total:	$86.03
Alfalfa, Hay					
	$P_2 0_5$	Lb.	60	$0.34	$20.40
	K_2O	Lb.	190	$0.23	$43.70
	Boron	Lb.	2	$2.38	$4.76
	Lime	Ton	0.67	$21.00	$14.07
				Total:	$82.93
Bermudagrass, Hay					
	N	Lb.	240	$0.48	$115.20
	$P_2 0_5$	Lb.	60	$0.34	$20.40
	K_2O	Lb.	180	$0.23	$41.40
	Lime	Ton	0.67	$21.00	$14.07
				Total:	$191.07
Clover, Hay					
	N	Lb.	60	$0.48	$28.80
	$P_2 0_5$	Lb.	30	$0.34	$10.20
	K_2O	Lb.	30	$0.23	$6.90
				Total:	$45.90
Switchgrass					
	N	Lb.	50	$0.40	$20.00
	$P_2 0_5$	Lb.	40	$0.33	$13.20
	K_2O	Lb.	60	$0.20	$12.00
				Total:	$45.20

Source: Dr. Delton C. Gerloff, Field Crop Budgets for 2007, University of Tennessee Extension Service.

Establishment and production costs are the two main expenses of switchgrass production. The budget for switchgrass establishment is contained in Appendix 13 and the estimated labor, power and machinery inputs for establishment are contained in Appendix 14. Reseeding, the budget for which is located in Appendix 15 and the estimated labor, power and machinery inputs for which are found in Appendix 16, adds a third cost component. This step consists of estimating the expected reseeding cost, including seeds, fertilizers, pesticide-related costs, and labor charges. The last step is estimating the annual production costs, the budget for which is located in Appendix 17. This budget includes costs such as weed control, fertilizer, twine, and labor charges. The budget for the estimated labor and machinery inputs for production are located in Appendix 18.

Switchgrass requires less labor during the establishment and growing periods than some of its closest competitive crops. Table 7 shows a break down of labor needs of several crops including switchgrass. No-tillage crops offered the closest competing labor time as that of switchgrass. However, harvest labor time is greater for switchgrass than the other crops. Currently, when switchgrass is harvested, it is typically baled into large round-bales. There is basically no easy way to deal with these types of bales; they are difficult to load, transport, and store. These difficulties add labor and hassle to the baling and loading stage of production. Rankin suggests that packaging into large square bales could provide some labor and handling advantages over large round bales. The University of Wisconsin states that another big part of the growing popularity of large square bales is the ease of stacking them on semi-

Table 7. Amount of Labor Needed for Production (Hours per Acre).

Crop	Establishment/Growth	Harvest	Total
Corn			
Conventional Tillage, 150 Bushel Yield	0.46	0.34	0.80
No Tillage, 150 Bushel Yield	0.17	0.34	0.51
Wheat			
55 Bushel Yield	0.53	0.30	0.83
Soybeans			
Roundup Ready-No Tillage, 40 Bushel Yield	0.20	0.30	0.50
Cotton			
Roundup Ready-Conventional Tillage	1.20	0.72	1.92
BgRR-Conventional Tillage	1.19	0.72	1.91
Roundup Ready-No Tillage	0.57	0.72	1.29
BgRR-No Tillage	0.56	0.72	1.28
Alfalfa, Hay [4]	0.08	5.57	5.65
Bermudagrass, Hay [Ibid]	0.00	5.44	5.44
Clover, Hay [5]	0.02	5.59	5.61
Switchgrass	0.19	1.80	1.99

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

[4] Assumes four balings per year. First baling includes the use of a tedder.

[5] Assumes three balings per year. All three balings include the use of a tedder. During the month of September, 0.10 unit of labor is adder to cover a fescue or orchardgrass overseeding.

trucks, railroad cars, etc., for transport (especially when compared to large round bales).

As with any potential change in crop production, there are costs associated. The budgets provided by UT Extension provide a helpful starting point for farmers who are considering a shift towards switchgrass production. During the establishment and growing periods of switchgrass, less labor is required then that of the competing crops. However, switchgrass does require more labor during harvest, which could potentially be alleviated by the use of large square bales as opposed to round bale usage. According to the UT Extension crop budgets, the only crop to require less fertilizer then switchgrass is that of soybeans. Although, the amount of fertilizer needed was similar for that of clover hay and switchgrass.

Opportunity Costs

Rental Value

Agricultural land rent values are basically how much a person is willing to pay to rent agricultural land from a landowner. Typically this is broken down into one of two categories: crop- and pasture- land. According to the Agriculture Statistics Board from the National Agriculture Statistics Service (NASS), the 2006 cash cropland rental rates in Tennessee averaged $68 per acre and the average pasture rental rate was $20 per acre (USDA 2007b). These values vary according to location and resources available on the land. Land that requires irrigation may go for less than land that does not require it, for instance (USDA 2007b).

Producing another Crop

UT Extension provided crop budgets for various crops for 2007, which are located in Appendices 2 through 9. The costs in this report are correlated with various expenses related to production. These estimates, however, are not exact figures. They do not encompass all possible costs in relationship to production of these crops. In the evaluation of these estimates, fertilizer recommendations were budgeted generally for soils that had a medium soil test. Fertilizer expenses might be higher or lower depending on soil conditions. As crop programs are planned, the fertilizer applications can be adjusted to the soil test recommendations (Gerloff). The UT analysis provides a starting point to estimate the returns above variable and fixed expenses associated with production verses not producing and performing other management practices on the land.

According to the corn production budget for 2007, found in Appendix 2, assuming a conventional tillage method, it is assumed that farmers will yield a quantity of 150 bushels per acre at a price of $3.40/bushel. This equates to gross revenue of $510.00 per acre. Subtracting the total variable expenses, of $199.29, this shows a return above variable expenses of $310.71. After subtracting machinery, equipment, and labor expenses, there is a return of $274.22 per acre. Lastly, after subtracting labor expenses, this shows a return to land, management, and risk of $267.42 per acre.

In regard to wheat production, budget found in Appendix 4, once again the UT Extension production budgets will be referenced. Assuming a 55 bushel yield and a price of $3.90/bushel, this equates to gross revenue of $214.50 per acre. After subtracting the

total variable expenses, as well as the machinery and labor expenses, this yields a return to land, management, and risk of $21.46 per acre.

Table 8 shows a breakdown of various crops and their associated returns to land, management, and risk. This table can be referenced to note the amount that switchgrass producers would need to receive in order to generate a net return greater than the opportunity costs.

Another comparison worthy of being made is to compare switchgrass production as opposed to producing hay. UT Extension also came up with Forage Crop Budgets for the year 2007, in particular, for the crops of alfalfa, bermudagrass and the cool seasonal grass of clover. Appendix 10 contains the production budget for Alfalfa. The production

Table 8. Return above Expenses, Various Crops.[6]

Crop	Return above Variable Expenses	Return to Land, Management, and Risk
Corn		
Conventional Tillage, 150 Bushel Yield	$310.71	$267.42
No Tillage, 150 Bushel Yield	$313.23	$281.38
Wheat		
55 Bushel Yield	$65.91	$21.46
Soybeans		
Roundup Ready-No Tillage, 40 Bushel Yield	$153.08	$121.96
Cotton		
Roundup Ready-Conventional Tillage	$131.34	$36.72
BgRR-Conventional Tillage	$123.85	$30.70
Roundup Ready-No Tillage	$143.63	$72.09
BgRR-No Tillage	$136.14	$66.06

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

[6] Alfalfa, bermudagrass, and clover are not listed considering the range of prices hay receives across the state for both square and round baled hay.

budget for bermudagrass can be found in Appendix 11, and clover's production budget is located in Appendix 12. Each of these forages requires nearly three times as much labor as switchgrass does. Something else to consider is that, according to the budgets presented by UT Extension, alfalfa and bermudagrass have total budgeted expenses of nearly twice that of switchgrass. Clover has a higher budgeted expense amount then switchgrass as well, at a cost of approximately $35 more. In order to calculate a net return above expenses for the hay forages, a farmer would need to take into account the price that the hay was getting on the market, multiply that by the amount of hay sold, and then subtract total expenses from that amount.

Benefits of Switchgrass Production

Revenue Streams

Harvested Switchgrass

Considering that large-scale production of switchgrass for energy doesn't have a market in Tennessee yet, there is not much data concerning current prices that producers are receiving. There is no steady demand for the crop in most areas; therefore prices fluctuate depending on its intended purposes. Future uses and acceptance of this crop will determine a market price for switchgrass. De la Torre Ugarte suggests that at a price of $40/dry ton, switchgrass production transformed into ethanol could displace 1.9 percent of all domestic gasoline consumption.

The ideal management for switchgrass production would probably be that of a one harvest/year scenario. This practice could benefit producers who are growing switchgrass

for both grazing and haying purposes as well as for an energy feedstock. Holmberg suggests that if switchgrass is being harvested for hay, it can only be cut once per year in order to retain the highest digestibility and the best possible nutritional values. The re-growth after the first cutting has a lower nutritional value since a higher percentage of it comes back as a stalk instead of the leafy produce of the first cutting (Holmberg). Also, if switchgrass is being grown for energy purposes, a producer would likely want to retain as much of the bulk of the plant as possible, since it is generally marketed on a tonnage basis.

In order to be competitive as a commodity crop, switchgrass will have to have higher production values than crops such as corn and wheat, depending on the intended purposes of the switchgrass production. In the case of energy production, the market will need to support prices that compare to the net profit of corn, or other competing crops, or government subsidies will need to be provided.

To calculate an anticipated return, net of variable, machinery and labor expenses, the switchgrass budgets (found in Appendices 13 through 18) will be referenced. The initial establishment costs were found to be around $167.23; however, this cost is annualized over the expected life of the plant for the purposes of making annual comparisons. This amount is prorated over 11 years to equal around $23.43. The reseeding cost of $130.73 is also prorated, over 10 years, for the annual amount of $3.90. These amounts are then added to the production budget per acre of roughly $191.43, equaling $218.76. Table 9 shows an analysis of the per-acre net returns for switchgrass as

they correspond with various yields at various prices. Tennessee is averaging switchgrass yields of approximately 10-15 tons/acre over the life of the plant (Holmberg).

Government Subsidies

There are a number of governmental programs in place in order to assist the farmer ranging from physical to financial assistance. Right now, the programs that allow switchgrass to be grown only allow it to be harvested for hay purposes, but there has been a recent push for the new Farm Bill to contain provisions that would assist landowners in producing switchgrass for energy purposes as well. Many of the plans call for taking land out of production of crop farming, and urge the landowner to plant that land with vegetation such as warm or cool seasonal grasses. Benefits of these plans include: controlled soil erosion, improved water quality in streams and ponds, increased the value of timber on the land, or even increased the profitability in farming operations (Anderson and Gudlin). Switchgrass has the ability to assist in these benefits; therefore more programs may provide revenue for switchgrass production in the future. Appendix 1

Table 9. Annual Net Return per Acre of Switchgrass Production.

Yield (Tons/Acre)	Price for Harvested Switchgrass						
	$20/ton	**$25/ton**	**$30/ton**	**$35/ton**	**$40/ton**	**$45/ton**	**$50/ton**
8	($58.76)	($18.76)	$21.24	$61.24	$101.24	$141.24	$181.24
9	($38.76)	$6.24	$51.24	$96.24	$141.24	$186.24	$231.24
10	($18.76)	$31.24	$81.24	$131.24	$181.24	$231.24	$281.24
11	$1.24	$56.24	$111.24	$166.24	$221.24	$276.24	$331.24
12	$21.24	$81.24	$141.24	$201.24	$261.24	$321.24	$381.24
13	$41.24	$106.24	$171.24	$236.24	$301.24	$366.24	$431.24
14	$61.24	$131.24	$201.24	$271.24	$341.24	$411.24	$481.24
15	$81.24	$156.24	$231.24	$306.24	$381.24	$456.24	$531.24

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

includes a list and brief description of a number of available programs offered in Tennessee. Most of the programs do not specifically disallow the harvesting of switchgrass, while under some programs, harvesting is completely prohibited. In other cases there are specific regulations around the times by which, and the amounts of, switchgrass that can be harvested.

One of the programs offered by the Natural Resources Conservation Service (NRCS) is the Environmental Quality Incentives Program (EQIP). EQIP is a voluntary conservation program that promotes agricultural production and environmental quality as compatible national goals. Approximately $500,000 has been set-aside in a Tennessee EQIP fund for landowners interested in establishing native grasses for hay, pasture, or field buffers. Producers are eligible for cost-share to establish native grasses and a $75/acre management incentive payment for the first two years of the contract to compensate for forage loss during establishment. In addition, TWRA is also providing a one time $55 per acre incentive payment for installing and managing these native grass practices, to accompany EQIP. Switchgrass, eastern gama-grass, big bluestem, indiangrass, and little bluestem are the recommended grasses for this program. In general, switchgrass is planted on EQIP land mostly because of its wildlife benefits; however, one of the recommended uses of switchgrass being produced on EQIP enrolled land is for it to be harvested for energy production (Brzostek). Therefore, switchgrass can be harvested on EQIP enrolled acreage without affecting the farmer's eligibility for the program, in fact it is a highly recommended use. Table 10 shows a possible profit per acre for the first two years of establishment of switchgrass on EQIP enrolled land. This

table begins with the profits from Table 8, then adding the additional program payments for the first two years. These payments are annualized over the life of a typical switchgrass stand of 11 years.

CRP provides landowners with annual rental payments and cost-share assistance to establish long-term, resource-conserving covers on eligible farmland. Landowners set aside acreage, particularly highly erodible land, and put the land into more resource conserving vegetative covers. There are two different sign-up methods: general sign-up and continuous sign-up. Producers can offer land for CRP general sign-up enrollment only during designated sign-up periods. For information on upcoming sign-ups, producers need to contact their local FSA office. Environmentally desirable land devoted to certain conservation practices may be enrolled at any time under CRP continuous sign-up. In this particular case, certain eligibility requirements still apply, but offers are not subject to competitive bidding. To be eligible to enroll in CRP, land must be either: (1) cropland that is planted or considered planted to an agricultural commodity four of the previous six crop years; or (2) certain marginal pastureland that was converted to wetland

Table 10. Annual Net Return per Acre of Switchgrass Production with EQIP and TWRA Payments.

Yield (Tons/Acre)	Price for Harvested Switchgrass						
	$20/ton	**$25/ton**	**$30/ton**	**$35/ton**	**$40/ton**	**$45/ton**	**$50/ton**
8	($29.37)	$10.63	$50.63	$90.63	$130.63	$170.63	$210.63
9	($9.37)	$35.63	$80.63	$125.63	$170.63	$215.63	$260.63
10	$10.63	$60.63	$110.63	$160.63	$210.63	$260.63	$310.63
11	$30.63	$85.63	$140.63	$195.63	$250.63	$305.63	$360.63
12	$50.63	$110.63	$170.63	$230.63	$290.63	$350.63	$410.63
13	$70.63	$135.63	$200.63	$265.63	$330.63	$395.63	$460.63
14	$90.63	$160.63	$230.63	$300.63	$370.63	$440.63	$510.63
15	$110.63	$185.63	$260.63	$335.63	$410.63	$485.63	$560.63

or established as wildlife habitat, or is suitable for similar water quality purposes such as a riparian buffer. In addition to the eligible land requirements, cropland must meet one of the following criteria: (a) have a weighted average erosion index (EI)—which is created by dividing potential erosion (from all sources except gully erosion) by the T-value, which is the rate of soil erosion above which long term productivity may be adversely affected—of eight or higher; (b) be expiring CRP acreage; (c) be located in a national or State CRP conservation priority area—land is eligible for designation as a priority area only if the region has actual significant adverse water quality or wildlife habitat impacts related to activities of agricultural production or if the designation helps agricultural producers to comply with Federal and State environmental laws; or (d) meet a number of other technical criteria designed to accomplish program goals. Offers for CRP contracts, general sign-up, are ranked according to the Environmental Benefits Index (EBI). FSA collects data for each of the EBI factors based on the relative environmental benefits for the land offered. Each eligible offer is ranked in comparison to all other offers and selections made from that ranking. FSA uses the following EBI factors to assess the environmental benefits for the land offered:

- Wildlife habitat benefits resulting from covers on contract acreage;
- Water quality benefits from reduced erosion, runoff, and leaching;
- On-farm benefits from reduced erosion;
- Benefits that will likely endure beyond the contract period;
- Air quality benefits from reduced wind erosion; and
- Cost.

The Commodity Credit Corporation (CCC) makes annual rental payments based on the agriculture rental value of the land, and it provides cost-share assistance for up to 50 percent of the participant's costs in establishing approved conservation practices. Contracts are not automatically awarded to everyone who enrolls. While the United States has over 350 million acres of cropland, the maximum CRP enrollment authority is 39.2 million acres. As such, the demand to enroll land in CRP is expected to be greater than the amount that FSA can accept. In order to have a higher chance of being accepted, the following should be considered:

- The single most important producer decision involves determining which cover practice to apply to the acreage offered. Planting or establishing the highest scoring cover mixture is the best way to improve the chances of an offer being accepted;
- Producers should only offer the most environmentally sensitive land. Where possible, subdividing fields to include only the most sensitive acreage can substantially increase the point score for erosion and improve the water quality score and/or air quality score. Offering land with the highest EBI will improve the score;
- Producers should consider enhancing covers for the benefit of wildlife by developing permanent water sources. In addition, producers may plant and manage hardwood or softwood trees that increase wildlife habitat values, or restore certain rare and declining habitats to increase the EBI score in subfactors N1a and N4; and

- Producers should consider accepting a lower payment rate than the maximum amount FSA is willing to offer.

Producers are encouraged to consult with local USDA experts on steps to take to maximize EBI points and increase the likelihood that an offer will be accepted (USDA 2006). As of December 2006, Tennessee had over 9,000 CRP contracts with a little over 280,000 acres enrolled with an average payment of $59.30 per acre (USDA 2007b).

Until recently, this program has only been interested in planting land to multi-cultural native grasses. Switchgrass is being planted on CRP land in some areas, but not completely encouraged as of yet since some sources believe that monoculture grasses aren't as beneficial as others. Many people have been pushing officials developing the upcoming Farm Bill towards making amendments to programs, such as CRP, in order to allow for the production of switchgrass for these purposes. If this plan could pass, economically, programs would need to pay farmers more in the beginning years of a contract and slowly decrease in payments, possibly to zero, as bio-fuel revenue started to generate for the farmer (Ducks Unlimited). Present CRP guidelines only allow for the land to be mowed one time per year with a limited amount of disking that can occur. CRP enrolled land can not be cut at all during the nesting season, which lasts from April 1st through July 15th (Jenkins).

Under the 1985 Farm Bill, harvesting was not automatically allowed on CRP enrolled acreage except at times of emergency or under authorized management (USDA). However, several amendments were made by the Farm Security and Rural Investment Act of 2002 (FSRIA). In particular, the new act allows for grazing, haying, and biomass

harvesting on grassland enrolled in CRP, as long as it is in conjunction with a conservation plan, and conforms to specifics on how often the land can be hayed and grazed, but results in a 25 percent reduction in annual rental payments (USDA 2003).

Table 11 shows a possible profit per acre assuming CRP land was planted to switchgrass. This table assumes the 25 percent reduction of the average payment of $59.30, which equates to a payment of roughly $44.47 per acre.

Hunting Leases

Leasing land for hunting is another way for farmers to earn extra income on their land. Switchgrass fields can also provide habitat and a home for many species of wildlife, including cover for deer and rabbits, and a nesting place for wild turkey and especially quail. This plant can bring many types of small game-animals and pheasants back to an area, which could increase the value of land being leased for hunting.

The harvesting of switchgrass could potentially put a damper on leases due to the harvest-times used by farmers. This depends on the animal that is being sought, because

Table 11. Annual Net Return per Acre of Switchgrass Production with Reduced CRP Payment.

Yield (Tons/Acre)	Price for Harvested Switchgrass						
	$20/ton	**$25/ton**	**$30/ton**	**$35/ton**	**$40/ton**	**$45/ton**	**$50/ton**
8	(14.29)	$25.71	$65.71	$105.71	$145.71	$185.71	$225.71
9	$5.71	$50.71	$95.71	$140.71	$185.71	$230.71	$275.71
10	$25.71	$75.71	$125.71	$175.71	$225.71	$275.71	$325.71
11	$45.71	$100.71	$155.71	$210.71	$265.71	$320.71	$375.71
12	$65.71	$125.71	$185.71	$245.71	$305.71	$365.71	$425.71
13	$85.71	$150.71	$215.71	$280.71	$345.71	$410.71	$475.71
14	$105.71	$175.71	$245.71	$315.71	$385.71	$455.71	$525.71
15	$125.71	$200.71	$275.71	$350.71	$425.71	$500.71	$575.71

many small birds actually prefer the shorter just-mowed areas of grasses. Therefore, harvesting could actually be utilized during or pre-hunting season in order to bring in more birds. Generally, switchgrass is mowed from the beginning to the middle of June for a first cutting of hay. At the time of this cutting, the plant is approximately three to four feet tall and has the most forage-benefits that it will have during a production year. If mowed later, there is a chance that the plant can lose some of its digestibility and become a less beneficial forage for an animal's consumption (Holmberg). Holmberg suggests that if the switchgrass is being harvested for energy production, it will generally only be mowed once during the latter part of the year around August in order to obtain the most possible tonnage from the plant.

Harvested and un-harvested switchgrass has the potential to provide habitat for declining grassland birds (CIAS). CIAS suggests that different bird species prefer a different range of conditions, from tall, dense vegetation to lower, sparse vegetation with patches of bare ground. Quails Unlimited (QU) suggests that quail typically prefer fields, brushy cover, and grassland for their habitat. QU also says that quail specifically favor short, bunch grass; therefore, post-harvest switchgrass could benefit these birds. Minnesota Department of Natural Resources states that mourning doves prefer to feed on the ground, so mowing or disking a crop, or a crop residue, can make an agricultural field more attractive. For that reason, if a switchgrass field is managed to where it would be mowed around the beginning of September, these fields could perhaps become desired feeding grounds for these particular birds. These birds also are fond of feeding near sources of water (Minnesota Department of Natural Resources), therefore, switchgrass

being used as a filter or buffer strip near creeks and other water resource could be that much more attractive for these birds. In order for ring-necked pheasants to prosper and escape predators, they require a thick, brushy-cover for them to hide (Ohio Department of Natural Resources). The Ohio Department of Natural Resources suggests that encouraging thick escape cover alongside of cropland fencing and a mixture of prairie grasses, such as switchgrass, will enhance winter habitat for ring-necked pheasants. Table 12 shows a break down of the various bird-hunting seasons in Tennessee in order to visualize a typical hunting timetable.

Spring turkey season generally ranges from the last day of March until mid-May. Switchgrass fields may be a potentially good place to locate turkeys. Considering how this bird tries to remain covered but also usually feeds in open fields, the switchgrass that has grown to a height of two to three feet may seem to be a safe place to the bird for feeding purposes. Many of the hunting seasons for game birds begin in the fall months of September through November. By this point, switchgrass fields may have been mowed and would provide a good cover of grass for the birds to be flushed out of.

Besides the benefits to farmers, leasing land also satisfies hunters because they feel there is a better chance at harvesting game. The Division of Forestry, a branch of the Tennessee Department of Agriculture, says that 7.5 percent of hunters currently lease private land, a similar number who are not leasing are “very interested,” and another 14 percent are “somewhat interested.” Hunters who lease land know they have a place to go. They feel greater ease and safety, and they feel they have a higher chance of success. The

Table 12. Migratory Bird Hunting Seasons. [7] [8]

Species	Opens	Closes
Dove	Sept. 1	Sept. 26
	Oct. 7	Oct. 22
	Dec. 16	Jan. 2
Woodcock	Oct. 28	Dec. 11
Wilson Snipe	Nov. 14	Feb. 28
Crow (Fri., Sat., Sun.)	June 1	Feb. 28
Canada Goose	Sept. 1	Sept. 15
Wood Duck/Teal (early season)	Sept. 9	Sept. 13
Wood Duck/Teal (full season)	Nov. 25	Nov. 26
	Dec. 2	Jan. 28
Turkey (Spring season)	Mar. 31	May 13
Turkey (Fall season)	Nov. 10	Nov. 16
	Dec. 10	Dec. 14
Quail	Nov. 11	Feb. 28
Pheasant[9]	Not Specified	Not Specified

Source: Sheila Dalton, sheila.dalton@state.tn.us. Tennessee Wildlife Resource Agency (TWRA).

[7] Migratory bird seasons are subject to change by federal framework.

[8] These are the basic seasons for these animals. There are cases in which particular areas may allow for special hunts beginning and ending on specified days.

[9] TWRA says that there is not a specified season for Pheasants since they are not native to Tennessee. Hunting is available on a number of privately owned farms where this bird has been introduced and raised.

quality of the hunting experience is as important to many hunters as hunting success. Surroundings, exclusive use of the land, availability of game, and services provided all contribute to a quality hunting experience. Advertising could be done by word of mouth, in newspapers, on bulletin boards, and through the Tennessee Private Lands Hunting Register (TDA). Figure 4 begins by showing the percentage of Tennessee hunters who lease land.

"The Hunters' Guide to a Successful Hunt Lease" discusses how many landowners do not publicly advertise their wish to lease property for hunting. This publication covers many issues revolving around how to find the best place to lease for hunting and also assists landowners in preparing and pricing their land for possible

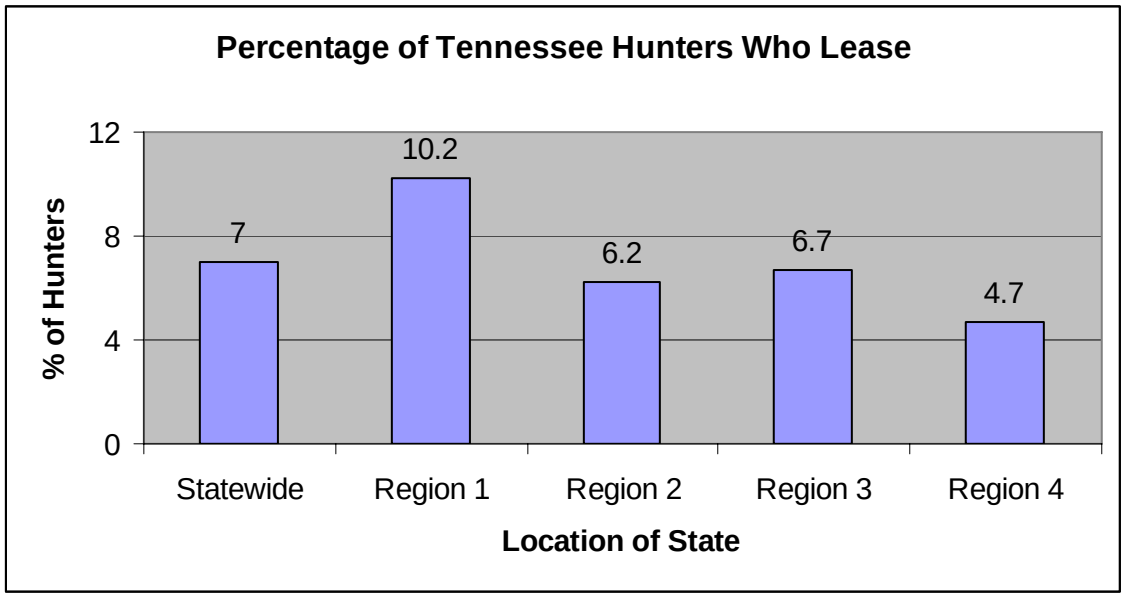

Figure 4. Percentage of Tennessee Hunters Who Lease.

Source: Craig Harper et al., charper@utk.edu, University of Tennessee Wildlife Extension.

leases. Harper et al. also reminds the hunter that some landowners do not make good partnerships, regardless of how accommodating the lessees are and contains steps to follow and items to remember when entering into a hunt lease, both as the landowner and the lessee.

Switchgrass can also benefit larger game animals, such as whitetail deer. It is important for many hunters to practice big-game management traditions. Many hunters are members of clubs that have certain specifications on what size of game they can bag, or shoot; for instance, the organization called "The 11-Points-Or-Better club." Practices such as these, which are called Quality Deer Management (QDM), are very common among deer hunters. QDM guidelines are formulated according to property-specific objectives, goals, and limitations. Participating hunters enjoy both the tangible and intangible benefits of this approach. What is important is the chance to harvest a quality buck - an opportunity lacking in many areas under traditional management (Quality Deer Management Association). Larger bodied deer are generally found in heavily covered areas. Switchgrass has the potential of providing a tall cover in which deer could keep their young protected, as well as provide the deer with forage. Therefore, the growing of switchgrass could help to potentially increase the deer population on privately owned land. When a landowner is an active contributor to such a practice by growing plants to support a higher quality herd of deer on their land, they gain the opportunity to charge higher prices for deer hunting leases. If a hunter desires to take a larger buck during a season, they would be more willing to pay the higher price.

The existence of quality practices, such as QDM, is not only important information for the hunter, but also the landowner. In order to calculate a lease price for a particular piece of land, the landowner can keep up with statistics from several years to see the size and amount of game taken from the region in which they are located. For example, the presence of waterfowl is a very important factor in determining lease price as it has been estimated that the opportunity to hunt waterfowl will add approximately $327 per year per farm to the total lease price in Tennessee (Harper et al.).

One possible reason behind the low amounts of leased-out land is that some farmers believe they have to have large amounts of land to offer for a lease. This is simply not true. Properties leased for hunting vary widely, from a 100-acre farm tract with 75 percent open ground surrounded by suburbia, to a 10,000 (or more)-acre tract of unbroken forest, to a three-acre beaver pond leased for duck hunting (Harper et al.).

Types of Leases

Harper et al. speaks of the different types of hunt lease arrangements. The most common hunt lease is an annual recreational lease for all wildlife species, which is renewed in late spring or early summer. This type of lease might also include other privileges in addition to hunting, such as camping, canoeing and fishing. "Alternative activities" are, of course, up to the discretion of the landowner and should be explained in the written lease agreement. Annual leases often evolve into multi-year or long-term agreements. Most often, this comes after the relationship has been established and the landowner feels comfortable with the arrangement and the lessees. Of course, landowners

have the possibility of reserving hunting rights for themselves plus their immediate family, but this could lower the value of the lease to the potential lessees.

Considering the wide range of species that switchgrass can accommodate, annual leases could make sense to a hunter. Annual leases can include options for lease renewal upon expiration in order to have long-term leases. Multi-year lease agreements are often desired when lessees conduct wildlife habitat improvement practices; help maintain roads, gates and fences; and patrol the leased property to guard against trespassers and poaching. Seasonal leases typically give hunters access to the property to hunt for one species only. This is not the most favorable lease option for hunters, due to the fact that most hunters hunt multiple game animals. However, this sometimes allows the landowner to make more money from the resources present on the property. The growth and production of switchgrass can perhaps benefit certain species more so then others, therefore hunters may be more willing to rent switchgrass land that is benefiting the type of animal that individual is seeking, such as the specific birds mentioned earlier.

The last type of lease is the short-term. These generally consist of daily, weekend, or week-long hunts, sometimes called day leases or "package" hunts. The traditional dove shoot is a good example. This type of lease is typically successful near populated areas where the demand for hunting opportunities is high, but each hunter may only go hunting a few times each season. Individuals who have leased the hunting rights on an annual basis from the landowner occasionally offer short-term leases. The lessee then acts as a broker by subleasing the hunting rights for profit. This type of lease may be best fitted to bird-hunting individuals around the time of a switchgrass harvest.

Lease Prices

Many landowners underestimate the value of hunting (Harper et al). Lease prices usually are determined by the local average or "the going rate" and are based on the quality and quantity of the habitat prevalence of wildlife. Most rates for annual and seasonal lease agreements are assessed on a per-acre basis. Once landowners have become familiar with what "the going rate" is for surrounding farms, they also need to realize that their property could offer different opportunities than neighboring tracts of land. The amounts and types of wildlife should definitely be considered when calculating a lease price, but amenities should also be measured. Harper et al states that the average annual deer-hunting lease in Tennessee is about $3.50 per acre. Most lease payments are made at the time of the agreement; however, a security deposit may be submitted in advance as well.

The Tennessee Department of Agriculture reports that hunting leases average $2 per acre for tracts over 150 acres and $4 per acre for less than 150 acres. Prime waterfowl areas can bring $7 per acre or more. Landowners can also increase lease prices by providing more habitat for wildlife and by employing improved wildlife management practices on their land (Tennessee Department of Agriculture). Referring to Table 8, a landowner could add the additional income from hunting leases to the profit per acre of switchgrass. Individuals interested in enrolling land in programs could also refer back to Tables 9 and 10 and add lease prices to the profits per acre. For example, if a farmer produced switchgrass with a yield of 10 tons per acre, while simultaneously leasing the acreage for hunting purposes at $4/acre, this would increase the farmer's net return by

$0.40 per ton. Figures 5 and 6 show the average lease sizes, in acres, in Tennessee, as well as, the average lease price per acre in the state.

Non-Revenue Benefits

There are many ecosystem services that can be attained by growing switchgrass on privately owned land: soil improvement; erosion control; intact ecosystems; reduced inputs; as well as the provision of habitat itself. Because it is native, switchgrass is resistant to many pests and plant diseases, and it is capable of producing high yields with very low applications of fertilizer, which means that the need for agricultural chemicals to grow switchgrass is relatively low and reduces the amounts of inputs used on the soil. Switchgrass has a large permanent root system that goes over 10 feet into the soil, and can weigh as much (6-8 tons/acres) as it's above ground counter part. It also has many small temporary roots, which increase the amounts of soil water and ability to hold nutrients (Bransby). These roots can also lead to extra storage of carbon deep underground. Switchgrass fields have been shown to have much more soil carbon then crops such as corn or wheat. Environmentally this is very beneficial, because the deeper carbon is underground, the less likely it is to get back into the atmosphere as carbon dioxide (USDA 2007c). This benefits not only the switchgrass producer, but the public as well.

Annual cultivation of many agricultural crops reduces the amount of organic matter in the soil, which can lead to reduced fertility. Switchgrass adds organic matter and can hold onto soil even in winter to prevent erosion due to the extensive roots. Switchgrass also has the ability to filter runoff from fields that are planted to other crops.

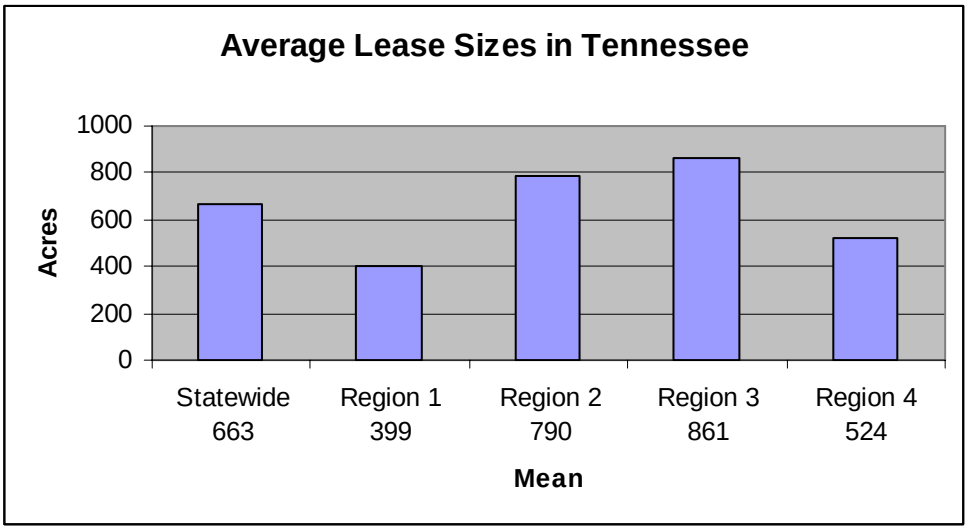

Figure 5. Average Lease Sizes in Tennessee.

Source: Craig Harper, charper@utk.edu, University of Tennessee Wildlife Extension.

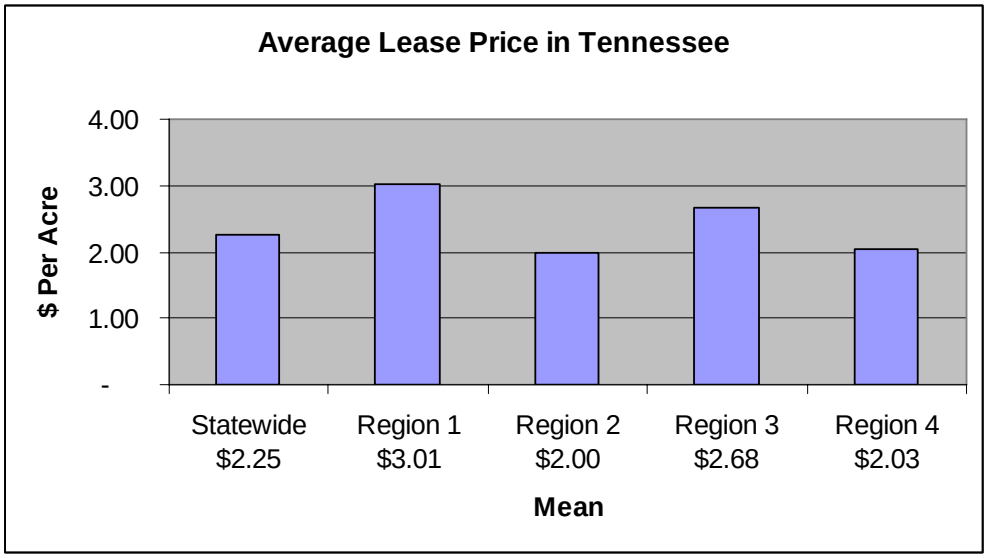

Figure 6. Average Lease Price per Farm in Tennessee.

Source: Craig Harper, charper@utk.edu, University of Tennessee Wildlife Extension.

Buffer strips of switchgrass can be planted near water sources, which would help remove harmful ingredients before they reach the water (Oak Ridge National Laboratory). Once again, this is not only a private benefit, but also an advantage for the public as well. These buffer strips could be extensive enough to where they could be harvested and provide the farmer with other benefits mentioned earlier in the chapter.

Public Costs and Benefits of Switchgrass Production

Non-producers also benefit from governmental programs in an indirect way. U.S. taxpayers are benefiting from cleaner air and improved water quality, due to the fact that switchgrass can remove greenhouse gases from the atmosphere, and reduce soil erosion and nutrient runoff into the waterways. Recovering wildlife populations are enjoyed by sportsmen and wildlife watchers, which can help generate income for an area from tourism or hunting. Many producers also have opened up the land they have enrolled in CRP to public access for hunting and fishing, which can improve the relationship between landowners, state fish and wildlife agencies and the hunting and fishing public (Ducks Unlimited).

Public costs may arise when transferring land into switchgrass production. If fields are converted from the harvest of one commodity and transferred into switchgrass, there is the potential of straining local commodity supplies, in turn increasing the commodity's price. Hay prices could possibly rise as well considering that some producers may take land out of hay production in order to grow switchgrass. Another concern is the possible reduction in the amount of wildlife in an area from a conversion

of a more appealing natural grass mix to a monoculture warm season, such as switchgrass.

Conclusion

This Chapter provides both a framework and information to assist landowners in evaluating the economics of switchgrass production. Switchgrass has the potential to be produced for energy as well as forage; however, currently there is not a stable market to provide incentives for a farmer to produce switchgrass for energy purposes.

A few governmental programs specifically allow switchgrass to be grown on enrolled land, but there has a been a recent push for the upcoming 2007 Farm Bill to provide more encouragement for farmers to grow this crop, as well as other biomass feedstocks. Farmers can receive some payments from these programs as well as the possibility of charging to hunt wildlife that has been attracted to the shelter and forage switchgrass provides. By producing switchgrass, a landowner has a chance of generating not only profits, but also environmental benefits. Growing switchgrass can lead to a reduction of inputs that other competing crops may require, as well as provide habitat for wildlife. If the future brings rises in oil prices—or if environmental taxes are eventually imposed on fossil fuels—energy from switchgrass could prove economically competitive with petroleum and coal, making biomass crops attractive to American farmers and the public economy.

CHAPTER IV

Conclusion

The analysis presented in this thesis has taken into consideration certain aspects related to wildlife habitat and the production of switchgrass. Providing wildlife habitat has benefits both seen and unseen. Not only can this provision improve the lives of wild animals, but it can also financially assist the landowner as well. Marginal land can be taken out of production and placed into government programs that actually pay the farmer to establish habitat friendly practices on their land. Farmers can also charge the public for admission onto their land by way of hunting leases or related factor.

The focus of Chapter II was on landowners and their interest in, or lack thereof, providing more wildlife habitat on their land. Specific characteristics of those farmers were examined from answers given by respondents of the Switchgrass Survey. Many governmental programs were outlined and discussed in order to show the assistance that landowners could earn by basically doing little work to their land. Switchgrass was shown as a potential habitat-providing plant that, in some instances, could also be harvested for additional income for the landowner.

In order to restore the diverse wildlife population that once inhabited the state of Tennessee, habitat needs to be restored. One of the problems is to recognize who is, or possibly would be, interested in participating in management practices that would benefit wildlife. After performing an ordered probit regression with the responses from the Switchgrass Survey, specific characteristics of interested landowners were recognized.

This way, government officials have a more specific idea of the individuals that would be interesting in providing more habitat.

The concentration was placed on switchgrass production in Chapter III. This chapter was designed to help farmers better visualize the possibilities of producing switchgrass for energy as biomass, forage and wildlife habitat. University of Tennessee Extension created a Field Crop Budget for 2005, which contains a break down of various input costs, such as fertilizer and seed, along with labor and machinery costs. Corresponding crop yields are also shown. The break-even analysis performed in this chapter can help farmers visualize the costs and benefits of growing switchgrass as opposed to growing another commodity. This chapter was designed as a decision aid for landowners to determine whether or not switchgrass production was a worthwhile crop to produce.

There are still a few gaps in the research. A specific survey could be produced to more specifically target potential program enrollees or those interested in providing more habitat. It remains to be seen how influential things such as location of the land, age of the farmer, and current program-enrollees, are on the possibility of following suggested farm management practices. Future research can take these factors into consideration and further assist government officials in targeting farmers and landowners of their potential programs that would lead to the increase of habitat. Another matter is that of the switchgrass market. Currently there is not a steady market for switchgrass production in Tennessee. As interest in this crop grows, more information can be gathered as to the prices farmers can expect to receive from switchgrass production for energy production

and as forage. An additional issue is that of governmental programs and how the approaching Farm Bill may change program guidelines in order to assist in the production of switchgrass for biomass.

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Appendices

Appendix 1. Available Government Programs and Descriptions.

Program	Agency	Goal	Switchgrass can be grown?	Harvesting of Switchgrass Allowed?
Conservation of Private Grazing Land Program (CPGL)	Natural Resource Conservation Service (NRCS) www.nrcs.usda.gov/programs/	Assists owners and managers of private grazing land address natural resource concerns while enhancing the economic and social stability of grazing land communities that depend on them.	Yes.	Yes.
Conservation Reserve Program (CRP)	NRCS www.nrcs.usda.gov/programs/	Takes highly erodible and other environmentally sensitive lands out of crop production and establishes a soil-conserving vegetative cover on them under a 10 to 15 year contract. Hunting leases are allowed at owner's discretion.	Yes.	Only with a 25percent reduction in payments.
Conservation Security Program (CSP)	NRCS www.nrcs.usda.gov/programs/	Supports un-going stewardship of private agricultural lands by providing payments for maintaining and enhancing natural resources.	Yes.	Yes.
Environmental Quality Incentives Program (EQIP)	NRCS www.nrcs.usda.gov/programs/	Promotes agricultural production and environmental quality as compatible national goals.	Yes.	Yes.
Farm and Ranch Lands Protection Program (FRPP)	NRCS, USDA www.nrcs.usda.gov/programs/	Assists farmers and ranchers keep their land in agriculture. Program provides matching funds to State, Tribal, and local governments and non-governmental organizations with existing farm and ranch land protection programs to purchase conservation easements.	Yes.	Yes.

Appendix 1 (cont.)

Program	Agency	Goal	Switchgrass can be grown?	Harvesting of Switchgrass Allowed?
Farm Wildlife Habitat Program (FWHP)	Tennessee Wildlife Resources Agency (TWRA) www.state.tn.us/twra/wildlife/conprowild.html	Cost shared improvements are targeted mainly towards open land wildlife species in decline, such as bobwhite quail, cottontail rabbits, and shrub and grassland songbirds.	Yes.	Yes, but only after the establishment period.
Grassland Reserve Program (GRP)	NRCS, FSA, and the Forest Service www.nrcs.usda.gov/programs/	A voluntary program that helps landowners and operators restore and protect grassland, including rangeland, pastureland, shrub-land, and certain other lands, while maintaining the areas as grazing lands.	Yes.	Yes, but it has to be as a part of a conservation program.
Northern Bobwhite Quail Habitat Initiative (CRP)	NRCS, USDA-FSA, TWRA, U.S. Fish and Wildlife Service (USFWS) www.qu.org/seqsg/nbci/nbci.cfm	Provides food and cover in cropland areas. Applied around field edges of eligible cropland. Involves natural regeneration of native grasses and forbs or planting of native warm-season grasses, legumes, forbs, and limited shrub and tree-plantings.	Not encouraged.	No.
Tennessee Landowner Incentive Program (TNLIP)	TWRA www.state.tn.us/twra/wildlife/conprowild.html	Designed to protect, enhance, or restore rare species habitats on TN's private lands. The program focus is rare species but the final product will reduce erosion or other negative impact and improve land quality.	Yes.	Yes.
Tennessee Partners Project (TPP)	USFWS, Ducks Unlimited, TWRA, TN Dept. of Ag, NRCS, and UT Extension. southern.ducks.org/TNPartners.php	To provide wintering water and food sources for waterfowl and associated wetland species in the TN portion of the birds' migration route. Hunting is allowed, but not after 12 noon.	Yes.	Yes.

Appendix 1 (cont.)

Program	Agency	Goal	Switchgrass can be grown?	Harvesting of Switchgrass Allowed?
Wetlands Reserve Program (WRP)	NRCS www.nrcs.usda.gov/programs/	The goal is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. Hunting and fishing allowed. Landowners reserve the right to lease recreational uses for financial gain.	Yes.	Yes, with approval from NRCS.
Wildlife Habitat Incentives Program (WHIP)	NRCS www.state.tn.us/twra/wildlife/conprowild.html	Encourages creation of high quality wildlife habitats that support wildlife populations of National, State, Tribal, and local significance.	No.	No.

Appendix 2. Corn – Conventional Tillage, 150 Bushel Yield

Estimated Returns and Expenses per Acre (12/16 Row Equipment)

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
REVENUE						
CORN [10]	GRAIN	BU.	150	$3.40	$510.00	_____
VARIABLE EXPENSES						
SEED KERNELS [11]	28 THOUSAND SEEDS	BAG	0.35	$95.00	$33.25	_____
SEED TREATMENT	INSECTICIDE	ACRE	1	$7.00	$7.00	_____
FERTILIZER	N (UREA)	LB.	170	$0.31	$52.70	_____
	P_2O_5	LB.	70	$0.32	$22.40	_____
	K_2O	LB.	70	$0.22	$15.40	_____
LIME	AG LIMESTONE	TON	0.5	$23.00	$11.50	_____
WEED CONTROL [12]						
BICEP II MAGNUM	5.5#/GAL.	QT.	2.1	$10.00	$21.00	_____
						_____
MACHINERY REPAIR		AC.	1	$14.96	$14.96	_____
MACHINERY FUEL	DIESEL @ $2.10/GALLON	AC.	1	$13.41	$13.41	_____
OPERATING CAPITAL	6 MONTHS	AC.	$191.62	8.00%	$7.66	_____
	TOTAL VARIABLE EXPENSES				$199.29	_____
	RETURN ABOVE VARIABLE EXPENSES				$310.71	_____
MACHINERY EXPENSES						
MACHINERY DEPRECIATION		AC.	1	$24.59	$24.59	_____
INTEREST EXPENSE	MACHINERY & EQUIP.	AC.	1	$11.90	$11.90	_____
	RETURN TO LAND, LABOR, MANAGEMENT, AND RISK				$274.22	_____
LABOR EXPENSES						
LABOR		HR.	0.80	$8.50	$6.80	_____
	RETURN TO LAND, MANAGEMENT, AND RISK				$267.42	_____

Source: Dr. Delton C. Gerloff, Field Crop Budgets, 2007, University of Tennessee Extension Service.

[10] An in-furrow insecticide or insecticide seed treatment is not included.

[11] Assumes a bag of 80,000 seeds and a 90 percent germination rate for a final stand count of 25,200 plants per acre.

[12] If johnsongrass is a problem, use Accent or Beacon, which would increase herbicide costs, 0.37 pounds active ingredients of Atrazine could be added on non-highly erodible soils.

Appendix 3. Corn – No Tillage, 150 Bushel Yield

Estimated Returns and Expenses per Acre (12/16 Row Equipment)

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
REVENUE						
CORN [13]	GRAIN	BU.	150	$3.40	$510.00	_____
VARIABLE EXPENSES						
SEED KERNELS [14]	28 THOUSAND SEEDS	BAG	0.35	$95.00	$33.25	_____
SEED TREATMENT	INSECTICIDE	ACRE	1	$7.00	$7.00	_____
FERTILIZER	N (UREA)	LB.	170	$0.31	$52.70	_____
	P_2O_5	LB.	70	$0.32	$22.40	_____
	K_2O	LB.	70	$0.22	$15.40	_____
LIME	AG LIMESTONE	TON	0.5	$23.00	$11.50	_____
WEED CONTROL [15]						
BURNDOWN	GRAMOXONE MAX	PT.	1.25	$4.91	$6.14	_____
	SURFACTANT (80% ACT.)	PT.	0.2	$1.75	$0.35	_____
PRE-EMERGE	BICEP II MAGNUM	QT.	2.1	$10.00	$21.00	_____
	ATRAZINE 4L	OZ.	11.84	$0.07	$0.83	_____
MACHINERY REPAIR		AC.	1	$10.70	$10.70	_____
MACHINERY FUEL	DIESEL @ $2.10/GALLON	AC.	1	$7.93	$7.93	_____
OPERATING CAPITAL	6 MONTHS	AC.	$189.20	8.00%	$7.57	_____
	TOTAL VARIABLE EXPENSES				$196.77	_____
	RETURN ABOVE VARIABLE EXPENSES				$313.23	_____
MACHINERY EXPENSES						
MACHINERY DEPRECIATION		AC.	1	$19.15	$19.15	_____
INTEREST EXPENSE	MACHINERY & EQUIP.	AC.	1	$8.34	$8.34	_____
	RETURN TO LAND, LABOR, MANAGEMENT, AND RISK				$285.75	_____
LABOR EXPENSES						
LABOR		HR.	0.51	$8.50	$4.37	_____
	RETURN TO LAND, MANAGEMENT, AND RISK				$281.38	_____

Source: Dr. Delton C. Gerloff, Field Crop Budgets, 2007, University of Tennessee Extension Service.

[13] An in-furrow insecticide or insecticide seed treatment is not included.
[14] Assumes a bag of 80,000 seeds and a 90 percent germination rate for a final stand count of 25,200 plants per acre.
[15] If johnsongrass is a problem, use Accent or Beacon, which would increase herbicide costs.

Appendix 4. Wheat – Conventional Tillage, 55 Bushel Yield

Estimated Returns and Expenses per Acre (12/16 Row Equipment)

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
REVENUE						
WHEAT [16]	GRAIN	BU.	55	$3.90	$214.50	_____
VARIABLE EXPENSES						
SEED	TREATED/FUNGICIDE	BU.	2	$10.00	$20.00	_____
SEED TREATMENT [17]	GAUCHO XT	BU.	2	$6.00	$12.00	_____
FERTILIZER	N (AN)	LB.	80	$0.42	$33.60	_____
	P_2O_5	LB.	40	$0.32	$12.80	_____
	K_2O	LB.	20	$0.22	$4.40	_____
LIME	LIME APPLICATION	TON	0.5	$23.00	$11.50	_____
HERBICIDE	HARMONY EXTRA	OZ.	0.5	$12.50	$6.25	_____
	SURFACTANT (80% Act.)	PT.	0.1	$1.75	$0.18	_____
FUNGICIDE	TILT	OZ.	4	$2.61	$10.44	_____
MACHINERY REPAIR		AC.	1	$15.49	$15.49	_____
MACHINERY FUEL	DIESEL @ $2.10/GALLON	AC.	1	$14.41	$14.41	_____
OPERATING CAPITAL	8 MONTHS	AC.	$141.07	8.00%	$7.52	_____
				TOTAL VARIABLE EXPENSES	$148.59	_____
				RETURN ABOVE VARIABLE EXPENSES	$65.91	_____
MACHINERY EXPENSES						
MACHINERY DEPRECIATION		AC.	1	$24.54	$24.54	_____
INTEREST EXPENSE	MACHINERY & EQUIP.	AC.	1	$12.74	$12.74	_____
				RETURN TO LAND, LABOR, MANAGEMENT, AND RISK	$28.63	_____
LABOR EXPENSES						
LABOR		HR.	0.84	$8.50	$7.16	_____
				RETURN TO LAND, MANAGEMENT, AND RISK	$21.46	_____

Source: Dr. Delton C. Gerloff, Field Crop Budgets, 2007, University of Tennessee Extension Service.

[16] If a market for straw is available, add an appropriate amount to return to land, management, and risk, based on the expected yield and price of the straw, less harvest and marketing costs.

[17] Additional seed treatment is to protect against barley yellow dwarf virus.

Appendix 5. Soybeans – Roundup Ready, No Tillage, 40 Bushel Yield

Estimated Returns and Expenses per Acre (12/16 Row Equipment)

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
REVENUE						
SOYBEANS	BEANS	BU.	40	$6.55	$262.00	
REVENUE ADJUSTMENT	SPARC ASSESSMENT	BU.	40	-$0.033	-$1.31	_____
VARIABLE EXPENSES [18]						
SEED [19]	6-8 PLANTS/FT.	LB.	50	$0.62	$31.00	_____
SEED TREATMENT	APRONMAXX	BU.	0.83	$3.60	$2.99	_____
FERTILIZER	P_2O_5	LB.	20	$0.32	$6.40	_____
	K_2O	LB.	40	$0.22	$8.80	_____
LIME	2 TONS EVERY 4 YEARS	TON	0.5	$23.00	$11.50	_____
WEED CONTROL [20] [21]						
BURNDOWN [22] [23]	ROUNDUP ORIGINAL MAX	PT.	1.6	$2.84	$4.54	_____
PRE-EMERGE	ROUNDUP ORIGINAL MAX	PT.	1.6	$2.84	$4.54	_____
INSECTICIDE		AC.	1	$5.00	$5.00	_____
FUNGICIDE		AC.	1	$10.50	$10.50	_____
MACHINERY REPAIR		AC.	1	$10.28	$10.28	_____
MACHINERY FUEL	DIESEL @ $2.10/GALLON	AC.	1	$7.92	$7.92	_____
OPERATING CAPITAL	6 MONTHS	AC.	$103.48	8.00%	$4.14	_____
				TOTAL VARIABLE EXPENSES	$107.61	_____
				RETURN ABOVE VARIABLE EXPENSES	$153.08	_____

Source: Dr. Delton C. Gerloff, Field Crop Budgets, 2007, University of Tennessee Extension Service.

[18] Assumes normal crop rotation with minimum weed infestation. A continuous soybean system may require additional expenses for chemicals or land preparation.

[19] Seed price includes technology fee.

[20] Weed control chemicals should be selected for specific weed or grass problems which are present (for heavy infestations, use 1.67 pints of Gramoxone Max).

[21] The addition of Dicambra at 8oz/acre is necessary to manage Glyphosate resistant horseweed. This adds an additional $5.50/acre to the burndown spray cost.

[22] For and alternate control, use Gramoxone Max (1.25 pts., cost of $5.55/acre) plus a surfactant ($0.48/acre).

[23] Several other versions of Glyphosate, the active ingredient in Roundup Ultramax, are available. Check label for concentration, rates, and registration on Roundup ready soybeans.

Appendix 5. Soybeans – Roundup Ready, No Tillage (cont).

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
MACHINERY EXPENSES						
MACHINERY DEPRECIATION		AC.	1	$18.24	$18.24	_____
INTEREST EXPENSE	MACHINERY & EQUIP.	AC.	1	$8.58	$8.58	_____
	RETURN TO LAND, LABOR, MANAGEMENT, AND RISK				$126.25	_____
LABOR EXPENSES						
LABOR		HR.	0.51	$8.50	$4.30	_____
	RETURN TO LAND, MANAGEMENT, AND RISK				$121.96	_____

Appendix 6. Cotton, Roundup Ready – Conventional Tillage, 850 Pound Yield

Estimated Returns and Expenses per Acre (12/16 Row Equipment)

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
REVENUE						
COTTON [24] [25]	LINT	LB.	850	$0.55	$467.50	_____
VARIABLE EXPENSES						
SEED [26]	3.5 SEEDS/FOOT	THOUS	48.145	$0.40	$19.26	_____
TECH FEE [27]	ROUNDUP READY	ACRE	1	$27.00	$27.00	_____
FUNGICIDE	SEED TREATMENT	ACRE	1	$6.50	$6.50	_____
INSECTICIDE [28]						
SEED TREATMENT		ACRE	1	$8.20	$8.20	_____
IN-SEASON INSECTICIDES [29]:		ACRE	1	$40.00	$40.00	_____
FERTILIZER	N (UREA)	LB.	80	$0.42	$33.60	_____
	P_2O_5	LB.	60	$0.32	$19.20	_____
	K_2O	LB.	90	$0.22	$19.80	_____
BORON		LB.	0.5	$3.85	$1.93	_____
LIME		TON	0.5	$23.00	$11.50	_____
HERBICIDES:						
PRE-EMERG	COTORAN 4L	PT.	2	$5.15	$10.30	_____
OVER THE TOP	ROUNDUP ORIGINAL MAX	PT.	1.6	$2.84	$4.54	_____
OVER THE TOP	DUAL MAGNUM	PT.	1	$11.90	$11.90	_____
POST DIRECT	ROUNDUP ORIGINAL MAX	PT.	1.2	$2.84	$3.41	_____
POST-EMERGE	DIURON (DIRECTED)	LB.	0.375	$4.05	$1.52	_____
POST-EMERGE	ROUNDUP ORIGINAL MAX	PT.	1	$2.84	$2.84	_____
GROWTH REGULATOR	MEPEX (Mepiquat Chloride)	PT.	2	$2.70	$5.40	_____
SCOUTING		ACRE	1	$7.00	$7.00	_____
DEFOLIANT		OZ.	12	$0.33	$3.96	_____
BOLL OPENER	ETHEPHON	OZ.	32	$0.25	$8.00	_____
MACHINERY REPAIR		AC.	1	$40.28	$40.28	_____
MACHINERY FUEL	DIESEL @ $2.10/GALLON	AC.	1	$37.10	$37.10	_____
OPERATING CAPITAL	6 MONTHS	AC.	$323.23	8.00%	$12.93	_____
				TOTAL VARIABLE EXPENSES	$336.16	_____
				RETURN ABOVE VARIABLE EXPENSES	$131.34	_____

Source: Dr. Delton C. Gerloff, Field Crop Budgets, 2007, University of Tennessee Extension Service.

[24] Most arrangements involve trading seed for ginning costs.
[25] A second harvest may add as much as $25/acre to variable expenses.
[26] Seed cost varies per variety and seed size.
[27] Tech fees may vary and will have a cap per acre.
[28] Additional sprays may be necessary for specific insects.
[29] In-season per acre cost includes chemical expenses for bollworm and secondary spray, plus weevil eradication fee (WEF).

Appendix 6. Cotton, Roundup Ready – Conventional Tillage (cont.)

MACHINERY EXPENSES						
MACHINERY DEPRECIATION		AC.	1	$49.89	$49.89	_____
INTEREST EXPENSE	MACHINERY & EQUIP.	AC.	1	$28.39	$28.39	_____
	RETURN TO LAND, LABOR, MANAGEMENT, AND RISK				$53.06	_____
LABOR EXPENSES						
LABOR		HR.	1.92	$8.50	$16.34	_____
	RETURN TO LAND, MANAGEMENT, AND RISK				$36.72	_____

Appendix 7. Cotton, BgRR – Conventional Tillage, 850 Pound Yield

Estimated Returns and Expenses per Acre (12/16 Row Equipment)

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
REVENUE						
COTTON [30] [31]	LINT	LB.	850	$0.55	$467.50	_____
VARIABLE EXPENSES						
SEED [32]	3.5 SEEDS/FOOT	THOUS	48.145	$0.44	$21.18	_____
TECH FEE [33]	ROUNDUP READY	ACRE	1	$39.00	$39.00	_____
FUNGICIDE	SEED TREATMENT	ACRE	1	$6.50	$6.50	_____
INSECTICIDE [34]						
SEED TREATMENT		ACRE	1	$8.20	$8.20	_____
IN-SEASON INSECTICIDES [35]:		ACRE	1	$34.00	$34.00	_____
FERTILIZER	N (UREA)	LB.	80	$0.42	$33.60	_____
	P_2O_5	LB.	60	$0.32	$19.20	_____
	K_2O	LB.	90	$0.22	$19.80	_____
BORON		LB.	0.5	$3.85	$1.93	_____
LIME		TON	0.5	$23.00	$11.50	_____
HERBICIDES:						
PRE-EMERGE	COTORAN 4l	PT.	2	$5.15	$10.30	_____
OVER THE TOP	ROUNDUP ORIGINAL MAX	PT.	1.6	$2.84	$4.54	_____
OVER THE TOP	DUAL MAGNUM	PT.	1	$11.90	$11.90	_____
POST DIRECT	ROUNDUP ORIGINAL MAX	PT.	1.2	$2.84	$3.41	_____
POST-EMERGE	DIURON (DIRECTED)	LB.	0.375	$4.05	$1.52	_____
POST-EMERGE	ROUNDUP ORIGINAL MAX	PT.	1	$2.84	$2.84	_____
GROWTH REGULATOR	MEPEX (Mepiquat Chloride)	PT.	2	$2.70	$5.40	_____
SCOUTING		ACRE	1	$7.00	$7.00	_____
DEFOLIANT		OZ.	12	$0.33	$3.96	_____
BOLL OPENER	ETHEPHON	OZ.	32	$0.25	$8.00	_____
MACHINERY REPAIR		AC.	1	$39.78	$39.78	_____
MACHINERY FUEL	DIESEL @ $2.10/GALLON	AC.	1	$36.87	$36.87	_____
OPERATING CAPITAL	6 MONTHS	AC.	$330.43	8.00%	$13.22	_____
				TOTAL VARIABLE EXPENSES	$343.65	_____
				RETURN ABOVE VARIABLE EXPENSES	$123.85	_____

Source: Dr. Delton C. Gerloff, Field Crop Budgets, 2007, University of Tennessee Extension Service.

[30] Most arrangements involve trading seed for ginning costs.
[31] A second harvest may add as much as $25/acre to variable expenses.
[32] Seed cost varies per verity and seed cost.
[33] Tech fees may vary and will have a cap per acre.
[34] Additional sprays may be necessary for specific insects.
[35] In-season per acre cost includes chemical expenses for bollworm and secondary spray, plus weevil eradication fee (WEF).

Appendix 7. Cotton, BgRR – Conventional Tillage (cont).

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
MACHINERY EXPENSES						
MACHINERY DEPRECIATION		AC.	1	$49.05	$49.05	_____
INTEREST EXPENSE	MACHINERY & EQUIP.	AC.	1	$27.87	$27.87	_____
	RETURN TO LAND, LABOR, MANAGEMENT, AND RISK				$46.93	_____
LABOR EXPENSES						
LABOR		HR.	1.91	$8.50	$16.24	_____
	RETURN TO LAND, MANAGEMENT, AND RISK				$30.70	_____

Appendix 8. Cotton, Roundup Ready – No Tillage, 850 Pound Yield

Estimated Returns and Expenses per Acre (12/16 Row Equipment)

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
REVENUE						
COTTON [36] [37]	LINT	LB.	850	$0.55	$467.50	_____
VARIABLE EXPENSES						
SEED [38]	3.5 SEEDS/FOOT	THOUS	48.145	$0.40	$19.26	_____
TECH FEE [39]	ROUNDUP READY	ACRE	1	$27.00	$27.00	_____
FUNGICIDE	SEED TREATMENT	ACRE	1	$6.50	$6.50	_____
INSECTICIDE [40]						
SEED TREATMENT		ACRE	1	$8.20	$8.20	_____
IN-SEASON INSECTICIDES [41]:		ACRE	1	$40.00	$40.00	_____
FERTILIZER	N (UREA)	LB.	80	$0.42	$33.60	_____
	P_2O_5	LB.	60	$0.32	$19.20	_____
	K_2O	LB.	90	$0.22	$19.80	_____
BORON		LB.	0.5	$3.85	$1.93	_____
LIME		TON	0.5	$23.00	$11.50	_____
HERBICIDES:						
BURNDOWN	ROUNDUP ORIGINAL MAX	PT.	1.6	$2.84	$4.54	_____
BURNDOWN	CLARITY	OZ.	8	$0.56	$4.48	_____
PRE-EMERGE	COTORAN 4L	PT.	2	$5.15	$10.30	_____
OVER THE TOP	ROUNDUP ORIGINAL MAX	PT.	1.6	$2.84	$4.54	_____
OVER THE TOP	DUAL MAGNUM	PT.	1	$11.90	$11.90	_____
POST DIRECT	ROUNDUP ORIGINAL MAX	PT.	1.2	$2.84	$3.41	_____
POST-EMERGE	DIURON	LB.	0.375	$4.05	$1.52	_____
POST-EMERGE	ROUNDUP ORIGINAL MAX	PT.	1	$2.84	$2.84	_____
GROWTH REGULATOR	MEPEX (Mepiquat Chloride)	PT.	2	$2.70	$5.40	_____
SCOUTING		ACRE	1	$7.00	$7.00	_____
DEFOLIANT		OZ.	12	$0.33	$3.96	_____
BOLL OPENER	ETHEPHON	OZ.	32	$0.25	$8.00	_____

Source: Dr. Delton C. Gerloff, Field Crop Budgets, 2007, University of Tennessee Extension Service.

[36] Most arrangements involve trading seed for ginning costs.
[37] A second harvest may add as much as $25/acre to variable expenses.
[38] Seed cost varies per verity and seed cost.
[39] Tech fees may vary and will have a cap per acre.
[40] Additional sprays may be necessary for specific insects.
[41] In-season per acre cost includes chemical expenses for bollworm and secondary spray, plus weevil eradication fee (WEF).

Appendix 8. Cotton, Roundup Ready – No Tillage (cont).

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
MACHINERY REPAIR		AC.	1	$31.22	$31.22	_____
MACHINERY FUEL	DIESEL @ $2.10/GALLON	AC.	1	$25.32	$25.32	_____
OPERATING CAPITAL	6 MONTHS	AC.	$311.42	8.00%	$12.46	_____
				TOTAL VARIABLE EXPENSES	$323.87	_____
				RETURN ABOVE VARIABLE EXPENSES	$143.63	_____
MACHINERY EXPENSES						
MACHINERY DEPRECIATION		AC.	1	$39.10	$39.10	_____
INTEREST EXPENSE	MACHINERY & EQUIP.	AC.	1	$21.30	$21.30	_____
	RETURN TO LAND, LABOR, MANAGEMENT, AND RISK				$83.23	_____
LABOR EXPENSES						
LABOR		HR.	1.31	$8.50	$11.15	_____
	RETURN TO LAND, MANAGEMENT, AND RISK				$72.09	_____

Appendix 9. Cotton, BgRR – No Tillage, 850 Pound Yield

Estimated Returns and Expenses per Acre (12/16 Row Equipment)

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
REVENUE						
COTTON [42] [43]	LINT	LB.	850	$0.55	$467.50	_____
VARIABLE EXPENSES						
SEED [44]	3.5 SEEDS/FOOT	THOUS	48.145	$0.44	$21.18	_____
TECH FEE [45]	ROUNDUP READY	ACRE	1	$39.00	$39.00	_____
FUNGICIDE	SEED TREATMENT	ACRE	1	$6.50	$6.50	_____
INSECTICIDE [46]						
SEED TREATMENT		ACRE	1	$8.20	$8.20	_____
IN-SEASON INSECTICIDES [47]:		ACRE	1	$34.00	$34.00	_____
FERTILIZER	N (UREA)	LB.	80	$0.42	$33.60	_____
	P_2O_5	LB.	60	$0.32	$19.20	_____
	K_2O	LB.	90	$0.22	$19.80	_____
BORON		LB.	0.5	$3.85	$1.93	_____
LIME		TON	0.5	$23.00	$11.50	_____
HERBICIDES:						
BURNDOWN	ROUNDUP ORIGINAL MAX	PT.	1.6	$2.84	$4.54	_____
BURNDOWN	CLARITY	OZ.	8	$0.56	$4.48	_____
PRE-EMERGE	COTORAN 4L	PT.	2	$5.15	$10.30	_____
OVER THE TOP	ROUNDUP ORIGINAL MAX	PT.	1.6	$2.84	$4.54	_____
OVER THE TOP	DUAL MAGNUM	PT.	1	$11.90	$11.90	_____
POST DIRECT	ROUNDUP ORIGINAL MAX	PT.	1.2	$2.84	$3.41	_____
POST-EMERGE	DIURON	LB.	0.375	$4.05	$1.52	_____
POST-EMERGE	ROUNDUP ORIGINAL MAX	PT.	1	$2.84	$2.84	_____
GROWTH REGULATOR	MEPEX (Mepiquat Chloride)	PT.	2	$2.70	$5.40	_____
SCOUTING		ACRE	1	$7.00	$7.00	_____
DEFOLIANT		OZ.	12	$0.33	$3.96	_____
BOLL OPENER	ETHEPHON	OZ.	32	$0.25	$8.00	_____
MACHINERY REPAIR		AC.	1	$30.72	$30.72	_____
MACHINERY FUEL	DIESEL @ $2.10/GALLON	AC.	1	$25.09	$25.09	_____
OPERATING CAPITAL	6 MONTHS	AC.	$318.61	8.00%	$12.74	_____
				TOTAL VARIABLE EXPENSES	$331.36	_____
				RETURN ABOVE VARIABLE EXPENSES	$136.14	_____

Source: Dr. Delton C. Gerloff, Field Crop Budgets, 2007, University of Tennessee Extension Service.

[42] Most arrangements involve trading seed for ginning costs.
[43] A second harvest may add as much as $25/acre to variable expenses.
[44] Seed cost varies per verity and seed cost.
[45] Tech fees may vary and will have a cap per acre.
[46] Additional sprays may be necessary for specific insects.
[47] In-season per acre cost includes chemical expenses for bollworm and secondary spray, plus weevil eradication fee (WEF).

Appendix 9. Cotton, BgRR – No Tillage (cont).

ITEM	DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT	YOUR FARM
MACHINERY EXPENSES						
MACHINERY DEPRECIATION		AC.	1	$38.26	$38.26	_____
INTEREST EXPENSE	MACHINERY & EQUIP.	AC.	1	$20.78	$20.78	_____
	RETURN TO LAND, LABOR, MANAGEMENT, AND RISK				$77.10	_____
LABOR EXPENSES						
LABOR		HR.	1.30	$8.50	$11.04	_____
	RETURN TO LAND, MANAGEMENT, AND RISK				$66.06	_____

Appendix 10. Alfalfa, Hay: Estimated Expenses per Acre

Item	Description	Unit	Quantity	Price	Amount ($/Acre)	Your Farm
Variable Expenses [48]						
Fertilizer	P_2O_5	Lb.	60	$0.34	$20.40	_____
	K_2O	Lb.	190	$0.23	$43.70	_____
	Boron	Lb.	2	$2.38	$4.76	_____
	Custom Application	Acre	1	$5.00	$5.00	_____
Lime [49]	Custom Application	Ton	0.67	$21.00	$14.07	_____
Insect Control [50]	Furadan 4F	Pt.	2	$9.23	$18.46	_____
Weed Control						
Post-Emerge	Poast Plus [51]	Pt.	1.50	$6.50	$9.75	_____
	Crop Oil	Pt.	2	$1.73	$3.46	_____
	Custom Application	Acre	1	$5.00	$5.00	_____
	2,4-DB [52]	Pt.	1	$4.26	$4.26	_____
	Custom Application	Acre	0.25	$5.00	$1.25	_____
Dormant Spray	Gramoxone Max	Pt.	1	$4.91	$4.91	_____
	Surfactant	Pt.	0.5	$1.63	$0.82	_____
	Custom Application	Acre	1	$5.00	$5.00	_____
Twine		Bale	140	$0.04	$5.79	_____
Machinery						
Fuel		Acre	1	$28.96	$28.96	_____
Oil & Filter		Acre	1	$4.34	$4.34	_____
Repairs & Maintenance		Acre	1	$26.78	$26.78	_____
Interest on Operating Capital, 6 months		Acre	$206.72	8.0%	$8.27	_____
		Total Variable Expenses			$214.98	_____

Source: Dr. Delton C. Gerloff, Forage Budgets for 2007, University of Tennessee Extension Service.

[48] A hay preservative may be needed, please include the expense.
[49] Lime is applied at the rate of 2 tons every three years.
[50] Other materials may be used at slightly less cost, but do not appear as effective.
[51] Poast Plus is included for control of crabgrass, which is a common problem. If johnsongrass is a problem, Select may be used.
[52] Applied once every four years.

Appendix 10. Alfalfa, Hay (cont.)

Item	Description	Unit	Quantity	Price	Amount ($/Acre)	Your Farm
Fixed Expenses						
Establishment Cost	Prorated over 4 years	Acre	1	$50.31	$50.31	_____
Machinery						
Depreciation		Acre	1	$19.94	$19.94	_____
Interest		Acre	1	$24.66	$24.66	_____
Housing & Insurance		Acre	1	$2.21	$2.21	_____
		Total Fixed Expenses			$97.11	_____
Labor Expenses						
Labor [53]		Hour	5.62	$8.50	$47.80	_____
		Total Budgeted Expenses			$359.89	_____

[53] Labor expense is $8.50 per hour, including wages, Social Security and Medicaid taxes and payroll administration costs.

Appendix 11. Bermudagrass, Hay: Estimated Expenses per Acre

Item	Description	Unit	Quantity	Price	Amount ($/Acre)	Your Farm
Variable Expenses						
Fertilizer [54]	N	Lb	240	$0.48	$115.20	_____
	P_2O_5	Lb	60	$0.34	$20.40	_____
	K_2O	Lb	180	$0.23	$41.40	_____
	Custom Application	Acre	4.0	$5.00	$20.00	_____
Lime		Ton	0.67	$21.00	$14.07	_____
Twine		Bale	160	$0.04	$6.62	_____
Weed Control						
Dormant	Gramoxone Max	Pt.	1.50	$4.91	$7.37	_____
	Surfactant	Pt.	0.50	$1.63	$0.82	_____
	Custom Application	Acre	1	$5.00	$5.00	_____
Post-Emerge	Cimarron	Oz.	0.20	$21.90	$4.38	_____
	Custom Application	Acre	1	$5.00	$5.00	_____
Machinery						
Fuel		Acre	1	$27.89	$27.89	_____
Oil & Filter		Acre	1	$4.18	$4.18	_____
Repairs & Maintenance		Acre	1	$26.33	$26.33	_____
Interest on Operating Capital, 6 months		Acre	$298.65	8.0%	$11.95	_____
		Total Variable Expenses			$310.60	_____
Fixed Expenses						
Establishment Cost	Prorated over 10 years	Acre	1	$33.00	$33.00	_____
Machinery						
Depreciation		Acre	1	$19.62	$19.62	_____
Interest		Acre	1	$24.27	$24.27	_____
Housing & Insurance		Acre	1	$2.51	$2.51	_____
		Total Fixed Expenses			$79.40	_____
Labor Expenses						
Labor [55]		Hour	5.42	$8.50	$46.03	_____
		Total Budgeted Expenses			$436.02	_____

Source: Dr. Delton C. Gerloff, Forage Budgets for 2007, University of Tennessee Extension Service.

[54] 60 lbs of nitrogen applied in April, May, June, and July. Hybrids may require higher application rates.

[55] Labor expense is $8.50 per hour, including wages, Social Security and Medicaid taxes and payroll administration costs.

Appendix 12. Clover, Hay: Estimated Expenses per Acre

Item	Description	Unit	Quantity	Price	Amount ($/Acre)	Your Farm
Variable Expenses						
Fertilizer [56]	N	Lb.	60	$0.48	$28.80	_____
	P_2O_5	Lb.	30	$0.34	$10.20	_____
	K_2O	Lb.	30	$0.23	$6.90	_____
	Custom Application	Acre	1	$5.00	$5.00	_____
Overseeding [57]	Fescue or Orchardgrass	Lb.	2	$1.00	$2.00	_____
	White Clover	Lb.	0.33	$3.06	$1.01	_____
	Red Clover	Lb.	0.67	$2.86	$1.92	
No-Till Drill, Rental		Acre	0.17	$8.00	$1.36	_____
Weed Control [58]						_____
Post-Emerge	2,4-D Ester 4EC	Pt.	0.33	$2.04	$0.67	_____
	Custom Application	Acre	0.33	$5.00	$1.65	_____
Twine		Bale	5.00	$0.24	$1.19	_____
Machinery						
Fuel		Acre	1	$28.94	$28.94	_____
Oil & Filter		Acre	1	$4.27	$4.27	_____
Repairs & Maintenance		Acre	1	$33.27	$33.27	_____
Interest on Operating Capital, 6 months		Acre	$127.18	8.00%	$5.09	_____
		Total Variable Expenses			$132.27	_____
Fixed Expenses						
Establishment Cost		Acre	1	$36.54	$36.54	_____
Machinery						
Depreciation		Acre	1	$16.18	$16.18	_____
Interest		Acre	1	$20.00	$20.00	_____
Housing & Insurance		Acre	1	$1.81	$1.81	_____
		Total Fixed Expenses			$74.54	_____
Labor Expenses						
Labor [59]		Hour	5.62	$8.50	$47.76	_____
		Total Budgeted Expenses			$254.57	_____

Source: Dr. Delton C. Gerloff, Forage Budgets for 2007, University of Tennessee Extension Service.

[56] Fall application of nitrogen. Spring nitrogen provided by clover.

[57] To maintain clover in the pasture it should be overseeded once during the 5-year stand-life, at the rate of 2 lbs of white clover and 4 lbs of red clover per acre. 12 lbs of fescue or orchardgrass also overseeded once. These rates are prorated over the life of the stand.

[58] Weed spray is done once at a rate of 2 pt/acre, and is prorated over the 6-year stand-life.

[59] Labor expense is $8.50 per hour, including wages, Social Security and Medicaid taxes and payroll administration costs.

Appendix 13. Switchgrass No-tillage Establishment on Existing Cropland Estimated Expenses per Acre

Item	Description	Unit	Quantity	Price	Amount	Your Farm
Revenue						
Switchgrass	Biomass	Ton	0	0	$0.00	_____
Variable Expenses [60]						
Seed [61]	PLS (Pure Live Seed)	Lb.	8	$13.00	$104.00	_____
Fertilizer [62] [63]	P2O5	Lb.	40	$0.32	$12.80	_____
	K2O	Lb.	60	$0.22	$13.20	_____
Weed Control						
First Burndown	Roundup Original Max	Pt.	1.6	$2.84	$4.54	_____
Second Burndown	Roundup Original Max	Pt.	1.6	$2.84	$4.54	_____
Post-Emerge	Cimarron	Oz.	0.1	$21.90	$2.19	_____
Machinery Repair		Acre	1	$4.55	$4.55	_____
Machinery Fuel	Diesel @ $2.10/Gallon	Acre	1	$4.55	$4.55	_____
Operating Capital	6 Months	Acre	$149.58	8.00%	$5.98	_____
		TOTAL VARIABLE EXPENSES			$155.56	_____
Machinery Expenses						
Machinery Depreciation		Acre	1	$6.12	$6.12	_____
Interest Expense	Machinery & Equip.	Acre	1	$3.86	$3.86	_____
			MACHINERY COST		$48.68	_____
Labor Expenses						
Labor		Hour	0.20	$8.50	$1.68	_____
				LABOR COST	$1.68	_____
Total Establishment Cost					$167.23	_____
Establishment Cost Prorated Over 11 Years		Annual	$167.23	8.00%	$23.43	_____

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

[60] Switchgrass established using spring seeding with a no-till drill.

[61] There is a wide range in seed prices. The recommended seeding rate is 8 pounds of pure live seed per acre.

[62] Assumes a soil test low in P & K. If soil test values are medium or high in P & K, no P_2O_5 or K_2O is recommended. Cost of renting spreader is included in the fertilizer price.

[63] Lime is not recommended if the soil pH is 5.0 or above.

Appendix 14. Switchgrass No-Tillage Establishment on Existing Cropland Estimated Labor, Power and Machinery Inputs

Month	Operation	Equipment	Hours Per Acre Machine	Labor
May	Plant	Planter, 12-Row	0.06	0.08
	Burndown/Pre-Emerge	SP Sprayer, 90'	0.01	0.01
	Burndown/Pre-Emerge	SP Sprayer, 90'	0.01	0.01
	Spread Fertilizer	215hp Tractor	0.07	0.08
	Post-Emerge Spray	SP Sprayer, 90'	0.01	0.01
			Total	0.20

Machine	Hours Per Acre	-Interest Cost- Per Hour	Per Acre	-Cost Per Hour- F.C.	V.C.	-----Cost Per Acre----- Fixed	Repair	Fuel	Var
Tractor 215HP	0.13	$8.59	$1.10	$12.07	$35.96	$1.54	$1.52	$3.07	$4.59
Planter	0.06	$20.00	$1.21	$34.08	$25.00	$2.07	$1.52	$0.00	$1.52
Sprayer	0.03	$50.77	$1.55	$82.21	$71.72	$2.51	$1.51	$0.68	$2.19
Total			$3.86			$6.12	$4.55	$3.75	$8.30

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

Appendix 15. Switchgrass No-Tillage Reseeding Estimated Expenses per Acre

Item	Description	Unit	Quantity	Price	Amount	Your Farm
Revenue						
Switchgrass	Biomass	Ton	0	0	$0.00	_____
Variable Expenses [64]						
Seed [65]	PLS (Pure Live Seed)	Lb.	5.3	$13.00	$68.90	_____
Fertilizer [66] [67]	P_2O_5	Lb.	40	$0.32	$12.80	_____
	K_2O	Lb.	60	$0.22	$13.20	_____
Weed Control						
First Burndown	Roundup Original Max	Pt.	1.6	$2.84	$4.54	_____
Second Burndown	Roundup Original Max	Pt.	1.6	$2.84	$4.54	_____
Post-Emerge	Cimarron	Oz.	0.1	$21.90	$2.19	_____
Machinery Repair		Acre	1	$4.55	$4.55	_____
Machinery Fuel	Diesel @ $2.10/Gallon	Acre	1	$3.75	$3.75	_____
Operating Capital	6 Months	Acre	$114.48	8.00%	$4.58	_____
		TOTAL VARIABLE EXPENSES			$119.06	_____
Machinery Expenses						
Machinery Depreciation		Acre	1	$6.12	$6.12	_____
Interest Expense	Machinery & Equip.	Acre	1	$3.86	$3.86	_____
				MACHINERY COST	$9.99	_____
Labor Expenses						
Labor		Hour	0.20	$8.50	$1.68	_____
				LABOR COST	$1.68	_____
Total Establishment Cost					$130.73	_____
Establishment Cost Prorated Over 11 Years		Annual	$26.15	8.00%	$3.90	_____

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

[64] Switchgrass established using spread seeding with a no-till drill. The probability of reseeding spring switchgrass is estimated to be 20 percent.

[65] There is a wide range in seed prices. The recommended seeding rate is 8 pounds of Pure Live Seed (PLS) per acre. A rate of 5.3 pounds per acre is used for reseeding.

[66] Assumes a soil test low in P & K. If soil test values are medium or high in P & K, no P_2O_5 or K_2O is recommended. Cost of renting spreader is included in the fertilizer price.

[67] Lime is not recommended if the soil pH is 5.0 or above.

Appendix 16. Switchgrass No-Tillage Reseeding Estimated Labor, Power and Machinery Inputs

Month	Operation	Equipment	Hours Per Acre Machine	Labor
May	Plant	Planter, 12-Row	0.06	0.08
	Burndown/Pre-Emerge	SP Sprayer, 90'	0.01	0.01
	Burndown/Pre-Emerge	SP Sprayer, 90'	0.01	0.01
	Spread Fertilizer	215hp Tractor	0.07	0.08
	Post-Emerge Spray	SP Sprayer, 90'	0.01	0.01
			Total	0.20

Machine	Hours Per Acre	-Interest Cost- Per Hour	Per Acre	-Cost Per Hour- F.C.	V.C.	-------Cost Per Acre------- Fixed	Repair	Fuel	Var
Tractor 215hp	0.13	$8.59	$1.10	$12.07	$35.96	$1.54	$1.52	$3.07	$4.59
Planter	0.06	$20.00	$1.21	$34.08	$25.00	$2.07	$1.52	$0.00	$1.52
Sprayer	0.03	$50.77	$1.55	$82.21	$71.72	$2.51	$1.51	$0.68	$2.19
Total			$3.86			$6.12	$4.55	$3.75	$8.30

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

Appendix 17. Switchgrass Annual Production Budget Estimated Expenses per Acre

Item	Description	Unit	Quantity	Price	Amount	Your Farm
Revenue						
Switchgrass	Biomass	Ton	0	0	$0.00	_____
Variable Expenses						
Fertilizer [68] [69]	Nitrogen	lb.	50	$0.42	$21.00	_____
	P_2O_5	lb.	40	$0.32	$12.80	_____
	K_2O	lb.	60	$0.22	$13.20	_____
Triple Tie	Twine, 1500lb. Bale	Bale	7	$1.19	$8.33	_____
Weed Control						
Post-Emerge	Cimarron	Oz.	0.1	$21.90	$2.19	_____
Machinery Repair		Ac.	1	$28.13	$28.13	_____
Machinery Fuel	Diesel @ $2.10/gallon	Ac.	1	$36.22	$36.22	_____
Operating Capital	6 Months	Ac.	$121.87	8.00%	$4.87	_____
		TOTAL VARIABLE EXPENSES			$126.74	_____
Machinery Expenses						
Machinery Depreciation		Ac.	1	$30.94	$30.94	_____
Interest Expense	Machinery & Equip.	Ac.	1	$17.74	$17.74	_____
			MACHINERY COST		$48.68	_____

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

[68] Assumes a soil test low in P and K. If soil test values are medium or high in P and K, no P_2O_5 is recommended. Cost of renting spreader is included in the fertilizer price.

[69] Lime is not recommended if the soil pH is 5.0 or above.

Appendix 17. Switchgrass Annual Production Budget (cont.)

Item	Description	Unit	Quantity	Price	Amount	Your Farm
Labor Expenses						
Labor		Hr.	1.88	$8.50	$16.01	_____
			LABOR COST		$16.01	_____
Prorated Establishment Cost [70]					$23.43	_____
Prorated Reseeding Cost [71]					$3.90	_____
Production Cost, Excluding Land and Management Charges					$218.76	_____

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

[70] See switchgrass Establishment Budget.
[71] See switchgrass Reseeding Budget.

Appendix 18. Switchgrass Annual Production Budget Estimated Labor, Power and Machinery Inputs

			Hours Per Acre	
Month	**Operation**	**Equipment**	**Machine**	**Labor**
May	Herbicide Spray	SP Sprayer, 90'	0.01	0.01
	Spread Fertilizer	215HP Tractor	0.07	0.08
Nov/Dec	Mow	Mower	0.26	0.33
	Rake	Rake, 18'	0.17	0.21
	Bale	Baler, Large Round	0.50	0.63
	Stage/Load	Loader	0.50	0.63
			TOTAL	1.88

	Hours	--Interest Cost--		-Cost Per Hour-		----------Cost Per Acre----------			
Machine	Per Acre	Per Hour	Per Acre	F.C.	V.C.	Fixed	Repair	Fuel	Var
Tractor 215HP	1.50	$8.59	$12.86	$12.07	$35.96	$18.06	$17.84	$35.99	$53.83
Sprayer	0.01	$50.77	$0.52	$82.21	$71.72	$0.84	$0.50	$0.23	$0.73
Mower	0.26	$1.95	$0.51	$3.30	$4.88	$0.86	$1.27	$0.00	$1.27
Rake	0.17	$1.00	$0.17	$1.37	$0.72	$0.23	$0.12	$0.00	$0.12
Baler	0.50	$4.38	$2.19	$14.62	$13.80	$7.31	$6.90	$0.00	$6.90
Loader	0.50	$3.00	$1.50	$7.27	$3.00	$3.64	$1.50	$0.00	$1.50
TOTAL			$17.74			$30.94	$28.13	$36.22	$64.35

Source: Dr. Delton C. Gerloff, Switchgrass Working Budgets, April 2007, University of Tennessee Extension Service.

Vita

Janet LeAnne Jones was born in Greeneville, Tennessee, on February 6, 1982 to Elizabeth and Mark Jones. She attended schools in the public school system of Greene County, Tennessee, where she graduated from Greeneville High School in May 2000.

In August of 2000, she began her college career at the University of Tennessee, Martin. In December of 2004, she received a Bachelor of Science in Agriculture degree with a major in Agriculture Business and three minors in Spanish, English, and Business Administration. In August of 2005, Janet entered into the University of Tennessee, Knoxville in order to pursue a Master of Science degree in Agriculture Economics. She received her Master's degree in August of 2007.