THE ECONOMIC IMPACTS OF LAND USE CHANGES ASSOCIATED WITH SWITCHGRASS-BASED ETHANOL PRODUCTION IN OKLAHOMA

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CHAPTER I

INTRODUCTION

1.1. Background

The crude oil crisis occurring during the last decade impacted the weak economy of poor countries and seriously damaged the industrialized economy of rich nations. While consequences are more perceptible in the developing countries, they highlighted the issue of energy insecurity in the United States. A sudden increase in the petroleum barrel price in the Middle East inexorably leads to a decline in the purchasing power of a given household in Southern or Northern America. An increase in the energy price affects the price of commodities as the manufacturing costs and the transportation costs may increase.

The issues related to oil consumption are not only financial. Other voices acting in favor of a clean and environmentally friendly source of energy rose in support of those who suggested a reduction of the nation's fossil oil consumption. According to the Environmental Protection Agency (EPA), a significant source of greenhouse gas emissions in the United States is the consumption of fossil fuels. Carbon Dioxide (CO2) constitutes the main component of greenhouse gases with total emissions estimated at 5,975 million metric tons in 2000, 5,113 million metric tons in 2005, and a relatively slight decrease in 2009 according to the EPA.

The EPA (2010) revealed that the majority of carbon dioxide emissions come from fossil oil combustions.

The issue of energy availability and accessibility coupled with calls made by environmentalists and some civilian associations for safer environment initiatives pushed the United States' Congress to pass a series of laws. These laws provide tax incentives to energy companies to explore possibilities of producing energy from sustainable sources and encourage the use of clean energy, especially within the transportation sector. Most recently, the House Representatives approved the American Clean Energy and Security Act of 2009, which regulates greenhouse gas emissions, encourages renewable clean energy production and use, and protects Americans from energy price volatility. The main objective of these energy bills was to promote sustainability in the energy sector by creating new opportunities for the agricultural sector.

Among multiple alternatives, bioenergy was elected as a potential response to address to these energy issues. In 2005, the Energy Policy Act (EPAct-2005) mandated the production of 7.5 billion gallons of biofuels by 2012. However, the EPAct-2005 did not provide further specifications to where the mandated volume of biofuel had to be derived from. Corn, which has been previously used in the biofuel sector, received particular attention. Although corn has been the major feedstock for United States biofuel industries, its use raised many concerns among policymakers. Some people point out the fact that bioenergy using corn may compete with food production (Elobeid et al., 2006, Pimentel, 2003) while Lynd et al. (1996) reported that the energy output obtained from corn is less than the energy input used in the corn-ethanol production process.

As a result, research focused on biomass feedstocks to gradually replace the corn as a bioenergy feedstock. In early 1990, scientists brought evidence that switchgrass (Panicum Virgatum), a native grass in North America, is one of the most efficient feedstocks in terms of yield, cost of production, impacts on the environment, and returns to farmers (Sanderson et al., 1996; McLaughlin and Walsh, 1998; McLaughlin and Kszos, 2005; Vadas et al., 2008). Therefore, the problem becomes how and where to produce enough switchgrass to meet the demand for bioenergy production. In 2007, the Energy Independence and Security Act (EISA-2007) called for the production of at least 36 billion gallons of biofuel by 2022 with 21 billion gallons coming from cellulosic biomass. Each of the fifty states in the U.S. participated differently in the achievement of the 2007 renewable energy mandate. Oklahoma, with total farmland estimated at 35 million acres, appears to be potentially competitive. In 2006, when Richard Hamilton, Chief Executive of California Plant Genetics Company, declared that "you could turn Oklahoma into an OPEC member by converting all of farmland to switchgrass", some Oklahoma farmers were convinced and motivated by the benefits associated with switchgrass-based biofuel production. The Environmental Protection Agency (EPA) projected that by 2022, the Oklahoma switchgrass-based ethanol industry will produce a total of 793 million gallons per year (EPA, 2010). However, meeting the EPA projection will require some changes in the Oklahoma agriculture landscape, which would probably lead to variations in many aspects of the Oklahoma economy.

Until now, studies on the Oklahoma ethanol sector have examined switchgrass production costs, the impact of switchgrass production on land use and land degradation, and the environmental implications of switchgrass production. The most recent study conducted by the Division of Agricultural Sciences and Natural Resources of Oklahoma State University, gives an overview of the switchgrass production from the soil preparation to the conversion of switchgrass in the refineries, and the costs associated with the establishment, harvest, storage, transportation, and conversion (Caddel et al. 2010). However, investigations should not stop at this step. Oklahomans and more specifically, policymakers, want to know how the production of ethanol using switchgrass will impact the local economy and precisely how it will affect local communities.

1.2. Objectives

The overall objective of this study was to determine how land use changes associated with switchgrass-based ethanol production would affect the Oklahoma economy. Specifically, this study aimed to determine the economic impacts of growing switchgrass for energy purposes in the area and examine the economic implications of operating ethanol production facilities in Oklahoma, and determine the economic impacts of land use changes based on nine ethanol plant scenarios.

CHAPTER II

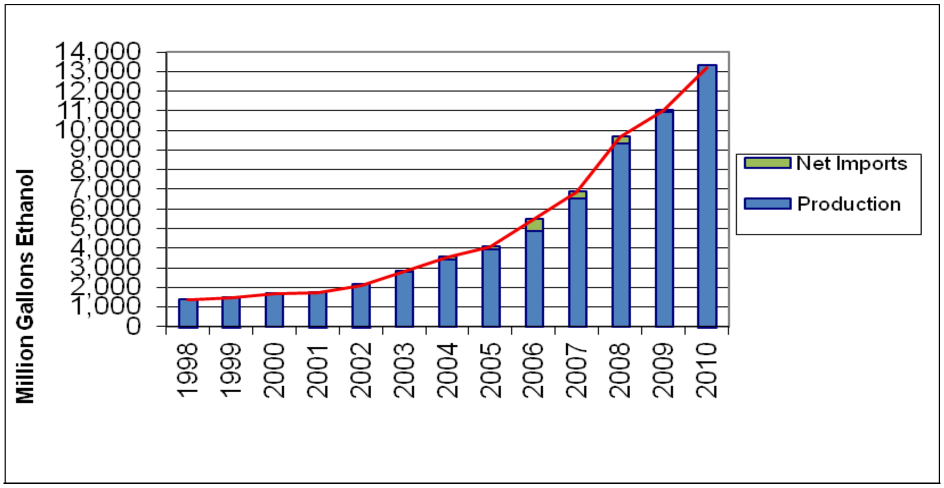
REVIEW OF LITERATURE

This chapter gives an overview about previous studies on the bioenergy sector in the United States, the impacts of switchgrass production on the agricultural sector, and the economic implications of biorefinery operations on local communities. The current situation of the U.S. bioenergy sector is discussed in the first section. The second and third sections focus on the economics of switchgrass production and the operation of biorefineries on local economies in the United States. The last part of this section discusses the use of the IMPLAN model for the economic impact analysis.

2.1. The United States Bioenergy Sector

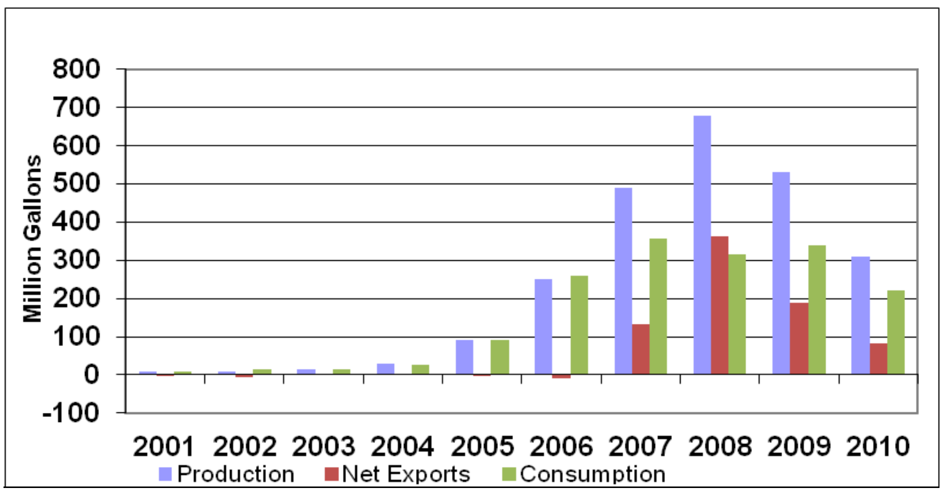
The history of bioenergy as engine fuel dates back to the early 1900's with the first Model T car invented by Henry Ford (Specht, 2011). However, the expansion of the biofuels sector occurred in the second half of the last decade. Figure 1 and figure 2 show the United States biofuel (ethanol and biodiesel) production and trade during the last decade. In these figures, biofuel production in the United States drastically increased after 2006. Ethanol production increased from 5,000 million gallons to almost 7,000 million gallons per year. The boom in the biodiesel sector was reflected by positive net exports after 2007, and increase in both production and consumption as well.

Figure 1: United States Ethanol Production, Consumption and Trade



Source: Renewable Fuel Association. 2011

Figure 2: United States Biodiesel Production, Export, and Consumption



Source: Renewable Fuel Association. 2011

In 2006, the number of refineries drastically increased, jumping from 16 in 2001 to more than one hundred in 2006 with total production reaching 4.9 billion gallons according to the Renewable Fuel Association (RFA). Today, there are currently 204 functional biorefineries and 9 under construction throughout the United States with an estimated capacity of 13,507.9 million gallons per year (RFA, 2011). With an estimated production capacity of 13 billion gallons, the ethanol industry enabled the United States to displace about 450 million barrels of imported fossil oil in 2010. The ethanol sector is by far the primary contributor to the bioenergy expansion. Table 1 and 2 show the United States ethanol and biodiesel production since 2000, respectively.

Many factors may have caused this sudden interest in the bioenergy sector, but the most important factors were the three crude oil crises of 1973, 1979, and 1990 (Specht, 2011). Many industrialized countries, including the United States, started to investigate new sources of fuels that could break their dependency on foreign oil and protect their economy against the adverse effects of the fossil fuel industry. Since then, many federal policies as well as pleadings from imminent political personalities and scientists encourage the production and consumption of energy derived from local materials, preferably those that can be sustainably used.

Table 1: The United States Ethanol Production Capacity

Year	Biorefinery online	Capacity (mg/y)
2000	54	1,748.70
2001	56	1,921.90
2002	61	2,347.30
2003	68	2,706.80
2004	72	3,100.80
2005	81	3,643.70
2006	95	4,336.40
2007	110	5,493.40
2008	139	7,888.40
2009	170	10,569.40
2010	189	11,877.40
2011	204	13,507.90

Source: Renewable Fuels Association, Ethanol Energy Outlook, 2011.

Table 2: Biodiesel Production in the United States

Year	Production (mg/y)
2000	2
2001	5
2002	15
2003	20
2004	25
2005	75
2006	250
2007	450
2008	700

Source: Renewable Fuels Association, Ethanol Energy Outlook, 2011.

The Energy Policy Act of 2005 was the starting point of the bioenergy boom. Approved by the Congress in July 2005, it was signed into law by President George W. Bush a month later. The Act was designed to "ensure jobs for our future with secure, affordable, and reliable energy", and it has contributed significantly to the success of biofuel initiatives. It mandated the production of 7.5 billion gallons of bio-based fuels by 2012. Then, the Biofuel Security Act of 2007 (BSAct-2007) required a gradual production of bio-based fuels from 10 billion gallons by 2010 up to 60 billion gallons by 2030. The Energy Independence and Security Act of 2007 (EISAct-2007) mandated the production of 36 billion gallons of biofuels by 2022 from which biomass-based feedstocks will contribute up to 16 billion gallons. In the same year, President George W. Bush declared in his state of the nation speech that Americans "must continue investing in new methods of producing ethanol- using everything from wood chips to grasses, to agricultural wastes." Steven Chu, the U.S. Energy Secretary explaining the need to invest on new generation fuels concluded that: "developing the next generation of biofuels is a key to our effort to end our dependence on foreign oil and address the climate crisis while creating millions of new jobs that can't be outsourced." Most recently in his state of the union speech, President Barack Obama clearly stated his support for bioenergy when he said: "with more research and incentives, we can break our dependence on oil with biofuels… We need to get behind this innovation. And to help pay for it, I'm asking Congress to eliminate the billions in taxpayer dollars we currently give to oil companies… So instead of subsidizing yesterday's energy, let's invest in tomorrow's."

However, some opinions are not in favor of biofuels expansion because of the implications that dedicated energy crops production may have on land use and soil quality. Based on the three steps of the 2007 Biofuels Security Act, De La Torre Ugarte et al. (2006) estimated that 35 million acres of land would be needed to grow the energy feedstocks. De La Torre Ugarte et al. (2007) projected the U.S potential of bioenergy feedstock production and estimated that by 2011, about 30.5 million dry tons of corn stover, 32.5 million dry tons of switchgrass and 2.32 billion bushels of corn would be used in the plants to produce 11.24 billion gallons of ethanol. Using two farm gate price scenarios, Walsh et al. (2003) determined the price over which, farmers are willing to assign some part of their lands to energy-based crops production. They reported that at farm gate prices of $40/dry ton, $42.32/dry ton, and $43.87/dry ton respectively for switchgrass, willow, and hybrid polar, an additional 23.4 million acres of land would be added to the existing agricultural lands for dedicated energy crops production. Although the majority of these lands will come from Conservation Reserve Program (CRP) land, the authors estimated that the remaining would be diverted from pasture or crop lands.

Corn remains the major ethanol feedstock in the United States unless biomass-based ethanol is proven cost-efficient and sufficiently available to meet the quantity mandated. However, some people suspect that the high demand for corn for energy production negatively impacted the acreage devoted to other agricultural commodities and may have caused increases in food prices. Johansson and Azar (2006) used a long-term economic optimization model (LUCEA) to determine how biofuels production could alter the U.S agricultural landscape and how the competition between dedicated energy grains and other agricultural commodities could impact food prices. They concluded that both cropland and grassland will suffer from the shift to dedicated energy crop production. Other studies focused on the impacts of biofuels expansion on food prices in the local and global agricultural markets (Walsh et al., 2003; Tyner and Taheripour, 2008; Hayes et al., 2009; Campiche, 2009).

One of the major objectives of bioenergy production in the United States is to develop the rural economy by creating new jobs, revitalize local economies, develop business opportunities and rebuild the agriculture sector. John Urbanchuk, a renewable fuel economist cited in the 2011 Ethanol Industry Outlook, estimated that 70,400 direct jobs were created by the United States biofuels industry in 2010. The 2010 outlook revealed that the biofuels sector has created 400,000 jobs throughout the whole economy in 2009 and generated an increase in the Gross Domestic Product (GDP) estimated at $53.3 billion in the same period. Households' income increased from $6.7 billion in 2006 to $36 billion in 2011. In addition, the expansion of the biofuels sector enabled the U.S government to reduce the amount of money used for foreign oil imports in 2010 by $34 billion.

Moreover, the biofuels sector provides various opportunities for farmers. The 109 million tons of switchgrass and 95.6 million tons of crop residues needed to meet the 36 billion gallons mandate as reported by Dicks et al. (2009) will come from U.S farmers. The agricultural sector, dominated for several generations by the four major crops, which are corn, wheat, cotton, and soybeans, no longer experiences its initial prosperity and seems to sink in a long hibernation accentuated by the economic crisis. Therefore, a deep restructuration appears to be imperative in order to give new hope to the thousands of farmers. The promotion of biofuels encourages a shift to dedicated energy crops, which may help to revitalize the United States agricultural market.

Another objective of developing biofuels is to take into account the environmental dimension. Chandel et al. (2007) reported that the use of ethanol or biodiesel as well as its production helps to reduce GHG emissions. Fraas and Johansson (2009) estimated that the combustion of a gallon of ethanol releases 50 to 90% less GHG than a gallon of gasoline. The study reported that biomass-based fuel production could generate a reduction in CO2 emissions by 900 lbs per dry tons. West et al. (2009) estimated that a 10 gallon per dry ton increase in the overall conversion yield would reduce the level of GHG emission by 3% of the current volume of GHG released. Besides GHG savings from biofuels combustions, dedicated energy crops such as switchgrass may be useful for the environment as it aids in soil conservation, provides habitat for wildlife, and plays an important role in carbon sequestration (Epplin, 1996; Wright, 2007).

The United States has important possibilities for bioenergy feedstock production. Bioenergy is derived from a variety of feedstocks: agricultural products such as corn, wheat, soybeans; agricultural residues such as corn stover, wheat straw; forest residues such as wood; cellulosic biomass such as switchgrass; and urban waste. A previous study found that the potential biomass supply in the United States is higher than what is required to meet the 2030 renewable energy mandate and provides better returns than traditional agricultural crops (Walsh et al., 2003).

However, high production costs and lack of adequate technology keep the bioenergy sector underdeveloped. Epplin (1996) conducted research on the costs associated with switchgrass production in Oklahoma and concluded that in 1996, the cost of establishing, harvesting, and transporting a dry Mg of switchgrass in a radius of 88 km was $37.08. Walsh et al. (1998) estimated that for a distance of 25 km, transporting a dry ton of switchgrass would cost $5 to $8, while the establishment and harvesting costs will range between $19.96 per dry ton and $99.82 per dry ton.

The Cellulosic Biomass Program was created in 2005 to support production and research of biomass-based ethanol. In 2007, the Energy Independence and Security Act renewed the government commitment to accompany any effort to develop the bioenergy sector. Concretely, these commitments intend to find alternatives to increase production and use of biofuels while increasing their competitiveness vis-à-vis other energy sources. Technically, the feedstock needed to meet the EISA mandate is challenging given the impact that this could have on land uses, food prices, greenhouse gas emissions, exports, and so on. The idea to use alternative cellulosic feedstocks, which do not disrupt the food market, which do not compete with other agricultural commodities for land, and do release less or no greenhouse gas into the atmosphere, could be reached with what is called second generation or next generation bioenergy crops. The most important and well known second generation bioenergy crop is switchgrass (Panicum Virgatum).

2.2. Economics of Switchgrass Production

Switchgrass is a perennial grass native to North America. It can easily adapt to the north freezing climates as well as the warm seasons of the Southern United States. Switchgrass is tolerant to less moisturized and less fertilized soils (Sokhansanj et al., 2009) and could adapt to varieties of land (uplands or lowlands), but still requires a certain level of nutrients for a better yield (Caddel et al., 2010). During its production life time, the stand generates an average annual yield of 6 to 8 tons per acre in the southern states. The average yield of wild switchgrass in the United States is estimated to be about 10 tons per acre per year. However, about 5 to 8 tons per acre is expected from the commercial fields in most of the Southern states (Caddell et al., 2010). Table 3 shows yield expectations in two study areas in Oklahoma. Two switchgrass ecotypes (Lowland and Upland) were grown on experimental plots at the Chickasha and Haskell stations. The results showed that the yield ranged from 4.3 tons per acre to 5.7 tons per acre in Chickasha and from 5.6 tons per acre to 7.6 tons per acre in Haskell.

Table 3: Estimated Yield for four switchgrass species in the Southern U.S

Varieties	Ecotypes	7 - Year Mean Yield (Tons/acre/year)	
		Chickasha	Haskell
Alamo	Lowland	5.7	7.6
Kanlow	Lowland	5.8	7.9
Blackwell	Upland	4.6	5.7
Caddo	Upland	4.3	5.6

Source: Caddell et al. 2010.

Investigating the potential yield of switchgrass as compared to other perennial grasses, the Oak Ridge National Laboratory (ORNL) concluded that its yield reliability given soil quality and precipitation is relatively higher than any other grass. They reported a high yield up to 30 dry mg/ha in some locations, but the average yield ranges from 10 to 20 dry mg/ha.

Another aspect of switchgrass management is the costs associated with establishment, harvest, storage, and transportation to the facility. A number of studies have focused on that aspect. Some studies focused on the cost of producing switchgrass in some specific regions in the United States (Duffy and Nanhou, 2001; Pimentel and Patzek, 2005; Perrin et al., 2008). Other, more comprehensive studies determined the cost associated with switchgrass production and delivery to the site of conversion (Epplin, 1996; Kumar and Sokhansanj, 2007; Haque et al., 2008; Wang et al., 2009; Larson et al., 2010).

Using an enterprise budgeting system and a GIS analysis, Larson et al. (2010) analyzed the costs associated with different methods of harvesting and delivering switchgrass in the southern states. This study found that the total cost of a round bale and a rectangular bale without any preprocessing methods is estimated to be $78.27 and $67.7, respectively. However, Larson et al. (2010) assumed that there is no storage cost and that switchgrass is directly transported to the ethanol conversion plant once harvested. Haque et al. (2008) evaluated the cost of establishing and harvesting a ton of switchgrass and concluded that when using a single harvest system, the cost ranges from $40.42 to $46.83 given various levels of nitrogen applied. This study also revealed that the cost will be lower when using a single harvest system with 60 pounds of nitrogen per acre each year. Haque et al. (2008) did not assume a zero storage cost, but did not include this cost as well as the transportation costs in their study, although many studies recognized the fact that storing and transporting biomass constitute a large part of total costs. Sokhansanj et al. (2009) estimated that the cost of delivering an Mg of switchgrass is $80.64 based on the current technology, and the cheapest transporting system within a radius of 160km is the truck. More detailed studies of switchgrass production are now available. The University of Tennessee has conducted a series of research projects that are relevant for switchgrass producers as well as farm management specialists. Table 4 gives an overview of switchgrass production costs in different regions of the United States.

Table 4: Estimated Switchgrass Production Costs ($/dry ton)

Study	State	Estimated Cost of Production ($/ ton)
Ferland (2001)	Georgia	$60
Duffy (2008)	Iowa	$114[a]
Carpenter and Brees (2008)	Missouri	$66
Bangsun et al. (2008)	North Dakota	$47 - $76

[a] Budget includes establishment, reseeding, production, storage, and transportation

Source: English and Mooney, 2009

Although many studies agree to the fact that harvesting, storing, and transporting switchgrass are expensive compared to other crops, other studies suggested alternative ways of pretreatment and transportation that minimize production and delivery costs (Wang et al., 2009; Larson et al., 2010). For cost minimizing farmers, their willingness to grow switchgrass depends primarily on the costs they are facing.

2.3. Economic Impacts of Ethanol Plant Operation on Local Communities

The economic implications of ethanol production have received considerable attention. Usually, the economic impacts of any investment are described in three ways: the direct, the indirect, and the induced effects. Studies on the impacts of bioenergy facilities have been conducted in many regions of the United States using various analysis systems. Bio-Economic Research Associates (2009) determined the economic implications of an expanded biofuels production policy in the United States economy. This study revealed that meeting the projected 21 billion gallons of biofuels by 2022 will generate 190,000 direct jobs and up to 807,000 jobs when considering the economic multiplier effects. The total economic impact is estimated to reach successively $20.2, $64.2, and $148.7 billion by 2012, 2016, and 2022. Using a CGE model, Dixon, Osborne, and Rimmer (2007) confirmed that the implementation of a renewable energy policy will have positive impacts on the United States economy. Going from a reduction in the unemployment rate to a decrease in the world crude oil price, the substitution of fossil fuel by biofuels could make Americans better off. Gehlhar, Winston, and Somwaru (2010) claimed that developing the nation's biofuels sector leads to a decline in the price of imported commodities while receiving a high price for exported items. Using the U.S Applied General Equilibrium (USAGE) model, they point out that an improvement in the technology sector coupled with good financial plans and policies could lead to a net gain for the overall economy. The increase in the production due to low energy costs will improve the GDP. American households will gain from an improved purchasing power resulting from lower commodity and energy prices, and the government could reduce its expenses for foreign oil down to $68 billion.

Besides the global effects of ethanol production, some studies determined more specifically how the plant construction impacts local economies. Urbanchuk and Kapell (2002) found that the construction of an ethanol facility, with an annual capacity of 40 million gallons, will inject $142 million into the local economy. Pierce, Horner, and Milhollin (2007) indicated that the construction of the four ethanol plants in Missouri created 2,098 jobs and generated an extra $207 million to the United States economy. This impact can be more important if taking into account the multiplier effects.

Other studies determined the economic impacts of operating the biofuels facility in the region, state, or county level. Pierce, Horner, and Milhollin (2007) reported that with an annual capacity of 500 million gallons of ethanol per year, the Missouri biofuels industries could create directly 358 full time jobs and up to 7,724 jobs when considering the multiplier effects. They estimated an increase in the income and the value added of $41 and $70 million respectively. A study by the Resource Systems Group (2000) assuming 50 million gallons and 100 million gallons per year plant, reported that the operation of the 50 million gallon plant will create 540 to 830 jobs, generate an annual income ranging from $41 to $48 million, and add $1 to $3 million to the government revenue. The 100 million gallon plant will create total effects of about 950 to 1,650 jobs, add $65 to $95 million to the annual income, and generate $2 to $6 million from the state taxes.

CHAPTER III

METHODS

3.1. Conceptual Framework

The economic implications of land use changes associated with the production of switchgrass-based ethanol in Oklahoma will be the main focus of this study. Currently, the switchgrass-based ethanol sector is facing a “chicken-and-egg” situation leaving the industry always in the stage of uncertainty. Farmers are seeking guaranties of durable markets before committing to switchgrass production, while investors need to be reassured that switchgrass will be supplied continuously for an annual non-interrupted run of the plants.

Oklahoma currently has 35 million acres throughout the nine agricultural districts (Panhandle, West Central, Southwest, North Central, Central, South Central, Northeast, East Central, and Southeast). The climate and the soil quality are favorable for switchgrass production. Almost all criteria about switchgrass production or ethanol conversion are known except the opportunity cost of producing switchgrass on lands that were previously used for other crops such as hay, wheat, and soybeans. The unknown parameter that this study aims to determine is whether the production of switchgrass for energy purposes is more profitable to the community than the production of existing crops.

Tembo (2000) identified eleven potential plant locations throughout Oklahoma). However, in this study, only nine plants were considered to account for the 10% change in croplands or pasture lands. In fact, considering more than nine plants could affect more than 10% the croplands or improved pasture lands. The selection of these locations was primarily based on biomass accessibility and the road infrastructures availability. For nine plant scenarios, the total projected capacity is 450 million gallon per year, given a production capacity of 50 MGY (50 million gallon of ethanol per plant each year). This would require 7,252,785 dry tons of switchgrass corresponding to 1,450,557 acres of land assuming an average annual yield of 5 dry tons per acre per year as reported by Caddel et al. (2010). However, Caddel et al. (2010) reported that switchgrass yield depends on soil characteristics and precipitation. Therefore, each ethanol plant is modeled as an independent region to capture the unique soil productivity of each region.

Producing that amount of switchgrass may change the agricultural land configuration, increase agricultural commodity prices, and reduce livestock production in Oklahoma. We assumed that the major crop acreage in each county will be primarily affected by the switchgrass production; that is to say, switchgrass production will take acreage away from the major crop (in terms of acres planted) produced in each region. Future research could possibly analyze crop profitability to determine which crops to replace with switchgrass production.

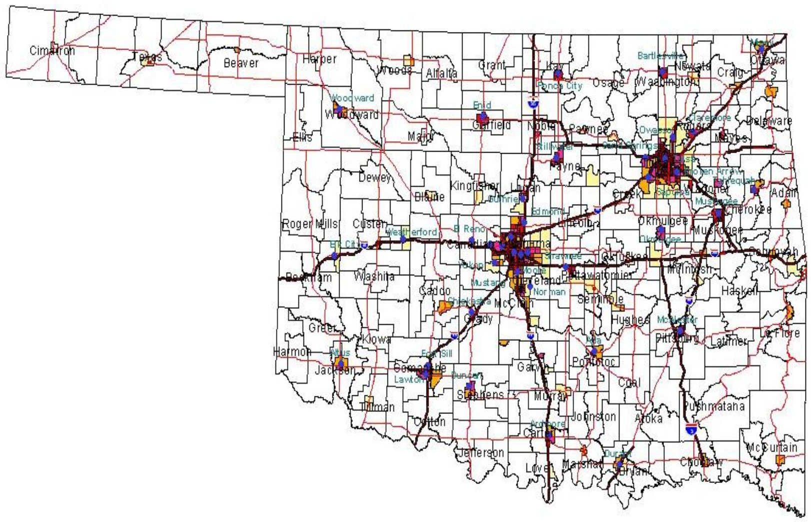
3.2. Data Descriptions and Assumptions

Potential biorefineries location

These locations are taken from Tembo (2000). Switchgrass is designated as the single feedstock used in the biorefineries. The study is based on the assumption that the demand for switchgrass for each ethanol facility will be supplied by the local farmers. Therefore, 20 counties out of the 77 in Oklahoma will be excluded from the study given that soil and climate characteristics limit switchgrass production in those areas (Tembo, 2000). Tembo (2000) did not specify which county will likely host the first facility or the ninth. However, some criteria such as switchgrass density, land availability, and road infrastructure availability have led to the designation of those nine counties.

The nine potential locations include Canadian and Payne Counties in the Central Region, Garfield and Woodward Counties in the North Central Region, Okmulgee in the East Central Region, Pontotoc County in the South Central, Jackson and Comanche Counties in Southwest Region, and Washington County in the Northeast Region. Figure 3 shows the Oklahoma road map. Each of these counties is located in an area with good access to road infrastructures, which guarantee easy access to biomass feedstocks for conversion facilities.

Figure 3: Oklahoma road map and cities



Source: http://www.state.ok.us/osfdocs/maps.html

The black lines represent highways and red lines represent state roads between cities. The map shows that road infrastructures are more developed in the Central and Eastern regions than they are in the Western Oklahoma. To help reduce the transportation costs, having ethanol facilities in regions with developed road infrastructures is important.

Switchgrass Biomass Yield

Mohua (2010) reported that switchgrass yield depends on the type of harvest and that harvesting either in September or October will provide higher yields. In this study, and to be consistent with Mohua (2010), a July – March harvest system is assumed. For a better yield for a July – March harvest system, 80 lbs of nitrogen (N) per acre is recommended. Yield is assumed to differ from one region to another. Table 5 gives the yield distribution per agricultural district in Oklahoma.

Table 5: Average Switchgrass Yield per Agricultural District in Oklahoma

Ag-District	Top five soil	Rainfall (inch)	Average Yield (Ton/acre)
Panhandle	1,862,584	110	3.264
West Central	999,656	172	3.585
Southwest	1,380,778	240	4.071
North Central	1,703,395	303	3.574
Southeast	597,872	233	4.998
Central	1,574,831	475	4.130
South Central	1,435,346	493	3.869
North East	1,888,175	442	4.478
East Central	1,041,258	415	5.091

The switchgrass biomass yield is higher in the East Central, Northeast, Southeast, Central, and Southwest region where the average yield exceeds 4 tons per acre. For the two types of land (cropland and improved pasture land), the switchgrass yield is assumed to be the same for the same study area. For example, no difference in yield is assumed for switchgrass grown on cropland and switchgrass grown on improved pasture land.

Land Allocation and Crop Loss

The major assumption in land use is that a shift to switchgrass production should not exceed 10% of cropland or 10% of improved pasture lands in each county. This assumption was also used in a study by Epplin et al. (2007). The annual land rent is assumed to be $60 per acre for cropland and $40 per acre for improved pasture land. The average rental rates for non-irrigated cropland and pasture land are $28 and $11, respectively (Doye and Sahs, 2010). However, for a guarantee that the land owner will accept the offer for a long-term lease, the above assumption of $60 per acre per year for cropland and $40 per acre per year for pasture land was made. Land is allocated differently for each of the nine plant scenarios. Cropland allocation and switchgrass production in tons for each county as well as crop loss for each scenario are shown in Appendix A (tables A1-A6).

Switchgrass Enterprise Budget

The switchgrass enterprise budget used in this study is from Mohua (2010). The switchgrass establishment budget and the annual maintenance budget are presented in Table 6-7.. One fertilizer application is needed each year at a price of $4.14 per acre. The establishment cost is amortized over 10 years at 7%. In this study, we assumed 63 lbs of nitrogen (N) per acre per year at a 2009 USD price of $0.46 per lb. The cost per acre of mowing and raking are $10.11 and $3.88, respectively. In addition, this analysis assumes 1,148 rectangular dry matter bales. The harvesting and baling cost are assumed to be $14.64 per bale.

Table 6: Switchgrass Establishment Budget

Item	Units	Quantity	Price	Value ($/acre)	Amortized Value	IMPLAN Sector
Machinery operation						
Tillage						
Moldboard plow	acre	1	$ 15.93	15.93	$2.27	19
Tandem disk	acre	2	$ 10.47	20.94	$2.98	19
Chemical and fertilizer application						
Spraying herbicide	acre	1	$ 4.94	4.94	$0.70	19
Applying nitrogen	acre	1	$ 4.14	4.14	$0.59	19
Planting					$0.00	
Cultipack	acre	1	$ 8.96	8.96	$1.28	19
Seeder	acre	1	$ 13.26	13.26	$1.89	19
Operating input						
Switchgrass seed	lbs.	6	$ 7.00	42	$5.98	319
Herbicide (2,4-D)	pt.	1.5	$ 1.90	2.85	$0.41	319
Nitrogen	lbs.	30	$ 0.46	13.8	$1.96	319
Annual operating capital	$	126.82	$ 0.07	8.88	$1.26	354
Land rental	acre	1	$ 60.00	60	$8.54	
Establishment labor cost				7.9084	$1.13	
Total machinery, input and land rental cost	$			195.7		
Establishment cost, amortized for 10 years at 7%	$		0.07	$27.86		

Source: Mohua (2010)

Table 7: Switchgrass Maintenance Budget

	Unit	Quantity	Price ($)	Value per acre	IMPLAN Sector
Establishment cost amortized	$		$ 0.07	$ 27.86	
Fertilizer application	acre	1	$ 4.14	$ 4.14	19
Operating inputs					
Nitrogen	LBS	63	$ 0.46	$ 28.98	319
Annual operating capital	$	16.56	$ 0.07	$ 1.16	354
Machinery operation					
Mowing	acre	1	$ 10.11	$ 10.11	19
Raking	acre	1	$ 3.88	$ 3.88	19
Harvesting (baling) 1,148 lb DM Rectangular bale	bale *	1	$ 14.64	$ 140.02	19
Land rental	acre	1	$ 60.00	$ 60.00	
Total production cost				**$ 276.15**	

Number of bales * is function of yield. For an average yield of 5.49 ton per acre, number of bales equals 9.564 per acre.
Estimation is based on one annual harvest (in July)

Source: Mohua (2010)

Switchgrass Biomass Transportation Cost

Wang (2009) reported a comprehensive estimation of switchgrass transportation cost in Tennessee. He assumed that each truck has the capacity to transport 16 dry tons of switchgrass from the field side to the biorefinery. The cost is then derived from the equation:

$$TRC_{ij} = 12.78 + 1.72d_{ij} \quad (1)$$

Where TRC_{ij}represents the transportation cost in U.S. dollars from the county I to the facility located in j per truck load. The truck load represents 16 dry tons of switchgrass.

The round trip distance in miles is represented by d_{ij}. Once (1) is known, the transportation cost for each single ton of switchgrass biomass is determined by dividing the total trip cost (TRC_{ij}) by 16 dry tons. Assuming a round trip distance of 75 miles, Mohua (2010) estimated the transportation cost for a dry ton of switchgrass in Oklahoma to be $8.86. Table 8 shows transportation expenditures for scenario one. Those values are calculated using the formula above. (See Appendix C for other scenarios)

Table 8: Transportation Expenditures for Plant 1

Counties	Biomass harvested (in tons)		Transportation Expenditure (in $)
Caddo	185,452.32	$	1,643,107.56
Canadian	92,560.19	$	820,083.28
Cleveland	37,328.43	$	330,729.89
Garvin	32,750.70	$	290,171.20
Grady	100,509.63	$	890,515.32
McClain	56,709.60	$	502,447.06
Oklahoma	45,637.32	$	404,346.66
Stephens	54,371.63	$	481,732.64
TOTAL	**605,319.81**	**$**	**5,363,133.61**

Employment and Labor Cost

The employment is calculated based on Lazarus (2009) and Mohua (2010). Lazarus (2009) estimated the labor requirement for wheat, soybeans, and hay. Table 9 gives the technical coefficients for each sub activity for each crop. An acre of wheat requires 0.79 hours of labor, 0.45 for soybeans, and 0.31 for prairie hay. The number of hours per acre is calculated using the sum product of time over and hours per acre and by multiplying this value by 1.21, (1.21 represents the adjustment coefficient of June as used by Mohua,

2010) to obtain an estimate of operator labor hours. These labor hours are then compared to those of switchgrass, which are reported in table 10. Switchgrass labor hours comprise establishment and harvesting as well.

Table 9: Labor requirement for wheat, soybeans, and prairie hay

Machinery Description	# Passes	Acres/hr	Hrs/Acre
Wheat			
Offset Disc	1.00	5.56	0.1799
Anhy. App.	1.00	13.03	0.0767
Field Cultivator	1.00	16.59	0.0603
Drill	1.00	12.73	0.0786
Sprayer	3.00	25.61	0.0390
Dry Fert. Spdr.	1.00	25.61	0.0390
Combine	1.00	10.18	0.0982
Total Operator Labor Hours per acre			0.7900
Soybeans			
Tandem Disk	1.00	12.22	0.0818
Drill	1.00	12.73	0.0786
Sprayer	2.00	25.61	0.0390
Combine	1.00	7.42	0.1348
Total Operator Labor Hours per acre			0.4500
Prairie Hay			
Mow	1.00	8.73	0.1145
Rake	1.00	26.18	0.0382
Bale	1.00	9.45	0.1058
Total Operator Labor Hours per acre			0.3100

Note: Mach hours times 1.21 gives the operator labor hours.
Source of Acres/hr : Lazarus, W. F., 2009.

Table 10: Switchgrass production labor requirement

Machinery Description	# Passes	Acres/hr	Hrs/Acre
Switchgrass Establishment			
Plow	1	5.56	0.1799
Disk	2	12.22	0.0818
Spray	1	25.61	0.0390
Apply Fert	1	25.61	0.0390
Field Cultivator	1	16.59	0.0603
Drill	1	12.73	0.0786
Total Operator Labor Hours per acre			0.6800
Switchgrass Maintenance and harvest			
Establishment	1		0.0680
Apply Fert	1		0.0390
Mowing	1		0.1250
Raking, Baling, stacking	1		0.3850
Total Operator Labor Hours per acre			0.6170

Note: Switchgrass establishment labor hours is from Mohua (2010)

The employment is then computed by multiplying the acre requirement by the total acres for each scenario. Table 11 shows the employment for the first plant scenario.

Table 11: Switchgrass Employment requirements for plant 1

Counties	Total Acres	Employment
Caddo	38,541.50	11.9
Canadian	21,412.70	6.6
Cleveland	7,773.70	2.4
Garvin	7,653.93	2.4
Grady	19,940.62	6.2
McClain	13,327.10	4.1
Oklahoma	8,466.70	2.6
Stephens	16,022.40	4.9
Total	**133,138.65**	**47.9**

For the first plant, which is theoretically located in Canadian county, Caddo would employ about 12 people to produce switchgrass on 38,541.50 acres of land to meet the demand for the first plant. The Canadian county plant would employ about 7 people, 2 for Cleveland and so forth.

The wage rate used in this study is from the University of Tennessee (Gerloff, 2008). They estimated the annual wage rate to be $11.63 per acre. Then, the wage rate is multiplied by the total acres and by the inverse of Full Time Equivalence (FTE) per employer, which is equal to 1.165615142 to get the total employee compensation. Table 12 shows employee compensation for plant 1.

Table 12: Employee Compensation for Scenario One

Counties	Total Acres	Employee Compensation
Caddo	38,541.50	$ 276,562.63
Canadian	21,412.70	$ 153,651.33
Cleveland	7,773.70	$ 55,781.82
Garvin	7,653.93	$ 54,922.37
Grady	19,940.62	$ 143,088.11
McClain	13,327.10	$ 95,631.40
Oklahoma	8,466.70	$ 60,754.58
Stephens	16,022.40	$ 114,972.10
TOTAL	**133,138.65**	**$ 955,364.34**

Livestock Dimension

The changes in pasture lands may have significant impacts on livestock production. Livestock production relies heavily on hay, alfalfa, or wheat production. Therefore, the 10% changes on pasture lands may take reduce cattle production. This number is computed as followed. We assume that each cow requires 9.55 acre of grass land. Therefore, the total number of cows (NC) is estimated using the relation:

$NC = \frac{ACRE_i}{9.55}$, where ACREi represents the total pasture land in acres in county i. The total value of livestock production is then determined by multiplying the number of cows by the price of each cow in 2009 U.S. dollars, which was $750. Table 13 shows the number of cows and the value of production for the first plant scenario.

Table 13: Number of Cows Displaced in each County for First Scenario

Counties	Biomass harvested(in tons)	Number of Cows Displaced(Head)	Value of Livestock (2009$)
Caddo	49,732.33	1,303.52	$ 977,638.74
Canadian	0.00	0.00	$ -
Cleveland	13,233.89	387.35	$ 290,513.09
Garvin	0.00	0.00	$ -
Grady	10,200.76	345.01	$ 258,755.50
McClain	21,299.64	655.98	$ 491,984.29
Oklahoma	12,375.52	307.99	$ 230,992.15
Stephens	30,983.02	1,046.21	$ 784,657.07
TOTAL	**137,825.16**	**4,046.05**	**$ 3,034,540.84**

Value of Production of Switchgrass

The value of production is determined by the sum of the total “Cash” cost, the employee compensation, and the proprietor income. Table 14 gives the Total Value of Production (TVP) for scenario one (See Appendix E for TVP of other scenarios). Total “Cash” Cost is calculated by multiplying the number of acres in each county by the cost of an acre of switchgrass. The labor cost is obtained by multiplying the average wage by the number of acres. The proprietor income is equal to the number of acres times the land rent.

Table 14: Total Value of Production for Scenario One

Counties	Total "Cash" Cost	Labor Cost	Proprietor Income	TVP
Caddo	$ 4,285,852.46	$ 276,562.63	$ 2,641,736.55	$ 7,204,151.64
Canadian	$ 2,330,857.54	$ 153,651.33	$ 1,467,683.21	$ 3,952,192.07
Cleveland	$ 864,074.83	$ 55,781.82	$ 532,830.00	$ 1,452,686.65
Garvin	$ 831,554.12	$ 54,922.37	$ 524,620.58	$ 1,411,097.07
Grady	$ 2,239,300.05	$ 143,088.11	$ 1,366,782.94	$ 3,749,171.10
McClain	$ 1,446,392.98	$ 95,631.40	$ 913,474.75	$ 2,455,499.14
Oklahoma	$ 965,008.09	$ 60,754.58	$ 580,330.06	$ 1,606,092.73
Stephens	$ 1,672,657.05	$ 114,972.10	$ 1,098,217.76	$ 2,885,846.90
Total	**$14,635,697.13**	**$ 955,364.34**	**$ 9,125,675.84**	**$ 24,716,737.31**

Ethanol Production Costs

Table 15 presents the ethanol conversion expenditures by IMPLAN sector. These expenditures are specific to a 50MGY facility. The values in 2009 USD of each of these inputs enable us to calculate the technical coefficients for the ethanol industry. The technical coefficients are obtained by dividing each input value by the total value of inputs. In terms of percentage, 41.4% of the total value of ethanol conversion expenditures goes to biomass feedstocks.

Table 15: Ethanol Conversion Expenditures and Technical Coefficients

IMPLAN Sector	Name of IMPLAN Sector	Expenditures	Technical Coefficients
33	Water, sewage and other treatment and delivery systems	$ 299,333.33	0.012
123	Alkalies and chlorine manufacturing	$ 175,063.74	0.007
126	Other basic organic chemical manufacturing	$ 6,621,177.49	0.276
130	Fertilizer manufacturing	$ 154,855.70	0.006
164	Lime and gypsum product manufacturing	$ 1,132,948.77	0.047
357	Insurance carriers	$ 485,111.83	0.02
368	Accounting, tax preparation, bookkeeping, and payroll services	$ 484,497.84	0.02
390	Waste management and remediation services	$ 1,500,216.45	0.063
417	Commercial and industrial machinery and equipment repair and maintenance	$ 1,714,124.82	0.071
35	Construction of new nonresidential manufacturing structures	$ 36,602.45	0.002
141	All other chemical product and preparation manufacturing	$ 1,114.72	0
188	Power boiler and heat exchanger manufacturing	$ 764,256.85	0.032
189	Metal tank (heavy gauge) manufacturing	$ 650,420.63	0.027
190	Metal can, box, and other metal container (light gauge) manufacturing	$ 42,170.27	0.002
203	Farm machinery and equipment manufacturing	$ 122,575.76	0.005
207	Other industrial machinery manufacturing	$ 640,788.60	0.027
213	Other commercial and service industry machinery manufacturing	$ 107,266.96	0.004
214	Air purification and ventilation equipment manufacturing	$ 1,019,031.02	0.043
215	Heating equipment (except warm air fumaces) manufacturing	$ 73,306.64	0.003
216	Air conditioning, refrigeration, and warm air heating equipment manufacturing	$ 220,336.22	0.009

Table 15: Ethanol Conversion Expenditures and Technical Coefficients (Cont.)

IMPLAN Sector	Name of IMPLAN Sector	Expenditures	Technical Coefficients
222	Turbine and turbine generator set units manufacturing	$ 829,566.38	0.035
226	Pump and pumping equipment manufacturing	$ 490,205.63	0.02
227	Air and gas compressor manufacturing	$ 80,202.02	0.003
228	Material handling equipment manufacturing	$ 1,481,998.56	0.062
230	Other general purpose machinery manufacturing	$ 21,563.49	0.001
251	Industrial process variable instruments manufacturing	$ 42,852.09	0.002
31	Electric power generation, transmission, and distribution	$ 4,721,594.52	0.197

3.3. Research Question

This research was conducted in order to find answers to current issues related to the expansion of the bio-ethanol industry in the United States. Government incentives and market forces have pushed private owners to invest in the biofuels sector. Currently, many states have a clear biofuels standards and a developed bioenergy sector. Oklahoma does not have a competitive bioenergy industry, but is said to be a promising region for cellulosic ethanol production area. This study aims to answer the question to what extent will the land use changes associated with switchgrass-based ethanol production affect local communities in Oklahoma? What is the opportunity cost of producing switchgrass on traditional croplands or improved pasture lands in rural Oklahoma? How will switchgrass production for energy purposes affect livestock production or food crop production?

3.4. The IMPLAN Model

The IMPLAN model is based on the input-output model, which is commonly used to quantify the changes in the local economy as a result of a variation in the demand of at least one industry in the same economic region. Those changes may be caused by a new government policy, the operation of a new business, or the shutdown of an existing project. The input-output model was developed in the 1930's by Wassily Leontief. Leontief represented the United States economy in three main components: (1) a matrix of transactions to capture interactions between industries, (2) a final demand sector, which reports the level of output that is consumed and not used for further production, and (3) a payment sector. The Social Accounting Matrix (SAM) improves upon this model by disaggregating the final demand and payment sectors to allow the researcher examine impacts on households, government, and businesses separately. There is a cyclical interrelationship between industries in the economy since firm X purchases output from firm Y to produce its output, row of which may be needed to produce firm's Y output. This interaction can occur locally or generates leakage to other regions.

The input-output model can be used to capture direct effects of a change in the economy or to report the secondary impacts associated with the initial changes using the multiplier effects (Perez-Verdin et al., 2008). The effects are classified in three groups: direct, indirect, and induced effects. The direct effects refer to changes generated directly by the activity or the policy; the indirect effects are the consequences of the primary changes, and the induced effects capture the variations due to the new income earned by those directly impacted (Perez-Verdin et al., 2008).

The Impact analysis for Planning (IMPLAN) model provides the SAM for about 440 economic sectors in the United States. Once the transaction matrix is established, a change is needed to transform the initial numbers, which represent the value of transactions in dollars, to coefficients, which give the magnitude of the impact generated by a one unit variation in the sales or purchases of one industry on the other industries, for prediction purposes. If X_{ij} represents the value of each cell in the transaction table and X_j the sum of each column plus value added components, the coefficients matrix is obtained by dividing each X_{ij} by the corresponding X_j . Mathematically, this relationship is given as follows:

$$a_{ij} = \frac{x_{ij}}{x_j}$$

The matrix (A) formed with the coefficients is then multiplied by the total industry output (X) and added to the final demands (Y), the vector obtained corresponds to the total industry output. The relationship is then stated as follows:

$AX + Y = X$ or $Y = X - AX$.

By rearranging the right hand side of the equation above, $Y = (I - A) * X$ is obtained. $Y = (I - A) * X$ can also be written as: $(I - A)^{-1}Y = X$, where $(I - A)^{-1}$ represent the Leontief inverse or multiplier matrix, which is needed for prediction and forecasting purposes. In fact, to predict the change brought by the creation of a new industry in the economy, the above equation should be changed to $\Delta X = (I - A)^{-1} * \Delta Y$, where ΔX corresponds to the total variation in the economy and ΔY represents the variation in final demand.

3.5 IMPLAN Inputs

Since a switchgrass sector does not exist in IMPLAN, the IMPAN sector 9 (Sugarcane and sugar beet farming) has been modified to reflect this new activity. A switchgrass production function is created taking into account all inputs required from its establishment to its transportation to the biorefineries. Table 16 presents the social accounting matrix (SAM) of the local economy under switchgrass production perspective. In the switchgrass production sector, four industries are interacting. Sector 19 (Support activities for agriculture and forestry), 319 (Wholesale trade businesses), 335 (Transport by truck), and 354 (Monetary authorities and depository credit intermediation activities) of IMPLAN are concerned. The shaded area represents the social accounting matrix. The row values correspond to the sales made by each industry to the other. The columns represent the purchase of each industry toward the others output.

Table 16: Social Accounting Matrix (SAM)

Industry	Sector 19	Sector 319	Sector 335	Sector 354	Final Demand	Total Output
Sector 19						
Sector 319		INTER-INDUSTRY				
Sector 335		TRANSACTION				
Sector 354						
Value Added						
Total Input						

Table 17 presents the technical coefficients for producing and transporting switchgrass from the field to the first conversion facility. These coefficients for the production stage show the value in percentage of each input needed to produce a $1 worth of switchgrass. To compute the coefficient of sector 19, all the inputs classified as belonging to this sector are summed up. In this study, this expenditure is estimated by acre. Then, multiplying total acres by this expenditure gives the total amount of money that goes to this sector as a result of switchgrass production. The ratio of total expenditures to the total value of production, which correspond to the technical coefficient is then determined.

Table 17: Technical Coefficients for Plant 1 Scenario

Counties	TVP	SEC 19	SEC 319	SEC 335	SEC 354
Caddo	$ 12,562,757.39	0.51	0.11	0.13	0.01
Canadian	$ 6,886,769.49	0.52	0.12	0.12	0.01
Cleveland	$ 2,533,189.07	0.52	0.11	0.13	0.01
Garvin	$ 2,458,696.65	0.52	0.12	0.12	0.01
Grady	$ 6,540,129.04	0.51	0.11	0.14	0.01
McClain	$ 4,278,305.98	0.52	0.12	0.12	0.01
Oklahoma	$ 2,803,147.96	0.51	0.11	0.14	0.01
Stephens	$ 5,021,228.95	0.54	0.12	0.10	0.01

CHAPTER IV

FINDINGS

4.1 Economic Impacts of Land Use Changes

In this section, three types of impacts are presented: the direct, the indirect and the induced impacts. The direct effects represent the change in permanent jobs, wages, and output associated with a given activity undertaken by an industry X. The indirect effects represent jobs, wages, and output generated by other industries that provide goods and services to industry X. Induced effects represent the change in the local economy as a result of wage and salaries spending by employees and proprietors.

The impacts are computed based on the input requirement for each of the traditional crops (wheat, hay, and soybeans) or livestock that were previously produced, and the input requirement for switchgrass production. The impacts reported by the IMPLAN model include employment impacts, labor income impacts, total value added impacts, and total output impacts. The results are reported in terms of net impacts to take into account the opportunity cost of moving from one activity to another. Each of those four impacts is presented in tables and the results discussed separately.

Employment

The impacts on employment represent the net difference in the number of jobs as a result of adopting dedicated energy crops (compared to growing existing crops). In terms of opportunity costs, these impacts on employment tell us how many jobs that Grady county and surrounding counties will gain or lose from producing switchgrass in lieu of hay, wheat, or soybeans.

The direct effect is the difference between the number of jobs required to grow and transport switchgrass form the field to the ethanol facility and the sum of jobs that were previously used for existing crops. It is assumed that the land was previously used to produce other crops such as wheat or soybeans and the job requirement is different from that of switchgrass. Wheat and soybeans are annual crops and have to be reseeded each year while switchgrass is a perennial grass and lasts longer than 10 years. Therefore, jobs needed for the traditional crops might differ from that for switchgrass. In addition, the technical coefficient of labor differs from one county to another and from crop to crop. Some counties have a higher technical coefficient, suggesting that a large percentage in terms of input value used in crop production comes from labor. Also, some crops are more labor intensive than some others so displacing some crops might have higher negative impacts on labor than displacing others. Also, for the same crop, a larger number of employees might be needed in one county or study area than in others.

Besides the impacts on croplands, taking pasture land out of production for switchgrass could affect the livestock industry. Reducing hay production will likely reduce the number of cows that were previously produced and might lead to a decline in labor in the long run. Table 18 shows the direct, indirect, and induced effects of land use changes on employment in each plant area.

Table 18: Net Employment impacts of switchgrass production

	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Scenario 1	4.3	53.7	130.2	188.1
Scenario 2	0.5	105.5	252.8	358.9
Scenario 3	3.8	304.0	412.8	720.5
Scenario 4	12.0	347.4	534.7	894.2
Scenario 5	6.7	432.5	664.9	1,104.3
Scenario 6	17.6	582.3	802.8	1,402.7
Scenario 7	14.9	291.1	875.3	1,181.4
Scenario 8	25.5	349.4	1,032.1	1,407.1
Scenario 9	36.8	820.2	1,272.1	2,129.1

The direct effects are positive for all the scenarios which implies that producing switchgrass on traditional croplands or improved pasture lands leads to a net positive impacts on employment. In the first plant area, 4.3 direct jobs will be generated as the result of shifting from traditional crops to switchgrass. The production of switchgrass production requires 4.3 more jobs than any other crop in the first plant area. The number of jobs is a function of the technical coefficient, which varies from county to county. The positive net effect is due to the fact that the technical coefficient of the major crop displaced in the area (wheat) is lower than that for switchgrass. The indirect effect of the first plant scenario is 53.7 jobs and 130.2 induced jobs. Thus, a total of 188 jobs are created due to switchgrass production in the first plant area.

The results of the other scenarios are interpreted as marginal effects. That is, the second scenario will create 0.5 more direct, 105.5 indirect, and about 253 more induced jobs than the first scenario. The fourth plant generates 20.63 direct jobs (12 more direct jobs than the third plant). The sixth and the ninth create 45 and 122 direct jobs, respectively. In total, all the nine facilities will create 2,129.1 jobs as a result of switchgrass production. This impact will be for the whole state of Oklahoma since the study area for the nine facilities encompasses all the 77 counties.

Labor Income

The labor income impacts reflect the change in all salary paid to employees and proprietor incomes. In Canadian county, for example, about $8,983,261 will be distributed among proprietor and employees as a result of their participation in switchgrass production. For the ninth plant scenario, this value will be $93,765,951 more than that of the eighth plant. The indirect, induced and total net effects of the ninth plant are $27,974,896, $46,653,169, and $168,394,015, respectively. The positive values indicate that producing switchgrass generates positive net returns for farmers and land owners than producing other crops (hay, soybean, and wheat). The labor income is a function of the number of employees since the land rent is assumed to be the same ($60) for all commodities. Table 18 presents the results of labor income for all the scenarios. The direct effect values increase with the number of plants. The introduction of a new plant increases the number of employees and the land use as well, creating a higher employee compensation and proprietor income. The total effects are $16,510,581, $85,513,784.7, and $168,394,015 for the first plant, the fifth plant, and the ninth plant, respectively.

Table 19: Net Labor Income impacts of switchgrass production

	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Scenario 1	$ 8,859,273	$ 2,763,760	$ 4,887,548	$ 16,510,581
Scenario 2	$ 18,461,056	$ 5,224,207	$ 9,540,214	$ 33,225,479
Scenario 3	$ 26,190,071	$ 9,355,263	$ 15,623,163	$ 51,168,497
Scenario 4	$ 35,172,713	$ 11,848,164	$ 20,054,205	$ 67,075,082
Scenario 5	$ 46,199,455	$ 14,345,475	$ 24,968,855	$ 85,513,785
Scenario 6	$ 55,194,616	$ 18,212,983	$ 29,819,451	$ 103,227,049
Scenario 7	$ 67,783,095	$ 12,171,114	$ 32,275,551	$ 112,229,760
Scenario 8	$ 80,703,276	$ 14,383,042	$ 37,908,077	$ 132,229,760
Scenario 9	$ 93,765,951	$ 27,974,896	$ 46,653,169	$ 168,394,015

Total Value Added

Similar to the employment and the labor income effects, the total value added effects are positive for all scenarios. This situation implies a net improvement of the local economy. The proprietor income, the employee compensation, and other indirect business taxes are higher compared to those with hay, wheat, and soybean. The net direct effects of total value added range from $8,170,063 for the first plant scenario to $84,971,884 for the ninth plant scenario. The net indirect effects range from $1,967,631 for the first plant to $27,842,578 for the eighth plant. The indirect effects are positive and increasing except for the ninth scenario, where the value is a bit lower. This decrease may be due to the size of the industry. At a certain point, when the number of facilities increases, the total value of production may decrease. The shift to switchgrass may have severe impacts on the output of other industries (livestock or chemicals industries for example) that used to provide input to traditional crop producers. Table 20 gives results of total value added impacts.

Table 20: Net Total Value Added impacts of switchgrass production

	Direct Effects	Indirect Effect	Induced Effect	Total Effect
Scenario 1	$ 8,170,063	$ 1,967,631	$ 8,366,445	$ 18,504,140
Scenario 2	$ 17,240,907	$ 3,062,404	$ 16,385,444	$ 36,688,755
Scenario 3	$ 23,598,633	$ 3,138,028	$ 26,720,536	$ 53,457,198
Scenario 4	$ 31,047,566	$ 5,762,971	$ 34,260,081	$ 71,070,618
Scenario 5	$ 41,582,509	$ 5,740,793	$ 42,658,024	$ 89,981,326
Scenario 6	$ 49,647,759	$ 8,764,851	$ 51,038,924	$ 109,451,534
Scenario 7	$ 61,726,215	$ 23,936,050	$ 55,712,324	$ 141,374,589
Scenario 8	$ 73,622,577	$ 27,842,578	$ 65,417,791	$ 166,882,947
Scenario 9	$ 84,971,884	$ 12,477,155	$ 80,296,228	$ 177,745,267

Total Output

Table 20 reports the impacts of land use changes on output for each of the nine plant scenarios. The output represents the total value of production for all the industries in the study area. The net direct impacts range from $16,293,639 for the first plant to $184,873,195 for the ninth plant. Here again, the positive and increasing trend of the net direct effects show that producing switchgrass on traditional croplands or pasture lands would make local economies better off. The indirect effects represent the variations on other industries output due to the change in the final demand of the switchgrass industry.

Table 21: Net Total Output impacts of switchgrass production

	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Scenario 1	$ 16,293,639	$ 2,859,111	$ 13,208,805	$ 32,361,555
Scenario 2	$ 30,560,946	$ 4,837,469	$ 25,953,570	$ 61,351,983
Scenario 3	$ 48,716,719	$ 1,976,129	$ 42,955,915	$ 93,648,764
Scenario 4	$ 73,932,892	$ 5,303,659	$ 55,337,483	$ 134,574,034
Scenario 5	$ 89,895,682	$ 3,386,662	$ 68,714,518	$ 161,996,863
Scenario 6	$ 110,982,898	$ 6,612,855	$ 82,512,911	$ 200,108,666
Scenario 7	$ 130,290,846	$ 39,631,792	$ 90,463,520	$ 260,386,159
Scenario 8	$ 153,025,093	$ 45,534,300	$ 106,200,314	$ 304,759,706
Scenario 9	$ 184,873,195	$ 5,342,444	$ 130,217,057	$ 320,432,697

4.2 Economic Impacts of Ethanol Facility Operation

In this section, the economic impacts of operating 50MGY ethanol facilities are discussed. Each plant has its study area and the local area refers to that study area. The impacts on employment, labor income, value added, and total outputs are presented.

Employment

Table 22 gives the results of each of the nine plant scenarios. The results show that for the first plant scenario, about 30 direct jobs will be created as the result of 50 MGY switchgrass-based ethanol facility operations in Grady county. As the number of plants increases, the number of direct jobs increases as well. The direct employment ranges from 30 jobs for one plant to about 274 for nine plants. The indirect jobs range from around 3 jobs to 46 jobs. In addition, the operation of one, five, and nine facilities will generate 12.6, 107.5, and 252.2 induced jobs, respectively. The total effects vary from 45.5 jobs to 573 jobs.

Table 22: Employment Impacts of Ethanol Plant Operation

	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Scenario 1	30.1	2.8	12.6	45.5
Scenario 2	69.5	12.3	44	125.8
Scenario 3	96.4	16.1	64.3	176.7
Scenario 4	132.8	21.7	86.2	240.6
Scenario 5	171.3	27.8	107.5	306.7
Scenario 6	186.1	32	130	348.1
Scenario 7	173.4	27.1	123.2	323.7
Scenario 8	242.9	39.9	217.9	500.7
Scenario 9	274.9	45.9	252.2	573

Labor Income

The production of switchgrass-based ethanol increases the labor income. This variation of the direct effects ranges from $1,274,176.40 for the one plant to $15,558,348 for all the nine plants (Table 23). The indirect effects vary from $104,692 if one facility is under operation up to $1,800,209.70 if all the nine facilities are operating. The induced effects are $374,810 and $7,893,762.60 for the first plant and the ninth plant, respectively.

Table 23: Labor Income Impacts of Ethanol Plant Operation

	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Scenario 1	$ 1,274,176.4	$ 104,692.0	$ 374,810.3	$ 1,753,678.7
Scenario 2	$ 3,771,295.5	$ 472,071.6	$1,436,981.4	$ 5,680,348.6
Scenario 3	$ 5,385,927.1	$ 611,729.1	$2,023,199.8	$ 8,020,855.9
Scenario 4	$ 7,340,907.6	$ 825,710.9	$2,711,101.2	$ 10,877,719.8
Scenario 5	$ 9,186,145.9	$1,051,869.0	$3,368,975.4	$ 13,606,990.4
Scenario 6	$10,116,592.9	$1,239,274.0	$4,136,300.5	$ 15,492,167.4
Scenario 7	$10,404,304.3	$1,061,274.5	$3,858,678.5	$ 15,324,257.3
Scenario 8	$13,754,719.2	$1,584,406.0	$6,859,009.1	$ 22,198,134.3
Scenario 9	$15,558,348.0	$1,800,209.7	$7,893,762.6	$ 25,252,320.3

Total Value Added

The total value added impacts of all the nine scenarios are reported in table 24. The direct value added impacts are projected to be $2,961,759.3 for one plant, $23,247,391.8 for five plants, and $39,295,214 for all the nine facilities (Table 24). The indirect effects are estimated at $160,424.9 and $2,833,364.6 for the first and the ninth plant, respectively. The induced effects range from $843,488.6 for one plant to $15,660,502.6 for nine plants.

Table 24: Total Value Added Impacts of Ethanol Plant Operation

	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Scenario 1	$ 2,961,759.3	$ 160,424.9	$ 843,488.6	$ 3,965,672.8
Scenario 2	$ 9,455,197.1	$ 736,985.9	$ 2,822,429.1	$ 13,014,612.0
Scenario 3	$ 13,343,989.0	$ 948,327.5	$ 4,006,511.8	$ 18,298,828.3
Scenario 4	$ 18,609,998.7	$1,277,615.6	$ 5,310,151.3	$ 25,197,765.7
Scenario 5	$ 23,247,391.8	$1,629,071.3	$ 6,613,501.4	$ 31,489,964.5
Scenario 6	$ 25,198,342.1	$1,911,307.1	$ 8,045,757.3	$ 35,155,406.5
Scenario 7	$ 26,478,095.6	$1,694,781.2	$ 7,810,628.2	$ 35,983,505.1
Scenario 8	$ 34,725,028.4	$2,510,449.3	$13,482,781.5	$ 50,718,259.2
Scenario 9	$ 39,295,214.0	$2,833,364.6	$15,660,502.6	$ 57,789,081.1

Total Output

The total output effects of ethanol plant operation are reported in table 25. These results show a net improvement of output value in the economy. The direct effects range from $4,500,186.2 for one plant to $63,202,483.2 for all the nine plants. The indirect effects are projected to be $289,521.1 for the first plant and up to $5,375,026.9 if all the nine facilities operate simultaneously. The induced effects are $1,362,045.5 and $26,344,702.8 for the first plant and the ninth plant, respectively.

Table 25: Total Output Impacts of Ethanol Plant Operation

	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Scenario 1	$ 4,500,186.2	$ 289,521.1	$ 1,362,045.5	$ 6,151,752.8
Scenario 2	$14,785,243.6	$1,353,987.8	$ 4,649,742.9	$20,788,974.4
Scenario 3	$20,878,358.6	$1,738,639.7	$ 6,643,712.7	$29,260,711.0
Scenario 4	$29,189,560.9	$2,359,028.5	$ 8,895,078.5	$40,443,667.9
Scenario 5	$36,590,154.6	$3,029,399.4	$11,078,384.5	$50,697,938.5
Scenario 6	$39,939,841.5	$3,580,395.9	$13,547,430.2	$57,067,667.6
Scenario 7	$41,840,469.5	$3,168,619.1	$13,060,092.1	$58,069,180.7
Scenario 8	$55,685,430.8	$4,742,907.8	$22,652,966.9	$83,081,305.4
Scenario 9	$63,202,483.2	$5,375,026.9	$26,344,702.8	$94,922,213.0

CHAPTER V

CONCLUSION

The objective of this research was to determine how operating switchgrass-based ethanol facilities can affect local communities in Oklahoma. The switchgrass-based ethanol facility operation will likely lead to land use changes in Oklahoma as the energy crop production may take away some lands previously used for traditional row cropping. Since there is no current switchgrass-based ethanol industry in the region, assumptions were made to facilitate this analysis. The IMPLAN model was also modified in its sector 9 (sugarcane and sugar beet farming) to reflect a switchgrass sector, which is a new activity in the region. The IMPLAN model is based on the input-output analysis and provides estimates of direct, indirect, and induced effects of the change in ethanol demand on employment, labor income, and total output.

Nine counties were identified as potential candidates to host each of the nine plants. Each of the nine facilities is assumed to operate throughout the year with an annual capacity of 50 million gallons of ethanol. Switchgrass used in the facility is supplied by the hosting county and surrounding counties as well. An assumption is made that major crop acreages in each county will be primarily affected by switchgrass production.

Two types of impacts were determined: the economic impacts of land use changes and the economic implications of converting biomass into ethanol. Analysis by parts was used to capture the impacts for each single facility area to take into account the difference among counties such as biomass density and commodity prices.

The results of the land use change impacts analysis shows that producing switchgrass for ethanol will create jobs, improve the labor income, increase the total value added, and the total output. The net total employment effects range from 188 jobs for the first plant scenario to 1,938 jobs for the ninth plant scenario. These results show that producing switchgrass will reduce unemployment in each area where the facility is located. The ninth plant scenario encompasses all the 77 counties of Oklahoma. Shifting from traditional crops (wheat, hay, or soybeans) to switchgrass will lead to the creation of 1,938 jobs throughout Oklahoma.

In addition, the results of labor income show a net improvement compared to the initial situation where only wheat, hay, or soybeans were grown. From the first to the ninth scenario, the labor income is increasing showing that as the number of plants increases, the amount of money paid to employees and to land owners increases as well. The total effects of labor income for the first plant scenario are $16,703,469, more than $51,168,497 for the third plant, and around $157,670,604 for the ninth plant.

Moreover, producing switchgrass-based ethanol will generate positive net total value added for the local economy. The first ethanol facility is projected to generate an equivalent of $18,860,069 for the first study area, $53,475,198 in the area where the third plant is located, and up to $160,752,900 for the ninth plant study area, which is the entire state of Oklahoma.

Also, in terms of total output, the results show positive net impacts of switchgrass production. In the first plant area, $32,410,275 are reported as total effects, more than $134,574,034 for the third plant, and about $267,155,672 for the ninth plant. The net total output values are increasing for the first eight plants, but decline at the ninth plant. This may be due to the fact that producing switchgrass for all the nine facilities may affect commodities whose values are higher than that for switchgrass such as livestock.

The results of an ethanol facility operation show positive net improvement of the local economy. The total effects on employment are projected to be 45.5 jobs, 306.7 jobs, and 573 jobs for the first, fifth, and ninth plant, respectively. The total effects of the labor income are projected to reach $25,252,320.3 if all the nine facilities are under operation in Oklahoma. The results also show that the net total impacts of total value added and total output of the ninth plant scenario are $57,789,081.1 and $94,922,213.0 respectively.

Based on the results of this study, each community under each plant scenario will be better off growing switchgrass for ethanol conversion than continuing to grow hay, wheat, or soybeans. A net improvement is reported for each of the four indexes of the impact analysis (employment, labor income, value added, and total output).

However, the IMPLAN model has some limitations that need to be mentioned. The IMPLAN model uses some assumptions that could make the analysis somewhat less realistic. One of those assumptions is the existence of constant returns to scale. The idea behind this assumption is that the output of the industry will increase in the same proportion as the increase of the input. Another simplistic assumption is that all industries have a fixed production function. A third assumption is that no substitution is allowed between inputs. In addition, the IMPLAN model assumes a lack of an input supply constraint. That is, all the inputs that the industry uses to produce its output are available in unlimited proportions.

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APPENDICES

APPENDIX A: Land Allocation, Switchgrass Production, and Crop Loss

Table A1: Land Allocation for Switchgrass Production for Plant 1

Counties	Total Acre	Biomass (in tons)	Crop Displaced	Value of Production (2009 $)
Caddo	26,092.90	135,719.99	WHEAT	$ 5,667,116.95
Canadian	21,412.70	92,560.19	WHEAT	$ 4,650,624.31
Cleveland	4,074.50	24,094.54	HAY	$ 1,143,182.47
Garvin	7,653.93	32,750.70	HAY	$ 2,147,462.86
Grady	16,645.80	90,308.87	WHEAT	$ 3,615,301.30
McClain	7,062.50	35,409.96	HAY	$ 1,981,525.63
Oklahoma	5,525.40	33,261.80	SOYBEAN	$ 1,324,438.38
Stephens	6,031.10	23,388.61	HAY	$ 1,692,145.73
TOTAL	**94,498.83**	**467,494.65**		**$ 22,221,797.62**

Table A2: Land Allocation for Switchgrass Production for Plant 2

Counties	**Total Acre**	**Biomass (in tons)**	**Crop Displaced**	**Value of Production (2009 $)**
Alfalfa	27,196.00	112,514.00	WHEAT	$ 5,906,699.24
Caddo	26,093.00	126,928.00	WHEAT	$ 5,667,138.67
Canadian	21,413.00	95,253.00	WHEAT	$ 4,650,689.47
Cleveland	4,075.00	23,015.00	HAY	$ 1,143,322.75
Garfield	37,041.00	213,300.00	WHEAT	$ 8,044,934.79
Garvin	9,018.00	38,130.00	HAY	$ 2,530,180.26
Grady	16,646.00	81,741.00	WHEAT	$ 3,615,344.74
Grant	37,120.00	137,708.00	WHEAT	$ 8,062,092.80
Kingfisher	25,921.00	113,145.00	WHEAT	$ 5,629,781.99
McClain	7,063.00	32,528.00	HAY	$ 1,981,665.91
Oklahoma	5,525.00	33,262.00	SOYBEAN	$ 1,324,342.50
Stephens	6,031.00	30,071.00	HAY	$ 1,692,117.67
TOTAL	**223,142.00**	**1,037,595.00**		**$ 50,248,310.79**

Table A3: Land Allocation for Switchgrass Production for Plant 3

Counties	Total Acre	Biomass (in tons)	Crop Displaced		Value of Production (2009 $)
Alfalfa	27,195.50	110,737.26	WHEAT	$	5,906,590.65
Caddo	26,092.90	138,719.36	WHEAT	$	5,667,116.95
Canadian	21,412.70	95,478.63	WHEAT	$	4,650,624.31
Cherokee	4,341.60	19,419.98	HAY	$	1,218,122.71
Cleveland	4,074.50	23,014.81	HAY	$	1,143,182.47
Creek	6,343.90	28,674.43	WHEAT	$	1,377,831.64
Garfield	37,040.60	224,254.43	WHEAT	$	8,044,847.91
Garvin	9,018.40	38,129.80	HAY	$	2,530,292.49
Grady	16,645.80	77,273.37	WHEAT	$	3,615,301.30
Grant	34,320.54	131,647.08	WHEAT	$	7,454,078.52
Haskell	5,309.20	22,670.28	WHEAT	$	1,153,105.15
Hughes	5,410.20	28,721.67	WHEAT	$	1,175,041.34
Kingfisher	25,920.50	110,685.98	WHEAT	$	5,629,673.40
McClain	7,062.50	32,527.76	HAY	$	1,981,525.63
McIntosh	5,449.20	29,992.40	WHEAT	$	1,183,511.75
Muskogee	11,055.20	58,375.88	SOYBEAN	$	2,649,931.44
Okfuskee	3,984.00	21,058.48	SOYBEAN	$	954,964.80
Oklahoma	5,525.40	33,261.80	SOYBEAN	$	1,324,438.38
Okmulgee	6,453.00	38,347.60	WHEAT	$	1,401,527.07
Pittsburg	7,263.10	35,141.65	SOYBEAN	$	1,740,965.07
Rogers	7,867.80	45,486.12	WHEAT	$	1,708,807.48
Seminole	4,812.80	22,560.00	WHEAT	$	1,045,292.03
Stephens	6,031.10	23,388.61	HAY	$	1,692,145.73
Tulsa	5,156.00	24,130.08	SOYBEAN	$	1,235,893.20
Wagoner	10,248.00	50,912.06	WHEAT	$	2,225,763.12
TOTAL	**304,034.44**	**1,464,609.52**		**$**	**68,710,574.52**

Table A4: Land Allocation for Switchgrass Production for Plant 4

Counties	Total Acre	Biomass (in tons)	Crop Displaced	Value of Production
Alfalfa	27,195.50	110,345.74	WHEAT	$ 5,906,590.65
Caddo	26,092.90	135,957.06	WHEAT	$ 5,667,116.95
Canadian	21,412.70	95,334.76	WHEAT	$ 4,650,624.31
Carter	4,592.30	18,580.45	HAY	$ 1,288,461.61
Cherokee	4,341.60	19,419.98	HAY	$ 1,218,122.71
Cleveland	4,074.50	23,014.81	HAY	$ 1,143,182.47
Coal	3,540.30	20,082.70	HAY	$ 993,301.97
Creek	6,343.90	28,674.43	WHEAT	$ 1,377,831.64
Garfield	37,040.60	229,281.31	WHEAT	$ 8,044,847.91
Garvin	9,018.40	54,471.14	HAY	$ 2,530,292.49
Grady	16,645.80	84,141.59	WHEAT	$ 3,615,301.30
Grant	37,981.50	127,902.69	WHEAT	$ 8,249,201.12
Haskell	5,309.20	22,670.28	WHEAT	$ 1,153,105.15
Hughes	5,410.20	31,266.63	WHEAT	$ 1,175,041.34
Jefferson	4,618.30	17,295.53	WHEAT	$ 1,003,048.58
Johnston	3,682.60	18,394.59	WHEAT	$ 799,823.89
Kingfisher	25,920.50	108,094.51	WHEAT	$ 5,629,673.40
Lincoln	8,854.00	37,053.99	HAY	$ 2,484,166.78
Love	3,030.22	11,645.13	WHEAT	$ 658,133.26
Marshall	2,267.20	7,903.46	HAY	$ 636,108.30
McClain	7,062.50	32,839.80	HAY	$ 1,981,525.63
McIntosh	5,449.20	29,992.40	WHEAT	$ 1,183,511.75
Murray	2,457.70	12,099.26	WHEAT	$ 533,787.86
Muskogee	11,055.20	58,375.88	SOYBEAN	$ 2,649,931.44
Okfuskee	3,984.00	20,237.53	SOYBEAN	$ 954,964.80
Oklahoma	5,525.40	33,261.80	SOYBEAN	$ 1,324,438.38
Okmulgee	6,453.00	38,347.60	WHEAT	$ 1,401,527.07
Pittsburg	7,263.10	38,976.70	SOYBEAN	$ 1,740,965.07
Pontotoc	5,604.60	32,674.82	WHEAT	$ 1,217,263.07
Pottawatomie	7,707.70	37,125.57	HAY	$ 2,162,549.39
Rogers	7,867.80	42,245.76	WHEAT	$ 1,708,807.48
Seminole	4,812.80	23,763.20	WHEAT	$ 1,045,292.03
Sequoyah	5,895.20	25,956.57	SOYBEAN	$ 1,413,079.44

Table A4: Land Allocation for Switchgrass Production for Plant 4 (Cont.)

Counties	Total Acre	Biomass (in tons)	Crop Displaced	Value of Production (2009 $)
Tulsa	5,156.00	22,837.15	SOYBEAN	$ 1,235,893.20
Wagoner	10,248.00	48,083.62	WHEAT	$ 2,225,763.12
Washington	5,186.60	27,698.52	SOYBEAN	$ 1,243,228.02
TOTAL	**365,132.12**	**1,750,015.69**		**$ 83,938,649.31**

Table A5: Land Allocation for Switchgrass Production for Plant 5

Counties	Total Acre	Biomass (in tons)	Crop Displaced	Value of Production
Alfalfa	27,195.50	139,033.45	WHEAT	$ 5,906,590.65
Caddo	26,092.90	135,957.06	WHEAT	$ 5,667,116.95
Canadian	21,412.70	94,794.10	WHEAT	$ 4,650,624.31
Carter	4,592.30	18,580.45	HAY	$ 1,288,461.61
Cherokee	4,341.60	19,419.98	HAY	$ 1,218,122.71
Cleveland	4,074.50	23,014.81	HAY	$ 1,143,182.47
Coal	3,540.30	18,846.43	HAY	$ 993,301.97
Comanche	10,145.25	32,355.71	WHEAT	$ 2,203,447.50
Creek	6,343.90	28,630.70	WHEAT	$ 1,377,831.64
Dewey	14,441.60	66,532.45	WHEAT	$ 3,136,571.10
Garfield	37,040.60	213,227.28	WHEAT	$ 8,044,847.91
Garvin	9,018.40	46,845.18	HAY	$ 2,530,292.49
Grady	16,645.80	75,087.54	WHEAT	$ 3,615,301.30
Grant	39,051.90	139,236.03	WHEAT	$ 8,481,682.16
Harper	15,227.00	78,419.05	WHEAT	$ 3,307,152.13
Haskell	5,309.20	22,670.28	WHEAT	$ 1,153,105.15
Hughes	5,410.20	31,266.63	WHEAT	$ 1,175,041.34
Jefferson	4,618.30	17,295.53	WHEAT	$ 1,003,048.58
Johnston	3,682.60	14,306.90	WHEAT	$ 799,823.89
Kay	28,257.40	103,456.73	WHEAT	$ 6,137,224.71
Kingfisher	25,920.50	109,573.98	WHEAT	$ 5,629,673.40
Lincoln	8,854.00	39,511.44	HAY	$ 2,484,166.78
Love	4,241.30	16,299.32	WHEAT	$ 921,167.95
Major	18,171.80	61,379.63	WHEAT	$ 3,946,733.24
Marshall	2,267.20	7,903.46	HAY	$ 636,108.30
McClain	7,062.50	32,939.50	HAY	$ 1,981,525.63
McIntosh	5,449.20	29,012.26	WHEAT	$ 1,183,511.75
Murray	2,457.70	12,099.26	WHEAT	$ 533,787.86
Muskogee	11,055.20	58,375.88	SOYBEAN	$ 2,649,931.44
Noble	16,213.20	51,436.38	WHEAT	$ 3,521,344.91
Okfuskee	3,984.00	20,237.53	SOYBEAN	$ 954,964.80
Oklahoma	5,525.40	33,261.80	SOYBEAN	$ 1,324,438.38
Okmulgee	6,453.00	38,347.60	WHEAT	$ 1,401,527.07
Pittsburg	7,263.10	37,650.43	SOYBEAN	$ 1,740,965.07
Pontotoc	5,604.60	29,407.34	WHEAT	$ 1,217,263.07
Pottawatomie	7,707.70	37,038.34	HAY	$ 2,162,549.39

Table A5: Land Allocation for Switchgrass Production for Plant 5 (Cont.)

Counties	Total Acre	Biomass (in tons)	Crop Displaced	Value of Production
Seminole	4,812.80	23,763.20	WHEAT	$ 1,045,292.03
Sequoyah	5,895.20	25,956.57	SOYBEAN	$ 1,413,079.44
Stephens	6,031.10	23,388.61	HAY	$ 1,692,145.73
Tulsa	5,156.00	24,130.08	SOYBEAN	$ 1,235,893.20
Wagoner	10,248.00	50,912.06	WHEAT	$ 2,225,763.12
Washington	4,737.07	25,352.87	SOYBEAN	$ 1,135,476.64
Woods	24,699.80	129,868.71	WHEAT	$ 5,364,549.56
Woodward	9,056.68	29,547.42	WHEAT	$ 1,967,020.33
TOTAL	**503,176.81**	**2,311,778.93**		**$ 113,910,457.14**

Table A6: Land Allocation for Switchgrass Production for Plant 6

Counties	Total Acre	Biomass	Crop Displaced		Value of Production
Adair	4,632.40	20,039.76	WHEAT	$	1,006,110.96
Alfalfa	27,195.50	139,033.45	WHEAT	$	5,906,590.65
Blaine	10,120.84	32,305.71	WHEAT	$	2,198,144.15
Caddo	26,092.90	135,957.06	WHEAT	$	5,667,116.95
Canadian	21,412.70	94,786.94	WHEAT	$	4,650,624.31
Carter	4,592.30	18,580.45	HAY	$	1,288,461.61
Cherokee	4,341.60	19,419.98	HAY	$	1,218,122.71
Cleveland	4,074.50	23,014.81	HAY	$	1,143,182.47
Coal	3,540.30	17,312.42	HAY	$	993,301.97
Comanche	2,526.18	7,939.77	WHEAT	$	548,659.95
Craig	10,088.00	56,638.40	HAY	$	2,830,390.16
Creek	6,343.90	28,674.43	WHEAT	$	1,377,831.64
Custer	215.614	709.37	WHEAT	$	46,829.20
Delaware	6,880.70	36,854.41	WHEAT	$	1,494,419.23
Dewey	14,441.60	66,532.45	WHEAT	$	3,136,571.10
Garfield	37,040.60	214,264.52	WHEAT	$	8,044,847.91
Garvin	9,018.40	49,205.23	HAY	$	2,530,292.49
Grady	16,645.80	81,740.87	WHEAT	$	3,615,301.30
Grant	39,051.90	135,483.47	WHEAT	$	8,481,682.16
Harper	15,227.00	78,419.05	WHEAT	$	3,307,152.13
Haskell	5,309.20	22,670.28	WHEAT	$	1,153,105.15
Hughes	5,410.20	31,266.63	WHEAT	$	1,175,041.34
Jefferson	4,618.30	17,295.53	WHEAT	$	1,003,048.58
Johnston	3,682.60	14,306.90	WHEAT	$	799,823.89
Kay	28,257.40	103,210.15	WHEAT	$	6,137,224.71
Kingfisher	25,920.50	109,902.92	WHEAT	$	5,629,673.40
Latimer	2,669.40	12,273.37	HAY	$	748,953.56
Le Flore	9,338.56	51,227.56	SOYBEAN	$	2,238,452.35
Lincoln	8,854.00	39,524.26	HAY	$	2,484,166.78
Love	4,241.30	16,299.32	WHEAT	$	921,167.95
Major	18,171.80	61,605.33	WHEAT	$	3,946,733.24
Marshall	2,267.20	7,903.46	HAY	$	636,108.30
Mayes	9,480.50	40,742.45	HAY	$	2,659,943.89
McClain	7,062.50	32,939.50	HAY	$	1,981,525.63
McIntosh	5,449.20	29,992.40	WHEAT	$	1,183,511.75
Murray	2,457.70	13,443.62	WHEAT	$	533,787.86

Table A6: Land Allocation for Switchgrass Production for Plant 6 (Cont.)

Counties	Total Acre	Biomass	Crop Displaced	Value of Production
Noble	16,213.20	51,436.38	WHEAT	$ 3,521,344.91
Nowata	5,378.50	27,882.14	HAY	$ 1,509,045.75
Okfuskee	3,984.00	21,565.34	SOYBEAN	$ 954,964.80
Oklahoma	5,525.40	33,261.80	SOYBEAN	$ 1,324,438.38
Okmulgee	6,453.00	38,347.60	WHEAT	$ 1,401,527.07
Osage	7,930.40	34,973.06	HAY	$ 2,225,032.33
Ottawa	9,452.00	46,071.88	SOYBEAN	$ 2,265,644.40
Pittsburg	7,263.10	35,804.18	SOYBEAN	$ 1,740,965.07
Pontotoc	5,604.60	32,674.82	WHEAT	$ 1,217,263.07
Pottawatomie	7,707.70	37,354.13	HAY	$ 2,162,549.39
Rogers	7,867.80	44,662.98	WHEAT	$ 1,708,807.48
Seminole	4,812.80	23,763.20	WHEAT	$ 1,045,292.03
Sequoyah	5,895.20	25,956.57	SOYBEAN	$ 1,413,079.44
Stephens	6,031.10	23,388.61	HAY	$ 1,692,145.73
Tulsa	5,156.00	24,130.08	SOYBEAN	$ 1,235,893.20
Wagoner	10,248.00	46,133.02	WHEAT	$ 2,225,763.12
Washington	5,186.60	35,061.42	SOYBEAN	$ 1,243,228.02
Woods	24,699.80	129,759.11	WHEAT	$ 5,364,549.56
Woodward	12,811.10	41,796.21	WHEAT	$ 2,782,442.81
TOTAL	**575,948.58**	**2,673,914.61**		**$132,401,809.42**

APPENDIX B

Table B1: Number and Values of Cow Displaced by the Plant 1

Counties	Biomass harvested (in tons)	Number of Cow Displaced(Head)	Value of Livestock (2009$)
Caddo	49,732.33	1,303.52	$ 977,638.74
Cleveland	13,233.89	387.35	$ 290,513.09
Grady	10,200.76	345.01	$ 258,755.50
McClain	21,299.64	655.98	$ 491,984.29
Oklahoma	12,375.52	307.99	$ 230,992.15
Stephens	30,983.02	1,046.21	$ 784,657.07
TOTAL	**137,825.16**	**4,046.05**	**$ 3,034,540.84**

Table B2: Number and Values of Cow Displaced by the Plant 2

Counties	Biomass harvested (in tons)	Number of Cow Displaced(Head)	Value of Livestock (2009$)
Caddo	38,080.00	1,303.56	$ 977,670.16
Cleveland	12,352.00	387.33	$ 290,497.38
Garfield	30,769.00	809.53	$ 607,146.60
Jefferson	20,668	601.47	$ 451,099.48
McClain	21,300.00	656.02	$ 492,015.71
Oklahoma	11,550.00	307.96	$ 230,968.59
Stephens	38,875.00	1,046.18	$ 784,633.51
TOTAL	**173,594.00**	**5,112.04**	**$ 3,834,031.41**

Table B3: Number and Values of Cow Displaced by Plant 3

Counties	Biomass harvested (in tons)	Number of Cow Displaced(Head)	Value of Livestock (2009$)
Caddo	46,240.33	1,303.52	$ 977,638.74
Cleveland	13,251.39	387.35	$ 290,513.09
Garfield	30,769.38	809.53	$ 607,146.60
Grady	19,833.97	670.82	$ 503,114.29
Haskell	5,152.30	162.60	$ 121,950.31
Hughes	25,261.67	742.41	$ 556,806.28
McClain	21,299.64	655.98	$ 491,984.29
McIntosh	16,704.90	540.88	$ 405,659.69
Muskogee	19,748.41	635.30	$ 476,473.82
Okfuskee	23,656.50	589.79	$ 442,342.93
Oklahoma	12,375.52	307.99	$ 230,992.15
Okmulgee	23,300.17	514.88	$ 386,159.69
Pittsburg	26,355.91	914.74	$ 686,057.59
Rogers	24,870.97	562.18	$ 421,633.51
Stephens	30,983.02	1,046.21	$ 784,657.07
Tulsa	13,669.81	305.85	$ 229,390.05
TOTAL	**353,473.90**	**10,150.03**	**$ 7,612,520.10**

Table B4: Number and Values of Cow Displaced by the Plant 4

Counties	Biomass harvested (in Tons)	Number of Cow Displaced(Head)	Value of Livestock (2009 USD)
Caddo	47,320.35	1,303.52	$ 977,638.74
Canadian	13,268.99	494.81	$ 371,106.68
Carter	28,356.24	1,087.63	$ 815,725.13
Cleveland	14,116.15	387.35	$ 290,513.09
Coal	21,073.41	561.06	$ 420,793.19
Creek	18,613.98	708.25	$ 531,188.48
Garfield	30,769.38	809.53	$ 607,146.60
Garvin	34,369.19	943.1	$ 707,324.61
Grady	31,002.11	1,048.54	$ 786,408.38
Haskell	18,360.15	579.42	$ 434,568.06
Hughes	31,035.77	742.41	$ 556,806.28
Jefferson	29,152.80	848.43	$ 636,321.99
Johnston	21,403.80	622.57	$ 466,924.08
Love	17,129.18	540.58	$ 405,431.94
McClain	21,299.64	655.98	$ 491,984.29
McIntosh	16,704.90	540.88	$ 405,659.69
Murray	10,426.10	307.1	$ 230,324.61
Muskogee	19,748.41	635.3	$ 476,473.82
Okfuskee	23,656.50	589.79	$ 442,342.93
Oklahoma	12,536.50	307.99	$ 230,992.15
Okmulgee	23,300.17	514.88	$ 386,159.69
Pittsburg	26,355.91	914.74	$ 686,057.59
Pontotoc	30,257.74	904.98	$ 678,738.22
Rogers	24,681.42	562.18	$ 421,633.51
Seminole	21,369.83	722.76	$ 542,073.30
Sequoyah	15,582.68	460.67	$ 345,502.62
Stephens	37,570.19	1,046.21	$ 784,657.07
Tulsa	12,910.38	305.85	$ 229,390.05
TOTAL	**673,266.36**	**19,858.73**	**$14,894,043.85**

Table B5: Number and Values of Cow Displaced by the Plant 5

Counties	Biomass harvested (in tons)	Number of Cow Displaced(Head)	Value of Livestock
Alfalfa	15,935.96	523.1	$ 392,324.61
Caddo	46,240.33	1,303.52	$ 977,638.74
Canadian	3,717.48	138.63	$ 103,970.42
Carter	28,356.24	1,087.63	$ 815,725.13
Cleveland	14,116.15	387.35	$ 290,513.09
Coal	20,825.15	561.06	$ 420,793.19
Creek	18,613.98	708.25	$ 531,188.48
Dewey	18,381.73	629.02	$ 471,761.78
Garfield	30,769.38	809.53	$ 607,146.60
Garvin	30,677.13	943.1	$ 707,324.61
Grady	31,002.11	1,048.54	$ 786,408.38
Haskell	18,360.15	579.42	$ 434,568.06
Hughes	31,035.77	742.41	$ 556,806.28
Jefferson	29,152.80	848.43	$ 636,321.99
Johnston	16,647.40	622.57	$ 466,924.08
Love	17,129.18	540.58	$ 405,431.94
McClain	21,299.64	655.98	$ 491,984.29
McIntosh	16,704.90	540.88	$ 405,659.69
Murray	10,426.10	307.1	$ 230,324.61
Muskogee	22,111.60	635.3	$ 476,473.82
Okfuskee	23,656.50	589.79	$ 442,342.93
Oklahoma	13,035.55	307.99	$ 230,992.15
Okmulgee	23,300.17	514.88	$ 386,159.69
Pittsburg	26,355.91	914.74	$ 686,057.59
Pontotoc	30,257.74	904.98	$ 678,738.22
Pottawatomie	20,894.52	712.21	$ 534,157.07
Rogers	25,571.61	562.18	$ 421,633.51
Seminole	21,369.83	722.76	$ 542,073.30
Sequoyah	15,582.68	460.67	$ 345,502.62
Stephens	35,173.86	1,046.21	$ 784,657.07
Tulsa	13,669.81	305.85	$ 229,390.05
Woods	27,288.59	719.76	$ 539,819.37
TOTAL	**717,659.92**	**21,374.42**	**$16,030,813.35**

Table B6: Number and Values of Cow Displaced by the Plant 6

Counties	Biomass harvested (in Tons)	Number of Cow Displaced(Head)	Value of Livestock (2009 USD)
Alfalfa	15,935.96	523.1	$ 392,324.61
Caddo	46,240.33	1,303.52	$ 977,638.74
Canadian	26,233.74	978.27	$ 733,704.19
Carter	28,356.24	1,087.63	$ 815,725.13
Cleveland	14,116.15	387.35	$ 290,513.09
Coal	21,073.41	561.06	$ 420,793.19
Craig	23,058.42	557.75	$ 418,311.52
Creek	18,613.98	708.25	$ 531,188.48
Delaware	27,925.31	578.49	$ 433,869.11
Dewey	18,381.73	629.02	$ 471,761.78
Garfield	30,769.38	809.53	$ 607,146.60
Garvin	30,457.25	943.1	$ 707,324.61
Grady	31,002.11	1,048.54	$ 786,408.38
Haskell	18,360.15	579.42	$ 434,568.06
Hughes	31,035.77	742.41	$ 556,806.28
Jefferson	29,152.80	848.43	$ 636,321.99
Johnston	16,647.40	622.57	$ 466,924.08
Kingfisher	29,953.17	1,180.12	$ 885,086.39
Le Flore	35,396.40	885.43	$ 664,075.92
Love	17,129.18	540.58	$ 405,431.94
Marshall	5,727.36	240.66	$ 180,494.76
Mayes	16,286.98	592.17	$ 444,125.65
McClain	21,299.64	655.98	$ 491,984.29
McIntosh	16,704.90	540.88	$ 405,659.69
Murray	10,426.10	307.1	$ 230,324.61
Muskogee	24,262.33	635.3	$ 476,473.82
Nowata	12,972.63	434.96	$ 326,222.51
Okfuskee	23,656.50	589.79	$ 442,342.93
Oklahoma	13,035.55	307.99	$ 230,992.15
Okmulgee	23,300.17	514.88	$ 386,159.69
Osage	23,530.55	948.89	$ 711,667.54
Ottawa	14,071.76	318.66	$ 238,994.76
Pittsburg	26,355.91	914.74	$ 686,057.59
Pontotoc	30,257.74	904.98	$ 678,738.22
Pottawatomie	20,894.52	712.21	$ 534,157.07
Rogers	24,870.97	562.18	$ 421,633.51

Table B6: Number and Values of Cow Displaced by the Plant 6 (Cont.)

Counties	Biomass harvested (in Tons)	Number of Cow Displaced(Head)	Value of Livestock (2009 USD)
Sequoyah	15,582.68	460.67	$ 345,502.62
Stephens	33,456.70	1,046.21	$ 784,657.07
Tulsa	13,669.81	305.85	$ 229,390.05
Washington	10,976.84	246.13	$ 184,594.24
Woods	27,288.59	719.76	$ 539,819.37
Woodward	19,462.60	813.56	$ 610,170.16
TOTAL	**960,547.04**	**29,010.88**	**$21,758,159.69**

APPENDIX C:Transportation Cost

Table C1: Transportation Expenses for Scenario 1

Counties	Biomass harvested (in tons)		Transportation Expenditure (in $)
Caddo	185,452.32	$	1,643,107.56
Canadian	92,560.19	$	820,083.28
Cleveland	37,328.43	$	330,729.89
Garvin	32,750.70	$	290,171.20
Grady	100,509.63	$	890,515.32
McClain	56,709.60	$	502,447.06
Oklahoma	45,637.32	$	404,346.66
Stephens	54,371.63	$	481,732.64
TOTAL	**605,319.81**	**$**	**5,363,133.61**

Transportation Cost is from Mohua (2010). $8.89/dry ton assuming a round trip distance of less or equal 75 miles.

Table C2: Transportation Expenses for Scenario 2

Counties	Biomass harvested (in tons)	Transportation Expenditure (in $)
Alfalfa	112,514.00	$ 996,874.04
Caddo	165,008.16	$ 1,461,972.30
Canadian	95,252.54	$ 843,937.50
Cleveland	35,366.44	$ 313,346.66
Garfield	244,068.95	$ 2,162,450.90
Garvin	38,129.80	$ 337,830.03
Grady	81,740.87	$ 724,224.11
Grant	137,708.17	$ 1,220,094.39
Jefferson	20668.379	$ 183,121.84
Kingfisher	113,145.19	$ 1,002,466.38
McClain	53,827.40	$ 476,910.76
Oklahoma	44,812.29	$ 397,036.89
Stephens	68,945.82	$ 610,859.97
TOTAL	**1,211,187.99**	**$ 10,731,125.76**

Table C3: Transportation Expenses for Scenario 3

Counties	Biomass harvested		Transportation Expenditures
Alfalfa	110,737.26	$	981,132.12
Caddo	184,959.69	$	1,638,742.85
Canadian	95,478.63	$	845,940.66
Cherokee	19,419.98	$	172,061.02
Cleveland	36,266.21	$	321,318.62
Creek	28,674.43	$	254,055.45
Garfield	255,023.81	$	2,259,510.96
Garvin	38,129.80	$	337,830.03
Grady	97,107.35	$	860,371.12
Grant	131,647.08	$	1,166,393.13
Haskell	27,822.59	$	246,508.15
Hughes	53,983.34	$	478,292.39
Kingfisher	110,685.98	$	980,677.78
McClain	53,827.40	$	476,910.76
McIntosh	46,697.30	$	413,738.08
Muskogee	78,124.29	$	692,181.21
Okfuskee	44,714.98	$	396,174.72
Oklahoma	45,637.32	$	404,346.66
Okmulgee	61,647.77	$	546,199.24
Pittsburg	61,497.56	$	544,868.38
Rogers	70,357.08	$	623,363.73
Seminole	22,560.00	$	199,881.60
Stephens	54,371.63	$	481,732.64
Tulsa	37,799.89	$	334,907.03
Wagoner	50,912.06	$	451,080.85
TOTAL	**1,818,083.42**	**$**	**16,108,219.19**

Table C4: Transportation Expenses for Scenario 4

Counties	Biomass harvested (in tons)	Transportation Expenditure (in $)
Alfalfa	110,345.74	$ 977,663.26
Caddo	183,277.40	$ 1,623,837.76
Canadian	108,603.75	$ 962,229.23
Carter	46,936.68	$ 415,858.98
Cherokee	19,419.98	$ 172,061.02
Cleveland	37,130.96	$ 328,980.31
Coal	41,156.11	$ 364,643.13
Creek	47,288.41	$ 418,975.31
Garfield	260,050.69	$ 2,304,049.11
Garvin	88,840.32	$ 787,125.24
Grady	115,143.70	$ 1,020,173.18
Grant	127,902.69	$ 1,133,217.83
Haskell	41,030.44	$ 363,529.70
Hughes	62,302.39	$ 551,999.18
Jefferson	46,448.33	$ 411,532.20
Johnston	39,798.39	$ 352,613.74
Kingfisher	108,094.51	$ 957,717.36
Lincoln	37,053.99	$ 328,298.35
Love	28,774.31	$ 254,940.39
Marshall	7,903.46	$ 70,024.66
McClain	54,139.44	$ 479,675.44
McIntosh	46,697.30	$ 413,738.08
Murray	22,525.36	$ 199,574.69
Muskogee	78,124.29	$ 692,181.21
Okfuskee	43,894.03	$ 388,901.11
Oklahoma	45,798.30	$ 405,772.94
Okmulgee	61,647.77	$ 546,199.24
Pittsburg	65,332.61	$ 578,846.92
Pontotoc	62,932.56	$ 557,582.48
Pottawatomie	58,020.08	$ 514,057.91
Rogers	66,927.18	$ 592,974.81

Table C4: Transportation Expenses for Scenario 4 (Cont.)

Counties	Biomass harvested (in tons)	Transportation Expenditure (in $)
Sequoyah	41,539.24	$ 368,037.67
Stephens	61,538.95	$ 545,235.10
Tulsa	35,747.52	$ 316,723.03
Wagoner	48,083.62	$ 426,020.87
Washington	27,698.52	$ 245,408.89
TOTAL	2,423,282.05	$ 21,470,278.96

Table C5: Transportation Expenses for Scenario 5

Counties	Biomass harvested (in tons)	Transportation Expenditure (in $)
Alfalfa	154,969.41	$ 1,373,028.97
Caddo	182,197.38	$ 1,614,268.79
Canadian	98,511.58	$ 872,812.60
Carter	46,936.68	$ 415,858.98
Cherokee	19,419.98	$ 172,061.02
Cleveland	37,130.96	$ 328,980.31
Coal	39,671.58	$ 351,490.20
Comanche	32,355.71	$ 286,671.59
Creek	47,244.68	$ 418,587.86
Dewey	84,914.18	$ 752,339.63
Garfield	243,996.66	$ 2,161,810.41
Garvin	77,522.30	$ 686,847.58
Grady	106,089.65	$ 939,954.30
Grant	139,236.03	$ 1,233,631.23
Harper	78,419.05	$ 694,792.78
Haskell	41,030.44	$ 363,529.70
Hughes	62,302.39	$ 551,999.18
Jefferson	46,448.33	$ 411,532.20
Johnston	30,954.30	$ 274,255.10
Kay	103,456.73	$ 916,626.63
Kingfisher	109,573.98	$ 970,825.46
Lincoln	39,511.44	$ 350,071.36
Love	33,428.49	$ 296,176.42
Major	61,379.63	$ 543,823.52
Marshall	7,903.46	$ 70,024.66
McClain	54,239.14	$ 480,558.78
McIntosh	45,717.16	$ 405,054.04
Murray	22,525.36	$ 199,574.69
Muskogee	80,487.48	$ 713,119.07
Noble	51,436.38	$ 455,726.33
Okfuskee	43,894.03	$ 388,901.11
Oklahoma	46,297.35	$ 410,194.52
Okmulgee	61,647.77	$ 546,199.24
Pittsburg	64,006.33	$ 567,096.08
Pontotoc	59,665.08	$ 528,632.61

Table C5: Transportation Expenses for Scenario 5 (Cont.)

Counties	Biomass harvested (in tons)	Transportation Expenditure (in $)
Seminole	45,133.03	$ 399,878.65
Sequoyah	41,539.24	$ 368,037.67
Stephens	58,562.47	$ 518,863.48
Tulsa	37,799.89	$ 334,907.03
Wagoner	50,912.06	$ 451,080.85
Washington	25,352.87	$ 224,626.43
Woods	157,157.30	$ 1,392,413.68
Woodward	29,547.42	$ 261,790.14
TOTAL	**3,029,438.86**	**$26,840,828.30**

Table C6: Transportation Expenses for Scenario 6

Counties	Biomass harvested (in tons)	Transportation Expenditure (in $)
Adair	20,039.76	$ 177,552.27
Alfalfa	154,969.41	$ 1,373,028.97
Blaine	32,305.71	$ 286,228.59
Caddo	182,197.38	$ 1,614,268.79
Canadian	121,020.68	$ 1,072,243.22
Carter	46,936.68	$ 415,858.98
Cherokee	19,419.98	$ 172,061.02
Cleveland	37,130.96	$ 328,980.31
Coal	38,385.83	$ 340,098.45
Comanche	7,939.77	$ 70,346.36
Craig	79,696.82	$ 706,113.83
Creek	47,288.41	$ 418,975.31
Custer	709.37	$ 6,285.02
Delaware	64,779.71	$ 573,948.23
Dewey	84,914.18	$ 752,339.63
Garfield	245,033.90	$ 2,171,000.35
Garvin	79,662.48	$ 705,809.57
Grady	112,742.97	$ 998,902.71
Grant	135,483.47	$ 1,200,383.54
Harper	78,419.05	$ 694,792.78
Haskell	41,030.44	$ 363,529.70
Hughes	62,302.39	$ 551,999.18
Jefferson	46,448.33	$ 411,532.20
Johnston	30,954.30	$ 274,255.10
Kay	103,210.15	$ 914,441.93
Kingfisher	139,856.09	$ 1,239,124.96
Latimer	12,273.37	$ 108,742.06
Le Flore	86,623.96	$ 767,488.29
Lincoln	39,524.26	$ 350,184.94
Love	33,428.49	$ 296,176.42
Major	61,605.33	$ 545,823.22
Marshall	13,630.82	$ 120,769.07
Mayes	57,029.43	$ 505,280.75
McClain	54,239.14	$ 480,558.78
McIntosh	46,697.30	$ 413,738.08
Murray	23,869.72	$ 211,485.72
Muskogee	82,638.21	$ 732,174.54

Table C6: Transportation Expenses for Scenario 6 (Cont.)

Counties	Biomass harvested (in tons)	Transportation Expenditure (in $)
Noble	51,436.38	$455,726.33
Nowata	40,854.77	$361,973.26
Oklahoma	46,297.35	$410,194.52
Okmulgee	61,647.77	$546,199.24
Osage	58,503.61	$518,341.98
Ottawa	60,143.64	$532,872.65
Pittsburg	62,160.09	$550,738.40
Pontotoc	62,932.56	$557,582.48
Pottawatomie	58,248.64	$516,082.95
Rogers	69,533.95	$616,070.80
Seminole	46,380.58	$410,931.94
Sequoyah	41,539.24	$368,037.67
Stephens	56,845.30	$503,649.36
Tulsa	37,799.89	$334,907.03
Wagoner	46,133.02	$408,738.56
Washington	46,038.25	$407,898.90
Woods	157,047.70	$1,391,442.62
Woodward	61,258.81	$542,753.06
TOTAL	**3,634,461.65**	**$32,201,330.13**

Appendix D: Scenarios and Plant Locations

Table D1: Plant Locations

Assumptions	Plant Locations
restricted to 1 biorefinery	Grady
restricted to 2 biorefineries	Grady & Garfield
restricted to 3 biorefineries	Grady, Garfield, & Okmulgee
restricted to 4 biorefineries	Grady, Garfield, Okmulgee,& Pontotoc
restricted to 5 biorefineries	Grady, Garfield, Okmulgee, Pontotoc, & Woods
restricted to 6 biorefineries	Grady, Garfield, Okmulgee, Pontotoc, Woods, & Washington
restricted to 7 biorefineries	Canadian, Comanche, Garfield, Okmulgee, Pontotoc, Washington, Woodward
restricted to 8 biorefineries	Blaine, Garfield, Grady, Jackson, Okmulgee, Pontotoc, Washington, Woodward
restricted to 9 biorefineries	Blaine, Grady, Garfield, Jackson, Okmulgee, Pontotoc, Texas, Woods, Washington

Appendix E: Total Value of Production

Table E1: Total Value of Production for Plant 1

Counties	Total "Cash" Cost	Labor Cost	Proprietor Income	TVP
Caddo	$ 4,285,852.46	$ 276,562.63	$ 2,641,736.55	$ 7,204,151.64
Canadian	$ 2,330,857.54	$ 153,651.33	$ 1,467,683.21	$ 3,952,192.07
Cleveland	$ 864,074.83	$ 55,781.82	$ 532,830.00	$ 1,452,686.65
Garvin	$ 831,554.12	$ 54,922.37	$ 524,620.58	$ 1,411,097.07
Grady	$ 2,239,300.05	$ 143,088.11	$ 1,366,782.94	$ 3,749,171.10
McClain	$ 1,446,392.98	$ 95,631.40	$ 913,474.75	$ 2,455,499.14
Oklahoma	$ 965,008.09	$ 60,754.58	$ 580,330.06	$ 1,606,092.73
Stephens	$ 1,672,657.05	$ 114,972.10	$ 1,098,217.76	$ 2,885,846.90
Total	**$14,635,697.13**	**$ 955,364.34**	**$ 9,125,675.84**	**$ 24,716,737.31**

Table E2: Total Value of Production for Plant 2

Counties	Total "Cash" Cost	Labor Cost	Proprietor Income	TVP
Alfalfa	$ 2,936,136.13	$ 195,147.0	$ 1,864,051.64	$ 4,995,334
Caddo	$ 4,187,744.78	$ 276,562.6	$ 2,641,736.55	$ 7,106,043
Canadian	$ 2,343,777.61	$ 153,651.3	$ 1,467,683.21	$ 3,965,112
Cleveland	$ 854,659.65	$ 55,781.8	$ 532,830.00	$ 1,443,271
Garfield	$ 5,116,078.42	$ 321,268.0	$ 3,068,764.12	$ 8,506,110
Garvin	$ 977,591.30	$ 64,713.4	$ 618,145.04	$ 1,660,449
Grady	$ 1,858,924.84	$ 119,445.4	$ 1,140,947.25	$ 3,119,317
Grant	$ 3,931,519.05	$ 266,364.8	$ 2,544,326.96	$ 6,742,210
Jeffers	$ 605,324.95	$ 41,220.2	$ 393,736.95	$ 1,040,282
Kingfish	$ 2,826,824.54	$ 185,997.9	$ 1,776,659.76	$ 4,789,482
McClain	$ 1,432,561.81	$ 95,631.4	$ 913,474.75	$ 2,441,667
Oklahoma	$ 961,048.90	$ 60,754.5	$ 580,330.06	$ 1,602,133
Stephens	$ 1,742,595.87	$ 114,972.1	$ 1,098,217.76	$ 2,955,785
Total	$29,774,787.85	$1,951,510.8	$ 18,640,904.03	$ 50,367,202

Table E3: Total Value of Production for Plant 3

Counties	Total "Cash" Cost	Labor Cost	Proprietor Income	TVP
Alfalfa	$ 2,927,609.91	$ 195,147.02	$ 1,864,051.64	$ 4,986,808.57
Caddo	$ 4,283,488.42	$ 591,811.64	$ 2,641,736.55	$ 7,517,036.61
Canadian	$ 2,344,862.59	$ 456,720.20	$ 1,467,683.21	$ 4,269,265.99
Cherokee	$ 475,732.33	$ 322,083.83	$ 297,584.77	$ 1,095,400.93
Cleveland	$ 858,977.44	$ 349,152.12	$ 532,830.00	$ 1,740,959.57
Creek	$ 696,565.88	$ 337,875.58	$ 434,827.72	$ 1,469,269.17
Garfield	$ 5,168,648.75	$ 640,947.19	$ 3,068,764.12	$ 8,878,360.06
Garvin	$ 977,591.30	$ 358,968.82	$ 618,145.04	$ 1,954,705.16
Grady	$ 2,497,128.38	$ 469,650.00	$ 1,580,053.53	$ 4,546,831.91
Grant	$ 3,655,741.50	$ 558,521.78	$ 2,352,420.90	$ 6,566,684.18
Haskell	$ 738,130.97	$ 341,962.00	$ 470,342.00	$ 1,550,434.96
Hughes	$ 1,360,451.79	$ 386,429.09	$ 856,796.84	$ 2,603,677.71
Kingfish	$ 2,815,023.24	$ 492,272.32	$ 1,776,659.76	$ 5,083,955.32
McClain	$ 1,432,561.81	$ 392,950.68	$ 913,474.75	$ 2,738,987.25
McIntosh	$ 1,159,346.75	$ 371,557.74	$ 727,552.81	$ 2,258,457.30
Muskogee	$ 1,883,554.10	$ 422,882.67	$ 1,173,607.82	$ 3,480,044.59
Okfuskee	$ 1,061,891.12	$ 363,685.92	$ 659,140.40	$ 2,084,717.44
Oklahoma	$ 965,008.09	$ 354,617.68	$ 580,330.06	$ 1,899,955.82
Okmulgee	$ 1,297,658.54	$ 377,516.21	$ 779,336.79	$ 2,454,511.54
Pittsburg	$ 1,704,782.49	$ 414,022.64	$ 1,096,607.01	$ 3,215,412.13
Rogers	$ 1,503,910.71	$ 392,236.93	$ 907,271.64	$ 2,803,419.28
Seminole	$ 532,318.27	$ 325,800.10	$ 329,882.07	$ 1,188,000.43
Stephens	$ 1,672,657.05	$ 414,207.98	$ 1,098,217.76	$ 3,185,082.79
Tulsa	$ 893,052.35	$ 351,543.40	$ 553,612.13	$ 1,798,207.88
Wagoner	$ 1,147,271.39	$ 368,666.44	$ 702,425.08	$ 2,218,362.90
Total	$ 44,053,965.15	$10,051,229.97	$ 27,483,354.38	$ 81,588,549.50

Table E4: Total Value of Production for Plant 4

Counties	Total "Cash" Cost	Labor Cost	Proprietor Income	TVP
Alfalfa	$ 2,925,731.07	$ 195,147.02	$ 1,864,051.64	$ 4,984,929.73
Caddo	$ 4,275,415.44	$ 276,562.63	$ 2,641,736.55	$ 7,193,714.62
Canadian	$ 2,824,206.01	$ 187,559.60	$ 1,791,576.36	$ 4,803,341.97
Carter	$ 1,545,061.52	$ 107,486.40	$ 1,026,714.07	$ 2,679,261.98
Cherokee	$ 475,732.33	$ 31,154.06	$ 297,584.77	$ 804,471.16
Cleveland	$ 863,127.24	$ 55,781.82	$ 532,830.00	$ 1,451,739.05
Coal	$ 981,540.78	$ 63,852.34	$ 609,919.92	$ 1,655,313.03
Creek	$ 1,381,851.03	$ 94,057.05	$ 898,436.50	$ 2,374,344.58
Garfield	$ 5,192,771.83	$ 321,268.02	$ 3,068,764.12	$ 8,582,803.96
Garvin	$ 2,014,515.47	$ 129,342.17	$ 1,235,481.27	$ 3,379,338.91
Grady	$ 2,901,519.67	$ 191,300.12	$ 1,827,305.93	$ 4,920,125.72
Grant	$ 3,960,340.45	$ 272,544.20	$ 2,603,352.39	$ 6,836,237.04
Haskell	$ 1,152,250.48	$ 77,804.07	$ 743,187.39	$ 1,973,241.94
Hughes	$ 1,400,373.37	$ 89,697.81	$ 856,796.84	$ 2,346,868.02
Jeffers	$ 1,343,729.80	$ 91,280.77	$ 871,917.34	$ 2,306,927.91
Johnston	$ 1,039,319.38	$ 69,088.45	$ 659,935.49	$ 1,768,343.32
Kingfish	$ 2,802,587.26	$ 185,997.99	$ 1,776,659.76	$ 4,765,245.02
Lincoln	$ 957,943.38	$ 63,533.74	$ 606,876.62	$ 1,628,353.74
Love	$ 859,945.09	$ 58,788.58	$ 561,550.67	$ 1,480,284.34
Marshall	$ 237,690.80	$ 16,268.77	$ 155,399.90	$ 409,359.46
McClain	$ 1,434,059.27	$ 95,631.40	$ 913,474.75	$ 2,443,165.43
McIntosh	$ 1,159,346.75	$ 76,167.29	$ 727,552.81	$ 1,963,066.85
Murray	$ 583,053.33	$ 38,680.66	$ 369,479.16	$ 991,213.16
Muskogee	$ 1,883,554.10	$ 122,864.66	$ 1,173,607.82	$ 3,180,026.58
Okfuskee	$ 1,057,951.50	$ 69,005.22	$ 659,140.40	$ 1,786,097.11
Oklahoma	$ 965,780.61	$ 60,754.58	$ 580,330.06	$ 1,606,865.25
Okmulgee	$ 1,297,658.54	$ 81,588.54	$ 779,336.79	$ 2,158,583.87
Pittsburg	$ 1,723,186.16	$ 114,803.47	$ 1,096,607.01	$ 2,934,596.63
Pontotoc	$ 1,557,326.04	$ 102,233.78	$ 976,540.85	$ 2,636,100.66
Pottawatomie	$ 1,556,845.68	$ 104,114.53	$ 994,505.87	$ 2,655,466.09
Rogers	$ 1,487,451.23	$ 94,982.00	$ 907,271.64	$ 2,489,704.87
Seminole	$ 1,248,814.25	$ 84,064.88	$ 802,990.86	$ 2,135,869.99
Sequoyah	$ 1,106,398.90	$ 73,871.06	$ 705,619.17	$ 1,885,889.13
Stephens	$ 1,707,051.71	$ 114,972.10	$ 1,098,217.76	$ 2,920,241.57
Tulsa	$ 883,203.41	$ 57,957.49	$ 553,612.13	$ 1,494,773.03
Wagoner	$ 1,133,698.19	$ 73,536.68	$ 702,425.08	$ 1,909,659.95
Washing	$ 589,912.67	$ 37,217.54	$ 355,503.31	$ 982,633.52
Total	$ 60,510,944.76	$ 3,980,961.49	$ 38,026,292.97	$ 102,518,199.22

Table E5: Total Value of Production for Plant 5

Counties	Total "Cash" Cost	Labor Cost	Proprietor Income	TVP
Alfalfa	$ 3,580,035.32	$ 230,994.00	$ 2,206,463.31	$ 6,017,492.62
Caddo	$ 4,270,232.62	$ 276,562.63	$ 2,641,736.55	$ 7,188,531.80
Canadian	$ 2,476,065.45	$ 163,151.18	$ 1,558,426.13	$ 4,197,642.76
Carter	$ 1,545,061.52	$ 107,486.40	$ 1,026,714.07	$ 2,679,261.98
Cherokee	$ 475,732.33	$ 31,154.06	$ 297,584.77	$ 804,471.16
Cleveland	$ 863,127.24	$ 55,781.82	$ 532,830.00	$ 1,451,739.05
Coal	$ 974,416.79	$ 63,852.34	$ 609,919.92	$ 1,648,189.05
Comanche	$ 1,049,169.87	$ 72,799.39	$ 695,382.53	$ 1,817,351.79
Creek	$ 1,381,641.19	$ 94,057.05	$ 898,436.50	$ 2,374,134.74
Dewey	$ 2,209,227.47	$ 146,733.94	$ 1,401,608.09	$ 3,757,569.50
Garfield	$ 5,115,731.54	$ 321,268.02	$ 3,068,764.12	$ 8,505,763.67
Garvin	$ 1,960,202.42	$ 129,342.17	$ 1,235,481.27	$ 3,325,025.86
Grady	$ 2,858,070.95	$ 191,300.12	$ 1,827,305.93	$ 4,876,677.00
Grant	$ 4,109,040.62	$ 280,225.11	$ 2,676,720.72	$ 7,065,986.45
Harper	$ 1,717,973.24	$ 109,264.54	$ 1,043,698.93	$ 2,870,936.71
Haskell	$ 1,152,250.48	$ 77,804.07	$ 743,187.39	$ 1,973,241.94
Hughes	$ 1,400,373.37	$ 89,697.81	$ 856,796.84	$ 2,346,868.02
Jeffers	$ 1,343,729.80	$ 91,280.77	$ 871,917.34	$ 2,306,927.91
Johnston	$ 996,878.27	$ 69,088.45	$ 659,935.49	$ 1,725,902.21
Kay	$ 2,986,236.27	$ 202,766.91	$ 1,936,837.08	$ 5,125,840.26
Kingfish	$ 2,809,686.97	$ 185,997.99	$ 1,776,659.76	$ 4,772,344.72
Lincoln	$ 969,736.21	$ 63,533.74	$ 606,876.62	$ 1,640,146.57
Love	$ 988,988.31	$ 67,478.94	$ 644,561.37	$ 1,701,028.63
Major	$ 1,895,671.31	$ 130,395.57	$ 1,245,543.33	$ 3,271,610.21
Marshall	$ 237,690.80	$ 16,268.77	$ 155,399.90	$ 409,359.46
McClain	$ 1,434,537.69	$ 95,631.40	$ 913,474.75	$ 2,443,643.85
McIntosh	$ 1,154,643.24	$ 76,167.29	$ 727,552.81	$ 1,958,363.35
Murray	$ 583,053.33	$ 38,680.66	$ 369,479.16	$ 991,213.16
Muskogee	$ 1,894,894.60	$ 122,864.66	$ 1,173,607.82	$ 3,191,367.08
Noble	$ 1,675,382.77	$ 116,341.22	$ 1,111,295.70	$ 2,903,019.69
Okfuskee	$ 1,057,951.50	$ 69,005.22	$ 659,140.40	$ 1,786,097.11
Oklahoma	$ 968,175.44	$ 60,754.58	$ 580,330.06	$ 1,609,260.08
Okmulgee	$ 1,297,658.54	$ 81,588.54	$ 779,336.79	$ 2,158,583.87
Pittsburg	$ 1,716,821.62	$ 114,803.47	$ 1,096,607.01	$ 2,928,232.09
Pontotoc	$ 1,541,646.01	$ 102,233.78	$ 976,540.85	$ 2,620,420.63
Pottawatomie	$ 1,556,427.10	$ 104,114.53	$ 994,505.87	$ 2,655,047.51
Rogers	$ 1,506,902.96	$ 94,982.00	$ 907,271.64	$ 2,509,156.60

Counties	Total "Cash" Cost	Labor Cost	Proprietor Income	TVP
Seminole	$ 1,248,814.25	$ 84,064.88	$ 802,990.86	$ 2,135,869.99
Sequoyah	$ 1,106,398.90	$ 73,871.06	$ 705,619.17	$ 1,885,889.13
Stephens	$ 1,692,768.12	$ 114,972.10	$ 1,098,217.76	$ 2,905,957.98
Tulsa	$ 893,052.35	$ 57,957.49	$ 553,612.13	$ 1,504,621.97
Wagoner	$ 1,147,271.39	$ 73,536.68	$ 702,425.08	$ 1,923,233.14
Washing	$ 539,048.49	$ 33,991.87	$ 324,691.61	$ 897,731.97
Woods	$ 3,536,117.68	$ 226,562.28	$ 2,164,131.36	$ 5,926,811.32
Woodward	$ 939,778.93	$ 64,988.11	$ 620,768.85	$ 1,625,535.89
Total	$ 76,858,315.24	$ 5,075,397.60	$ 48,480,387.61	$ 130,414,100.45

Table E6: Total Value of Production for Plant 6

Counties	Total "Cash" Cost	Labor Cost	Proprietor Income	TVP
Adair	$ 504,329.02	$ 33,240.76	$ 317,516.97	$ 855,086.76
Alfalfa	$ 3,580,035.32	$ 230,994.00	$ 2,206,463.31	$ 6,017,492.62
Blaine	$ 1,046,778.41	$ 72,624.18	$ 693,708.85	$ 1,813,111.44
Caddo	$ 4,270,232.62	$ 276,562.63	$ 2,641,736.55	$ 7,188,531.80
Canadian	$ 3,290,604.20	$ 220,690.40	$ 2,108,042.91	$ 5,619,337.51
Carter	$ 1,545,061.52	$ 107,486.40	$ 1,026,714.07	$ 2,679,261.98
Cherokee	$ 475,732.33	$ 31,154.06	$ 297,584.77	$ 804,471.16
Cleveland	$ 863,127.24	$ 55,781.82	$ 532,830.00	$ 1,451,739.05
Coal	$ 968,246.72	$ 63,852.34	$ 609,919.92	$ 1,642,018.98
Comanche	$ 260,683.39	$ 18,127.10	$ 173,150.73	$ 451,961.22
Craig	$ 1,740,625.68	$ 110,609.98	$ 1,056,550.68	$ 2,907,786.34
Creek	$ 1,381,851.03	$ 94,057.05	$ 898,436.50	$ 2,374,344.58
Custer	$ 22,401.94	$ 1,547.18	$ 14,778.75	$ 38,727.88
Delaware	$ 1,403,899.90	$ 89,016.84	$ 850,292.14	$ 2,343,208.87
Dewey	$ 2,209,227.47	$ 146,733.94	$ 1,401,608.09	$ 3,757,569.50
Garfield	$ 5,120,709.03	$ 321,268.02	$ 3,068,764.12	$ 8,510,741.16
Garvin	$ 1,970,472.73	$ 129,342.17	$ 1,235,481.27	$ 3,335,296.17
Grady	$ 2,889,999.02	$ 191,300.12	$ 1,827,305.93	$ 4,908,605.07
Grant	$ 4,091,032.78	$ 280,225.11	$ 2,676,720.72	$ 7,047,978.61
Harper	$ 1,717,973.24	$ 109,264.54	$ 1,043,698.93	$ 2,870,936.71
Haskell	$ 1,152,250.48	$ 77,804.07	$ 743,187.39	$ 1,973,241.94
Hughes	$ 1,400,373.37	$ 89,697.81	$ 856,796.84	$ 2,346,868.02
Jeffers	$ 1,343,729.80	$ 91,280.77	$ 871,917.34	$ 2,306,927.91
Johnston	$ 996,878.27	$ 69,088.45	$ 659,935.49	$ 1,725,902.21
Kay	$ 2,985,053.00	$ 202,766.91	$ 1,936,837.08	$ 5,124,656.99
Kingfish	$ 3,948,016.56	$ 266,868.96	$ 2,549,142.29	$ 6,764,027.81
Latimer	$ 294,099.11	$ 19,154.84	$ 182,967.75	$ 496,221.70
Le Flore	$ 1,983,566.44	$ 127,687.87	$ 1,219,679.31	$ 3,330,933.62
Lincoln	$ 969,797.73	$ 63,533.74	$ 606,876.62	$ 1,640,208.09
Love	$ 988,988.31	$ 67,478.94	$ 644,561.37	$ 1,701,028.63
Major	$ 1,896,754.41	$ 130,395.57	$ 1,245,543.33	$ 3,272,693.30
Marshall	$ 467,679.15	$ 32,760.70	$ 312,931.47	$ 813,371.32
Mayes	$ 1,607,283.96	$ 108,609.39	$ 1,037,440.99	$ 2,753,334.34
McClain	$ 1,434,537.69	$ 95,631.40	$ 913,474.75	$ 2,443,643.85
McIntosh	$ 1,159,346.75	$ 76,167.29	$ 727,552.81	$ 1,963,066.85
Murray	$ 589,504.68	$ 38,680.66	$ 369,479.16	$ 997,664.50
Muskogee	$ 1,905,215.57	$ 122,864.66	$ 1,173,607.82	$ 3,201,688.05
Noble	$ 1,675,382.77	$ 116,341.22	$ 1,111,295.70	$ 2,903,019.69

Counties	Total "Cash" Cost	Labor Cost	Proprietor Income	TVP
Nowata	$ 1,035,956.63	$ 68,401.74	$ 653,375.96	$ 1,757,734.33
Okfuskee	$ 1,064,323.45	$ 69,005.22	$ 659,140.40	$ 1,792,469.06
Oklahoma	$ 968,175.44	$ 60,754.58	$ 580,330.06	$ 1,609,260.08
Okmulgee	$ 1,297,658.54	$ 81,588.54	$ 779,336.79	$ 2,158,583.87
Osage	$ 1,777,943.81	$ 121,931.82	$ 1,164,697.27	$ 3,064,572.90
Ottawa	$ 1,389,573.37	$ 89,661.93	$ 856,454.12	$ 2,335,689.42
Pittsburg	$ 1,707,961.82	$ 114,803.47	$ 1,096,607.01	$ 2,919,372.29
Pontotoc	$ 1,557,326.04	$ 102,233.78	$ 976,540.85	$ 2,636,100.66
Pottawatomie	$ 1,557,942.49	$ 104,114.53	$ 994,505.87	$ 2,656,562.89
Rogers	$ 1,499,960.65	$ 94,982.00	$ 907,271.64	$ 2,502,214.29
Seminole	$ 1,254,801.03	$ 84,064.88	$ 802,990.86	$ 2,141,856.76
Sequoyah	$ 1,106,398.90	$ 73,871.06	$ 705,619.17	$ 1,885,889.13
Stephens	$ 1,684,527.76	$ 114,972.10	$ 1,098,217.76	$ 2,897,717.61
Tulsa	$ 893,052.35	$ 57,957.49	$ 553,612.13	$ 1,504,621.97
Wagoner	$ 1,124,337.67	$ 73,536.68	$ 702,425.08	$ 1,900,299.42
Washing	$ 885,024.77	$ 54,084.04	$ 516,612.81	$ 1,455,721.63
Woods	$ 3,535,591.73	$ 226,562.28	$ 2,164,131.36	$ 5,926,285.38
Woodward	$ 2,107,331.53	$ 147,680.42	$ 1,410,648.87	$ 3,665,660.81
Total	$ 92,599,369.59	$ 6,120,898.44	$ 58,467,050.71	$ 157,187,318.74

VITA

Frederic Bouinzemwinde Ouedraogo

Candidate for the Degree of

Master of Science

Thesis: THE ECONOMIC IMPACTS OF LAND USE CHANGES ASSOCIATED WITH SWITCHGRASS-BASED ETHANOL PRODUCTION IN OKLAHOMA

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Title of Study: THE ECONOMIC IMPACTS OF LAND USE CHANGES ASSOCIATED WITH SWITCHGRASS-BASED ETHANOL PRODUCTION IN OKLAHOMA

Pages in Study: 93 Candidate for the Degree of Master of Science

Major Field: Agricultural Economics

Scope and Method of Study: According to the Environmental Protection Agency (EPA), Oklahoma may have the potential to produce up to 700 million gallons of cellulosic ethanol by 2022. However, the production of switchgrass could significantly affect the agricultural landscape in Oklahoma. This paper investigates the economic implications of potential land use changes associated with switchgrass-based ethanol production on local communities in Oklahoma. The IMPLAN input-output model was used for the economic impacts analysis.

Findings and Conclusions: The results show that producing switchgrass on traditional croplands for energy purposes will have positive impacts on the local economy. Under the first plant scenario, results indicate that producing switchgrass for 50 MGY plant will generate a total effect of about 188 jobs. The total effects increase as the number of plant increases and the total effects will reach 2,129 jobs at the ninth plant scenario. Results also show a net improvement of the labor income. Labor income varies from $16,510,581 for the first plant scenario to $168,394,015 for the ninth plant scenario. The total value added (TVA) and the total output also are positively affected by switchgrass production. The total effects on the TVA when all the nine plants are operating are $177,745,267 and $320,432,697 for the total output. For the ethanol facility operation, results show also net improvement of the local economy. Operating nine switchgrass-based ethanol plants will add 275 direct jobs, 46 indirect and 252 induced jobs to the economy. The direct effects on the labor income, total value added, and total output will be respectively $15,558,348, $39,295,214, and $63,202,483.

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