AN ECONOMIC ANALYSIS OF PRODUCING GRAIN AND BIOMASS IN KANSAS

by

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Abstract

This study examines the net returns from grain and biomass production from seven annual crop rotations using six different management scenarios. This study also examines the profitability of producing biomass from three perennial crops using four management scenarios. Soybeans were rotated with grain sorghum, dual purpose sorghum, photoperiod sensitive sorghum, brown mid-rib (BMR) sorghum, and corn. Continuously cropped corn was also included. Perennial grasses including switchgrass and big bluestem were compared to a traditional crop, alfalfa. Yields and input data for the crops was from an experimental field study conducted at Kansas State University, Manhattan KS.

Enterprise budgets were constructed for rotations of five sorghum varieties with soybeans, corn and soybeans, and continuous corn. Enterprise budgets were also constructed for three perennial crops; consisting of switchgrass, big bluestem grass, and alfalfa. Perennial crop costs and returns are estimated over an assumed 10 year production horizon. Costs and net returns for each of these budgets were compared to determine which crop rotation was the most economically feasible. Yield and input rates, excluding soybean yield and inputs, used were collected from an agronomic field experiment at Manhattan located in Riley County, Kansas (Propheter, 2009; Roozeboom et al., 2011). Costs of inputs were from USDA Agricultural Prices, Kansas State University farm management guides, and Sharpe Brothers Seed Company. Harvest costs are from Kansas State University farm management guides and a Northeastern Colorado and Northwestern Kansas producer survey.

The corn- soybean rotation had the highest net returns per acre across all annual crop scenarios. The corn-soybean rotation did not have the highest net returns per acre when an alternative price was used for the photoperiod sensitive sorghum-soybean rotation. The dual

purpose sorghum-soybean rotation had the second highest net returns per acre across all annual crop scenarios. The corn-soybean and dual purpose sorghum-soybean rotations had high grain net returns, and low to average biomass production costs. Alfalfa had the highest amortized net returns of the perennial crops, and had positive establishment year net returns. Alfalfa had higher amortized net returns and establishment year net returns than switchgrass and big bluestem.

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List of Acronyms

a.i.	Active Ingredient
BCAP	Biomass Crop Assistance Program
BMR	Brown Mid-rib
bu	Bushel
CC	Continuously Cropped Corn
CO	Colorado
CRP	Conservation Reserve Program
DDGS	Dry Distillers Grain with Solubles
DP	Dual Purpose Sorghum
EIA	Energy Information Administration
EPA	Environmental Protection Agency
FEA	Field Experiment Annuals
FEAE	Field Experiment Annuals Excluding
FEP	Field Experiment Perennials
FEPL	Field Experiment Perennials with Lime
FMG	Farm Management Guide
FMGA	Farm Management Guide Alfalfa
FMGAL	Farm Management Guide Alfalfa with Lime
FMGBNRA	Farm Management Guide Biomass Nutrient Replacement Annuals
FMGBNRAE	Farm Management Guide Biomass Nutrient Replacement Annuals Excluding
FMGGBNRA	Farm Management Guide Grain and Biomass Nutrient Replacement Annual
FMGGBNRAE	Farm Management Guide Grain and Biomass Nutrient Replacement Annual Excluding
FOB	Free on Board
GS	Grain Sorghum
ha	Hectare
K	Potassium
KS	Kansas
Mg	Mega gram
N	Nitrogen
ND	North Dakota
NE	Nebraska
NE	Northeast
NW	Northwest
OPEC	The Oil Producing and Exporting Countries
P	Phosphorous
PS	Photo-period Sensitive Sorghum
RC	Rotated Corn
SD	South Dakota
SS	Sweet Sorghum

TSP	Triple Super Phosphorous
USDA	United States Department of Agriculture
WDGS	Wet Distillers Grain with Solubles

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Chapter 1 - Chapter 1 Introduction

1.1 Background

With oil prices becoming more volatile, staying at historically high levels, and with political turmoil embroiling major oil exporting nations, the U.S. demand for alternative, domestically produced fuel could increase dramatically. The Organization of the Petroleum Exporting Countries (OPEC) is forecasting increased oil demand in 2014 based on a gradual economic recovery. Additionally, OPEC suggests that geopolitical tensions in the Ukraine, Russia, and other regions provide favorable conditions for increased oil demand and oil prices. Fears that Russia will close off its gas exports, as political retribution, have set traders on edge because such a supply restriction will cause a major price spike (Macalister, 2014).

Ethanol's profitability struggled in 2013 because high corn prices have caused returns from ethanol production to fall. Coupled with reduced gasoline demand because of the "Great Recession" and more efficient vehicles, starch ethanol plants were idled in 2013 (Eligon and Wald, 2013). Livestock producers were left seeking replacements for the starch ethanol co-products they have come to rely on. These co-products are used as corn substitutes (and replace soybean meal) that lowers production costs by allowing livestock producers to feed the co-products in conjunction with lower quality forages and roughages than feeding a corn based diet would allow.

The cellulosic biofuel requirement proposal is for 17 million gallons in 2014, up from the 2013 requirement of 6 million gallons (U.S. Environmental Protection Agency, 2013 a). Both requirements are much larger than the 20,000 gallons of cellulosic biofuel that was produced in 2012, as reported by the Energy Information Administration (EIA) (EIA, 2013). The

Environmental Protection Agency (EPA) is proposing to reduce the biofuel renewable energy standards for 2014 below the original target of 1.75 billion gallons (U.S. Environmental Protection Agency, 2013 b).

Several cellulosic biofuel plants are anticipated to come online in 2014 (Helman, 2013). These plants, depending on capacity and biomass demand, could produce a structural shock in forage and roughage markets. This structural change may produce similar results to the West Texas drought of 2011, which created an integrated forage and roughage market in the Great Plains and outlying regions, compared to normally highly regional markets (Fernandez, 2011). Future cellulosic ethanol production will create competition for forage and roughages used in livestock production, which may exacerbate the food versus fuel debate.

Corn and other grain prices are projected to remain below the recent peaks. With the recent drought and reduced corn acreages, these lower prices may hold or rise again, though neither has yet to be seen. Livestock producers are sure to benefit from the lower feed prices (Russel, 2013). Cattle markets appear to have the fundamentals to be highly profitable this year. But with drought conditions in some areas of the nation, finding roughages may prove to be a struggle (Henderson, 2013).

As the conservation reserve program (CRP) program undergoes changes in the farm bill, with strong commodity prices and land rental rates, the possibility of not having acreage reenrolled is high. But with recent drought, a reduction in accepted acreages in 2013, and contracts covering 3.3 million acres expiring in 2013 there is an increase in the amount of medium-quality land or highly erodible land that is available for production (Doane Advisory Services, 2013). Perennial bioenergy crops have been suggested as a crop which farmers can grow profitably while retaining the environmental benefits of the CRP program (reduced soil erosion, water quality, wildlife habitat) (Farm Service Agency, 2013). This marginal land may be well suited to grow most types of perennial crops, or possibly annual forage or roughage rotations using no-till, depending on field characteristics.

1.2 Statement of the Problem

The objective of this analysis is to estimate returns from growing and harvesting both annual and perennial biomass of dedicated biomass crops for potential cellulosic ethanol production or expanded livestock uses. This also needs to be compared to the estimated returns from harvesting the biomass of grain crops as a value-added product. This analysis will estimate the annual returns from producing and harvesting biomass from grain crops, and annual and perennial crops in North-Central and Northeast Kansas.

1.3 Objectives of the Study

This study examines the net returns of seven annual crop rotations using six different management scenarios. This study also examines the profitability of three perennial crops using four management scenarios. Management scenarios differ because of yields, fertilizer applications, chemical use, and lime applications. Soybeans were rotated with grain sorghum, dual purpose sorghum, photoperiod sensitive sorghum, brown mid-rib (BMR) sorghum, and corn. Continuously cropped corn was also included. Perennial grasses including switchgrass and big bluestem were compared to the more traditional crop, alfalfa. Sensitivity analysis to determine the effects of various yield and price levels on net returns is performed using the most realistic management scenario.

Specific study objectives are as follows:

1. Identify cropping rotations and management scenarios that are feasible for North-Central and North-Eastern Kansas.
2. Collect yield, nutrient removal, fertilizer usage, and chemical usages data from an agricultural experiment for the feasible cropping rotation.
3. Collect historic price data from the United States Department of Agriculture.
4. Collect appropriate regional input usages and costs from the Kansas State University farm management guides.
5. Collect appropriate biomass harvest costs from Kansas State University farm management guides and from businesses engaged in biomass harvest.
6. Determine the field operations for each rotation based on the agricultural experiment, and on regional practices.
7. Construct enterprise budgets for each crop rotation for each scenario.
8. Perform sensitivity analysis on net returns.

1.4 Organization of the Thesis

The thesis is organized in the following manner. Chapter 2 contains a review of relevant literature. Chapter 3 provides a description of methods and data sources. Chapter 4 contains the results, analysis, and sensitivity analysis. Chapter 5 contains the summary and conclusions. Appendix A contains the average annual yields per crop from Propheter (2009) and Roozeboom et al. (2011). Appendix B contains the specific rates of fertilizer and chemicals applied to each crop rotation in the analysis. Appendix C contains the sensitivity analysis of the most realistic scenarios.

Chapter 2 - Chapter 2: Review of Literature

2.1.: Energy Crop Yields

Perrin et al. (2008) collected switchgrass yield and input data for five years from ten farms in ND, SD, and NE which was extrapolated to a 10 year horizon. They averaged the yields from years two through five and made that average the constant rate of yield in years six through ten. They acknowledged that full yield potential may not be realized until year three. Average dry matter yield across the ten sites was 5.0 Mg/ha (2.23 tons/acre) over the growing period. The average yield for the 10 year horizon was 7.0 Mg/ha (3.122 tons/acre).

Khanna, Dhungana, and Clifton-Brown (2006) used a simulation model to predict switchgrass yields using parameter estimates of precipitation, temperature, solar radiation, soil moisture holding capacity, and potential evaporation for Illinois. Switchgrass production was simulated over a 10 year horizon. The average "peak" yield of switchgrass dry matter for Illinois was 9.42 metric tons/ha (3.80 tons/acre).

Casler, Pedersen, and Undersander (2003), confirming others, found that the brown mid-rib (BMR) trait severely reduces grain yields of sorghum sudangrass as well as marginally reducing the biomass yield compared to the non-BMR varieties. The sorghum sudangrass was grown in Nebraska and Wisconsin and harvested twice in a single year. Each of four varieties of sorghum sudangrass were grown, Piper, Piper-bmr, Greenleaf, and Greenleaf-bmr. Forage yields for Piper-bmr were on average 30% less than Piper. Greenleaf-bmr yields in the second harvest were 15% lower than Greenleaf. However, the BMR trait does increase the palatability and nutritional value to ruminant animals. In dairy operations, the BMR trait performed significantly better than other forage sorghums in milk production, increasing relative feed values from 7% to 23%. The photoperiod sensitive (PS) varieties had the highest average silage yields while the BMR varieties had the lowest average silage yields. Other sorghum varieties had yields between the BMR and PS varieties.   However the PS varieties were not as palatable nor as digestible as the BMR or other varieties when used as ruminant feed (McCollum III, McCuistion, and Bean, 2005).

2.2: Biomass Production Costs

2.2.a: Annual Crop Biomass Production Costs

Sokhansanj and Turhollow (2002) simulated corn stover harvest costs from formulas using technical coefficients (collection efficiency, residue specifications, etc.). Prices of fuel and equipment efficiency were from 2001 United States Department of Agriculture, National Agricultural Statistics Service (USDA/NASS) data. Costs, including transportation to a storage facility for square baling were estimated to be $21.40 per dry ton, and costs for round bales were estimated to be $19.70 per dry ton. Harvest costs were similar to custom rates in Kansas and Colorado in 2013. The author's method and ordering of field operations for square bales are as follows; combine to harvest grain, stalk shredding with raking, baling, stacking, and storage. The methods used in this analysis differ because raking after stalk shredding for corn stalks was not included.

Petrolia (2008) used a theoretical model based on actual yields, actual transport distances to a proposed ethanol production facility, regional custom harvesting costs, and land rental costs. Petrolia's study used large square corn stover bale weights of 609 kg (1342.24 pounds), which are similar to those used in this study. Petrolia (2008) proposed two harvest variants; the first was baling the chaff directly behind the baler, which results in lower yields. The second included a stalk shredding in conjunction with a rake, then baling the corn stover, which resulted in the highest yields. Petrolia's study accounts for nutrient removal due to biomass harvest. The average removal of phosphorus used was of 3.1 kg per Mg of corn stover (1.55 pounds per ton) and the average potassium removal of 16.5 kg per Mg of corn stover (8.25 pounds per ton). The average nutrient replacement cost was $4.64 per Mg of corn stover ($4.21 per ton). Petrolia (2008) also discussed the differences between round and square baling methods and the impacts on cost due to the choice of each method and found that round bales were less costly when delivery to the edge of the field was considered without transport to the bio-refinery. However, round bales were more costly when transport costs were included. Costs, including transportation, ranged from $44 to $66 per square bale and $55 to $77 per round bale.

Wortmann et al. (2008) estimated that nutrient removal costs due to corn stover harvest were $17.93 per ton of corn stover for a typical Nebraska farm. Additionally, lime applications would have to be added to prevent the soil from becoming acidic. This study found that corn stover replacement costs ranged from $10.90 per ton to $13.77 per ton, depending on the assumptions used. Appendix B contains the costs of replacement in more detail.

2.2.b: Perennial Crop Biomass Production Costs

Duffy and Nanhou (2001) estimated switchgrass production costs in Southern Iowa. Switchgrass was not harvested in the establishment year, and switchgrass was grown over a 10 year horizon. They also included a probability of reseeding, to adjust their seeding costs, depending on when the initial seeding occurred, spring versus fall seeding. The establishment costs were amortized over 10 years at 8%. All year-to-year activities incurred interest costs of 9%. The authors assumed that harvest costs are non-linear by nature, as yield increases, so do harvest costs, but harvest cost per ton is decreased. The authors varied yield from 1.5, 3, 4, and 6 tons per acre to determine costs. The authors estimated a total cost range of $175-$325 per acre and $50-$135 per ton, depending on switchgrass yield and the type of land switchgrass was grown on (cropland versus grassland).

Perrin et al. (2008) collected data from ten farms in ND, SD, and NE. Switchgrass was grown on marginal ground following best management practices. Some farmers used custom application and some performed field activities themselves. Historic custom rates were used in the latter. Costs were only incurred when the farmer performed an activity. Land rental rates, based on the farmer's estimates for the region's land rental rate for similar land, were included in the cost calculations. Costs and returns were discounted to an annual annuity to compare costs; the real discount rate was 10% due to the risk of unknown crop performance. Costs were compared in dollars per mega gram of production. For a 10 year production period, costs were estimated to be $59.10 per Mg ($65.16 per ton) and the costs for the five years which the switchgrass stands were grown was $65.86 per Mg ($72.61 per ton). The first three years of growth had costs of $89.02 per Mg ($98.15 per ton) which is a proxy for the costs of establishment.

Khanna and Dhungana (2006) found the first year costs of $44.12 per ha ($17.85 per acre) for switchgrass was higher than following years. They included a probability of reseeding switchgrass. Fertilizer applications were site-specific across the locations considered in Illinois. Harvest costs were the largest cost category. Harvest was assumed to occur at 15% moisture. Using a 4% discount rate, costs were amortized over the 10 year horizon. Annualized operation costs, including storage and transportation but excluding a land charge, were estimated to be $374.67 per ha ($151.62 per acre). The authors performed breakeven sensitivity analysis, including opportunity costs, and determined that $98.18 per dry metric ton ($89.07 per ton) was the delivered breakeven price. A 25% change in corn/soybean composite price (part of the authors calculation of opportunity cost) led to a 30% increase in the switchgrass breakeven price, and a 25% increase in the switchgrass harvest cost led to a 10% increase in the switchgrass breakeven price. Breakeven costs are all field activities associated with switchgrass production but not including land rental rates.

2.3: Land Use Costs

2.3.a: Marginal Land Use Change

Swinton et al. (2011) contend that there is a small response by farmers to put marginal land into biomass crop production in the short-run. The authors expect the prairie states and the Southeast to have the most potential for bioenergy crop acreage expansion, especially as the Ogallala aquifer becomes depleted. However, farmers are more likely to grow biomass crops on marginal land, rather than prime land which can be used to grow crops with higher profitability, i.e. corn and soybeans. The authors contend that due to the uncertainty in profitability, production practices, markets, and technology, farmers will require a much higher price threshold than currently predicted to switch acreage into bioenergy production.

2.3.b: Conservation Reserve Program Acreage

McLaughlin et al. (2002) used an agricultural sector model to determine land use changes, expected yields of switchgrass, and prices of switchgrass so that switchgrass is competitive in both the energy sector and the crop production sector. The authors expect conservation reserve program (CRP) acreage to be shifted into switchgrass production, and some corn or soybean ground would be fungible depending on biomass price. An estimated 5,221 hectares (12,901 acres) of CRP acreage would be converted to switchgrass production by 2004 if switchgrass prices were $44/Mg ($39.91 per ton). An estimated 16,830 total hectares (41,587 acres) would be converted to switchgrass production at $44/Mg ($39.91 per ton).

At the time of publication, policy prevented the harvest and sale of biomass from CRP acres. As the CRP program undergoes changes in the farm bill, with strong commodity prices, and land rental rates, the possibility of not having acreage reenrolled is high (Doane Advisory Services, 2013). But with recent drought, the program reducing accepted acreages in 2013, and contracts covering 1.7 million acres set to expire, there may be an increase in medium quality land or highly erodible land that is available for perennial biomass production. Andrews (2006) suggests that perennials, such as switchgrass, reduce potential soil erosion and that marginal, highly erodible land is ideal for dedicated energy production crops.

2.4: Uses of Biomass

2.4.a: Cellulosic Ethanol

The Energy Independence and Security Act of 2007 set a mandate that new biofuels produced after 2016 must be produced from cellulosic feedstocks (U.S. Congress, House of Representatives, 2007). With gasoline consumption falling below the Energy Independence and Security Act of 2007's expectations, the Environmental Protection Agency (EPA) is proposing to reduce the biofuel renewable energy standards for 2014 (U.S. Environmental Protection Agency, Nov 2013). The cellulosic biofuel requirement is proposed to be 17 million gallons in 2014, up from the 2013 requirement of 6 million gallons (U.S. Environmental Protection Agency, Aug

2013). Both requirements are much larger than the 20,000 gallons of cellulosic biofuel that was produced in 2012, as reported by the Energy Information Administration (EIA) (EIA, 2013).

Lynes et al. (2014) attribute the shortfall of cellulosic ethanol to a shortage in biomass available for energy production, and seeks to determine the factors that affect farmers adoption of bioenergy crop production. Helman (2013) finds that due to a lack of plants currently producing cellulosic ethanol, production is very limited. However in 2014, DuPont and Abengoa have plants slated to go into cellulosic ethanol production. The success of cellulosic biofuel plants has been limited so far, and may be hampered by high breakeven prices per gallon.

2.4.b: Ethanol Production Co-Products as Animal Feedstock

The co-products of starch ethanol production reduce the number of net acres of corn required to satisfy ethanol production and livestock production simultaneously because they provide wet distillers grain with solubles (WDGS) or dry distillers grain with solubles (DDGS). The WDGS and DDGS, when mixed with low quality roughages, provide higher feed to gain ratios, average daily gain, and dry matter intake for cattle (Morris et al. 2005; Hales et al. 2013). WDGS and DDGS are substitutes for corn, and due to high corn prices their use is becoming more prevalent in the cattle and dairy industries. WDGS and DDGS have to be used in conjunction with forages to prevent dietary health problems in cattle (Morrow et al., 2013). The co-product of cellulosic ethanol production, biodiesel glycerol, is a feed supplement that has potential for the treatment of ketosis in dairy cattle (Donkin, Doane, and Cecava, 2013).

2.5: Factors Affecting Farmers Willingness to Supply Biomass

A variety of factors may influence farmers willingness to supply biomass to the ethanol industry. Larson et al. (2005) suggest farmers would be willing to supply biomass at prices greater than $40 per dry ton. Larson et al. (2005) used a typical farm in northwest Tennessee as the basis of their analysis. Using non-linear programing, in conjunction with cropping simulations, the authors were able to estimate the market-clearing price of wheat straw ($27.47 per dry ton), corn stover ($28.56 per dry ton), and switchgrass ($30.14 per dry ton). The prices used in the models were from 1997 to 2001.

Fewell et al. (2013), using Kansas survey results, found that farmers in Kansas who are younger, produce livestock, or have higher rented acres are more willing to grow perennial biomass crops. However, farmers with larger acreages are more willing to harvest annual crop residues. Additionally, contracts and price structure influences farmers willingness to produce biomass. The authors also contend that in drier regions (Western Kansas) farmers were less willing to produce biomass in order to conserve water and reduce erosion. Marra et al. (2012), using national survey results, found that farmers believed potential benefits of switchgrass production included to reduced fertilizer and chemical use and costs, as well as helping the environment.

Research on farmers willingness to grow or harvest biomass if biomass removal increased the risk of erosion, and or reduced soil quality is limited. Andrews (2006) examines most of the existing literature on effects biomass removal has on the ecosystem. While soil degradation may occur it isn’t a certainty when removing biomass, Andrews (2006), and Blanco-Canqui and Lal (2009) provide guidelines for relatively safe removal rates. With the advancement of strip-till there have been issues with excessive biomass in some regions and with certain management practices. Therefore, removing some biomass increases yields by increasing soil temperature earlier in the growing season, thus allowing longer growing season for some varieties (Andrews, 2006). These practices are highly dependent on soil type, precipitation, topography, yields (of grain and biomass), field conditions, drainage, and soil quality. The effects of removal can be both beneficial and harmful, depending on the exact circumstances. If soil organic matter is depleted through removal of biomass, this may lead to an increase in non-point pollution, runoff, and soil erosion (Blanco-Canqui and Lal, 2009).

The Biomass Crop Assistance Program (BCAP), created in the 2008 Farm Bill, seeks to induce farmers to change production practices by growing biomass for the cellulosic ethanol industry. Aguilar, Song, and Shifley (2011) find that BCAP's effectiveness has yet to be explored, but funds were fully allocated to projects. These projects include 75% of the establishment cost of bioenergy perennial crops, up to 15 years of annual payments for woody crops, and matching payments for selling eligible materials to bioenergy conversion plants. Producers can receive matching payments up to $45 / ton.

Chapter 3 - Data and Methods

3.1 Overview

Enterprise budgets were constructed for the eight annual crops; consisting of five sorghum varieties, corn, and soybeans. Enterprise budgets were also constructed for three perennial crops; consisting of switchgrass, big bluestem grass, and alfalfa. Costs and net returns for each of these budgets were compared to determine which crop rotation was the most economically feasible. Yield and input rates, excluding soybean yield and inputs, were collected from a agronomic field experiment at Manhattan located in Riley County, Kansas (Propheter, 2009; Roozeboom et al., 2011). The annual budgets were constructed for a rotation with soybeans, with the exception of continuously cropped corn. Perennial crop costs and returns are budgeted over an assumed 10 year production horizon. Costs of inputs were from USDA Agricultural Prices, Kansas State University farm management guides, and Sharpe Brothers Seed Company. Harvest costs are from Kansas State University farm management guides and a Northeastern Colorado and Northwestern Kansas producer survey.

Soybeans [*Glycine max* L. Merr.] provide a rotational crop in many farming systems, and are rotated with either sorghum or corn in this study. The sorghum varieties included grain sorghum (GS), dual purpose (DP), brown mid-rib (BMR), photoperiod sensitive (PS) and sweet (SS) [*Sorghum bicolor* (L.) Moench]. DP and GS are both varieties of sorghum used for grain production in semi-arid regions because they are considered to have high water use efficiency (Martin et al., 1976). BMR is used as an animal feed due to high palatability and digestibility (Marsalis, 2006). PS is grown for biomass production in northern latitudes because the day length is not long enough for it to set seed (McCollum, McCuistion, and Bean, 2005). SS produces high levels of fermentable carbohydrates which are conducive to ethanol production (Smith et al., 2008; Smith et al., 1987). Corn [*Zea mays* L.] was rotated with soybeans (RC) in the experiment, which is a common practice in Northeast and North Central Kansas (NE-NC KS). Corn was also continuously cropped (CC) in the experiment.

Alfalfa [*Medicago sativa* L.] is a commonly grown forage crop in NE-NC KS and is used as a benchmark for comparison to the other perennial crops. Big bluestem [*Andropogon gerardii* Vitman] is a native grass used for animal feed and is noted as a drought resistant species (Knapp, 1985). Switchgrass is another native grass that is regarded as a crop that has high potential to provide biomass for ethanol production, and it also is a source of animal feed (McLaughlin et al., 1999; Cogel et al., 1985).

3.1.a Annual Crop Budget Scenarios

Six scenarios are examined for each annual crop rotation, resulting in 42 crop rotation budgets for comparison. The six scenarios are explained below.

1. FEA: Field Experiment Annuals scenario uses all inputs and activities for annual crops from the field experiment from Propheter (2009) and Roozeboom et al. (2011).
2. FEAE: Field Experiments Annuals Excluding scenario uses the same data as the FEA scenario but excludes all non-soybean yields from 2009 and 2011 due to incomplete data points in those two years.
3. FMGBNRA: Farm Management Guide Biomass Nutrient Replacement Annuals scenario uses the yield data from Propheter (2009). Field operations, chemical, and fertilizer use are from the farm management guides by O'Brien and Duncan (2012; a, b, and c).

Nutrients removed by biomass are replaced, as a supplemental fertilizer, according to the field experiment rates of removal from Propheter (2009).

4. FMGBNRAE: Farm Management Guide Biomass Nutrient Replacement Annuals Exclude scenario uses the same yield, and inputs as the FMGBNRA scenario but excludes the non-soybean yield data from 2009 and 2011 because of missing yield data points.
5. FMGGBNRA: Farm Management Guide Grain and Biomass Nutrient Replacement Annual scenario uses yield data from the field experiment, chemical usage, and field operations from O'Brien and Duncan (2012; a b, and c). Nutrients removed by both grain and biomass are replaced according to the field experiment rates of removal from Propheter (2009).
6. FMGGBNRAE: Farm Management Guide Grain and Biomass Nutrient Replacement Annual Exclude scenario is the same as the FMGGBNRA scenario but excludes all the 2009 and 2011 non-soybean yield data due to missing yield data points.

3.1.b Perennial Crop Budget Scenarios

There are four budget scenarios for each of the three perennial crops; switchgrass, big bluestem, and alfalfa for a total of six budgets. The four scenarios are described below.

1. FEP: Field Experiment Perennials scenario uses all chemical, fertilizer, and field operations from the field experiment for switchgrass and big bluestem (Propheter, 2009; Roozeboom et al., 201).
2. FEPL: Field Experiment Perennials with Lime scenario are the same as the FEP scenario but include lime applications which were not included in the five years of data from

Propheter (2009) and Roozeboom et al. (2011) but may be applied in a 10 year production horizon.

3. FMGA: Farm Management Guide Alfalfa scenario serves as a comparison to the perennial crops of big bluestem and switchgrass even though alfalfa was not part of the field experiment. Field operations, chemical, and fertilizer use, excluding the lime application, are from Dumler and Shoup (2012) and yields are from Herbel (2013).
4. FMGAL: Farm Management Guide Alfalfa with Lime scenario is the same as the FMGA scenario with the addition of the Kansas State University farm management guide lime recommendations (Dumler and Shoup, 2012).

3.2 Field Experiment Data

3.2.a Overview of Data Sources

Annual and perennial grain and biomass harvest data was collected from 2007 to 2011 from an experimental field study at Kansas State University, Manhattan KS (Propheter, 2009, Roozeboom et al., 2011). The crops were: Grain Sorghum (GS) [*Sorghum bicolor* (L.) Moench] , Brown Mid-rib Sorghum (BMR), Photosensitive Sorghum (PS), Dual Purpose Sorghum (DP), Sweet Sorghum (SS) , Corn rotated with soybeans (RC) [*Zea mays* L.], Continuous Corn (CC), Switchgrass [*Panicum virgatum* L.], and Big bluestem [*Andropogon gerardii* Vitman]. There were four yield observations per year for each crop. Yield data observations for BMR and SS are both missing 2009 and 2011 data, with other crops missing a single observation sporadically. Refer to Appendix A for all of the plot data. The missing observations were not assigned as zeroes in the annual and total average yield calculations. Using a harvest index could have provided an estimate of the yield, but there were harvest index data observations missing as well.

The GS, BMR, PS, DP, SS, and RC rotations all include soybeans in rotation. Propheter (2009) did not report the soybean yields, so it was necessary to use soybean yields for the same experiment area. Soybean [*Glycine max* L. Merr.] yields for Riley County KS were provided by Dr. Kraig Roozeboom for 2007 to 2011 (Roozeboom 2013). Alfalfa [*Medicago sativa* L.] yields were obtained from KFMA enterprise data for two Riley County Kansas farms (Herbel 2013) and the alfalfa data was used as a perennial crop benchmark. Nutrient removal, fertilizer application, and chemical use for 2007 and 2008 were obtained from Propheter (2009). The 2009 and 2010 fertilizer and chemical applications were obtained from field notes (Roozeboom et al. 2011). Kansas State University farm management guides provide the inputs and field operations for alfalfa and soybeans (Dumler and Shoup, 2013; O'Brien and Duncan, 2012, c).

The soil types of the field experiment were Ivan, Kennebec, and Kahola silt loam (fin-silty, mixed, superactive, mesic Cumulic Hapludolls). A randomized complete block experiment with four replications was used. Plot sizes were 6.1 m wide by 10.7 m long (20.01 feet by 35.105 feet). Pioneer '33K40 (Bt) and Pioneer '33K44' (Bt) were the corn hybrids used in the field experiment, and had relative maturity of 114 days. The Sorghum cultivars were: Crosbyton 'GW8528' BMR FS, Land-O-Lankes 'DKS59-09' DP FS, Mississippi State 'M81E' sweet sorghum, Sorghum Partners 'NK300' DP FS, and Sorghum Partners '1990CA' PS sorghum. Soybean varieties used in Propheter (2009) were may not be the same as soybean varieties used in Roozeboom (2013). Perennial grass varieties were 'Kanlow' switchgrass, and 'Kaw' big bluestem. Alfalfa varieties were unavailable. Additional information about the field operations can be found in Propheter (2009).

3.2.b Yield Data

The yield data obtained from Propheter (2009) and Roozeboom et al. (2011) was in metric units (Mg/ha) and was converted to English units (US units) (ton/acre or bushel/acre). Biomass yield data was provided in both fresh and dry matter weights. The oven dried mass of biomass from Propheter (2009) was increased to account for 15% moisture content. This is close to what a farmer harvesting biomass would expect to achieve.

Annual yields from Propheter (2009) and Roozeboom et al. (2011) were determined by averaging the four plot observations of each year for each crop. Annual alfalfa yields in tons per acre were acquired from KFMA farm level data records in Riley County KS (Herbel, 2013) for 2007 to 2011. Annual soybean yields in bushels per acre were from Roozeboom (2013) for 2007 to 2011. The annual average yields years were averaged to create an average crop grain and biomass yield for each crop.

3.2.B.i Annual Crops

Biomass Yields for FEAE, FMGBNRAE, and FMGGBNRAE Scenarios

Table 3.1 reports the grain yields and biomass yields for each of the annual crops when the years 2009 and 2011 are excluded due to incomplete data for some of the crops in these years. The SS crop had the largest annual average yield of biomass at 13.42 tons / acre followed by the PS crop at 11.92 tons / acre and the DP crop at 8.66 tons / acre. Of the sorghums, the GS crop had the lowest average annual biomass yield at 6.37 tons / acre, the BMR crop was close to the GS crop's yield at 6.41 tons / acre. Of the corn crops, the RC crop had the highest biomass yield of 7.25 tons / acre. The CC crop was the lowest total yield of all annual crops with an average annual yield of 6.20 tons / acre.

Biomass Yields for FEA, FMGBNRA, and FMGGBNRA Scenarios

When all available data is considered, and zeroes are not used for missing data observations, the PS crop has a slightly higher yield than the SS crop; 10.48 tons / acre versus 10.31 tons / acre, respectively. These yields are 3.11 tons / acre and 1.44 tons / acre lower, respectively, than when 2009 and 2011 yield observations was excluded. The rank in terms of yield from highest to lowest for the remaining crops did not change. There was no difference in the DP crop, and a difference of less than 0.1 tons / acre for the RC, GS, and BMR crops. The CC crop had a biomass yield of 0.47 tons / acre less when all data was included and zeroes are not used for missing data observations.

Grain Yields for FEAE, FMGBNRAE, and FMGGBNRAE Scenarios

All crops but the PS crop had a grain yield. Table 3.1 reports the annual average grain yields in bushels / acre. When the years of 2009 and 2011 were excluded the RC crop had the largest grain yield of 157.95 bushels / acre. The CC crop was considerably lower at 122.82 bushels / acre. Of the sorghum crops, the DP crop had the highest grain yield at 100.67 bushels / acre and the SS sorghum had the lowest at 34.99 bushels / acre. Soybeans had a grain yield of 58.20 bushels / acre. Soybean yields had complete data from 2007 to 2011, so no soybean yields were excluded.

Grain Yields for FEA, FMGBNRA, and FMGGBNRA Scenarios

When all available data was considered the rank by yield from highest to lowest did not change. However, the yield for the DP crop, GS crop, CC crop, BMR crop, RC crop, and SS crop were 27.42, 24.39, 23.00, 22.68, 22.43, and 13.99 bushels/acre lower, respectively.

3.2.b.i Perennial Crop Yields

Both big bluestem and switchgrass, the grasses, had complete yield data from 2007 to 2011. So the years 2009 and 2011 were never excluded in the economic analysis. Table 3.2 provides the biomass yields for the perennial crops.

3.2.c Field Experiment Annual Crop Methodology

In the field experiment nitrogen (N), phosphorous (P), and potassium (K) was applied to all of the annual crops with the exception of soybean. Nitrogen was applied annually, while P and K were applied less frequently. Weed control was accomplished with herbicides using a no-tillage system. Annual crops were fertilized in early spring (March or April) before planting. The soybean, corn, and sorghum crops were all planted with a no-till row crop planter in late spring (April or May).

Harvest was performed by hand in the center of the plots after the crop had reached maturity and had standard moisture content. This would be at the same time a farm manager would harvest the crop. Depending on the crop, this would be in late September for soybeans and sorghum and late November for corn. The whole plant was harvested, then grain and stover were separated. Grain was threshed and measured. Biomass was measured then dried and measured to ascertain the moisture content of the biomass. Soybeans were harvested with a combine and the stover was spread evenly on the plot. Because the crop was harvested by hand, the residue left on the field was less than a machine could achieve, but Roozeboom, Waite, and McGowan (2013) indicated that the loss would be minimal, as well as the loss due to field traffic, combine chaff loss, and other factors that would occur in field operations. Therefore the yield data was not adjusted from that determined by the experiment.

3.2.d Field Experiment Perennial Crop Methodology

Perennial crops were no-till drilled into soybean residue in late spring and early summer (May and June). Seeding rates were based on pure live seed for big bluestem and switchgrass, while alfalfa was based on pounds of seed per acre.

In year one (establishment) of the perennial crops, big bluestem and switchgrass were not fertilized. Only alfalfa was fertilized in year one, because it was based on the farm management guide recommendations of Dumler and Shoup (2012). Alfalfa fertilizer rates for N, P, and K remained constant though the 10 year production horizon. Alfalfa needs annual fertilizer applications of phosphorus and potassium because it would be harvested while the crop is still growing and the nutrients would not be returned to the root system for winter dormancy. Data on nutrient removal from perennial crops was unavailable from Propheter (2009).

In year two, the grasses were fertilized with N from urea, P from TSP, and K from potash (Propheter, 2009). Although N was not applied in every year of the experiment, it was assumed that the 50 pounds per acre of N would be applied each year to the perennial grasses over 10 year production horizon in the economic analysis. Additional P or K application data for 2009 and 2010 were not available in the experimental data. To account for P and K that would be needed to ensure nutrients were not limiting, an assumption was made that one application occurred in year six, using the actual 2008 rate from the field experiment.

The perennial grasses were harvested after physiological maturity, waiting until the plant goes dormant and the majority of the plant's nutrients have moved to the root system. This minimizes the removal of nutrients. This method only works in perennial crops because the crop has evolved to prepare for its next growing season by recycling as many nutrients as possible.

Weed control was accomplished in the experiment with the use of herbicides in years one and two. In year one, the perennial grasses were mowed for weed control. The cost of mowing was excluded from the economic analysis because a farmer would typically just harvest any weeds as biomass in the first year. In year one, alfalfa would be harvested three times instead of the typical four. In the year of establishment, alfalfa requires 60 to 70 days before harvest can occur (Dixon et al., 2005).

3.3 Input Prices

3.3.a Custom Farming Costs

3.3.a.i Custom Grain Harvest Costs

Custom rates for field operations were obtained from Dhuyvetter (2013). Farm managers may have to move the grain some distance to a storage or selling site. Therefore, grain transport costs were also included in the enterprise budgets. The transport costs for grain were based on a distance of 15 miles from farm to a storage facility (Dhuyvetter 2013). Table 3.3 reports the custom grain harvest costs used in this analysis.

For the economic analysis, it was assumed a farmer would harvest non-soybean crops with a combine, without chaff spreaders turned on, at the highest header height possible, while still harvesting nearly all the grain, to maximize the length of uncut stover left in the field and minimize grain loss in the sieves. There is no need to adjust harvest costs for this type of harvest, as compared with typical harvest procedures, because they are practically identical.

Another alternative that was considered was to combine the sorghum crops, that were harvested for grain with the header as close to the ground as possible, to reduce the number of field passes. This method would allow the residue to be baled directly behind the combine. However, this method was dismissed because it would drastically slow the speed of grain harvest, resulting in more grain loss in the sieves and less stable bales.

3.3.a.ii Custom Biomass Harvest Costs

To determine custom rates for biomass harvesting, a phone survey of seven northeastern Colorado (NE CO) hay producers was conducted. The data collected was for large square bales. The survey costs are for individual field operation instead of the whole harvest operation. Table 3.4 provides the biomass harvest costs, and average weight per bale by crop from the NE CO producer survey. These rates were from producers who had practical experience with harvesting some or all of the crops examined in this study. Additionally, custom harvesting rates for perennial and annual crops should be reasonably similar across the Great Plains region.

Costs of swathing per acre were delineated into using a draper type header, or using a rotary or sickle type head with a conditioner (roller, crimper, etc.). The rotary or sickle type heads were approximately the same cost per acre. The average of these costs were used to calculate the swathing cost. Raking was a per acre cost. Baling and stacking could be done as either a per acre or per bale cost. The drawback of per acre costs is that baling and stacking become more costly, in terms of time, and machinery wear and tear in higher yielding and or more abrasive crops. Per bale costs of baling were the same for perennial biomass crops and annual sorghum crops. Per bale costs of baling were higher for corn stover due to the abrasive nature of the residue.

Different crop residues have different densities. The survey data was used to estimate a weight range for each type of residue. These weight ranges were averaged to create an average weight per bale for each crop. The average weight per bale was then used to determine the number of bales per acre based on the tons per acre harvested (see equation 3.1).

$$(Tons/Acre)/(Tons/Bale) = Bales/Acre \tag{3.1}$$

Once this was completed, the costs of stacking and baling were calculated, and are based on the number of bales per acre, which is a function of tons per acre and bale weights per crop for biomass. Stacking costs, but not transportation costs, are used in the economic analysis because biomass is sold at the edge of the field, FOB (free on board). The purchaser would then pay for loading, unloading, and transport costs.

Dhuyvetter (2013) provides custom harvest rates for swathing, raking, baling, and the whole harvest operation. Dhuyvetter (2013) did not provide harvest costs for round and large square bales or stacking costs. The individual field operation harvest costs from the survey were were similar to the costs from Dhuyvetter (2013). The whole harvest operation costs from Dhuyvetter (2013) and the whole operation cost from the survey data that were used in the economic analysis were relatively similar. The survey data allowed for more explicit accounting of costs and was used instead of the costs from Dhuyvetter (2013).

Crop Residue

For sorghum crops which were harvested for grain, the stover was assumed to be harvested with a draper head in the opposite direction the combine traveled during the grain harvest operation to attempt to harvest the stover knocked down by the grain harvest. Several inches of stover would be left remaining depending on soil type, erosion potential. According to Propheter (2009), approximately 10 cm (3.93 inches) of annual stover was left remaining in the field, data for perennial crops was unavailable. Sorghum crops that were harvested for grain could be swathed with a rotary or sickle type conditioning head, but for every field, field conditions are different. The draper type harvest would be the most common type of biomass harvest method, so it was assumed in this analysis. Sorghum crops that had no grain harvest would be swathed with a rotary or sickle type conditioning head, which would necessitate raking the windrows together for ease of baling.

Corn stover would be harvested with a stalk shredder. The stover would then be baled in large square bales to expedite transport to biomass processing facilities. Round bales could also be used but there is more difficulty in transport of these bales. Finally the bales would be stacked at the edge of the field, where they are typically stored for sale. Because biomass is typically sold at the edge of the field (FOB), transport costs were not included in the analysis.

Perennial Grasses

Perennial grass was harvested once each year. Alfalfa is typically harvested multiple times per year. The average number of cuttings per year in Riley County, KS is four (Llewelyn 2013). To account for four cuttings of alfalfa per year, the per acre harvest cost was multiplied by four. In the first year, alfalfa was only harvested three times to allow for proper establishment (Dixon et al., 2005). The harvest costs ($ / ton) were based on the total annual yields, independent of the distribution of the yields within the year. The sequence of harvest begins with swathing with a conditioner, then letting the crop dry down , and followed by raking. After raking, the crop would be baled and stacked at the edge of the field. No tarps or specialized storage should be necessary. By allowing the grasses to reach maturity, the dry-down time should be relatively short.

3.3.b Seed Costs

3.3.b.i Annual Crop Seed Costs

Seed prices were from Dhuyvetter et al. (2012), and O'Brien and Duncan (2012; a, b, and c). Planting operation costs were from Dhuyvetter (2013). Table 3.5 provides the seeding rates, seed costs, and planting operations costs used in the analysis.

FEA and FEAE Scenarios

Annual crop seeding rates (seeds per hectare) in 2007 and 2008 were from Propheter (2009). These rates were converted into seeds per acre. Seeding rates (seeds per acre) in 2009 and 2010 were from the experiment's field notes (Roozeboom et al., 2011). Soybean seeding rates are from Propheter (2009). The annual seeding rates were averaged for use in the analysis. The sorghum seeding rates were then converted to pounds per acre, because sorghum seed is sold in dollars per pound units. Corn, and soybean seeding rates of total seeds per acre were divided by a 1,000 to obtain a rate of thousands of seeds per acre. Corn and soybean seed is typically in units of dollars per bag. The price per bag was divided by the number of 1,000 seeds per bag to obtain a cost in dollars per 1,000 seeds.

FMGBNRA, FMGBNRAE, FMGGBNRA, and FMGGBNRAE Scenarios

Annual crop seeding rates for all sorghums, soybeans, and corn were from the respective O'Brien and Duncan (2012; a, b, and c) crop budgets. Sorghum seeding rates were in pounds per acre. Corn and soybean seeding rates were in 1,000 of seeds per acre.

3.3.b.ii Perennial Crop Seed Costs

The perennial crops seeding rates in 2007 and 2008 were from the experiment and given in pounds of pure live seed per hectare (Propheter 2009). These rates were converted into pounds of pure live seed per acre. Perennial seed prices in dollars per pound of pure live seed for 2013 were obtained on June 5, 2013 from Sharpe Brothers Seed Company for 2013 (Sharpe Brothers Seed Company,2013). Sharp Brothers reports that due to the recent drought, the seed prices were higher than typical. However, historical data was not available to calculate an average price for a longer period. Switchgrass had to be reestablished in year two of the field experiment but this was taken as a rare occurrence by Roozeboom, Waite, and McGowan (2012) and thus only one seeding rate was provided. Drilling operations costs were provided by Dhuyvetter (2013). Table 3.6 provides the seed costs, seeding rates, and drilling operations costs used in this analysis.

3.3.c Fertilizer Costs

Fertilizer rates are reported in pounds of active ingredient (a.i.) per acre, not in pounds of product (urea, potash, TSP, etc). (For TSP the a.i. is pounds of P_2O_5 not pounds of P, and for potash the a.i. is pounds of K_2O not pounds of K.) Fertilizer prices were from the USDA farm price report April edition (USDA, 2013). Fertilizer prices were verified by Dhuyvetter et al. (2012). Fertilizer prices are in dollars per pound of active ingredient. The rates of application used in the analysis are the same quantity of N, P, and K irrespective of the commercial product used. Table 3.7 reports the fertilizer costs and chemical costs used. The specific rates of fertilizer applied to each annual crop rotation and perennial crop are reported in Appendix B.

3.3.c.i Annual Crops Fertilizer Costs

For the purposes of the analysis, soybeans are planted in the first year with the rotated annual crop following in the second year. Typically farm managers would determine a N credit from soybean when determining the fertilization rate for the following crop with a soil test or other estimation. However the experiment did not alter the N application to the following crop due to a soybean credit (Propheter, 2009). Therefore the FEA and FEAE scenarios do not consider a soybean N credit. The N credit in the scenarios beginning with FMG is 30 pounds of N per acre from O'Brien and Duncan (2012; a, b, and c). This is to adjust fertilizer application and resulting cost.

Appendix B contains the cost of biomass nutrient replacement per ton for the scenarios beginning with FMG (the biomass replacement cost is the same for all scenarios beginning with FMG). Appendix B also contains the cost of grain nutrient replacement per bushel for the FMGGBNRA and FMGGBNRAE scenarios. The 2007 to 2011 yield data was used to determine the nutrient replacement cost that matches the costs faced in the scenarios. The 2007 to 2008 yield data matches the nutrient replacement data from Propheter (2009).

FEA and FEAE Scenarios

Fertilizer use was obtained from Propheter (2009) and Roozeboom et al. (2011). Fertilizer was applied to all annual crops with the exception of soybeans. Nitrogen (N) in the form of urea (46-0-0) was broadcast applied pre-plant (a separate operation before planting). In 2007, nitrogen was applied at a rate of 150 pounds of a.i. per acre. From 2008-2011 nitrogen was applied at a rate of 160 pounds of a.i. per acre. Phosphorous (P) was broadcast applied once in 2008 at 134 pounds of a.i. per acre as triple super phosphorous (TSP) (0-46-0). Potassium (K) was applied at planting in 2007 and 2008 at rates of 159 and 241 pounds of a.i. per acre, respectively, as potash (0-0-60). The experiment data did not include any phosphorous applications after 2008. Phosphorous can be applied once every several years to prevent the soil from being deficient.

These rates were then averaged for each crop. The average N, P, and K was then used as the respective fertilizer rate for each crop. There was no difference between the FEA and FEAE scenarios fertilizer costs. Data from Propheter (2009) did not specify the amount of fertilizer needed for grain separately from that for biomass production, just the whole production system .

FMGBNRA and FMGBNRAE Scenarios

Fertilizer recommendations for all crops were from O'Brien and Duncan (2012, a, b, and c). To replace the nutrients removed through biomass harvesting the nutrient removal data from Propheter (2009) was used. Data for the 2008 and 2009 nutrient removal was averaged and used as annual supplemental fertilizer to the O'Brien and Duncan (2012, a, b, and c) recommendations. The supplemental nutrient expenses were separated from the total fertilizer application recommended by O'Brien and Duncan (2012, a, b, and c). The scenarios ending in AE generally had higher yields but because no nutrient removal data is available for the 2009 and 2011 years (the years excluded from the scenarios ending in AE), there is no difference in fertilizer application rates between the scenarios ending in A and scenarios ending in AE.

FMGGBNRA and FMGGBNRAE Scenarios

Grain nutrient removal and biomass nutrient removal data for 2008 and 2009 was used (Propheter, 2009). The grain nutrient removal and biomass nutrient removal data was averaged to create the fertilizer recommendations for grain and biomass production. Yields determine the quantity of nutrients removed. The scenarios ending in AE generally had higher yields but because nutrient removal data was not available for the 2009 and 2011 years (the years excluded from the scenarios ending in AE), there is no difference in fertilizer application rates between the scenarios ending in A and scenarios ending in AE.

3.3.c.ii Perennial Crops Fertilizer Costs

Switchgrass and big bluestem (perennial grasses) were not fertilized in the first year. In the second year the perennial grasses were fertilized with 40.19 pounds of a.i. per acre of N from urea (32-0-0). Additionally, in the second year 58.85 pounds of a.i. per acre of P from TSP (0-46-0), and 249.07 pounds of a.i. per acre of K from potash (0-0-60) were applied (Propheter, 2009). In the third and fourth years (2009 and 2010) 50 pounds of a.i. per acre of N from urea was applied. The scenarios for perennial grasses assumed that the 50 pounds of a.i. per acre of N would continue to be applied to the perennial grasses over growing horizon. Additional P or K application data for 2009 and 2010 was not available in the experimental data. To account for P and K that would be needed to ensure nutrients were not limiting, an assumption of one application of the 2008 rates (year two of the experiment and scenarios) was applied in year six of the 10 year production horizon. Because the perennial grasses were harvested after physiological maturity the removal of nutrients would be minimized.

Alfalfa had 40 pounds of a.i. per acre of P and 60 pounds of a.i. per acre of K per year applied (Dumler and Shoup, 2012). Alfalfa needs annual fertilizer applications of P and K because it is harvested while the crop is still growing and the nutrients would not be returned to the root system for winter dormancy.

Data on nutrient removal from perennial crops was unavailable from Propheter (2009). Therefore only the application rates from the field experiment and field experiment notes were used.

3.3.d Chemical Costs

Prices for the chemicals are from the Thompson et al. (2013). These prices were verified using the farm management guides by O'Brien and Duncan (2012, a, b, and c) and Dumler and Shoup (2012). Table 3.7 reports the fertilizer costs and chemical costs.

3.3.d.i Annual Crops Chemical Costs

FEA and FEAE Scenarios

Chemical use data was only available for 2007 and 2008 from Propheter (2009). Each crop (corn, sorghum, and soybeans) had different chemicals or rates of application in each year, necessitating a weighted average per acre cost of the chemicals. Chemicals application rates from the field experiment were converted from percent active ingredient per hectare to ounces per acre for calculating the per acre costs of a specific product except glyphosate, which was converted to a generic ounce per acre (equations 3.2, 3.3, and 3.4). Because 2007 and 2008 used different chemicals and application rates, a weighted cost was calculated based on the percentage of each chemicals use pre or post emergence over the 2008 and 2009 growing seasons. The Propheter (2009) data did not specify the amount of chemicals needed for grain separately from that of biomass production, just the whole production system.

$$kilograms\ per\ hectare * .893 = pounds\ of\ active\ ingredient\ per\ acre \tag{3.2}$$

$$\frac{pounds\ of\ active\ ingredient\ per\ acre}{pounds\ of\ active\ ingredient\ per\ gallon} = gallons\ per\ acre \tag{3.3}$$

$$gallons\ per\ acre * 128\ ounces\ per\ gallon = ounces\ per\ acre \tag{3.4}$$

FMGBNRA, FMGBNRAE, FMGGBNRA, and FMGGBNRAE Scenarios

The chemical rates used in these scenarios were from O'Brien and Duncan (2012, a, b, and c) and were in ounces per acre of product.

3.3.d.ii Perennial Crops Chemical Costs

Weed control was accomplished in the experiment with the use of herbicides in year one and two. Most literature indicates that mowing without harvest in the first year is the preferred method of weed control. Typically in the literature, first year harvests (generally a mowing operation) are not counted toward the yield. However, the farmer would typically harvest the weeds in year one (probably mid-year) and incur higher second year fertilizer costs (higher nutrient removal than post-dormancy harvesting). Without data on nutrient removal the second year fertilizer rates and costs were not adjusted from having the first year biomass harvested. Hand weeding was performed in some instances, but according to Roozeboom, Waite, and McGowan (2012) the decrease in yield would be negligible. The use of hand weeding was not considered in the economic analysis nor were the yields adjusted.

Chemical used data was only available for 2007 and 2008 from the experiment. Chemicals were converted from percent active ingredient per hectare of a specific chemical compound to ounces per acre. The chemicals used in 2007 and the rate of application were different from the 2008. The 2007 rates of use were applied in year one of the analysis and 2008 rates of use in the second year of the analysis. No additional chemicals were applied. Alfalfa chemical use each year was from the Dumler and Shoup (2012).

3.3.e Land Rental Costs

Land rental costs were obtained from Dhuyvetter et al. (2012) and reported by three land productivity classes; prime, medium, and marginal. Annual crops and perennial crops have different prime, medium, and marginal land rental costs. For the purpose of the analysis the annual crop scenarios use prime rental rates and perennial crops scenarios use medium rental rates. This assumes prime crop land would most likely be used for annual crop rotations. Perennial crops would be grown on less productive ground, that may be more susceptible to erosion and growing perennial crops reduces the likelihood of erosion occurring. The prime annual cropland rental rate is $139.20 per acre. The median perennial cropland rental rate is $72.00. Table 3.8 reports all three classes of annual and perennial land productivity class rental costs.

3.3.f Interest Rates

Interest costs were calculated for each crop's variable cost, assuming interest accrued on variable inputs for half of a year. Interest rates are from Dhuyvetter et al. (2012). The rate used was 6.5%. A nominal discount rate of 6.5% was used for perennial crops. Using an annual inflation rate of 3%, a real discount rate of 3.40% was derived using equation 3.5 for annualizing costs and returns in the perennial grass and alfalfa scenarios (Williams, 2013).

$$Real\ Discount\ Rate = \frac{(1 + Nominial\ Interest\ Rate)}{(1 + Inflation\ Rate)} - 1 \qquad (3.5)$$

3.4 Output Prices

3.4.a Grain Prices

Grain prices were the 2013 average prices for soybeans, corn, and sorghum from Dhuyvetter (2014). Table 3.9 provides the grain prices used in this analysis.

3.4.b Biomass Prices

Table 3.10 provides the 2013 average biomass prices used for this analysis. Biomass prices were collected from the USDA biomass report, and the KS hay reports from 2007 to 2013 (Pitcock, 2013; Hessman and Hruska, 2013).

The USDA biomass report reported weekly biomass prices for sorghum straw and corn stalks in $/ton range. This range was averaged to provide a average weekly price. The average weekly price was averaged to provide an average annual price, which was used in this analysis.

The KS hay reports had four classes of large square alfalfa bales, round and large square bluestem, round and large square brome grass bales that were collected. Each class of perennial biomass prices were averaged to obtain a period average price and an average annual price. Before September 2, 2009, there were two hay price reports per week. Only the Tuesday report was used because after September 2, 2009, the reports were reduced to one per week which were published on Tuesdays. Some prices were reported in cents per relative feed value (RFV) and were then converted to dollars per ton using the RFV chart provided in the reports (Hessman and Hruska, 2013).

3.4.b.i Annual Crop Biomass Prices

Biomass prices, for annual crops, were the average of the weekly 2013 prices from the USDA biomass report (Pitcock, 2013). The USDA biomass report had weekly prices for most of 2013 and so this price data was used.

3.4.b.ii Perennial Crop Biomass Prices

The 2013 average weekly square bale biomass price from the KS hay report was used (Hessman and Hruska, 2013). Utility grade alfalfa prices were used because these represent the lowest class of alfalfa. The utility price is a guaranteed price the farmer would receive, because as the quality of alfalfa harvested increase so would the price. Inclement weather would create a wide variety of returns within a given year (different quality at each cutting). For the sake of simplicity, the utility prices were used for all cuttings. Big bluestem prices were included in the weekly hay reports, so the average large square bale price was used, because all big bluestem production and costs were reported in large square bales. Switchgrass is not commonly grown or used, so there is no market price for it. Switchgrass is a relative of brome grass and brome grass prices do exist. The brome grass prices were used as a proxy. Brome grass is considered a higher quality grass and the quality of switchgrass as an animal feed has yet to be determined.

3.5 Scenario Format

3.5.a Annual Crop Scenarios

Each annual crop (GS, BMR, PS, DP, SS, and RC) , excluding CC, was planted into soybean residue resulting in a two-year rotation with soybeans. Tables 3.11, 3.12, and 3.13 provide an example for the FEA and FEAE, FMGBNRA and FMGBNRAE, and FMGGBNRA and FMGGBNRAE scenarios.

The first column shows the field operation performed for each crop. The second column is the number of operations or the application rate of the input. The third column reports the appropriate units. The fourth column contains the price or cost per unit and column five shows the units associated with the input on field operation. Column six displays the cost per acre for each field operation or input. Column seven contains cost subtotals for herbicide, fertilizer, planting, harvest, and interest costs, and revenue subtotals for grain and biomass.

Costs were calculated for grain production and biomass production separately, with the exception of the FEA and FEAE scenarios. Fertilizer costs were calculated for farm management guide recommendations incurred by grain production separately from biomass fertilizer replacement costs due to biomass removal. Seed rates and chemical costs were included in grain production costs because these would occur regardless of biomass harvest. Harvest costs were separated for grain and biomass harvest. Total costs for grain production, and biomass production were reported. The total cost for each crop (within the rotation) was then reported. Once the costs are calculated, gross revenue was calculated for grain, biomass and both products (with the exception of the FEA and FEAE scenarios). Net returns are then reported for each crop within the rotation for grain, biomass, and in total. The FEA and FEAE scenarios could only report the total net return.

Field operation costs are summed for all crops and subtracted from the sum of all returns and divided by two (two acres) to calculate the net return per acre of rotation. Per acre of rotation measures, for each field operation, cost, or return, are the sum of that field operation, cost, or return for all crops within the rotation divided by two. The net returns per acre of rotation are reported in four versions; including biomass production while including or excluding land rental rates, and excluding biomass production while including or excluding land rental rates. The four versions of returns per rotation were reported for all annual crop scenarios except the FEA and FEAE scenarios. Net returns for the FEA and FEAE scenarios could only be reported including biomass while including or excluding land rental rates, because biomass production costs could not be separated from grain production costs. Tables 3.12 and 3.13 provide examples of the four versions of the net returns per rotation for the FMGBNRA and FMGGBNRA scenarios, respectively. Table 3.11 provides the FEA and FEAE scenario net return per rotation example.

3.5.a.i Harvest Costs and Revenue

In instances where grain harvest costs are greater than the revenue generated from the grain, no grain harvest occurs in the analysis. In these instances, the biomass harvest operation is different. Instead of using a draper header for the swathing operation, a swather head with a conditioning roller was used. The use of a conditioning roller necessitates raking the swaths of biomass together for more efficient baling.

If the annual crop does not incur grain harvest costs, the rotation is classified as a biomass rotation. In biomass rotation the annual crop, which had grain harvest costs greater than grain revenues, will have all costs and revenues of that crop classified as biomass production expenses and returns. Biomass rotations were fertilized according to the specifications in the scenarios. In the FEA and FEAE scenarios, the fertilizer requirements are from Propheter (2009), and Roozeboom et al. (2011). In the FMGBNRA, and FMGBNRAE scenarios, the fertilizer requirements are from O'Brien and Duncan (2012, a, b, and c) and the average biomass nutrient removal from Propheter (2009). In the FMGGBNRA and FMGGBNRAE scenarios, the fertilizer requirements are the average grain and biomass nutrient removal from Propheter (2009). The grain that was produced and was not harvested still contains nutrients that were removed in harvesting the biomass. Biomass harvesting is considered the primary activity of the annual crop (excluding soybeans) and thus all activities for growing that crop are directly associated with biomass production.

In instances where biomass harvest costs are greater than the revenue generated from the biomass, there will be no biomass harvest. Regardless of whether or not biomass harvest costs are incurred, the rotations that incur grain harvest costs for all crops within the rotation are classified as grain rotations. Biomass harvest is considered a secondary activity in grain rotations, thus only activities and costs directly associated with biomass production are incurred for biomass production. The biomass rotation is the PS rotation in all scenarios.

3.5.a.i FEA and FEAE Scenarios

1. FEA: Field Experiment Annuals scenarios derive all inputs and activities for annual crops from the field experiment from Propheter (2009) and Roozeboom et al. (2011).
2. FEAE: Field Experiments Annuals Excluding scenarios use the same data as the FEA scenarios but exclude all yields from 2009 and 2011 due to incomplete data points in those two years.

Table 3.11 is an example of the FEA and FEAE scenarios for the GS rotation. The input products and rates of application were prescribed by Propheter (2009), Roozeboom et al. (2011), and O'Brien and Duncan (2012, c). Yield data were from Propheter (2009), Roozeboom et al. (2011), and Roozeboom (2012).

3.5.a.ii FMGBNRA and FMGBNRAE Scenarios

3. FMGBNRA: Farm Management Guide Biomass Nutrient Replacement Annuals scenarios use the yield data and the biomass nutrient removal data to estimate supplemental fertilizer due to biomass removal for the annual crops from the field experiment. It derives the field activities, chemical and fertilizer usages from the farm management guides by O'Brien and Duncan (2012; a, b, and c).
4. FMGBNRAE: Farm Management Guide Biomass Nutrient Replacement Annuals Exclude scenarios use the same yield, and inputs as the FMGBNRA scenarios but exclude the yield data from 2009 and 2011 because of missing yield data points.

Table 3.12 provides an example of FMGBNRA and FMGBNRAE scenarios for the GS rotation. The FMGBNRA and FMGBNRAE scenarios were created using the recommended seed, chemical rates and fertilizer rates, from the farm management guide budgets from O'Brien and Duncan (2012, a, b, and c). The FEA and FEAE scenarios used chemicals, chemical application rates, and fertilizer application rates that were not typical. For instance, the use of the chemical Liberty on glyphosate resistant corn isn’t common. Additionally, the experiment was designed so nutrients were not limiting. This resulted in fertilizer rates that were higher than normally used by farm managers from an economic perspective (P and K, especially).

The input rates from O’Brien and Duncan (2012, a, b, and c) were viewed as more in line with a typical farm managers input usage. Yield data from Propheter (2009), Roozeboom et al. (2011) and Roozeboom (2013) were used instead of the farm management guides yields. The fertilizer rates from O’Brien and Duncan (2012, a, b, and c) only take into account grain production nutrient requirements. By harvesting the biomass, nutrients were removed from the system. These needed to be added back. Nutrient removal from biomass was measured by Propheter (2009) in 2007 and 2008 for each crop. These two years of data were averaged to find the average annual replacement required. Biomass nutrient replacement rates of use were then added into FMGBNRA and FMGBNRAE, as a supplement to the O’Brien and Duncan (2012, a, b, and c) recommendations. Lime applications were included in FMGBNRA and FMGBNRAE.

3.5.a.iii FMGGBNRA and FMGGBNRAE Scenarios

5. FMGGBNRA: Farm Management Guide Grain and Biomass Nutrient Replacement Annual scenarios derive yield data from the field experiment, chemical usage and field operations from O'Brien and Duncan (2012; a b, and c). Nutrients removed by grain and biomass are replaced according to the rates of removal from Propheter (2009).
6. FMGGBNRAE: Farm Management Guide Grain and Biomass Nutrient Replacement Annual Exclude scenarios are the same as the FMGGBNRA scenario, but exclude all the 2009 and 2011 yield data due to missing yield data points.

The FMGGBNRA and FMGGBNRAE scenarios were modifications of FMGBNRA and FMGBNRAE. Instead of following the farm management guide fertilizer recommendation, the grain nutrient removal from Propheter (2007 and 2008) was averaged and used as the grain fertilizer. Nutrients removed by grain were replaced and incurred a cost to grain production. Biomass nutrient removal fertilizer requirements were fulfilled by averaging the biomass nutrient removal from 2007 and 2008. Chemical usage was from O'Brien and Duncan (2012, a, b, and c). Soybeans were not fertilized in FMGGBNRA and FMGGBNRAE according to the nutrient removal data but were fertilized according O'Brien and Duncan (2012, a, b, and c) at a rate of 35 pounds of nitrogen per acre. This is assuming that the recommendations were a reasonable approximation of the nutrient removal from the soybean grain. Lime applications were included in both soybean and GS, BMR, DP, SS, PS, RC and CC budgets. Costs were calculated separately for grain production, biomass production, and in total. Returns per crop and rotation followed the same format as the other budgets. Table 3.13 is an example of the FMGGBNRA and FMGGBNRAE scenarios for the BMR rotation.

3.5.b Perennial Scenarios

Two scenarios were created for perennial crops; the FEP scenario was based on Propheter (2009), and the FEPL scenario was the same as the FEP scenario with the addition of lime expenses. The reason for the two scenarios was the alfalfa budget from Dumler and Shoup (2012) contained lime, but the experimental data for switchgrass and big bluestem did not contain lime. Alfalfa scenarios of FMGAL and FMGA reflect the use of lime and without lime, respectively. Alfalfa yield data was obtained from Herbel (2013). Lime applications in FEPL and FMGAL scenarios were annual and applied at the rates of use recommended by Dumler and Shoup (2012).

The perennial rotations, for big bluestem, switchgrass, and alfalfa, were based on 10 years of production. To create the yields for the 10 year production horizon from the 2007 to 2011 data, each year had a different average and was used to create a log style graph. This style of graph was desired because yields increase with crops then reach a plateau and would be taken out of production when yields begin to lag. The year-one yield was set equal to the annual yield of 2007, year two was the annual yield of 2008, and year three was the annual yield of 2009. Year four was the average of the annual 2008 and 2009 yields. The fifth year was the average of the annual 2008 to 2010 yields. Years six through ten are the average of the annual 2009 to 2011 yields. Table 3.14 provides the yields used for the 10 year production horizon for the grasses and alfalfa.

The format is the same for FEP and FEPL scenarios because all that changes is the use and cost of lime. FMGA and FMGAL have the same format as well due to the use and cost of lime, table 3.15 provides an example of the FMGA and FMGAL scenarios.

The first column (referenced by a centered bold number in brackets) of the budget is the field operation or input that is used in producing the crop. The second column has the costs for the input or field operation or returns per unit for the biomass. Columns three through five contain the appropriate units for the input rates and input costs. Columns seven through sixteen contain the yields for each year and the input rates subsequently followed by the per acre costs and then returns. Seeding costs only occurred in the first year of the 10 year production horizon. Input, field operations, and harvest costs are all sub-totaled in cost per acre and cost per ton. Total costs, revenues and net returns are all reported by year and also reported as an annualized value per acre, annualized value per ton, and total net present value in column two. The real discount rate used is 3.4%.

To be able to compare the perennial crop returns to annual crop returns, the perennial returns costs, returns, and net returns were annualized. The cost of the marginal land was included in the annual total cost as well as interest costs. The net present value of years two through ten was calculated and year one's value was added in to give the present value of the cost, return, or net return. To create an annual cost per acre, the net present value was annualized. This allows the net returns from the perennial crops to be compared to annual crops on the annual cost per acre or the cost per ton.

3.5.b.i FEP and FEPL Budget Types

1. FEP: Field Experiment Perennials scenario derives all chemical, fertilizer, and field operations from the field experiment for switchgrass and big bluestem.
2. FEPL: Field Experiment Perennials with Lime scenario are the same as the FEP scenario but include lime applications which were not included in the five years of data

from Propheter (2009) and Roozeboom et al. (2011) but may be applied in a 10 year production horizon.

Table 3.15 provides an example of the FEPL budget for switchgrass.

3.5.b.ii FMGA and FMGAL Budget Types

3. FMGA: Farm Management Guide Alfalfa scenario is a comparative benchmark budget for perennial crops even though alfalfa was not part of the field experiment. Field operations, chemical, and fertilizer use rates, excluding the lime application, are from Dumler and Shoup (2012) and yields are from Herbel (2013). use the Dumler and Shoup (2012) recommendations.
4. FMGAL: Farm Management Guide Alfalfa with Lime scenario is the same as the FMGA scenario with the addition of the lime recommendation from Dumler and Shoup (2012).

Table 3.16 provides an example of the FMGAL budget for alfalfa. The perennial grasses were compared to a typical perennial alfalfa crop produced in Kansas. Because there was no corresponding experiment to use to construct an alfalfa budget, the budget from Dumler and Shoup (2012) was used. This includes seeding, fertilizer, and chemical rates. The rates for harvest were from the NE CO/NW KS producers' survey.

3.6 Sensitivity Analysis

Price and yield sensitivity on net returns was performed on each crop rotation in each scenario. Grain yield and biomass yield were assumed to be perfectly correlated. Yields were varied at a given grain and biomass price level to estimate the yield impact on net returns. Biomass prices and grain prices were assumed to be perfectly correlated. Prices were varied at a given grain yield and biomass yield level to estimate the price impact on net return. When severe to extreme droughts occur it is likely that the crop will not produce grain, which would void the perfect correlation assumption. This study avoided these scenarios by restricting the range of yield changes.

Grain harvest costs were discovered to outweigh the revenue generated by the grain for BMR and PS crops, because yields for these crops were low. Therefore farm managers would be unlikely to harvest those crops for grain. Because the yields of biomass and grain were assumed to be perfectly correlated, there was a chance that the cost of harvesting grain or biomass could outweigh revenue generated by harvesting the grain or biomass as the yields were increased or decreased in sensitivity analysis. The investment of seed, fertilizer, and chemicals would still be incurred. The yield of grain or biomass would be determined by outside factors (weather) but the farm manager would still plan on full production. In instances where the cost of harvest was greater than the revenue generated from the grain or biomass, there was no harvest and no revenue from the crop. Harvest costs were treated like variable costs while inputs were treated like sunk costs.

Chapter 3 Tables and Figures

Table 3.1 Average Grain and Biomass Yields for Annual Crop Rotations by Scenario

	FEA, FMGBNRA, and FMGGBNRA			FEAE, FMGBNRAE, and FMGGBNRAE[1]		
	Bushels per Acre	Tons per Acre	Bales per Acre	Bushels per Acre	Tons per Acre	Bales per Acre
GS	66.96	6.29	11.43	91.36	6.37	11.59
BMR	34.02	6.44	11.71	56.69	6.41	11.65
PS	0.00	10.48	19.05	0.00	11.92	21.67
DP	73.25	8.66	15.75	100.67	8.66	15.74
SS	20.99	10.31	18.75	34.99	13.42	24.41
RC	135.52	7.32	12.46	157.95	7.25	12.35
CC	99.83	5.73	9.74	122.82	6.20	10.55
Soybeans	58.20	0.00		58.20	0.00	

[1] These management scenarios excluded 2007 and 2011 yield data, refer to 3.2.b Yield Data.

Table 3. 2 Perennial Crop Annual Average Yield

Crop	Switchgrass Yield	Big Bluestem Yield	Alfalfa Yield
2007	1.99	2.03	3.01
2008	3.67	3.94	4.39
2009	4.67	2.39	3.68
2010	4.05	1.95	3.47
2011	6.15	5.57	3.48
Average	4.11	3.18	3.60

Table 3. 3 Grain Harvest Costs

	Sorghum	Corn	Soybeans
Base Harvest Rate per Acre	$21.77	$26.36	$26.41
Minimum Premium Yield (bu/acre)	36	74	28
Premium rate per bushel above Minimum Premium Yield	$0.21	$0.21	$0.20
Transportation Cost per Bushel (limit of 15 miles)	$0.19	$0.18	$0.18

Table 3. 4 Producer Survey Biomass Harvest Costs and Average Bale Weights

Field Operation		
Swathing and Conditioning	$ 14.00	/acre
Swathing with Draperhead	$ 18.00	/acre
Stalk Shredding	$ 14.00	/acre
Raking	$ 7.00	/acre
Baling (Alfalfa, Sorghum, Grasses)	$ 14.00	/bale
Baling (Corn Stalks)	$ 15.00	/bale
Stacking	$ 4.00	/bale

Average Weight per Bale (pounds)	
Alfalfa	1650
Corn Stalks	1175
Straw	1100
CRP Grass	1150

Table 3. 5 Annual Seeding Rates, Seed Costs, and Planting Costs for Annual Crops

Crop	For FEA and FEAE from Propheter, 2009		For FMGBNRA, FMGBNRAE, FMGGBNRA, and FMGGBNRAE from O'Brien and Duncan (2012)		Planting Costs all Scenarios from Dhuyvetter, 2013		Seed Costs all Scenarios from Dhuyvetter et al., 2012	
GS	5	lbs/acre	4.67	lbs/acre	$17.47	per acre	$3.60	$/lbs
BMR	5	lbs/acre	4.67	lbs/acre	$17.47	per acre	$3.60	$/lbs
PS	5	lbs/acre	4.67	lbs/acre	$17.47	per acre	$3.60	$/lbs
DP	5	lbs/acre	4.67	lbs/acre	$17.47	per acre	$3.60	$/lbs
SS	5	lbs/acre	4.67	lbs/acre	$17.47	per acre	$3.60	$/lbs
RC	28.27	1000 seeds/acre	27	1000 seeds/acre	$17.47	per acre	$0.37	$/1000 seeds
CC	28.27	1000 seeds/acre	27	1000 seeds/acre	$17.47	per acre	$0.37	$/1000 seeds
Soybeans	110.565	1000 seeds/acre	140	1000 seeds/acre	$16.01	per acre	$3.51	$/1000 seeds

Table 3. 6 Perennial Seeding Rates, Seed Costs, and Drilling Costs

	Seed Prices, 2012		Seeding Rates		Drilling Operation Cost	
Alfalfa	$ 4.43	/lbs	3.0	lbs/acre	$12.46	/acre
Switchgrass	$13.00	/lbs	3.572	lbs of PLS/ac	$12.46	/acre
Big Bluestem	$15.00	/lbs	5.6259	lbs of PLS/ac	$12.46	/acre

Table 3. 7 Fertilizer and Chemical Costs

Chemical Name	Cost	Unit
2,4-D LV Ester	$ 0.23	fl oz
AMSU Adjuvant	$ 0.34	lb
Atrazine	$ 0.12	fl oz
Bicep II Magnum	$ 10.58	qt
Bicep II Magnum + Glyphosate + AMSU Adjuvant	$ 27.87	acre
Buctril + Atrazine	$ 6.34	pint
Callisto	$ 5.50	fl oz
Clarity	$ 0.69	fl oz
Crop Oil Concenterate	$ 0.08	fl oz
Dual II Magnum	$ 1.02	fl oz
Glyphosate	$ 0.11	fl oz
Headline	$ 2.63	oz
Liberty	$ 0.66	fl oz
Porsuit	$ 3.81	fl oz
Roundup Weather Max	$ 0.19	fl oz
Warrior !EC	$ 1.77	fl oz
Fertilizer Name	**Cost**	**Unit**
46-0-0 Urea	$ 0.63	$/lb. of actual N
0-46-0 TSP	$ 0.67	$/lb. of actual P
0-0-60 K	$ 0.50	$/lb of actual K
Lime (with application)	$ 0.05	$/lbs

Table 3. 8 Land Rental Rates per Class for 2013 ($/acre)

	Annual Cropland	Perennial Crop Land
Prime Land	$139.20	$91.20
Medium Land	$116.00	$76.00
Marginal Land	$92.80	$60.80

Table 3. 9 2013 Average Grain Prices for Annual Crops ($ / bushel)[2]

Crop	Price
Soybeans	$13.72
Corn	$5.88
Sorghum (all)	$5.34

Table 3.10 Average 2013 Biomass Prices[3] ($ / ton)

Crop	2013 Average Price
Sorghum Straw	$78.33
Corn Stover	$60.90
Utility Alfalfa	$180.27
Brome	$140.27
Big Bluestem	$140.00

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[2] KSU Cash Grain Price and Basis Database. Data retrieved 3/3/2014

[3] Annual prices from NW-GR-310; Perennial prices from DC-GR-310

Table 3. 11: FEA and FEAE Scenario Example[4]

NT Soybean (Sorghum)						
Soybean						
		Cost				
	Application and Rates		**Prices**		**Cost**	
Herbicide- #1	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	12.57344	fl oz	$ 0.11	fl oz	$ 1.38	
Dual II Magnum	10.6032	fl oz	$ 1.02	fl oz	$ 10.85	
Atrazine	25.7184	fl oz	$ 0.12	fl oz	$ 3.05	
						$ 20.82
Fertilizer-Broadcast	0	application	$ 5.39	acre	$ -	
Urea (46-0-0)	0	lb of N	$ 0.63	$/lb. of actual N	$ -	
TSP (0-46-0)	0	lbs of P	$ 0.67	$/lb. of actual P	$ -	
						$ -
Lime	0	lbs	$ 0.05	$/lbs	$ -	
						$ -
Planting-Notill (Corn Planter)	1	application	$ 16.01	acres	$ 16.01	
Soybean Seed	110.565	1000 seeds	$ 0.37	$/1000 seeds	$ 40.91	
						$ 56.92
Herbicide- #2	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	25.14688	fl oz	$ 0.11	fl oz	$ 2.77	
						$ 8.29
Herbicide - #3	1	application	$ 5.53	acre	$ 5.53	
Glyphosate #2	25.14688	fl oz	$ 0.11	fl oz	$ 2.77	
						$ 8.29
Harvest	1	application	$ 26.41	acres	$ 26.41	
above 28 bu/ac	30.20		$ 0.20	bushels	$ 6.08	
haul (w/in 16 miles)	58.20		$ 0.18	bushels	$ 10.51	
						$ 43.00
Interest	6.5%	per annum	50%	% of year financed		$ 4.46
Total Variable Cost per Acre						**$ 141.78**
		Revenue				
Grain Revenue (yield*$/bu)	58.20	bu/ac	$ 13.72	bushel	$ 798.49	
Return per Acre						**$ 656.71**
		Fixed Costs				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 517.51**
Grain Sorghum (Milo)						
		Costs				
	Application and Rates		**Prices**		**Cost**	
Herbicide #1	1	application	$ 5.53	acre	$ 5.53	
Dual II Magnum	21.2064	fl oz	$ 1.02	fl oz	$ 21.70	
Atrazine	51.4368	fl oz	$ 0.12	fl oz	$ 6.11	
Glyphosate	12.57344	fl oz	$ 0.11	fl oz	$ 1.38	
						$ 34.72
Fertilizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Urea (46-0-0)	158.061	lb of N	$ 0.63	$/lb. of actual N	$ 99.73	
TSP (0-46-0)	67.4215	lbs of P	$ 0.67	$/lb. of actual P	$ 45.03	
						$ 150.16
Lime	0	lbs	$ 0.05	$/lbs	$ -	
						$ -
Planting Notill (Corn Planter)	1	application	$ 17.47	acres	$ 17.47	
GS Seed	5.20	lbs/ac	$ 3.60	$/lbs	$ 18.73	
Potash (0-0-60)	150.024	lbs of K	$ 0.50	$/lb. of actual K	$ 75.45	
						$ 111.65
Herbicide #2	1	application	$ 5.53	acre	$ 5.53	
Clarity	6.00096	fl oz	$ 0.69	fl oz	$ 4.15	
Atrazine	15.7168	fl oz	$ 0.12	fl oz	$ 1.87	
						$ 11.54
Harvest	1	application	$ 21.77	acre	$ 21.77	
above 36 bu/ac	30.96	bu/ac	$ 0.21	bu	$ 6.37	
hauling (w/in 15 miles)	66.96	bu	$ 0.19	bu	$ 12.86	
						$ 41.00
Harvest (Biomass)	1	application				
Swath (with draper)	1	acre	$ 18.00	acre	$ 18.00	
Rake	0	acre	$ 7.00	acre	$ -	
Bale (Lrg Sqr @ approx 1100 lbs)	11.43046984	bale	$ 14.00	bale	$ 160.03	
Stacking	11.43	bale	$ 4.00	bale	$ 45.72	
Loading	6.29	ton	$ 5.00	ton	$ 31.43	
Haul	6.29	ton	$ 2.33	$/ton CS,S,CRP	$ 34.88	
						$ 223.75
Interest	6.5%	per annum	50%	% of year financed		$ 18.62
Total Variable Cost per Acre						**$ 591.44**
Revenue						
Grain Revenue (yield*$/bu)	66.96	bu/ac	$ 5.34	bu	$ 357.62	
Biomass Revenue (yield*$/ton)	6.29	ton/ac	$ 78.33	$/ton	$ 492.46	
					$ 850.09	
Return per Acre						**$ 258.64**
		Fixed Costs				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 119.44**
Net Return on Rotation	**With Land Cost**					**$ 318.48**
	Without Land Cost					**$ 457.68**

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4 Rows highlighted in blue are not included in the cost calculations, these are merely for additional information if the biomass transport costs were to be included in cost calculations.

Table 3. 12: FMGBNRA and FMGGBNRAE Scenario Example

NT Soybean (Sorghum)						
Soybean						
		Cost				
	Application and Rates		**Prices**		**Cost**	
Herbicide- #1	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	24	fl oz	$ 0.11	fl oz	$ 2.64	
AMS	1.5	lb	$ 0.34	lb	$ 0.51	
						$ 8.68
Fertilizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Urea (46-0-0)	0	lbs. of N	$ 0.63	$/lb. of actual N	$ -	
TSP (0-46-0)	35	lbs. of P	$ 0.67	$/lb. of actual P	$ 23.38	
						$ 28.77
Lime	500	lbs.	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting-Notill (Corn Planter)	1	application	$ 16.01	acres	$ 16.01	
Soybean Seed	140	1000 seeds	$ 0.37	$/1000 seeds	$ 51.80	
						$ 67.81
Herbicide- #2	1	application	$ 5.53	acres	$ 5.53	
Roundup Weather Max	22		$ 0.19	fl oz	$ 4.18	
AMS	1.5		$ 0.34	lb	$ 0.51	
						$ 10.22
Harvest	1	application	$ 26.41	acres	$ 26.41	
above 28 bu/ac	30.20		$ 0.20	bushels	$ 6.08	
haul (w/in 16 miles)	58.20		$ 0.18	bushels	$ 10.51	
						$ 43.00
Interest	6.5%	per annum	$ 0.50	% of year financed		$ 5.93
Total Variable Cost per Acre						**$ 188.32**
Revenue						
Grain Revenue (yield*$/bu)	58.20	bu/ac	$ 13.72	bushel	$ 798.49	
						$ 610.17
		Net Income per Acre				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 470.97**
Grain Sorghum (Milo)						
		Costs				
	Application and Rates		**Prices**		**Cost**	
Herbicide #1	1	application	$ 5.53	acre	$ 5.53	
Bicep II Magnum	1.6	qt/ac	$ 10.58	qt	$ 16.93	
						$ 22.46
Fertilizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Fertilizer for Grain						
Urea (46-0-0)	43	lbs. of N	$ 0.63	$/lb. of actual N	$ 27.13	
TSP (0-46-0)	41	lbs. of P	$ 0.67	$/lb. of actual P	$ 27.39	
						$ 59.91
Fertilizer for Stover						
Urea (46-0-0)	63.403	lbs. of N	$ 0.63	$/lb. of actual N	$ 40.01	
TSP (0-46-0)	9.3765	lbs. of P	$ 0.67	$/lb. of actual P	$ 6.26	
						$ 46.27
Lime	500	lbs.	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting Notill (Corn Planter)	1	application	$ 17.47	acres	$ 17.47	
GS Seed	4.67	lbs./ac	$ 3.60	$/lbs	$ 16.81	
Fertilizer for Grain						
Potash (0-060)	0	lbs. of K	$ 0.50	$/lb. of actual K	$ -	
Fertilizer for Stover						$ 34.28
Potash (0-060)	200.4785	lbs. of K	$ 0.50	$/lb. of actual K	100.823979	
						$ 100.82
Herbicide #2	1	application	$ 5.53	acre	$ 5.53	
Buctril + Atrazine	2	pt./ac	$ 6.34	pint	$ 12.68	
						$ 18.21
Harvest	1	application	$ 21.77	acre	$ 21.77	
above 36 bu/ac	30.96	bu/ac	$ 0.21	bu	$ 6.37	
hauling (w/in 15 miles)	66.96	bu	$ 0.19	bu	$ 12.86	
						$ 41.00
Harvest (Biomass)	1	application				
Swath	1	acre	$ 18.00	acre	$ 18.00	
Rake	0	acre	$ 7.00	bale	$ -	
Bale (Lrg Sqr @ approx 1100 lbs.)	11.43046984	bale/ac	$ 14.00	bale	$ 160.03	
Stacking	11.43046984	bale/ac	$ 4.00	bale	$ 45.72	
Loading	6.29	ton	$ 50.00	load	$ 314.34	
Haul	6.29	ton	$ 2.33	$/ton CS,S,CRP	$ 14.62	
						$ 223.75
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 18.55
Interest Grain	6.5%	per annum	$ 0.50	% of year financed		$ 6.49
Interest Biomass	6.5%	per annum	$ 0.50	% of year financed		$ 12.05
Total Variable Cost per Acre						**$ 589.17**
Total Variable Cost per Acre Grain						**$ 206.28**
Total Variable Cost per Acre Biomass						**$ 382.89**
		Revenue				
Grain Revenue (yield*$/bu)	66.96	bu/ac	$ 5.34	bu	$ 357.62	
Biomass Revenue (yield*$/ton)	6.29	ton/ac	$ 78.33	$/ton	$ 492.46	
					$ 850.09	
Return per Acre						**$ 260.92**
Return per Acre Grain						**$ 151.35**
Return per Acre Biomass						**$ 109.57**
		Fixed Costs				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 121.72**
Net Return per Acre Grain						**$ 12.15**
Net Return per Acre Biomass						**$ (29.63)**
Net Return on Rotation	With Biomass	Excluding Land Rent/Charge				$ 435.54
		Including Land Rent/Charge				$ 296.34
	Without Biomass	Excluding Land Rent/Charge				$ 380.76
		Including Land Rent/Charge				$ 241.56

Table 3. 13: FMGGBNRA and FMGGBNRAE Scenario Example

NT Soybean (Sorghum)						
Soybean						
	Cost					
	Application and Rates		**Prices**		**Cost**	
Herbacide- #1	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	24	fl oz	$ 0.11	fl oz	$ 2.64	
AMS	1.5	lb	$ 0.34	lb	$ 0.51	
						$ 8.68
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Urea (46-0-0)	0	lb of N	$ 0.63	$/lb. of actual N	$ -	
TSP (0-46-0)	35	lbs of P	$ 0.67	$/lb. of actual P	$ 23.38	
						$ 28.77
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting-Notill (Corn Planter)	1	application	$ 16.01	acres	$ 16.01	
Soybean Seed	140	1000 seeds	$ 0.37	$/1000 seeds	$ 51.80	
						$ 67.81
Herbacide- #2	1	application	$ 5.53	acres	$ 5.53	
Roundup Weather Max	22		$ 0.19	fl oz	$ 4.18	
AMS	1.5		$ 0.34	lb	$ 0.51	
						$ 10.22
Harvest	1	application	$ 26.41	acres	$ 26.41	
above 28 bu/ac	30.20		$ 0.20	bushels	$ 6.08	
haul (w/in 16 miles)	58.20		$ 0.18	bushels	$ 10.51	
						$ 43.00
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 5.93
Total Variable Cost per Acre						**$ 188.32**
	Revenue					
Grain Revenue (yield*$/bu)	58.20	bu/ac	$ 13.72	bushel	$ 798.49	
Return per Acre						**$ 610.17**
	Fixed Costs					
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 470.97**
BMR Sorghum						
	Costs					
	Application and Rates		**Prices**		**Cost**	
Herbacide #1	1	application	$ 5.53	acre	$ 5.53	
Bicep II Magnum	1.6	qt/ac	$ 10.58	qt	$ 16.93	
						$ 22.46
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Fertalizer Grain						
Urea (46-0-0)	20.008	lb of N	$ 0.63	$/lb. of actual N	$ 12.62	
TSP (0-46-0)	9.823	lbs of P	$ 0.67	$/lb. of actual P	$ 6.56	
						$ 24.58
Fertalizer Biomass						
Urea (46-0-0)	50.901	lb of N	$ 0.63	$/lb. of actual N	$ 32.12	
TSP (0-46-0)	10.716	lbs of P	$ 0.67	$/lb. of actual P	$ 7.16	
						$ 39.28
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting Notill (Corn Planter)	1	application	$ 17.47	acres	$ 17.47	
BMR Seed	4.67	lbs/ac	$ 3.60	$/lbs	$ 16.81	
Fertalizer Grain						
Potash (0-060)	12.502	lbs of K	$ 0.50	$/lb. of actual K	$ 6.29	
Fertalizer Biomass						$ 40.57
Potash (0-060)	148.238	lbs of K	$ 0.50	$/lb. of actual K	$ 74.55	
						$ 74.55
Herbacide #2	1	application	$ 5.53	acre	$ 5.53	
Buctril + Atrazine	2	pt/ac	$ 6.34	pint	$ 12.68	
						$ 18.21
Harvest	1	application	$ 21.77	acre	$ 21.77	
above 36 bu/ac	-	bu/ac	$ 0.21	bu	$ -	
hauling (w/in 15 miles)	34.02	bu	$ 0.19	bu	$ 6.53	
						$ 28.31
Harvest (Biomass)	1	application				
Swath	1	acre	$ 14.00	acre	$ 14.00	
Rake	1	acre	$ 7.00	bale	$ 7.00	
Bale (Lrg Sqr @ approx 1100 lbs)	11.71165652	bale	$ 14.00	acre	$ 163.96	
Stacking	11.71	bale	$ 4.00	bale	$ 46.85	
Loading	6.44	ton	$ 2.00	bale	$ 12.88	
Haul	6.44	ton	$ 2.33	$/ton CS,S,CRP	$ 34.88	
						$ 231.81
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 16.37
Interest Grain	6.5%	per annum	$ 0.50	% of year financed		$ 5.14
Interest Biomass	6.5%	per annum	$ 0.50	% of year financed		$ 11.23
Total Variable Cost per Acre						**$ 520.05**
Total Variable Cost per Acre Grain						**$ 197.16**
Total Variable Cost per Acre Biomass						**$ 356.87**
Revenue						
Grain Revenue (yield*$/bu)	34.02	bu/ac	$ 5.34	bu	$ 181.67	
Biomass Revenue (yield*$/ton)	6.44	ton/ac	$ 78.33	$/ton	$ 504.58	
					$ 686.25	
Return Per Acre						**$ 166.19**
Return Per Acre Grain						**$ (15.49)**
Return Per Acre Biomass						**$ 147.71**
	Fixed Costs					
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 26.99**
Net Return per Acre Grain						**$ (154.69)**
Net Return per Acre Biomass						**$ 8.51**
Net Return on Rotation	With Biomass	Excluding Land Rent/Charge				$ 388.18
		Including Land Rent/Charge				$ 248.98
	Without Biomass	Excluding Land Rent/Charge				$ 297.34
		Including Land Rent/Charge				$ 158.14

Table 3. 14 Perennial Yields Over the 10 Year Production Horizon [5]

Crop	Switchgrass Yield (tons/acre)	Switchgrass Yield (Bales/acre)	Big Bluestem Yield (tons/acre)	Big Bluestem Yield (Bales/acre)	Alfalfa Yield (tons/acre)	Alfalfa Yield (Bales/acre)
Year 1	1.99	3.47	2.03	3.53	3.01	3.64
Year 2	3.67	6.38	3.94	6.86	4.39	5.32
Year 3	4.67	8.12	2.39	4.15	3.68	4.46
Year 4	4.17	7.25	3.16	5.50	4.03	4.89
Year 5	4.13	7.18	2.76	4.80	3.84	4.66
Year 6	4.96	8.62	3.30	5.74	3.54	4.29
Year 7	4.96	8.62	3.30	5.74	3.54	4.29
Year 8	4.96	8.62	3.30	5.74	3.54	4.29
Year 9	4.96	8.62	3.30	5.74	3.54	4.29
Year 10	4.96	8.62	3.30	5.74	3.54	4.29

[5] Refer to 3.5.b Perennial Scenarios for more information on how these yields were calculated.

Table 3. 15: FEP and FEPL Scenario Example

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
Grass Budget															
Switchgrass		**Number of Years**	**10**												
						Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
						Biomass Removal tons/acre									
Yield															
Yield (tons/acre)						2.0	3.7	4.7	4.2	4.1	5.0	5.0	5.0	5.0	5.0
Applications															
Urea N				lbs/acre			40.19	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Phosphorus P				lbs/acre			58.85				58.85				
Potassium K				lbs/acre			249.07				249.07				
Lime				lbs/acre		333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00
Chemicals															
Glyphosate				oz/acre		22.38									
2,4-D LV Ester				oz/acre		14.23									
Clarity (dicambia)				oz/acre			10.69								
Crop Oil Concentrate (adjuvant)				oz/acre		12.87	31.50								
Atrazine				oz/acre											
Input Costs															
Seed	$13.00	$/lb	3.572	lbs/acre		$46.44									
Fertalizer (Costs)															
Urea N	$0.63	$/lb.					$25.36	$31.55	$31.55	$31.55	$31.55	$31.55	$31.55	$31.55	$31.55
Phosphorus P	$0.67	$/lb.					$39.30				$39.30				
Potassium K	$0.50	$/lb.					$125.26				$125.26				
Lime	$0.05	$/lb.				$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93
Chemicals															
Glyphosate	$0.11	$/oz				$2.46									
2,4-D LV Ester	$0.23	$/oz				$3.33									
Clarity (dicambia)	$0.69	$/oz					$7.39								
Crop Oil Concentrate (adjuvant)	$0.08	$/oz				$1.01	$2.46								
Atrazin	$0.12	$/oz													
Total ($/acre)						$69.16	$215.71	$47.48	$47.48	$47.48	$212.05	$47.48	$47.48	$47.48	$47.48
Total ($/ton)						$34.68	$58.77	$10.17	$11.39	$11.49	42.77310025	$9.58	$9.58	$9.58	$9.58
Summary of Input Costs															
Input Costs/Acre PV Years 1-10	$734.04														
Amortized Input Costs/Acre Years 1-10	$87.81														
Total Tons produced over Years 1-10	43.4														
Input Cost/Ton of PV Years 1-10	$16.90														
Field Operations Costs															
Planting (Drill) without Fert (Year 1 Only)	$12.46	$/acre				$12.46									
Fertilizer (Broadcast)	$5.39	$/acre					$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Chemical (Spray)	$5.53	$/acre				$5.53	$5.53								
Total ($/acre)						$17.99	$10.92	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Total ($/ton)						$9.02	$2.97	$1.15	$1.29	$1.31	$1.09	$1.09	$1.09	$1.09	$1.09
Summary of Field Operations															
Field Operations Cost/Acre PV Years 1-10	$64.54														
Amortized Field Operations Cost/Acre Years 1-10	$7.72														
Total Tons produced over Years 1-10	43.4														
Field Operations Cost/Ton PV Years 1-10	$1.49														
Harvest Costs (Years 2-10, 13-22)															
Swathing	$14.00	$/acre				$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00
Sideraking	$7.00	$/acre				$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00
Baling	$14.00	$/bale				$48.56	$89.37	$113.68	$101.52	$100.58	$120.71	$120.71	$120.71	$120.71	$120.71
Stacking	$4.00	$/bale				$13.87	$25.53	$32.48	$29.01	$28.74	$34.49	$34.49	$34.49	$34.49	$34.49
Harvest Cost															
Total ($/acre)						$90.43	$142.90	$174.17	$158.53	$157.31	$183.19	$183.19	$183.19	$183.19	$183.19
Total ($/ton)						$45.34	$38.93	$37.30	$38.02	$38.08	$36.95	$36.95	$36.95	$36.95	$36.95
Summary of Harvest Operations															
Harvest Cost/Acre PV Years 1-10	$1,398.31														
Amortized Harvest Cost/Acre Years 1-10	$167.27														
Total Tons produced over Years 1-10	43.4														
Harvest Cost/Ton PV Years 1-10	$32.20														
Interest on Operating Costs	6.50%	%/year				$5.77	$12.01	$7.38	$6.87	$6.83	$13.02	$7.67	$7.67	$7.67	$7.67
Total ($/acre)						$5.77	$12.01	$7.38	$6.87	$6.83	$13.02	$7.67	$7.67	$7.67	$7.67
Total ($/ton)						$2.89	$3.27	$1.58	$1.65	$1.65	$2.63	$1.55	$1.55	$1.55	$1.55
Land Charge															
Rental rate ($/acre) (Medium Land)						$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00
Total Costs															
Total ($/acre)						$259.35	$457.53	$310.42	$294.28	$293.02	$489.65	$319.74	$319.74	$319.74	$319.74
Total ($/ton)						$130.05	$124.66	$66.48	$70.57	$70.93	$98.77	$64.50	$64.50	$64.50	$64.50
Summary of Costs				Total ($/acre)		$259.35	$457.53	$310.42	$294.28	$293.02	$489.65	$319.74	$319.74	$319.74	$319.74
Total Cost/Acre PV Years 1-10	$2,925.20														
Amortized Total Cost/Acre Years 1-10	$349.93														
Total Tons produced over Years 1-10	43.4														
Total Cost/Ton PV Years 1-10	$67.37														
Price Received $/Ton FOB				Price ($/ton)	$	140.27	$140.27	$ 140.27	$140.27	$ 140.27	$ 140.27	$140.27	$140.27	$140.27	$140.27
Revenue				Total ($/acre)	$	279.74	$514.85	$ 654.96	$584.91	$ 579.44	$ 695.41	$695.41	$695.41	$695.41	$695.41
Summary of Revenue				Total ($/acre)		$279.74	$514.85	$654.96	$584.91	$579.44	$695.41	$695.41	$695.41	$695.41	$695.41
Revenue/Acre PV Years 1-10	$5,181.26														
Amortized Revenue/Acre Years 1-10	$619.80														
Total Tons produced over Years 1-10	43.4														
Revenuet/Ton PV Years 1-10	119.3230684														
Summary of Net Return				Total ($/acre)		$20.39	$57.32	$344.54	$290.63	$286.42	$205.75	$375.67	$375.67	$375.67	$375.67
Net Return/Acre PV Years 1-10	$2,256.06			Total ($/ton)	$	10.22	$ 15.62	$ 73.79	$ 69.70	$ 69.34	$ 41.50	$ 75.78	$ 75.78	$ 75.78	$ 75.78
Amortized Net Return/Acre Years 1-10	$269.88														
Total Tons produced over Years 1-10	43.4														
Net Return/Ton PV Years 1-10	$51.96														
Nominal Discount Rate (annual)	6.50%														
Inflation (annual)	3.00%														
Real Discount Rate (annual)	3.40%														
http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.aspx		2.90%													

Table 3. 16: FMGA and FMGAL Scenario Example

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
Grass Budget															
Bigblue Stem		**Number of Years**	**10**												
						Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
						Biomass Removal tons/acre									
Yield															
Yield (tons/acre)						3.0	4.4	3.7	4.0	3.8	3.5	3.5	3.5	3.5	3.5
Applications															
Urea N				lbs/acre											
Phosphorus P				lbs/acre		40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Potassium K				lbs/acre		60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Lime				lbs/acre											
Chemicals															
Pursuit				oz/acre		1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Warrior 1EC				oz/acre		3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
				oz/acre											
				oz/acre											
				oz/acre											
Input Costs															
Seed	$4.43	$/lb	3	lbs/acre		$13.29									
Fertalizer (Costs)															
Urea N	$0.63	$/lb.													
Phosphorus P	$0.67	$/lb.				$26.72	$26.72	$26.72	$26.72	$26.72	$26.72	$26.72	$26.72	$26.72	$26.72
Potassium K	$0.50	$/lb.				$30.18	$30.18	$30.18	$30.18	$30.18	$30.18	$30.18	$30.18	$30.18	$30.18
Lime	$0.05	$/lb.													
Chemicals															
Pursuit	$3.81	$/oz				$4.57	$4.57	$4.57	$4.57	$4.57	$4.57	$4.57	$4.57	$4.57	$4.57
Warrior 1EC	$1.77	$/oz				$5.31	$5.31	$5.31	$5.31	$5.31	$5.31	$5.31	$5.31	$5.31	$5.31
		$/oz				$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
		$/oz				$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
		$/oz				$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total ($/acre)						$80.06	$66.77	$66.77	$66.77	$66.77	$66.77	$66.77	$66.77	$66.77	$66.77
Total ($/ton)						$26.63	$15.22	$18.16	$16.56	$17.37	$ 18.85	$18.85	$18.85	$18.85	$18.85
Summary of Input Costs															
Input Cost/Acre PV Years 1-10	$590.46														
Amortized Input Cost/Acre Years 1-10	$70.63														
Total Tons produced over Years 1-10	36.7														
Input Cost/Ton PV Years 1-10	$16.11														
Field Operations Costs															
Planting (Drill) without Fert (Year 1 Only)	$12.46	$/acre				$12.46									
Fertilizer (Broadcast)	$5.39	$/acre				$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Chemical (Spray)	$5.53	$/acre				$5.53									
Total ($/acre)						$23.38	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Total ($/ton)						$7.78	$1.23	$1.47	$1.34	$1.40	$1.52	$1.52	$1.52	$1.52	$1.52
Summary of Field Operations Costs															
Field Operations Cost/Acre PV Years 1-10	$64.58														
Amortized Field Operations Cost/Acre Years 1-10	$7.73														
Total Tons produced over Years 1-10	36.7														
Field Operations Cost/Ton PV Years 1-10	$1.76														
Harvest Costs			# of cutting	4											
Swathing	$14.00	$/acre				$42.00	$56.00	$56.00	$56.00	$56.00	$56.00	$56.00	$56.00	$56.00	$56.00
Sideraking	$7.00	$/acre				$21.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00
Baling	$14.00	$/bale				$42.00	$74.46	$62.38	$68.42	$65.23	$60.10	$60.10	$60.10	$60.10	$60.10
Stacking	$4.00	$/bale				$12.00	$21.28	$17.82	$19.55	$18.64	$17.17	$17.17	$17.17	$17.17	$17.17
Harvest Cost															
Total ($/acre)						$117.00	$179.74	$164.20	$171.97	$167.87	$161.27	$161.27	$161.27	$161.27	$161.27
Total ($/ton)						$38.92	$40.96	$44.67	$42.65	$43.67	$45.54	$45.54	$45.54	$45.54	$45.54
Summary of Harvest Costs															
Harvest Cost/Acre PV Years 1-10	$1,385.74														
Amortized Harvest Cost/Acre Years 1-10	$165.77														
Total Tons produced over Years 1-10	36.7														
Harvest Cost/Ton PV Years 1-10	$37.81														
Interest on Operating Costs	6.50%	%/year				$7.16	$8.19	$7.68	$7.93	$7.80	$7.59	$7.59	$7.59	$7.59	$7.59
Total ($/acre)						$7.16	$8.19	$7.68	$7.93	$7.80	$7.59	$7.59	$7.59	$7.59	$7.59
Total ($/ton)						$2.38	$1.87	$2.09	$1.97	$2.03	$2.14	$2.14	$2.14	$2.14	$2.14
Land Charge															
Rental rate ($/acre) (Medium Land)						$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00
Total Costs															
Total ($/acre)						$303.61	$336.09	$320.05	$328.07	$323.84	$317.02	$317.02	$317.02	$317.02	$317.02
Total ($/ton)						$101.00	$76.59	$87.06	$81.37	$84.24	$89.52	$89.52	$89.52	$89.52	$89.52
Summary of Costs				Total ($/acre)		$303.61	$336.09	$320.05	$328.07	$323.84	$317.02	$317.02	$317.02	$317.02	$317.02
Total Cost/Acre PV Years 1-10	$2,764.01														
Amortized Total Cost/Acre Years 1-10	$330.64														
Total Tons produced over Years 1-10	36.7														
Total Cost/Ton PV Years 1-10	$75.41														
Price Received $/Ton FOB				Price ($/ton)		$180.27	$180.27	$180.27	$180.27	$180.27	$180.27	$180.27	$180.27	$180.27	$180.27
Revenue				Total ($/acre)		$541.90	$791.04	$662.68	$726.86	$693.00	$638.44	$638.44	$638.44	$638.44	$638.44
Summary of Revenue				Total ($/acre)		$541.90	$791.04	$662.68	$726.86	$693.00	$638.44	$638.44	$638.44	$638.44	$638.44
Revenue/Acre PV Years 1-10	$5,719.81														
Amortized Revenue/Acre Years 1-10	$684.23														
Total Tons produced over Years 1-10	36.7														
Revenuet/Ton PV Years 1-10	$ 156.05														
Summary of Net Return				Total ($/acre)		$238.29	$454.95	$342.63	$398.79	$369.16	$321.41	$321.41	$321.41	$321.41	$321.41
Net Return/Acre PV Years 1-10	$2,955.80			Total ($/ton)		$79.27	$103.68	$93.21	$98.91	$96.03	$90.76	$90.76	$90.76	$90.76	$90.76
Amortized Net Return/Acre Years 1-10	$353.59														
Total Tons produced over Years 1-10	36.7														
Net Return/Ton PV Years 1-10	$80.64														
Nominal Discount Rate (annual)	6.50%														
Inflation (annual)	3.00%														
Real Discount Rate (annual)	3.40%														
http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.aspx		2.90%													

Chapter 4 - Results and Analysis

4.1 Overview

The annual scenarios analyzed are Field Experiment Annuals (FEA), Field Experiment Annuals Excluding 2009 and 2011 yield data (FEAE), Farm Management Guide Biomass Nutrient Replacement Annuals (FMGBNRA), Farm Management Guide Biomass Nutrient Replacement Annuals Excluding 2009 and 2011 yield data (FMGBNRAE), Farm Management Guide Grain and Biomass Nutrient Replacement Annuals (FMGGBNRA), and Farm Management Guide Grain and Biomass Nutrient Replacement Annuals Excluding 2009 and 2011 yield data (FMGGBNRAE). Annual crops rotated with soybeans are grain sorghum (GS), brown mid-rib sorghum (BMR), photoperiod sensitive sorghum (PS), dual purpose sorghum (DP), and rotated corn (RC). Continuously cropped corn (CC) is compared to the rotations.

The perennial scenarios analyzed are Farm Management Guide Alfalfa (FMGA), Farm Management Guide Alfalfa with Lime (FMGAL), Field Experiment Perennial (FEP), and Field Experiment Perennial with Lime (FEPL). Big bluestem grass, and switchgrass were the perennial crops from the field experiment included in the FEP and FEPL scenarios. Alfalfa was used as a benchmark crop to help evaluate big bluestem and switchgrass economic feasibility.

Costs and returns were calculated for each crop rotation in each scenario. These costs and returns were then used to provide a comparison across crop rotations within each scenario. Sensitivity analysis was performed by varying the price of grain, the price of biomass, and the yields of biomass and grains. For the purpose of the results and analysis, it was assumed each type of grain and biomass was marketable (e.g. grain from sweet sorghum was conventionally marketable and did not require niche marketing).

In instances where grain harvest occurs for a crop within a rotation, the biomass specific input expenses (fertilizer and harvest costs) and output revenues are viewed as separable and in addition to the grain input costs and output revenues. Biomass production, in these instances, is a secondary, or added value, activity to grain production for that crop within a given rotation. There are two instances, disregarding sensitivity analysis, which grains are not harvested for a specific crop in all scenarios. The PS sorghum crop does not produce grain while the soybean components of those rotations produce grain. The PS sorghum crop costs are incurred solely for biomass production in each scenario. The PS crop is designated as primary biomass crop rotations for every scenario, while all other crops within each scenario are primarily grain crop rotations.

Each annual crop rotation (GS, BMR, PS, DP, SS, RC, and CC) for each scenario (FEA, FEAE, FMGBNRA, FMGBNRAE, FMGGBNRA, and FMGGBNRAE) was compared to one another. This analysis shows the major differences in the results due to differences in the scenarios. If the costs and net returns across all scenarios for a given rotation are similar, this indicates the robustness of the general results. If the costs and net returns across all scenarios for a given rotation have major disparities, it is worthwhile to examine why these differences exist and if these differences are significant.

Price and yield sensitivity on net returns was performed on each crop rotation for the most realistic scenarios. Grain yield and biomass yield were assumed to be perfectly correlated. Yields were varied at given grain and biomass price levels to estimate the yield impact on net returns. Biomass prices and grain prices were assumed to be perfectly correlated. Prices were varied at given grain yield and biomass yield levels to estimate the price impact on net return. Prices and yields were varied by increasing and decreasing the values used in the original analysis by increments of 5%, 10% and 25%. Alternative price sensitivity analysis was performed on the most realistic annual and perennial scenarios. The sensitivity to fertilizer timing was performed on the most realistic perennial grasses scenario.

4.2 Annual Scenarios: Crop Rotation Comparison

4.2.a FEA Scenario

Table 4.1 provides fertilizer and chemical costs per acre, harvest costs per acre of rotation, harvest costs per ton of rotation, total costs per rotation, gross returns per acre of rotation, and net returns per acre of rotation for each crop in given the FEA scenario.

4.2.a.i FEA Costs

Fertilizer Costs

Fertilizer and chemical costs ranged from $154.64 per acre of rotation to $278.43 per acre of rotation. All sorghum crop rotations had the same fertilizer and chemical costs and also had the smallest costs. The CC rotation had the maximum fertilizer and chemical costs.

Harvest Costs

Grain harvest costs for the rotations ranged from $21.50 per acre of rotation to $52.89 per acre of rotation; with the PS rotation having the lowest and with the RC rotation having the maximum. The RC rotation had high grain yields and the CC rotation had the second highest yielding rotation. The biomass rotation only had grain harvested for the soybean portion of the rotation. The SS and BMR rotations had the second and third lowest grain harvest cost per acre of rotation, respectively. These differences are based solely on yield, with higher yielding crops incurring higher per acre costs.

Biomass harvest costs ranged from $111.87 per acre of rotation for GS to $199.15 per acre of rotation for CC. The BMR and RC rotations had relatively low biomass harvest costs. The CC crop had the highest quantity of bales produced, but not the highest tons per acre. The number of bales per acre is the variable harvest cost term that is the most important, because there is a cost for stacking and baling associated with bales per acre. The CC and RC bales are the densest which leads to lower numbers of bales per acre versus sorghum bales. The RC rotation had the maximum biomass yield (in tons per acre), with the SS and PS rotations being close to the maximum. The biomass rotation used both swathing and raking operations while grain rotations used only draper head swathing.

Total harvest costs (both grain and biomass costs collectively) ranged from $151.56 for BMR per acre of rotation to $248.24 for CC per acre of rotation. These cost differences were due mainly to differences in yields. The lack of grain yield for the PS rotation reduced the number of harvest operations, and thus reduced its costs. The CC rotation had the highest biomass harvest cost which was triple its grain harvest cost, and was as large or larger than four rotations total harvest costs. The costs of harvesting biomass were larger than the costs of grain harvest.

Per Ton Costs

Total biomass harvest costs per ton of biomass produced ranged from $34.25 per ton of biomass produced for the RC rotation to $35.99 per ton of biomass produced for the GS rotation. Biomass harvest costs per ton are non-linear in yield. As yield increases the per ton cost of harvest decreases, causing the fixed costs of harvesting biomass to be spread over more tons. The lowest biomass yielding rotations have the highest costs per ton, and vice versa.

Costs of biomass production are not completely separable from grain production costs in the FEA scenarios, with the exception of harvest costs. Complete variable costs per ton of biomass production are not calculable. Production costs are all costs associated with growing and harvesting the crop. These include seed, chemicals, fertilizer, planting operations, application operations and harvesting operations.

Total Costs

Total costs per acre of rotation is the only total cost metric available because costs could not be delineated by grain producing activities or biomass producing activities individually, but only as a complete system of costs. Total costs per acre of rotation ranged from $503.42 per acre of rotation for BMR to $798.86 per acre of rotation for CC. The GS rotation had the second lowest total cost. These are mainly dependent on the grain and biomass yields, and also the type of crop grown within the rotation affects the cost of seeds.

4.2.a.ii FEA Gross Returns

Grain production gross returns ranged from $399.25 per acre of rotation for PS to $798.86 per acre of rotation for RC. Soybeans had the highest price per bushel at $13.72 per bushel and the sorghum crops' grain price was the lowest at $5.34 per bushel. The RC rotation had high corn yields coupled with a $5.88 per bushel price and the standard soybean return. The high corn yield and a price which was $0.54 per bushel higher than sorghum made the RC rotation a better performer than the other rotations. The DP rotation had the second highest grain net return. The CC rotation had the third highest grain returns, although it had the highest corn yields, but did not have the standard soybean return. The PS rotation had the lowest grain return due to soybeans being the only crop which was harvested for grain.

Biomass production gross returns ranged from $222.97 per acre of rotation for RC to $410.31 per acre of rotation for PS rotation. Sorghum biomass prices were $78.33 per ton, while corn stover biomass prices were $60.90 per ton. The CC rotation had the highest yielding biomass but due to lower prices per ton received, it had less revenue than the PS and SS rotations. The SS rotation was close to PS in yield and gross return. The GS and BMR rotations had lower biomass yields than the RC rotation, but due to higher prices for sorghum biomass, the GS and BMR rotations had slightly higher gross returns.

Total gross returns ranged from $742.37 per acre of rotation for BMR to $1,020.92 per acre of rotation for RC. The CC and DP rotations had the second and third highest gross returns, respectively. The higher grain gross returns of the RC rotation overcame its low biomass gross returns. The grain gross returns in all grain rotations were significantly higher than the biomass gross returns. In biomass rotation, the grain gross return from soybeans and biomass gross returns were roughly equal.

4.2.a.iii FEA Net Returns

Net returns per acre of rotation could not be separated into net returns for grain or biomass individually. Net returns ranged from $137.19 per acre of rotation for CC to $426.86 per acre of rotation for RC. The DP rotation was close to the maximum and the BMR and PS rotations were close to the minimum. The RC rotation had the second highest total cost and the highest gross returns, thus it was the highest net return per acre of rotation. The DP rotation had the third lowest cost, the third highest grain yield and fourth highest biomass yield which caused it to outperform the CC rotation which had higher costs and higher gross returns. The biomass rotation (the PS rotation) was among the lowest net returns because they didn't receive any grain revenue in addition to the soybean grain revenue.

4.2.a.iv FEA Scenario Conclusions

Figure 4.1 provides a bar chart of total costs, gross returns, and net returns for the FEA scenario. The GS and BMR rotations performed the worst in terms of biomass yields and had the highest harvest costs per ton of biomass. CC and SS both had some of the lowest harvest costs per ton of biomass. As yields increase, the cost per acre increases, but the fixed costs per acre of harvesting are distributed across more tons per acre, thus lowering per ton costs.

The PS rotation has no harvestable sorghum grain production, so this rotation only incurred grain harvest costs for the soybeans. The PS crops was among the lowest net return rotations while rotations that were composed entirely of grain crops performed markedly better in terms of net returns, excluding the CC and BMR rotations. The RC and DP rotations had the highest net returns per acre in the FEA scenario. The SS, and GS rotations were average net return performers. The CC rotation didn't perform well because of higher costs which reduced the profitability of one of the highest yielding rotations.

In the PS rotation grain harvest costs for the biomass crop (not soybeans) were greater than the potential grain revenue. Biomass harvest costs were always less than the revenue generated from the biomass for every rotation. In the FEA scenario, the profitability of biomass production was indeterminable.

4.2.b FEAE Scenario

Table 4.2 provides fertilizer and chemical costs per acre, harvest costs per acre of rotation, harvest costs per ton of rotation, total costs per rotation, gross returns per acre of rotation, and net returns per acre of rotation for the FEAE scenario. In this set of scenarios (all scenarios ending with an E) 2009 and 2011 yield data were excluded due to an incomplete data set. This generally led to a higher average yield of grain and biomass.

4.2.b.i: FEAE Costs

Fertilizer Costs

Fertilizer and chemical costs ranged from $154.64 per acre of rotation to $278.43 per acre of rotation. All sorghum crop rotations had the same fertilizer and chemical costs and also had the smallest costs. The CC rotation had the maximum fertilizer and chemical costs.

Harvest Costs

Grain harvest costs for the rotations ranged from $21.50 per acre of rotation for PS to $57.91 per acre of rotation for CC. The RC rotation was close to the maximum grain harvest cost. The CC rotation had the highest yielding rotation. The PS rotation only had a harvest operation for soybeans, and thus much lower costs.

Biomass harvest costs ranged from $113.32 per acre of rotation for GS to $228.68 per acre of rotation for SS. The BMR and RC rotations were close to the minimum biomass harvest cost. The CC and PS rotations were close to the maximum biomass harvest cost. The SS rotation had the highest yielding rotation in tons per acre and bales per acre. The PS rotation had more bales per acre than the CC rotation, while the CC rotation had more tons per acre, and a higher cost of biomass harvest than the PS rotation. The GS, RC and BMR rotations had the lowest yields of tons and bales per acre. The biomass rotation also incurred higher fixed portions of their costs due to different field operations. The biomass rotation used both swathing and raking operations, while grain rotations used only draper head swathing.

Total harvest costs (both grain and biomass costs) ranged from $155.31 per acre of rotation for BMR to $272.30 per acre of rotation for CC. The SS rotation was close to the maximum total harvest cost and the GS rotation was close to the minimum total harvest cost. Total harvest costs are a combination of the grain and biomass harvest costs. The rotations with the highest yields had the highest costs, and vice versa. The CC rotation had the highest grain and close to the highest biomass yields, and thus had the highest total harvest cost per acre of rotation. The costs of harvesting biomass were larger than the costs of grain harvest.

Per Ton Costs

Biomass harvest costs per ton of biomass produced were calculable and ranged from $34.07 per ton of biomass for SS to $36.00 per ton of biomass for GS. The PS, RC, and CC rotations were close to the minimum. The harvest costs per ton of biomass are nonlinear, as yield increases the cost per ton decreases. The highest yielding rotations had low per ton harvest costs because the fixed portion of the harvests was spread amongst more tons of yield.

Costs of biomass production were not separable from grain production costs in the FEAE scenario, so costs per ton of biomass production are not calculable. Thus the variable cost per ton of biomass produced could not be determined.

Total Costs

Total costs per acre of rotation are the only total cost metric available because costs could not be delineated by grain producing activities or biomass producing activities individually, but only as a complete system of costs. Total costs per acre of rotation ranged from $497.74 per acre of rotation for BMR to $823.71 per acre of rotation for CC. The GS rotation had the second lowest total cost. These are mainly dependent on the grain and biomass yields. Also the type of crop grown within the rotation affects the cost of seeds which isn't included in any of the above measures, for instance corn has a high seed cost due to the population (seeds per acre) and the cost per seed.

4.2.b.ii FEAE Gross Returns

Grain production gross returns ranged from $399.25 per acre of rotation for PS to $863.95 per acre of rotation for RC. Soybeans had the highest price per bushel at $13.72 per bushel and the sorghum crops' grain price was the lowest at $5.34 per bushel. The RC rotation had high corn yields coupled a $5.88 price per bushel and the standard soybean return. The high corn yield and a price which was $0.54 per bushel higher than sorghum made the RC rotation a better performer than the other rotations. The CC rotation was second in grain returns due to the highest corn yields. The PS rotation had the lowest grain return due to soybeans being the only crop which was harvested for grain.

Biomass production gross returns ranged from $220.88 per acre of rotation for RC to $525.81 per acre of rotation for SS. Sorghum biomass prices were $78.33 per ton, while corn stover biomass prices were $60.90 per ton. The SS rotation had the highest yielding biomass crop and outperformed the PS rotation in gross returns. The PS rotation was close to SS in yield and return, CC was a distant third in returns. The GS and BMR rotations yielded lower than the RC rotation, but due to higher prices the GS and BMR rotations had slightly higher gross returns.

Total gross returns ranged from $801.67 per acre of rotation for BMR to $1,100.05 per acre of rotation for CC. The RC, SS, and DP rotations were the second, third, and fourth closest to the maximum. The higher biomass gross returns of the CC rotation caused it to outperform the RC rotation even though the RC rotation had higher grain yields and revenues. The biomass rotation (PS rotation) and the SS rotation had biomass gross returns that were greater than the grain gross returns. For grain rotations, excluding the SS rotation, grain gross returns were significantly higher than the biomass gross returns.

4.2.b.iii FEAE Net Returns

Net returns per acre of rotation could not be separated into net returns for grain or biomass individually, only total net returns per acre of rotation were calculable. Net returns per acre ranged from $276.35 per acre of rotation for CC to $500.03 per acre of rotation for RC. The PS rotation had the second lowest net return per acre of rotation while the DP rotation had second highest net return per acre of rotation. The CC rotation had the second highest gross returns but also the highest costs and it resulted in the CC rotation having the lowest net return. The RC rotation had the second highest grain costs, the highest grain revenues, the third lowest biomass costs and the lowest biomass revenues. Grain gross returns dominated the costs that could be attributable to grain production, while biomass gross returns were very near to the costs attributable to biomass production. Conclusions about grain versus biomass profitability cannot be drawn due to the lack of attributable production costs.

4.2.b.iv FEAE Scenario Conclusions

Figure 4.2 provides a bar chart of total costs, gross returns, and net returns for the FEAE scenario. The GS and BMR rotations performed the worst in terms of biomass yields and had the highest harvest costs per ton of biomass. The CC, PS, and SS rotations had high biomass harvest costs and some of the lowest harvest costs per ton of biomass. As yields increase, the cost per acre increases, but the fixed costs per acre of harvesting are distributed amongst more tons per acre thus lowering per ton costs. The harvest costs for biomass are non-linear.

The PS rotation only incurred grain harvest costs for the soybean aspect of those rotations, so the actual PS crop was a biomass crop. The PS rotation had the lowest net return, while rotations that were composed entirely of grain crops performed markedly better in terms of net returns. The RC and DP rotations had the highest net returns per acre within the FEAE scenario. The SS and GS rotations were average net return performers. The highest grain and relatively high biomass yields helped the CC rotation remain competitive, despite its high costs.

In the PS rotation, grain harvest costs for the biomass crop (not soybeans) were greater than the potential grain revenue. Biomass harvest costs were always less than the revenue generated from the biomass for every rotation. In the FEAE scenario, the profitability of biomass production was indeterminable.

4.2.c FMGBNRA Scenario

Table 4.3 provides fertilizer and chemical costs per acre, harvest costs per acre of rotation, harvest costs per ton of rotation, total costs per rotation, gross returns per acre of rotation, and net returns per acre of rotation for the FMGBNRA scenario. The FMGBNRA scenarios used the input recommendations for grain production for all crops in all rotations (all sorghum rotations had the same base inputs regardless of a crops designation as a grain or biomass crop) (O'Brien and Duncan, 2012, a, b, and c). The costs of nutrients removed in the biomass harvest were replaced and added to the costs from the O'Brien and Duncan (2012, a, b, and c) recommendations.

4.2.c.i FMGBNRA Costs

Fertilizer Costs

Fertilizer and chemical costs were separable between biomass and grain production, because the O'Brien and Duncan (2012, a, b, and c) recommendations are grain producing recommendations and the nutrient replacement is for biomass. For grain production crops, lime applications were considered grain production costs. For the biomass crop (PS), all inputs for the biomass specific crop were for biomass production, thus for the biomass specific crop within the rotation all costs accrued to biomass production.

Fertilizer and chemical costs for grain production ranged from $35.79 per acre of rotation for PS to $190.48 per acre of rotation for CC. The biomass rotation only had grain fertilizer costs for the soybean portion of the rotation. The grain rotations had grain fertilizer recommendations and chemical usages following O'Brien and Duncan (2012, a, b, c), which differed for corn, sorghum, and soybeans.

Fertilizer and chemical costs for biomass production ranged from $41.70 per acre of rotation for RC to $171.41 per acre of rotation for PS. The SS rotation had the second highest biomass fertilizer and chemical cost. The biomass rotation had significantly higher biomass fertilizer and chemical costs, because all fertilizer and chemical inputs were accrued to the PS crop within the rotation. The grain crops only had biomass nutrient replacement as the biomass production costs, which was determined by the biomass yields of the crops and the crop harvested. The higher the biomass yield the higher the cost of nutrient replacement.

Total fertilizer and chemical costs ranged from $154.96 per acre of rotation for BMR to $269.32 per acre of rotation for CC. The RC rotation had the second lowest total fertilizer and chemical cost. The costs of chemicals between the corn, sorghum, and soybean crops do impact these costs. The corn crop's chemicals were the most expensive and the sorghum's chemicals were the least expensive. The BMR rotation had the lowest total fertilizer and chemical cost due to its low biomass yields. The SS and PS rotations had the second and third highest total chemical and fertilizer cost due to its high biomass yields, respectively.

Harvest Costs

Grain harvest costs for the rotations ranged from $21.50 per acre of rotation to $52.89 per acre of rotation, with the PS rotation having the lowest and with the RC rotation having the maximum. The RC rotation had the highest grain yields and the CC rotation had the second highest yielding rotation. The biomass rotation only had grain harvested for the soybean portion of the rotation. The SS and BMR rotations had the second and third lowest grain harvest cost per acre of rotation, respectively. These differences are based solely on yield, with higher yielding crops incurring higher per acre costs.

Biomass harvest costs ranged from $111.87 per acre of rotation for GS to $199.15 per acre of rotation for CC. The BMR and RC rotations had relatively low biomass harvest costs. The CC crop had the highest quantity of bales produced but not the highest tons per acre. The number of bales per acre is the variable harvest cost term that is the most important, because there is a cost for stacking and baling associated with bales per acre. The CC and RC bales are the densest which leads to lower numbers of bales per acre versus sorghum bales. The RC rotation had the maximum biomass yield (in tons per acre), with the SS and PS rotations being close to the maximum. The biomass rotation used both swathing and raking operations while grain rotations used only draper head swathing.

Total harvest costs (both grain and biomass costs collectively) ranged from $151.56 for BMR per acre of rotation to $248.24 for CC per acre of rotation. These cost differences were due mainly to differences in yields. The lack of grain yield for the PS rotation reduced the number of harvest operations, and thus reduced its costs. The CC rotation had the highest biomass harvest cost which was triple its grain harvest cost, and was as large or larger than four rotations total harvest costs. The costs of harvesting biomass were larger than the costs of grain harvest.

Per Ton Costs

Total biomass harvest costs per ton of biomass produced ranged from $34.25 per ton of biomass produced for the RC rotation to $35.99 per ton of biomass produced for the GS rotation. Biomass harvest costs per ton are non-linear in yield. As yield increases the per ton cost of harvest decreases, and the fixed costs of harvesting biomass are spread over more tons. The lowest biomass yielding rotations have the highest costs per ton, and vice versa.

The costs associated with biomass production only ranged from $47.12 per ton of biomass for RC to $73.03 per ton of biomass for PS. The GS rotation had the second highest variable cost per ton, and the CC rotation had the second lowest variable cost per ton. The biomass rotation had higher variable cost per ton rotations due to the PS crop incurring all crop specific expenses for biomass production, whereas grain rotations incurred harvest costs and nutrient replacement costs for biomass production.

Total Costs

Total grain production costs (harvest, fertilizer, seed, chemicals, interest, and etc.) ranged from $163.76 per acre of rotation for PS to $502.43 per acre of rotation for CC. The biomass rotation had the lowest total grain production costs, because only the soybean portion of the rotation incurred grain production expenses. The CC rotation had the second highest grain yield, second highest grain harvest cost, and highest fertilizer and chemical cost.

Total biomass production cost ranged from $172.53 per acre of rotation for RC to $452.12 per acre of rotation for PS. The SS and CC rotations were the second and third highest total biomass production costs, respectively. The PS crops' costs were biomass production oriented. The CC rotation had the third highest cost because it had the highest yields. The RC rotation was less expensive than the BMR rotation due to its lower fertilizer replacement costs.

Total production costs ranged from $508.38 per acre of rotation for BMR to $789.46 per acre of rotation for CC. The GS rotation had the second lowest total production cost. The SS, PS, and RC rotations were the second, third, and forth highest total costs of production, respectively. The CC rotation had the highest fertilizer and chemical costs and was the highest biomass yielding rotation and biomass harvest costs are significantly higher than grain harvest costs. The BMR rotation had the lowest total production cost due to its low yields and low input costs.

4.2.c.ii FMGBNRA Gross Returns

Grain production gross returns ranged from $399.25 per acre of rotation for PS to $798.86 per acre of rotation for RC. Soybeans had the highest price per bushel at $13.72 per bushel and the sorghum crops' grain price was the lowest at $5.34 per bushel. The RC rotation had high corn yields coupled with a $5.88 per bushel price and the standard soybean return. The high corn yield and a price which was $0.54 per bushel higher than sorghum made the RC rotation a better performer than the other rotations. The DP rotation had the second highest grain net return. The CC rotation had the third highest grain returns although it had the highest corn yields, but did not have the standard soybean return. The PS rotation had the lowest grain return due to soybeans being the only crop which was harvested for grain.

Biomass production gross returns ranged from $222.97 per acre of rotation for RC to $410.31 per acre of rotation for PS rotation. Sorghum biomass prices were $78.33 per ton, while corn stover biomass prices were $60.90 per ton. The CC rotation had the highest yielding biomass, but due to lower prices per ton received it had less revenue than the PS and SS rotations. The SS rotation was close to PS in yield and gross return. The GS and BMR rotations had lower biomass yields than the RC rotation, but due to higher prices for sorghum biomass the GS and BMR rotations had slightly higher gross returns.

Total gross returns ranged from $742.37 per acre of rotation for BMR to $1,020.92 per acre of rotation for RC. The CC and DP rotations had the second and third highest gross returns, respectively. The higher grain gross returns of the RC rotation overcame its low biomass gross returns. The grain gross returns in all grain rotations were significantly higher than the biomass gross returns. In biomass rotation the grain gross return from soybeans and biomass gross returns were roughly equal.

4.2.c:iii FMGBNRA Net Returns

Grain net returns ranged from $84.95 per acre of rotation for CC to $385.66 per acre of rotation for RC. The SS was the second lowest grain net return, and the BMR rotation was the third lowest grain net return. The RC rotation had the highest grain yields and returns which outweighed its high grain harvest costs. The biomass rotation only had soybean net returns because the PS crop was for biomass production only. The CC rotation had the highest grain fertilizer and chemical cost, the second highest grain harvest cost, and the third highest grain gross return which led to the CC rotation having the lowest grain net return.

Biomass net returns ranged from $(41.81) per acre of rotation for PS to $113.79 per acre of rotation for DP. The SS rotation had the second highest biomass net return, followed by the BMR rotation. The CC rotation had slightly higher yields, much higher harvest costs, and moderately higher fertilizer and chemical costs than the SS and DP rotations, but due to a lower price was not as profitable. The PS rotation had the highest biomass costs, and the highest breakeven prices.

Total net returns ranged from $146.59 per acre of rotation for CC to $436.11 per acre of rotation for RC. The PS rotation had the second lowest net return. The DP rotation had the second highest total net return. The RC rotation had the highest grain net returns, which were significantly larger than any biomass net return. The DP rotation’s grain net returns were nearly double its biomass net returns per acre of rotation. The biomass rotation's net returns were limited by their negative biomass net return.

4.2.c.iv FMGBNRA Conclusions

Figure 4.3 provides a bar chart of total costs, gross returns, and net returns for the FEA scenario. The PS rotation had the second lowest net return rotations due to the negative biomass net returns. The CC rotation's net returns were barely smaller than the PS rotation, due to high grain and biomass costs. The PS and CC rotations had relatively high biomass yields which increased their costs, while the BMR rotation had relatively low biomass yields which reduced gross biomass revenue.

The RC and DP rotations were the top two net return rotations, due to relatively high grain gross returns and low biomass production costs. The SS rotation had the second lowest grain net return but because the SS crop was harvested for grain it increased the biomass net return. The grain rotations, excluding the CC and BMR rotations, had much higher net returns than the PS rotation.

The biomass harvest costs were much larger than grain harvest costs. However, the revenue from biomass harvest was always greater than the biomass harvest costs; grain harvest costs did outweigh the grain revenue in the PS rotation. Biomass rotations have the lowest net returns.

4.2.d FMGBNRAE Scenario

Table 4.4 provides fertilizer and chemical costs per acre, harvest costs per acre of rotation, harvest costs per ton of rotation, total costs per rotation, gross returns per acre of rotation, and net returns per acre of rotation for the FMGBNRAE budgets. The FMGBNRAE budgets used the input recommendations for grain production for all crops in all rotations (all sorghum rotations had the same base inputs regardless of a crops designation as a grain or biomass crop) (O'Brien and Duncan, 2012, a, b, and c). The costs of nutrients removed in the biomass harvest were replaced and added to the costs from the O'Brien and Duncan (2012, a, b, and c) recommendations.

4.2.d.i FMGBNRAE Costs

Fertilizer Costs

Fertilizer and chemical costs were separable between biomass and grain production, because the O'Brien and Duncan (2012, a, b, and c) recommendations are grain producing recommendations and the nutrient replacement is for biomass. For grain production crops lime applications were considered grain production costs. For biomass crop (PS), all inputs for the biomass specific crop were for biomass production, thus for the biomass specific crop within the rotation, all costs accrued to biomass production.

Fertilizer and chemical costs for grain production ranged from \$35.79 per acre of rotation for PS to \$190.48 per acre of rotation for CC. The biomass rotation only had grain fertilizer costs for the soybean portion of the rotation. The grain rotations had grain fertilizer recommendations and chemical usages following O'Brien and Duncan (2012, a, b, c), which differed for corn, sorghum, and soybeans.

Fertilizer and chemical costs for biomass production ranged from \$41.70 per acre of rotation for RC to \$171.41 per acre of rotation for PS. The SS rotation had the second highest biomass fertilizer and chemical cost. The biomass rotation had significantly higher biomass fertilizer and chemical costs, because all fertilizer and chemical inputs were accrued to the PS crop within the rotation. The grain crops only had biomass replacement as the biomass production costs, which was determined by the biomass yields of the crops and for the crop harvested, the higher the biomass yield the higher the cost of nutrient replacement.

Total fertilizer and chemical costs ranged from $154.96 per acre of rotation for BMR to $269.32 per acre of rotation for CC. The RC rotation had the second lowest total fertilizer and chemical cost. The costs of chemicals between the corn, sorghum, and soybean crops do impact these costs. The corn crop's chemicals were the most expensive and the sorghum's chemicals were the least expensive. The BMR rotation had the lowest total fertilizer and chemical cost due to its low biomass yields. The SS and PS rotations had the second and third highest total chemical and fertilizer cost due to its high biomass yields, respectively.

Harvest Costs

Grain harvest costs for the rotations ranged from $21.50 per acre of rotation for PS to $57.91 per acre of rotation for CC. The RC rotation was close to the maximum grain harvest cost. The CC rotation had the highest yielding rotation. The PS rotation only had a harvest operation for soybeans, and thus much lower costs.

Biomass harvest costs ranged from $113.32 per acre of rotation for GS to $228.68 per acre of rotation for SS. The BMR and RC rotations were close to the minimum biomass harvest cost. The CC and PS rotations were close to the maximum biomass harvest cost. The SS rotation had the highest yielding rotation in tons per acre and bales per acre. The PS rotation had more bales per acre than the CC rotation. While the CC rotation had more tons per acre, and a higher cost of biomass harvest than the PS rotation. The GS, RC and BMR rotations had the lowest yields of tons and bales per acre. The biomass rotation also incurred higher fixed portions of their costs due to different field operations. The biomass rotation used both swathing and raking operations while grain rotations used only draper head swathing.

Total harvest costs (both grain and biomass costs) ranged from $153.81 per acre of rotation for BMR to $272.30 per acre of rotation for CC. The SS rotation was close to the maximum total harvest cost and the GS rotation was close to the minimum total harvest cost. Total harvest costs are a combination of the grain and biomass harvest costs. The rotations with the highest yields had the highest costs, and vice versa. The CC rotation had the highest grain and close to the highest biomass yields and thus had the highest total harvest cost per acre of rotation. The costs of harvesting biomass were larger than the costs of grain harvest.

Per Ton Costs

Biomass harvest costs per ton of biomass produced were calculable and ranged from $34.07 per ton of biomass for SS to $36.00 per ton of biomass for GS. The PS, RC, and CC rotations were close to the minimum. The harvest costs per ton of biomass are nonlinear, as yield increases the cost per ton decreases. The highest yielding rotations had low per ton harvest costs because the fixed portion of the harvests was spread amongst more tons of yield.

The variable costs per ton associated with biomass production only ranged from $47.26 per ton for RC to $68.28 per ton for PS. The CC and SS rotations had the second and third lowest variable costs per ton, respectively. The biomass rotation had higher variable cost per ton rotations due to the PS crop incurring all crop specific expenses for biomass production, whereas grain rotations incurred harvest costs and nutrient replacement costs for biomass production.

Total Costs

Total production costs included; fertilizer and chemicals, harvest costs, seed, interest, and planting operations. The biomass crops within a rotation incurred all costs as biomass production costs for that crop, while for grain crops within a rotation the biomass production activities only incurred a subset of total expenses that were associated with biomass production.

Total grain production costs ranged from $163.76 per acre of rotation for PS to $511.55 per acre of rotation for CC. The RC rotation had the second highest grain production cost. The biomass rotation had the lowest total grain production costs because soybeans were the only grain portion of those rotations.

The total biomass production cost ranged from $171.38 per acre of rotation for RC to $476.49 per acre of rotation for PS. The BMR and GS rotations had the second and third lowest total biomass production costs, respectively. The biomass production costs for grain rotations are largely dependent on yield, and bales per acre. The RC rotation was less expensive than the lower yielding GS rotation due to its low fertilizer replacement costs.

Total cost for the rotations ranged from $509.35 per acre of rotation for BMR to $814.30 per acre of rotation for CC. The GS and DP rotations had the second and third lowest total costs, respectively. The SS rotation had the second highest total cost, followed by the PS rotation. Grain production costs were lowest for the biomass rotation. The PS and SS rotations had high biomass yields and costs. The CC rotation had the highest fertilizer and chemical costs for grain, the highest grain harvest cost, and the second highest biomass harvest cost.

4.2.d.ii FMGBNRAE Gross Returns

Grain production gross returns ranged from \$399.25 per acre of rotation for PS to \$863.95 per acre of rotation for RC. Soybeans had the highest price per bushel at \$13.72 per bushel and the sorghum crops' grain price was the lowest at \$5.34 per bushel. The RC rotation had high corn yields coupled with a \$5.88 price per bushel and the standard soybean return. The high corn yield and a price which was \$0.54 per bushel higher than sorghum made the RC rotation a better performer than the other rotations. The CC rotation was second in grain returns due to the highest corn yields. The PS rotation had the lowest grain return due to soybeans being the only crop which was harvested for grain.

Biomass production gross returns ranged from \$220.88 per acre of rotation for RC to \$525.81 per acre of rotation for SS. Sorghum biomass prices were \$78.33 per ton, while corn stover biomass prices were \$60.90 per ton. The SS rotation had the highest yielding biomass crop and outperformed the PS rotation in gross returns. The PS rotation was close to SS in yield and return, CC was a distant third in returns. The GS and BMR rotations yielded lower than the RC rotation but due to higher prices the GS and BMR rotations had slightly higher gross returns.

Total gross returns ranged from \$801.67 per acre of rotation for BMR to \$1,100.05 per acre of rotation for CC. The RC, SS, and DP rotations were the second, third, and fourth closest to the maximum. The higher biomass gross returns of the CC rotation caused it to outperform the RC rotation even though the RC rotation had higher grain yields and revenues. The biomass rotation and the SS rotation had biomass gross returns that were greater than the grain gross returns. The grain rotations, excluding the SS rotation, grain gross returns were significantly higher than the biomass gross returns.

4.2.d.iii FMGBNRAE Net Returns

Grain net returns ranged from $162.63 per acre of rotation for SS to $447.22 per acre of rotation for RC. The BMR rotation had the second lowest grain net return. The RC rotation had the highest gross returns, the second highest fertilizer and chemical cost for grain production, the second highest grain harvest costs, and the second highest total grain production costs. The PS rotation only had soybean grain revenue and grain costs. The SS rotation had the third highest fertilizer and chemical costs and the second lowest grain harvest cost, but the lowest grain yield, excluding the biomass rotation, thus it was the lowest grain net return rotation.

The biomass net returns ranged from $(9.68) per acre of rotation for PS to $168.63 per acre of rotation for SS. The RC rotation had the second lowest biomass net return of $49.50 per acre of rotation. The DP rotation had the second highest biomass net return. The CC rotation had slightly higher yields, slightly lower variable costs per ton, slightly lower biomass harvest costs than the DP rotation, but because the DP rotation had a higher biomass price and lower fertilizer and chemical costs the DP rotation had higher net returns than the CC rotation. The PS rotation had the highest per acre costs and variable costs per ton.

Total net returns ranged from $225.80 per acre of rotation for PS to $496.72 per acre of rotation for RC. The DP and GS rotations had the second and third highest total net returns per acre, respectively. The BMR and CC rotations had the second and third lowest total net return per acre of rotation, respectively. The DP rotations grain net returns were nearly three times larger than the biomass net returns. The biomass rotation' net returns were limited by their low biomass net return. The SS rotation had the third lowest net return and its grain net returns were approximately equal to its biomass net returns.

4.2.d.iv FMGBNRAE Conclusions

Figure 4.4 provides a bar chart of total costs, gross returns, and net returns for the FEA scenario. The PS rotation had the lowest net return due to the lowest biomass net returns. The SS rotation had the second best biomass production and biomass net return per acre of rotation, but underperformed the biomass rotation in grain net return. The grain rotations had higher net returns than biomass rotation. The RC, DP, and GS rotations were the top performers, in that order.

The biomass harvest costs were much larger than grain harvest costs. However, the revenue from biomass harvest was always greater than the biomass harvest costs. Grain harvest costs did outweigh the grain revenue in biomass rotation.

4.2.e FMGGBNRA Scenario

Table 4.5 provides fertilizer and chemical costs per acre, harvest costs per acre of rotation, harvest costs per ton of rotation, total costs per rotation, gross returns per acre of rotation, and net returns per acre of rotation for the FMGGBNRA scenario. The FMGGBNRA scenario used the nutrient removal from grain and biomass data in the Propheter (2009) thesis as the fertilizer input. All other inputs were from the O'Brien and Duncan (2012, a, b, and c) recommendations.

4.2.e.i FMGGBNRA Costs

Fertilizer Costs

Fertilizer and chemical costs were separable between biomass and grain production because nutrient replacement for grain was separate from nutrient replacement for biomass. For biomass crops (BMR and PS) all inputs for the biomass specific crop were for biomass production, thus for the biomass specific crop, within the rotation, all costs accrued to biomass production. For grain production crops, lime applications were considered grain production oriented.

Fertilizer and chemical cost for grain production ranged from $35.79 acre of rotation for PS to $152.12 per acre of rotation for CC. The RC rotation had the second highest grain fertilizer and chemical cost. Each rotations fertilizer requirements for grain nutrient replacement were based on the yield of that crop and the content of nutrients removed in the given grain.

Fertilizer and chemical cost for biomass production ranged from $41.70 per acre of rotation for RC to $134.69 per acre of rotation for PS. The BMR rotation had the second lowest biomass fertilizer and chemical cost. The SS rotation had the second highest biomass fertilizer and chemical cost. The biomass rotation (the PS rotation) had grain that was produced but not harvested; this grain was harvested in the biomass and contributed to the biomass rotation's high fertilizer and chemical costs. The grain crops only had biomass nutrient replacement as the biomass production costs, which was determined by the biomass yields of the crops and the crop harvested. The higher the biomass yield the higher the cost of nutrient replacement.

The total fertilizer and chemical costs ranged from $140.43 per acre of rotation for BMR to $230.95 per acre of rotation for CC. The SS and PS rotations had the second and third highest total fertilizer and chemical costs, respectively. The RC rotation had the second lowest cost. The corn crop's chemicals were the most expensive and the sorghum's chemicals were the least expensive. The BMR rotation had the lowest total fertilizer and chemical cost due to its low yield, but had a relatively high biomass fertilizer and chemical cost because all fertilizer and chemical inputs were accrued to biomass production. The SS and PS rotations had the second and third highest total chemical and fertilizer costs, respectively, due to their relatively high biomass yields. The relative size between biomass and grain fertilizer and chemical requirements varied across all rotations.

Harvest Costs

Grain harvest costs for the rotations ranged from $21.50 per acre of rotation to $52.89 per acre of rotation; with the PS rotation having the lowest and with the RC rotation having the maximum. The RC rotation had high grain yields and the CC rotation was the second highest yielding rotation. The biomass rotation only had grain harvested for the soybean portion of the rotation. The SS rotation was the second lowest grain harvest cost per acre of rotation. These differences are based solely on yield, with higher yielding crops incurring higher per acre costs.

Biomass harvest costs ranged from $98.46 per acre of rotation for GS to $175.00 per acre of rotation for CC. The BMR and RC rotations had relatively low biomass harvest costs. The CC crop had the highest quantity of bales produced but not the highest tons per acre. The number of bales per acre is the variable harvest cost term that is the most important, because there is a cost for stacking and baling associated with bales per acre. The CC and RC bales are the densest, which leads to lower numbers of bales per acre versus sorghum bales. The RC rotation had the maximum biomass yield (in tons per acre), with the SS and PS rotations being close to the maximum. The biomass rotation also incurred higher fixed portions of their costs due to different field operations. The biomass rotation used both swathing and raking operations while grain rotations used only draper head swathing.

Total harvest costs (both grain and biomass costs collectively) ranged from $123.66 for BMR per acre of rotation to $224.09 for CC per acre of rotation. These cost differences were due mainly to differences in yields. The lack of grain yield for the PS rotation reduced the number of harvest operations, and thus reduced its costs. The CC rotation had the highest biomass harvest cost, which was triple its grain harvest cost, and was as large or larger than four rotations total harvest costs. The costs of harvesting biomass were larger than the costs of grain harvest.

Per Ton Costs

Total biomass harvest costs per ton of biomass produced ranged from $34.54 per ton of biomass produced for the RC rotation to $35.99 per ton of biomass produced for the BMR rotation. Biomass harvest costs per ton are non-linear in yield. As yield increases the per ton, cost of harvest decreases. The fixed costs of harvesting biomass are thus spread over more tons. The lowest biomass yielding rotations have the highest costs per ton, and vice versa.

The variable costs per ton associated with biomass production only ranged from $47.12 per ton of biomass for RC to $65.79 per ton of biomass for PS. The GS rotation had the second highest variable cost and the CC rotation had the second lowest variable cost. The biomass rotation had higher variable cost per ton rotations due to the PS crop incurring all crop specific expenses for biomass production, whereas grain rotations incurred harvest costs and nutrient replacement costs for biomass production.

Total Costs

Total grain production costs ranged from $163.76 per acre of rotation for PS to $463.20 per acre of rotation for CC. The RC rotation had the second highest total grain production cost. The CC rotation had the highest grain fertilizer and chemical costs, the second highest biomass harvest cost, and relatively high seed costs. The PS rotation had the lowest total grain production costs, because soybeans were the only grain portion of those rotations.

Total biomass production costs ranged from $172.53 per acre of rotation for RC to $414.20 per acre of rotation for PS. The BMR and GS rotations had the second and third lowest total biomass cost, respectively. The SS and CC rotations had the second and third highest total biomass costs, respectively. The biomass rotation had the highest cost because the PS crop incurred all costs for biomass production. The biomass production costs are mainly a function of yield, and bale density.

Total production costs ranged from $493.39 per acre of rotation for BMR to $750.23 per acre of rotation for CC. The GS and DP rotations had the second and third total production costs, respectively. The CC rotation had the highest grain fertilizer and chemical costs, the highest biomass harvest costs, and the second highest grain harvest cost; these are all dependent on yield. The SS rotation had the second highest biomass yielding rotation, but the PS rotation had all costs of the PS crop associated with biomass production while the SS rotation only had the costs that were directly attributable to biomass production.

4.2.e.ii FMGGBNRA Gross Returns

Grain production gross returns ranged from $399.25 per acre of rotation for PS to $798.86 per acre of rotation for RC. Soybeans had the highest price per bushel at $13.72 per bushel and the sorghum crops' grain price was the lowest at $5.34 per bushel. The RC rotation had high corn yields coupled with a $5.88 per bushel price and the standard soybean return. The high corn yield and a price which was $0.54 per bushel higher than sorghum made the RC rotation a better performer than the other rotations. The DP rotation had the second highest grain net return. The CC rotation had the third highest grain returns, although it had the highest corn yields, but did not have the standard soybean return. The PS rotation had the lowest grain return, due to soybeans being the only crop which was harvested for grain.

Biomass production gross returns ranged from $222.97 per acre of rotation for RC to $410.31 per acre of rotation for PS rotation. Sorghum biomass prices were $78.33 per ton, while corn stover biomass prices were $60.90 per ton. The CC rotation had the highest yielding biomass, but due to lower prices per ton received it had less revenue than the PS and SS rotations. The SS rotation was close to PS in yield and gross return. The GS and BMR rotations had lower biomass yields than the RC rotation, but due to higher prices for sorghum biomass the GS and BMR rotations had slightly higher gross returns.

Total gross returns ranged from $742.37 per acre of rotation for BMR to $1,020.92 per acre of rotation for RC. The CC and DP rotations had the second and third highest gross returns, respectively. The higher grain gross returns of the RC rotation overcame its low biomass gross returns. The grain gross returns in all grain rotations were significantly higher than the biomass gross returns. In biomass rotation the grain gross return from soybeans and biomass gross returns were roughly equal.

4.2.e.iii FMGGBNRA Net Returns

Grain net returns ranged from $124.17 per acre of rotation for CC to $397.59 per acre of rotation for RC. The SS and BMR rotations had the second and third lowest net returns. The CC rotation had the highest total cost for grain but had the second highest grain gross return. The RC rotation had the second highest total cost for grain, but its gross return for grain was over double its total cost for grain. The soybeans of the biomass rotation had higher grain net returns than the CC rotation.

Biomass net returns ranged from $(3.90) per acre of rotation for PS to $113.79 per acre of rotation for DP. The RC rotation had the second lowest biomass net return. The SS rotation had the second highest biomass net return. The CC rotation out-yielded the DP rotation but due to slightly higher costs and a lower biomass price it did not perform well. The biomass rotation had the highest per acre costs and variable costs per ton.

Total net returns ranged from $185.82 per acre of rotation for CC to $448.03 per acre of rotation for RC. The DP rotation had the second highest net return, and the PS rotation had the second lowest net return. The grain net returns of the RC rotation were over double the biomass net returns and, because the RC rotation performed well in grain yields and grain gross returns, was the top total net returner. The biomass rotation didn't have grain yields other than soybeans and that lowered their net returns. The CC rotation had high costs associated with it having relatively high biomass yields, but it did not have the highest grain gross returns to offset the high biomass costs.

4.2.e.iv FMGGBNRA Conclusions

Figure 4.5 provides a bar chart of total costs, gross returns, and net returns for the FEA scenario. The RC and DP rotations had the highest total net returns because of relatively low biomass production costs and relatively high gross grain returns. The PS rotation had the second lowest total net returns. The CC rotation had relatively high costs which were large relative to its gross returns. The PS rotation had net returns that were just the soybean crop's net returns, which performed as well or better than some grain rotations.

The grain rotations performed marginally better than biomass rotation, excluding the CC rotation. The rotations with biomass crops have a much higher variable biomass production cost than grain rotations The biomass harvest costs were much larger than grain harvest costs. However, the revenue from biomass harvest was always greater than the biomass harvest costs. Grain harvest costs did outweigh the grain revenue in biomass rotation.

4.2.f FMGGBNRAE Scenario

Table 4.6 provides fertilizer and chemical costs per acre, harvest costs per acre of rotation, harvest costs per ton of rotation, total costs per rotation, gross returns per acre of rotation, and net returns per acre of rotation for the FMGGBNRAE scenario The FMGGBNRAE scenario used the nutrient removal from grain and biomass data in the Propheter (2009) thesis as the fertilizer input. All other inputs were from the O'Brien and Duncan (2012, a, b, and c) recommendations. Due to missing data in the FMGGBNRA scenario, the FMGGBNRAE scenario have two years (2009 and 2011) yield and input data removed.

4.2.f.i FMGGBNRAE Costs

Fertilizer Costs

Fertilizer and chemical costs were separable between biomass and grain production because nutrient replacement for grain was separate from nutrient replacement for biomass. For biomass crop (PS), all inputs for the biomass specific crop were for biomass production, thus for the biomass specific crop, within the rotation, all costs accrued to biomass production. For grain production crops, lime applications were considered grain production oriented.

Fertilizer and chemical cost for grain production ranged from $35.79 acre of rotation for PS to $152.12 per acre of rotation for CC. The RC rotation had the second highest grain fertilizer and chemical cost. Each rotations fertilizer requirements for grain nutrient replacement was based on the yield of that crop and the content of nutrients removed in the given grain.

Fertilizer and chemical cost for biomass production ranged from $41.70 per acre of rotation for RC to $134.69 per acre of rotation for PS. The BMR rotation had the second lowest biomass fertilizer and chemical cost. The SS rotation had the second highest biomass fertilizer and chemical cost. The biomass rotation (the PS rotation) had grain that was produced but not harvested; this grain was harvested in the biomass and contributed to the biomass rotation' high fertilizer and chemical costs. The grain crops only had biomass replacement as the biomass production costs, which was determined by the biomass yields of the crops and the crop harvested. The higher the biomass yield the higher the cost of nutrient replacement.

The total fertilizer and chemical costs ranged from $140.43 per acre of rotation for BMR to $230.95 per acre of rotation for CC. The SS and PS rotations had the second and third highest total fertilizer and chemical costs, respectively. The RC rotation had the second lowest cost.

The corn crop's chemicals were the most expensive and the sorghum's chemicals were the least expensive. The BMR rotation had the lowest total fertilizer and chemical cost due to its low yield, but had a relatively high biomass fertilizer and chemical cost because all fertilizer and chemical inputs were accrued to biomass production. The SS and PS rotations had the second and third highest total chemical and fertilizer costs, respectively, due to their relatively high biomass yields. The relative size between biomass and grain fertilizer and chemical requirements varied across all rotations

Harvest Costs

Grain harvest costs for the rotations ranged from $21.50 per acre of rotation for PS to $57.91 per acre of rotation for CC. The RC rotation was close to the maximum grain harvest cost. The CC rotation had the highest yielding rotation. The PS rotation only had a harvest operation for soybeans, and thus much lower costs.

Biomass harvest costs ranged from $113.32 per acre of rotation for GS to $228.68 per acre of rotation for SS. The BMR and RC rotations were close to the minimum biomass harvest cost. The CC and PS rotations were close to the maximum biomass harvest cost. The SS rotation had the highest yielding rotation in tons per acre and bales per acre. The PS rotation had more bales per acre than the CC rotation. While the CC rotation had more tons per acre, and a higher cost of biomass harvest than the PS rotation. The GS, RC and BMR rotations had the lowest yields of tons and bales per acre. The biomass rotation also incurred higher fixed portions of their costs due to different field operations. The biomass rotation used both swathing and raking operations while grain rotations used only draper head swathing.

Total harvest costs (both grain and biomass costs) ranged from $153.81 per acre of rotation for BMR to $272.30 per acre of rotation for CC. The SS rotation was close to the maximum total harvest cost and the GS rotation was close to the minimum total harvest cost. Total harvest costs are a combination of the grain and biomass harvest costs. The rotations with the highest yields had the highest costs, and vice versa. The CC rotation had the highest grain and close to the highest biomass yields, and thus had the highest total harvest cost per acre of rotation. The costs of harvesting biomass were larger than the costs of grain harvest.

Per Ton Costs

Biomass harvest costs per ton of biomass produced were calculable and ranged from $34.07 per ton of biomass for SS to $36.00 per ton of biomass for PS. The CC, RC, and DP rotations were close to the minimum. The harvest costs per ton of biomass are nonlinear, as yield increases the cost per ton decreases. The highest yielding rotations had low per ton harvest costs, because the fixed portion of the harvests was spread amongst more tons of yield.

The costs associated with only biomass production, variable cost of biomass, ranged from $47.26 per ton for RC to $61.92 per ton for PS. The GS rotation had the second highest variable cost per ton, and the CC and DP rotations were the second and third lowest variable costs per ton, respectively. The biomass rotation were higher variable cost per ton rotations due to the PS crop incurring all crop specific expenses for biomass production, whereas grain rotations incurred harvest costs and nutrient replacement costs for biomass production.

Total Costs

Total cost for grain production ranged from $163.76 per acre of rotation for PS to $472.32 per acre of rotation for CC. The RC rotation had the second highest total cost for grain production. The SS rotation had the second lowest total cost for grain production. Total cost for grain production was higher for grain rotations than it was for biomass rotation. The grain yields of each rotation directly affect the total costs, as do seed costs which are highest for corn crops.

Total cost for biomass production ranged from $171.38 per acre of rotation for RC to $438.58 per acre of rotation for PS. The SS and CC rotations were the second and third highest total costs for biomass production, respectively. The BMR rotation was the second lowest biomass production total cost. The SS rotation had the second highest biomass yielding rotation, but the PS rotation had all costs of the PS crop associated with biomass production, while the SS rotation only had the costs that were directly attributable to biomass production. The BMR rotation had a yield similar to the RC rotation, but was lower cost.

Total costs ranged from $494.35 per acre of rotation for BMR to $775.07 per acre of rotation for CC. The SS, PS, and RC rotations were the second, third and fourth highest total cost, respectively. Total costs are highest for the CC rotation due to its high fertilizer requirements, and high harvest cost for both grain and biomass. The lower yielding rotations are the lowest cost rotations.

4.2.f.ii FMGGBNRAE Gross Returns

Grain production gross returns ranged from $399.25 per acre of rotation for PS to $863.95 per acre of rotation for RC. Soybeans had the highest price per bushel at $13.72 per bushel and the sorghum crops' grain price was the lowest at $5.34 per bushel. The RC rotation had high corn yields coupled a $5.88 price per bushel and the standard soybean return. The high corn yield and a price which was $0.54 per bushel higher than sorghum made the RC rotation a better performer than the other rotations. The CC rotation was second in grain returns due to the highest corn yields. The PS rotation had the lowest grain return due to soybeans being the only crop which was harvested for grain.

Biomass production gross returns ranged from $220.88 per acre of rotation for RC to $525.81 per acre of rotation for SS. Sorghum biomass prices were $78.33 per ton, while corn stover biomass prices were $60.90 per ton. The SS rotation had the highest yielding biomass crop and outperformed the PS rotation in gross returns. The PS rotation was close to SS in yield and return, while the CC rotation was a distant third in returns. The GS and BMR rotations yielded lower than the RC rotation, but due to higher prices the GS and BMR rotations had slightly higher gross returns.

Total gross returns ranged from $801.67 per acre of rotation for BMR to $1,100.05 per acre of rotation for CC. The RC, SS, and DP rotations were the second, third, and fourth closest to the maximum. The higher biomass gross returns of the CC rotation caused it to outperform the RC rotation even though the RC rotation had higher grain yields and revenues. The biomass rotation and the SS rotation had biomass gross returns that were greater than the grain gross returns. The grain rotations, excluding the SS rotation, grain gross returns were significantly higher than the biomass gross returns.

4.2.f.iii FMGGBNRAE Net Returns

Net returns for grain production ranged from $188.51 per acre of rotation for SS to $459.15 per acre of rotation for RC. The PS rotation had the second lowest grain net returns. The SS rotation had the second lowest grain fertilizer and chemical costs, the second lowest grain harvest cost and the lowest harvested grain yields which resulted in its low return. The soybeans of the biomass rotation had higher grain net returns than the SS rotation.

Net returns for biomass production ranged from $28.24 per acre of rotation for PS to $168.63 per acre of rotation for SS. The RC rotation had the second lowest biomass net per acre of rotation, and the DP rotation had the second highest biomass net return. The SS rotation had the second highest biomass yielding rotation. The PS rotation had higher biomass yields and prices than the CC rotation, but due to the PS rotation having the highest total cost for biomass production it did not perform well.

Total net returns ranged from $263.72 per acre of rotation for PS to $508.64 per acre of rotation for RC. The DP and GS rotations had the second and third highest total net return, respectively. The BMR rotation had the second lowest total net return. The grain net returns of DP and RC were over double the biomass net returns and because both performed well in grain yields and grain gross returns, they were the top total net returners. The SS rotation had grain net returns nearly equal to the biomass net returns. The biomass rotation did not have grain yields other than soybeans and that lowered their net returns.

4.2.f.iv FMGGBNRAE Conclusions

Figure 4.6 provides a bar chart of total costs, gross returns, and net returns for the FEA scenario. The PS rotation had the lowest net return rotations due to the two lowest biomass net returns. The SS rotation had the second best biomass yield and the best biomass net return per acre of rotation, but underperformed the biomass rotation in grain net return. The grain rotations had higher net returns than biomass rotation. The RC, DP, and GS rotations were the top performers, in that order.

The biomass harvest costs were much larger than grain harvest costs. However, the revenue from biomass harvest was always greater than the biomass harvest costs. Grain harvest costs did outweigh the grain revenue in biomass rotation. Biomass rotation are the least profitable.

4.2.G Summary Conclusions of Annual Scenarios: Crop Rotation Comparison

The RC rotation had the highest total net return rotation across all scenarios. The DP rotation has the second highest net return across all scenarios. The CC rotation had the lowest net returns in the FEA, FEAE, FMGBNRA, and FMGGBNRA scenarios, and the third lowest net returns in the FMGBNRAE and FMGGBNRAE scenarios. The PS rotation was either the lowest or among the three lowest net returning rotations. The GS rotation was generally among the top three net returns.

The FEA and FEAE scenarios do not provide the grain net returns. The RC rotation had the highest grain net return across the FMGBNRA, FMGBNRAE, FMGGBNRA, and FMGGBNRAE scenarios. The DP rotation had the second highest grain net return across all scenarios. The SS rotation had the lowest grain net return for the FMGBNRAE and FMGGBNRAE scenarios. The CC rotation had the lowest grain net return for the FMGBNRA and FMGGBNRA scenarios.

The FEA and FEAE scenarios do not provide the biomass net returns. The SS rotation was the highest biomass net return for the FMGBNRAE and FMGGBNRAE scenarios. The DP rotation had the highest biomass net returns for the FMGBNRA and FMGGBNRA scenarios. The PS rotation had the lowest biomass net returns for the FMGBNRA, FMGBNRAE, FMGGBNRA, and FMGGBNRAE scenarios. The PS rotation had positive biomass net returns for the FMGGBNRAE scenario only. The RC rotation was the second lowest for the FMGBNRA, FMGBNRAE, FMGGBNRA, and FMGGBNRAE scenarios

The scenarios that are the lowest net returns are accounting more exactly for the costs of production. For the FEA and FEAE scenarios, the fertilizer and chemical costs are fixed, but in the FMGGBNRA and FMGGBNRAE scenarios, the fertilizer inputs are tied to yield and crop nutrient density and composition. The latter scenarios provide a more accurate representation of the true cost and returns of harvesting both grain and biomass in the grain rotations and biomass in the biomass rotation.

4.3 Annual Rotations: Cross Scenario Comparisons

Each annual crop rotation (GS, BMR, PS, DP, SS, RC, and CC) for each scenario (FEA, FEAE, FMGBNRA, FMGBNRAE, FMGGBNRA, and FMGGBNRAE) was compared to one another. This analysis shows the major differences in the results due to differences in the scenarios. If the costs and net returns across all scenarios for a given rotation are similar this indicates the robustness of the general results. If the costs and net returns across all scenarios for a given rotation have major disparities it is worthwhile to examine why these differences exist and if these differences are significant.

Fertilizer and chemical costs are the same for the respective scenarios (FEA and FEAE; FMGBNRA and FMGBNRAE; FMGGBNRA and FMGGBNRAE). The FMGBNRA, FMGBNRAE, FMGGBNRA, and FMGGBNRAE scenarios (scenarios beginning with FMG) have the same seed and chemical costs for each respective crop. The FMGBNRA and FMGGBNRA scenarios (scenarios ending in A) use different yields than the FMGBNRAE and FMGGBNRAE scenarios (scenarios ending in AE), but do not result in different nutrient replacement rates due to a lack of data. The FMGBNRAE and FMGGBNRAE scenarios (scenarios ending in AE) did not result in any differences from the FMGBNRA and

FMGGBNRA scenarios (scenarios ending in A) in nutrient replacement cost for a given rotation even though the 2009 and 2011 yield data was excluded from the scenarios ending in AE. The FMGBNRA and FMGBNRAE scenarios replace nutrients harvested from the biomass. The FMGGBNRA and FMGGBNRAE replace nutrients harvest from the grain and biomass. Thus, fertilizer and chemical costs do not vary when the yield varied between scenarios ending in A and the scenarios ending in AE.

4.3.a The GS Rotation

Table 4.7 provides the scenario comparisons for the GS rotation. Figure 4.7 provides a bar chart of the total costs, gross returns, and net returns for the GS rotation. The FEAE scenario had the highest net return of $393.13 per acre of rotation, while the FMGBNRA scenario had the lowest net return of $296.34 per acre of rotation. The FEA and FEAE scenarios offer less insight into the grain and biomass aspects of the GS rotation than the other scenarios. In the FEA and FEAE scenarios some costs and returns could not be allocated to grain production and biomass production separately, because they do not account for all the nutrients removed as explicitly as the FMGGBNRA and FMGGBNRAE scenarios do.

The scenarios ending with AE had higher net returns than the scenarios ending with A because yields were higher in the scenarios ending with AE. The scenarios beginning with FMG had similar net returns, while the FEA and FEAE scenarios operated at lower costs and thus higher net returns. Because the scenarios beginning with FMG use more explicit accounting of fertilizer costs than the FEA and FEAE by using nutrient removal as the fertilizer requirements, the scenarios beginning with FMG had higher costs. The FMGBNRA's and FMGBNRAE's use of supplemental fertilizer contributed to these scenarios being the most expensive. Generally the results are robust across all scenarios, with most of the differences occurring due to the exclusion of 2009 and 2011 yield data, which had lower yields, in the scenarios beginning with AE.

4.3.b The BMR Rotation

Table 4.8 provides the scenario comparisons for the BMR rotation. Figure 4.8 provides a bar chart of the total costs, gross returns, and net returns for the BMR rotation. The FEAE scenario had the highest net return of $306.86 per acre of rotation. The FMGBNRA scenario had the lowest net return of $233.99 per acre of rotation. The FEA and FEAE scenarios offer less insight into the grain and biomass aspects of the BMR rotation than the other four scenarios. In the FEA and FEAE scenarios some costs and returns could not be allocated to grain production and biomass production separately, because they do not account for all the nutrients removed as explicitly as the FMGGBNRA and FMGGBNRAE scenarios do. Because soybean fertilizer requirements are consistent between the FMG prefixed scenarios and the BMR rotation is a biomass rotation, there is no variance in grain fertilizer and chemical costs.

The scenarios ending with A had higher net returns than the scenarios ending with AE, but the differences between the scenarios ending with A and the scenarios ending with AE were very small. The FEA and FEAE scenarios operate at lower costs and thus higher net returns. Because the scenarios beginning with FMG use more explicit accounting of fertilizer costs than the FEA and FEAE by using nutrient removal as the fertilizer requirements, the scenarios beginning with FMG had higher costs. The FMGBNRA’s and FMGBNRAE’s use of supplemental fertilizer contributed to these scenarios being the most expensive. Generally, the returns for the BMR rotation are all nearly the same; the differences in yield are miniscule.

4.3.c The PS Rotation

Table 4.9 provides the scenario comparisons for the PS rotation. Figure 4.9 provides a bar chart of the total costs, gross returns, and net returns for the PS rotation. The FEAE scenario had the highest net returns of $297.27 per acre of rotation. The FMGBNRA scenario had the lowest net return of $193.67 per acre of rotation. The FEA and FEAE scenarios offer less insight into the grain and biomass aspects of the PS rotation than the other four scenarios. In the FEA and FEAE scenarios some costs and returns could not be allocated to grain production and biomass production separately because they do not account for all the nutrients removed as explicitly as the FMGGBNRA and FMGGBNRAE scenarios do. Because soybean fertilizer requirements are consistent between the FMG prefixed scenarios and the PS rotation is a biomass rotation there is no variance in grain fertilizer and chemical costs.

The scenarios ending with AE had higher net returns than the scenarios ending with A because yields were higher in the scenarios ending with AE. The FMGGBNRAE scenario was the only scenario which had a positive biomass net return. The scenarios beginning with FMG had similar net returns, while the FEA and FEAE scenarios operated at lower costs and thus higher net returns. Because the scenarios beginning with FMG use more explicit accounting of fertilizer costs than the FEA and FEAE by using nutrient removal as the fertilizer requirements, the scenarios beginning with FMG had higher costs. The FMGBNRA's and FMGBNRAE's use of supplemental fertilizer contributed to these scenarios being the most expensive. Generally the results are robust across all scenarios, with most of the differences occurring due to the exclusion of 2009 and 2011 yield data, which had lower yields, in the scenarios beginning with AE.

4.3.d The DP Rotation

Table 4.10 provides the scenario comparisons for the DP rotation. Figure 4.10 provides a bar chart of the total costs, gross returns, and net returns for the DP rotation. The FEAE scenario had the highest net return of $466.93 per acre of rotation. The FMGBNRA scenario had the lowest net return of $370.86 per acre of rotation. The FEA and FEAE scenarios offer less insight into the grain and biomass aspects of the DP rotation than the other scenarios. In the FEA and FEAE scenarios some costs and returns could not be allocated to grain production and biomass production separately, because they do not account for all the nutrients removed as explicitly as the FMGGBNRA and FMGGBNRAE scenarios do.

The scenarios ending with AE had higher net returns than the scenarios ending with A because yields were higher in the scenarios ending with AE. The scenarios beginning with FMG had similar net returns, while the FEA and FEAE scenarios operated at lower costs and thus higher net returns. Because the scenarios beginning with FMG use more explicit accounting of fertilizer costs than the FEA and FEAE by using nutrient removal as the fertilizer requirements, the scenarios beginning with FMG had higher costs. The FMGBNRA's and FMGBNRAE's use of supplemental fertilizer contributed to these scenarios being the most expensive. Generally the results are robust across all scenarios, with most of the differences occurring due to the exclusion of 2009 and 2011 yield data, which had lower yields, in the scenarios beginning with AE.

4.3.e The SS Rotation

Table 4.11 provides the scenario comparisons for the SS rotation. Figure 4.11 provides a bar chart of the total costs, gross returns, and net returns for the SS rotation. The FEAE scenario had the highest net return of $398.53 per acre of rotation. The FMGBNRA scenario had the lowest net return of $225.91 per acre of rotation. The FEA and FEAE scenarios offer less insight into the grain and biomass aspects of the SS rotation than the other scenarios. In the FEA and FEAE scenarios some costs and returns could not be allocated to grain production and biomass production separately, because they do not account for all the nutrients removed as explicitly as the FMGGBNRA and FMGGBNRAE scenarios do.

The FMGGBNRA and FMGGBNRAE scenarios that had nutrient replacement for grain and biomass had lower costs than the FMGBNRA and FMGBNRAE scenarios. The scenarios ending with AE had higher net returns than the scenarios ending with A because yields were higher in the scenarios ending with AE. The scenarios beginning with FMG had similar net returns, while the FEA and FEAE scenarios operated at lower costs and thus higher net returns. Because the scenarios beginning with FMG use more explicit accounting of fertilizer costs than the FEA and FEAE by using nutrient removal as the fertilizer requirements, the scenarios beginning with FMG had higher costs. The use of supplemental fertilizer in the FMGBNRA and FMGBNRAE scenarios had a higher cost than replacing all nutrients. Generally the results are similar across all scenarios. The SS rotation had large variations due to fertilizer costs and biomass harvest costs, with most of the differences occurring due to the exclusion of 2009 and 2011 yield data, which had lower yields, in the scenarios beginning with AE.

4.3.f The RC Rotation

Table 4.12 provides the scenario comparisons for the RC rotation. Figure 4.12 provides a bar chart of the total costs, gross returns, and net returns for the RC rotation. The FMGGBNRAE scenario had the highest net return of $508.64 per acre of rotation. The FEA scenario had the lowest net return of $426.86 per acre of rotation. The FEA and FEAE scenarios offer less insight into the grain and biomass aspects of the GS rotation than the other scenarios.

In the FEA and FEAE scenarios some costs and returns could not be allocated to grain production and biomass production separately, because they do not account for all the nutrients removed as explicitly as the FMGGBNRA and FMGGBNRAE scenarios do.

The scenarios ending with AE had higher net returns than the scenarios ending with A because yields were higher in the scenarios ending with AE. The scenarios beginning with FMG had similar net returns, while the FEA and FEAE scenarios operated at higher costs and thus lower net returns. Because the scenarios beginning with FMG use more explicit accounting of fertilizer costs than the FEA and FEAE by using nutrient removal as the fertilizer requirements, the scenarios beginning with FMG had lower costs. The FEA and FEAE scenarios overstated the cost of fertilizer required by the RC rotation. Generally the results are robust across all scenarios, with most of the differences occurring due to the exclusion of 2009 and 2011 yield data, which had lower yields, in the scenarios beginning with AE.

4.3.g The CC Rotation

Table 4.13 provides the scenario comparisons for the CC rotation. Figure 4.13 provides a bar chart of the total costs, gross returns, and net returns for the CC rotation. The FMGGBNRAE scenario had the highest net return of $324.98 per acre of rotation. The FEA scenario had the lowest net return of $276.35 per acre of rotation. The FEA and FEAE scenarios offer less insight into the grain and biomass aspects of the GS rotation than the other scenarios. In the FEA and FEAE scenarios some costs and returns could not be allocated to grain production and biomass production separately because they do not account for all the nutrients removed as explicitly as the FMGGBNRA and FMGGBNRAE scenarios do.

The scenarios ending with AE had higher net returns than the scenarios ending with A because yields were higher in the scenarios ending with AE. The scenarios beginning with FMG had similar net returns, while the FEA and FEAE scenarios operated at higher costs and thus lower net returns. Because the scenarios beginning with FMG use more explicit accounting of fertilizer costs than the FEA and FEAE by using nutrient removal as the fertilizer requirements the scenarios beginning with FMG had lower costs. The FEA and FEAE scenarios overstated the cost of fertilizer required by the CC rotation. Generally the results are robust across all scenarios, with most of the differences occurring due to the exclusion of 2009 and 2011 yield data, which had lower yields, in the scenarios beginning with AE.

4.3.h General Annual Rotations: Cross Scenario Comparisons Conclusions

Across the all rotations the scenarios ending in AE had higher net returns than the scenarios ending in A. This is due to the scenarios ending in AE having higher yields than the scenarios ending in A due to the exclusion of the 2009 and 2011 yield data.   The FMGBNRA and FMGBNRAE scenario net returns in all sorghum rotations were the minimum net returns. The FEA and FEAE scenarios had the minimum net returns in the corn rotations (CC and RC rotations).

In the FEA and FEAE scenarios the fertilizer and chemical costs are fixed, but in the FMGGBNRA and FMGGBNRAE scenarios, the fertilizer inputs are tied to yield and crop nutrient density and composition. The latter scenarios provide a more accurate representation of the true cost and returns of harvesting both grain and biomass in the grain rotations and biomass in the biomass rotation.

4.4 Perennial Scenarios: 10 Year Horizon Comparison

4.4.a FEP and FMGA Scenarios

The FEP scenario derives all chemical, fertilizer, and field operations and yields from the field experiment for switchgrass and big bluestem. The FMGA scenario is used to compare a typical perennial crop, alfalfa, produced by farm managers but that was not part of the field experiment. The FMGA scenario's field operations, chemical, and fertilizer use rates, excluding the lime application, are from Dumler and Shoup (2012) and yields are from Herbel (2013). Table 4.14 provides the annualized costs and returns for the 10 year production horizon and also the establishment costs incurred in the first year on a per acre and per ton basis for the FEP and FMGA scenarios. Figure 4.14 provides a bar chart of the amortized per acre total cost, gross returns, and net returns. Figure 4.15 provides a bar chart of the establishment year per acre total costs, gross returns, and net returns.

4.4.a.i FEP and FMGA Scenarios: Amortized Per Acre

Amortized Per Acre Costs

Amortized fertilizer, chemical, and seed costs were $70.63, $71.33, and $75.87 per acre for alfalfa, switchgrass, and big bluestem, respectively. The switchgrass and big bluestem (FEP) crops had fertilizer applications delayed until year two, while alfalfa (FMGA) had fertilizer applications every year.

Amortized field operation costs for applying chemicals, fertilizer, and planting the crop were $7.72, $7.73, and $8.34 per acre for switchgrass, alfalfa, and big bluestem, respectively. Big bluestem had two more applications of chemical than alfalfa and one more application than switchgrass. Big bluestem had chemical applications in years one, two, and three. Alfalfa only had chemical applications in year one, and switchgrass had chemical applications in years one and two. Alfalfa had fertilizer applications every year, while switchgrass and big bluestem had fertilizer applications every year but year one.

Amortized total input costs were $78.36, $79.05, and $84.21 per acre for alfalfa, switchgrass, and big bluestem, respectively. These differences were due to grasses not having applications of fertilizer and chemical applications in the first year, different numbers of applications in year three, and different rates of application.

Amortized harvest costs were $127.93, $165.77, and $167.27 per acre for big bluestem, alfalfa, and switchgrass, respectively. Harvest costs are a function of yields and bale densities. Due to switchgrass and big bluestem bales weighing less than an alfalfa bale the grass crops' harvest cost per acre would be higher if tons per acre were equal among the crops (1150 pounds per bale for the grasses versus 1650 pounds per bale for alfalfa). Switchgrass had an average yield that was 0.67 tons per year per acre higher than alfalfa and also had lower density bales which caused higher harvest costs. Lower density bales cause higher bales per acre which results in higher harvest costs.

Amortized total variable costs, including all input and harvest costs, were $212.15, $244.13, and $246.33 per acre for big bluestem, alfalfa, and switchgrass, respectively. The yield differences that affect harvest cost, and different annual applications fertilizer and chemicals are the main reason for the cost differences.

Amortized total costs, including variable cost and a land rental charge, were $297.62, $330.64, and $332.91 per acre for big bluestem, alfalfa, and switchgrass, respectively. Alfalfa had the second highest fertilizer, chemical, and seed cost, and the highest harvest cost' so it had the second highest total cost.

Amortized per Acre Returns

Amortized gross returns were $442.66, $619.80, and $684.23 per acre for big bluestem, switchgrass, and alfalfa, respectively. The prices were $140.00 per ton for big bluestem and switchgrass, and $180.27 per ton for alfalfa. The alfalfa price was $40.27 per ton higher than the big bluestem and switchgrass prices which caused alfalfa to have higher gross returns than switchgrass which had a yield that was 6.77 total tons per acre (0.67 average annual tons per acre) higher than alfalfa.

Amortized net returns were $145.04, $286.89, and $353.59 per acre for big bluestem, switchgrass, and alfalfa, respectively. Switchgrass performed well due the highest perennial crop yield, gross return and the second highest biomass price. Big bluestem had the lowest cost, but also had the lowest yield crop which resulted in the lowest net returns.

4.4.a.ii FEP and FMGA Scenarios: Amortized Per Ton

Amortized Per Ton Costs

Amortized fertilizer, chemical, and seed costs were $13.73, $16.11, and $20.60 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively.

Amortized field operation costs for applying chemicals, fertilizer, and planting the crop were $1.49, $1.76, and $2.26 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively.

Amortized total input costs were $15.22, $17.87, and $22.86 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively. Switchgrass had the lowest per acre field operation cost and the highest yield, which resulted in the lowest per ton cost. Big bluestem had the lowest yields which increased per ton costs.

Amortized harvest costs were $32.20, $34.73, and $37.81 per ton of biomass for switchgrass, big bluestem, and alfalfa, respectively. Big bluestem had the lowest yields and the lowest harvest cost per acre. Switchgrass had the highest per acre harvest costs but due to its high yield, it had the lowest harvest cost per ton. Alfalfa had the second highest harvest cost per acre but due to the second highest yield, it had the highest harvest cost per ton.

Amortized total variable costs, including all input and harvest costs, were $47.42, $55.68, and $57.59 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively. The low yields of big bluestem and high fertilizer, chemical, and seed costs were what caused big bluestem to have to highest total variable cost per ton. With alfalfa having the highest harvest cost per ton and the second highest total input cost per ton, alfalfa had the second highest total variable cost.

Amortized total costs, including variable costs and a land rental charge, were $64.09, $75.41, and $80.80 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively.

Amortized per Ton Returns

Amortized gross returns were $119.32, $120.18, and $156.05 per ton of biomass for switchgrass, big bluestem, and alfalfa, respectively. Switchgrass had higher yields and higher revenue per acre than big bluestem but due to higher yields, its gross returns per ton were slightly less than big bluestem. Switchgrass' high yields lead to higher harvest costs. Alfalfa had a price that was \$40.27 per ton higher than both switchgrass and big bluestem, which caused it to have higher gross returns per ton.

Amortized net returns were \$39.38, \$55.23, and \$80.64 per ton of biomass for big bluestem, switchgrass, and alfalfa, respectively. Yield was the major difference between big bluestem and switchgrass. Alfalfa having the highest price and the second highest yield caused it to have the highest net return per ton.

4.4.b FEPL and FMGAL Scenarios

The FEPL scenario derives all chemical, fertilizer, and field operations and yields from the field experiment for switchgrass and big bluestem. The FMGAL scenario is used to compare a typical perennial crop, alfalfa, produced by farm managers, but was not part of the field experiment. The FMGAL scenario's field operations, chemical, and fertilizer use rates, including the lime application, are from Dumler and Shoup (2012) and yields are from Herbel (2013). Both scenarios (FEPL and FMGAL) include lime applications but no other changes were made between the FEP and FEPL scenarios and the FMGA and FMGAL scenarios. Table 4.15 provides the annualized costs and returns for the 10 year production horizon and also the establishment costs incurred in the first year, on a per acre and per ton basis for the FEPL and FMGAL scenarios. Figure 4.16 provides a bar chart of the amortized per acre total cost, gross returns, and net returns. Figure 4.17 provides a bar chart of the establishment year per acre total costs, gross returns, and net returns.

4.4.b.i FEPL and FMGAL Scenarios: Amortized Per Acre

Amortized Per Acre Costs

Amortized fertilizer, chemical, lime, and seed costs were $87.11, $87.81, and $92.35 per acre for alfalfa, switchgrass, and big bluestem, respectively. The switchgrass and big bluestem (FEPL) crops had fertilizer applications delayed until year two, while alfalfa (FMGAL) had fertilizer applications every year. Lime was applied every year for switchgrass, big bluestem, and alfalfa.

Amortized field operation costs for applying chemicals, fertilizer, and planting the crop were $7.72, $7.73, and $8.34 per acre for switchgrass, alfalfa, and big bluestem, respectively. Big bluestem had two more applications of chemical than alfalfa and one more application than switchgrass. Big bluestem had chemical applications in years one, two, and three. Alfalfa only had chemical applications in year one, and switchgrass had chemical applications in years one and two. Alfalfa had fertilizer applications every year, while switchgrass and big bluestem had fertilizer applications every year but year one.

Amortized total input costs were $94.83, $95.53, and $100.69 per acre for alfalfa, switchgrass, and big bluestem, respectively. These differences were due to grasses not having applications of fertilizer and chemical applications in the first year, different numbers of applications in year three, and different rates of application.

Amortized harvest costs were $152.68, $184.51, and $201.86 per acre for big bluestem, alfalfa, and switchgrass, respectively. Harvest costs are a function of yields and bale densities. Due to switchgrass and big bluestem bales weighing less than an alfalfa bale, the grass crops' harvest cost per acre would be higher if tons per acre were equal among the crops (1150 pounds per bale for the grasses versus 1650 pounds per bale for alfalfa). Switchgrass had an average yield that was 0.67 tons per year per acre higher than alfalfa and also had lower density bales, which caused higher harvest costs.

Amortized total variable costs, including all input and harvest costs, were $253.37, $279.34, and $297.38 per acre for big bluestem, alfalfa, and switchgrass, respectively. The yield differences, and different annual applications fertilizer and chemicals are the main reason for the cost differences.

Amortized total costs, including variable cost and a land rental charge, were $340.18, $367.00, and $385.63 per acre for big bluestem, alfalfa, and switchgrass, respectively. Alfalfa had the second highest total cost because it had the second highest fertilizer, chemical, and seed cost, and the second highest harvest cost.

Amortized per Acre Returns

Amortized gross returns were $442.66, $619.80, and $684.23 per acre for big bluestem, switchgrass, and alfalfa, respectively. The prices were $140.00 per ton for big bluestem and switchgrass, and $180.27 per ton for alfalfa. The alfalfa price was $40.27 per ton higher than the big bluestem and switchgrass prices, which caused alfalfa to have higher gross returns than switchgrass which had a yield that was 6.77 total tons per acre (0.67 average annual tons per acre) higher than alfalfa.

Amortized net returns were $128.03, $269.88, and $336.57 per acre for big bluestem, switchgrass, and alfalfa, respectively. Switchgrass performed well due the highest perennial crop yield, gross return and the second highest biomass price. Big bluestem had the lowest cost, but also had the lowest yield crop which resulted in the lowest net returns.

4.4.b.ii FEPL and FMGAL Scenarios: Amortized Per Ton

Amortized Per Ton Costs

Amortized fertilizer, chemical, lime, and seed costs were $16.90, $19.87, and $25.07 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively.

Amortized field operation costs for applying chemicals, fertilizer, and planting the crop were $1.49, $1.76, and $2.26 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively.

Amortized total input costs were $18.39, $21.63, and $27.34 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively. Switchgrass had the lowest field operation costs per acre and the highest yield, which resulted in the lowest cost per ton. Big bluestem had the lowest yield, which increased per ton costs.

Amortized harvest costs were $32.20, $34.73, and $37.81 per ton of biomass for switchgrass, big bluestem, and alfalfa, respectively. Big bluestem had the lowest yields and the lowest harvest cost per acre. Switchgrass had the highest per acre harvest costs, but due to its high yield it had the lowest harvest cost per ton. Alfalfa had the second highest harvest cost per acre but due to the second highest yield it had the highest harvest cost per ton.

Amortized total variable costs, including all input and harvest costs, were $50.59, $59.43, and $62.07 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively. The low yields of big bluestem were what caused big bluestem to have to second highest total variable cost per ton. With alfalfa having the highest harvest cost per ton and the second highest total input cost per ton alfalfa had the highest total variable cost.

Amortized total costs, including variable cost and a land rental charge, were $67.37, $79.29, and $85.42 per ton of biomass for switchgrass, alfalfa, and big bluestem, respectively

Amortized per Ton Returns

Amortized gross returns were $119.32, $120.18, and $156.05 per ton of biomass for switchgrass, big bluestem, and alfalfa, respectively. Switchgrass had higher yields and higher revenue per acre than big bluestem, but due to higher yields its gross returns per ton were slightly less than big bluestem. Alfalfa had a price that was $40.27 per ton higher than both switchgrass and big bluestem, which caused it to have higher gross returns per ton.

Amortized net returns were $34.76, $51.96, and $76.76 per ton of biomass for big bluestem, switchgrass, and alfalfa, respectively. Yield was the major difference between big bluestem and switchgrass. Alfalfa had the highest net return per ton because it had the highest price and the second highest yield.

4.4.c Perennial Scenarios: 10 Year Horizon Conclusions

Across all scenarios (FEP, FEPL, FMGA, and FMGAL) the alfalfa scenario had the highest net return and big bluestem was the lowest net return, both in per acre and per ton measures. Switchgrass was the highest yielding crop but due to a $40.27 per ton higher alfalfa price, switchgrass was the second highest net return per acre and per ton crop.

The FEPL and FMGAL scenarios had net returns that were $17.01 per acre lower than the FEP and FMGA scenarios. This is due solely to the additional lime applications in the FEPL and FMGAL scenarios. Total variable costs per ton switched rankings of costs in the FEP and FMGA scenarios with alfalfa having the highest total variable cost per ton and big bluestem was the second highest total variable cost per ton. In the FEPL and FMGAL scenarios, big bluestem was the highest total variable cost per ton and alfalfa was the second highest total variable cost per ton.

4.5 Perennial Scenarios: Establishment Year Comparisons

Perennial crops generally have lower yields in the year of establishment (year one). Full yield potential happens in the second or third year of growth. Perennial crops may be profitable over the whole growing horizon, but may lose money in the year of establishment due to low yields, and higher costs of establishment. While annual crops have full yields each year they are planted, annual crops have costs and revenues that accrue during that growing year only. This creates a cash flow problem for perennial crops that annual crops do not incur. This analysis only classifies establishment as the first year, after the first year the crop is generally viable. Other research classifies establishment as years one, two, and three, which are the lowest yielding years.

4.5.a FEP and FMGA Scenarios: Establishment Year Comparison

Table 4.14 Provides the annualized costs and returns for the 10 year production horizon and also the establishment costs incurred in the first year on a per acre and per ton basis for the FEP and FMGA scenarios. Figure 4.15 provides a bar chart of the establishment year per acre total costs, gross returns, and net returns.

4.5.a i FEP and FMGA Scenarios: Establishment Year Per Acre Comparison

Establishment Year Costs Per Acre

Fertilizer, chemical, and seed costs used for establishment in the first year were $53.23, $80.06, and $91.18 per acre for switchgrass, alfalfa, and big bluestem, respectively. Seed costs were $13.29, $46.44, and $84.39 per acre for alfalfa, switchgrass, and big bluestem, respectively. Alfalfa had fertilizer applied in year one while big bluestem and switchgrass did not. This increased the establishment cost of alfalfa.

Field operation costs for applying chemicals, fertilizer, and planting to establishment the crop in the first year were $17.99 per acre for big bluestem and switchgrass. Alfalfa had a field operation cost of $23.38 per acre. Alfalfa's fertilizer applications were the only difference in field operations, because switchgrass and big bluestem did not have fertilizer applications in year one.

Establishment total input costs were $71.22, $103.44, and $109.17 per acre for switchgrass, alfalfa, and big bluestem, respectively.

Establishment harvest costs were $90.43, $91.53, and $117.00 per acre for switchgrass, big bluestem, and alfalfa, respectively. Establishment yields were 1.99, 2.03, and 3.01 tons per acre for switchgrass, big bluestem, and alfalfa, respectively. Due to higher yields, alfalfa had higher harvest costs.

Establishment total variable costs, including all input and harvest costs, were $161.65, $200.70, and $220.44 per acre for switchgrass, big bluestem, and alfalfa, respectively. Switchgrass had the lowest establishment total variable cost due to its low harvest cost, while alfalfa had the highest establishment total variable cost due to its high total input cost.

Establishment total costs, including variable cost and a land rental charge, were $242.90, $283.22, and $303.61 per acre for switchgrass, big bluestem, and alfalfa, respectively.

Establishment Year Returns per Acre

Establishment gross returns were $279.74, $284.11, and $541.90 per acre for switchgrass, big bluestem, and alfalfa, respectively. The prices were $140.27 per ton for big bluestem, $140.00 per ton for switchgrass, and $180.27 per ton for alfalfa. The alfalfa price was $40.00 per ton and $40.27 per ton higher than the big bluestem and switchgrass prices, respectively, and alfalfa had the highest establishment yield. Only the first year's yields were used to calculate establishment year gross returns.

Establishment net returns were $0.89, $36.84, and $238.29 per acre for big bluestem, switchgrass, and alfalfa, respectively. The high establishment cost and low yield of big bluestem resulted in a net return barely above zero.

4.5.a.ii FEP and FMGA Scenarios: Establishment Year Per Ton Comparison

Establishment Year Costs Per Ton

Fertilizer, chemical, and seed costs used to establish the crop in the first year were $26.63, $26.69, and $44.93 per ton for alfalfa, switchgrass, and big bluestem, respectively. The high establishment yield of alfalfa lowered its per ton cost relative to switchgrass and big bluestem.

Field operation costs for applying chemicals, fertilizer, and planting to establish the crop in the first year were $7.78, $8.86, and $9.02 for alfalfa, big bluestem, and switchgrass, respectively. The low yield of switchgrass made field operations relatively more expensive per ton than big bluestem even though the per acre costs were equal.

Establishment total input costs were $34.41, $35.71, and $53.80 per ton for alfalfa, switchgrass, and big bluestem, respectively.

Establishment harvest costs were $38.92, $45.10, and $45.34 per ton for alfalfa, big bluestem, and switchgrass, respectively. Establishment yields were 1.99, 2.03, and 3.01 tons per ton for switchgrass, big bluestem, and alfalfa, respectively. Because harvest costs are non-linear, per acre costs increase with yield increases but per ton costs decrease with yield increases. Alfalfa was the lowest establishment harvest cost per ton.

Establishment total variable costs, including all input and harvest costs, were $73.33, $81.06, and $98.90 per ton for alfalfa, switchgrass, and big bluestem, respectively.

Establishment total costs, including variable cost and a land rental charge, were $101.00, $121.80, and $139.56 per ton for alfalfa, switchgrass, and big bluestem, respectively.

Establishment per Ton Returns

Establishment gross returns per ton were the prices which were $140.27 per ton for big bluestem, $140.00 per ton for switchgrass, and $180.27 per ton for alfalfa. The alfalfa price was $40.00 per ton and $40.27 per ton higher than the big bluestem and switchgrass prices, respectively, and alfalfa had the highest establishment yield. Only the first year's yields were used to calculate establishment year gross returns.

Establishment net returns were $0.44, $18.20, and $79.27 per ton for big bluestem, switchgrass, and alfalfa, respectively. The high establishment cost and low yield of big bluestem resulted in a net return barely above zero.

4.5.b FEPL and FMGAL Scenarios: Establishment Comparison

Table 4.15 Provides the annualized costs and returns for the 10 year production horizon and also the establishment costs incurred in the first year on a per acre and per ton basis for the FEPL and FMGAL scenarios. Figure 4.17 provides a bar chart of the establishment year per acre total costs, gross returns, and net returns.

4.5.b.i FEPL and FMGAL Scenarios: Establishment Per Acre Comparison

Establishment per Acre Costs

Fertilizer, chemical, lime, and seed costs for establishing the crop in the establishment year were $69.16, $96.00, and $107.12 per acre for switchgrass, alfalfa, and big bluestem, respectively. Seed costs were $13.29, $46.44, and $84.39 per acre for alfalfa, switchgrass, and big bluestem, respectively. Alfalfa had fertilizer applied in year one, while big bluestem and switchgrass did not. This increased the establishment cost of alfalfa.

Field operation costs for applying chemicals, fertilizer, and planting the crop in the establishment year were $17.99 per acre for big bluestem and switchgrass. Alfalfa had a field operation cost of $23.38 per acre. Alfalfa's fertilizer applications were the only difference in field operations, because switchgrass and big bluestem did not have fertilizer applications in year one.

Establishment total input costs were $87.15, $119.38, and $125.10 per acre for switchgrass, alfalfa, and big bluestem, respectively.

Establishment harvest costs were $90.43, $91.53, and $117.00 per acre for switchgrass, big bluestem, and alfalfa, respectively. Establishment yields were 1.99, 2.03, and 3.01 tons per acre for switchgrass, big bluestem, and alfalfa, respectively. Due to higher yields alfalfa had higher harvest costs.

Establishment total variable costs, including all input and harvest costs, were $177.58, $216.63, and $236.38 per acre for switchgrass, big bluestem, and alfalfa, respectively. Switchgrass had the lowest establishment total variable cost due to its low harvest cost, while big bluestem had the highest establishment total variable cost, due to its high total input cost.

Establishment total costs, including variable cost and a land rental charge, were $259.35, $299.67, and $320.06 per acre for switchgrass, big bluestem, and alfalfa, respectively.

Establishment per Acre Returns

Establishment gross returns were $279.74, $284.11, and $541.90 per acre for switchgrass, big bluestem, and alfalfa, respectively. The prices were $140.00 per ton for big bluestem and switchgrass, and $180.27 per ton for alfalfa. The alfalfa price was $40.00 per ton and $40.27 per ton higher than the big bluestem and switchgrass prices, respectively, and alfalfa had the highest establishment yield. Only the first year's yields were used.

Establishment net returns were $(15.56), $20.39, and $221.84 per acre for big bluestem, switchgrass, and alfalfa, respectively. The high establishment cost and low yield of big bluestem resulted in a net return below zero.

4.5.b.ii FEPL and FMGAL Scenarios: Establishment Per Ton Comparison

Establishment per Ton Costs

Fertilizer, chemical, lime, and seed costs for establishing the crop in the first year were $31.94, $34.68, and $52.78 per ton for alfalfa, switchgrass, and big bluestem, respectively. The high establishment yield of alfalfa lowered its cost per ton relative to switchgrass and big bluestem.

Field operation costs for applying chemicals, fertilizer, and planting the crop in the establishment year were $7.78, $8.86, and $9.02 per ton for alfalfa, big bluestem, and switchgrass, respectively. The low yield of switchgrass made field operations relatively more expensive per ton than big bluestem, even though the per acre costs were equal.

Establishment total input costs were $39.71, $43.70, and $61.65 per ton for alfalfa, switchgrass, and big bluestem, respectively.

Establishment harvest costs were $38.92, $45.10, and $45.34 per ton for alfalfa, big bluestem, and switchgrass, respectively. Establishment yields were 1.99, 2.03, and 3.01 tons per ton for switchgrass, big bluestem, and alfalfa, respectively. Alfalfa was the lowest establishment harvest cost per ton because harvest costs are non-linear, thus per acre costs increase with yield increases but per ton costs decrease with yield increases.

Establishment total variable costs, including all input and harvest costs, were $78.63, $89.05, and $106.75 per ton for alfalfa, switchgrass, and big bluestem, respectively.

Establishment total costs, including variable cost and a land rental charge, were $106.47, $130.05, and $147.67 per ton for switchgrass, alfalfa, and big bluestem, respectively.

Establishment per ton Returns

Establishment gross returns per ton were the prices which were $140.27 per ton for big bluestem, $140.00 per ton for switchgrass, and $180.27 per ton for alfalfa. The alfalfa price was $40.00 and $40.27 per ton higher than the big bluestem and switchgrass prices, respectively, and alfalfa had the highest establishment yield.

Establishment net returns were \$(7.67), \$10.22, and \$73.80 per ton for big bluestem, switchgrass, and alfalfa, respectively. The high establishment cost and low yield of big bluestem resulted in a net return below zero.

4.5.c Perennial Scenarios: Establishment Year Conclusions

Across all scenarios, alfalfa had the highest net return per acre and per ton in the year of establishment followed by switchgrass. When lime applications were included, the big bluestem net returns per acre and per ton in the year of establishment went from being nearly negative to being negative. The FEP and FMGA scenarios' net returns were \$17.01 per acre higher than the FEPL and FMGAL scenarios. This is due solely to the additional lime applications in the FEPL and FMGAL scenarios.

High seed costs of big bluestem are the major cause of its negative profitability. The delay of applying fertilizer until the second year for switchgrass and big bluestem caused the grasses to have lower establishment costs.

4.6 Perennial Scenarios Conclusions

Alfalfa in both the FMGA and FMGAL scenarios had positive establishment year net returns (per ton and per acre; if one is positive, the other is also positive). Switchgrass in both the FEP and FEPL scenarios had positive establishment year net returns. Big bluestem had essentially zero establishment year net returns for the FEP scenario, but had negative net returns in the FEPL scenarios. Switchgrass, big bluestem, and alfalfa had positive amortized net returns for the FEP, FEPL, FMGA, and FMGAL scenarios. Big bluestem would have a cash flow problem due to its high establishment costs in the FEPL scenario.

4.7 Breakeven Analysis

The breakeven price in $/ton for crop residue biomass was determined for each crop in each annual crop rotation in each of the six scenarios. The maximum and minimum breakeven prices found across the six scenarios are reported for each annual crop rotation in Table 4.16. The breakeven price in $/ton for biomass from the two perennial grasses and alfalfa was also determined. The maximum and minimum breakeven prices across the four scenarios are also found in Table 4.16. Due to excluding 2009 and 2011 yield data from annual scenarios ending in AE, the harvest costs differed from the annual scenarios ending in A. These yield differences resulted in different breakeven costs due to differences in harvest costs.

The GS rotation had the minimum biomass breakeven price of $60.53 per ton with the FMGGBNRAE and FMGBNRAE scenarios and the maximum biomass breakeven price of $60.90 per ton with the FMGBNRA and FMGGBNRA scenarios. The scenarios differed by $0.38 per ton.

The BMR rotation had the minimum biomass breakeven price with the FMGGBNRA and FMGBNRA scenarios and the maximum biomass breakeven price with the FMGBNRAE and FMGGBNRAE scenarios. The scenarios differed by $0.11 per ton.

The PS rotation had the minimum biomass breakeven with the FMGGBNRAE scenario and the maximum biomass breakeven with the FMGBNRA scenario. The scenarios differed by $11.11 per ton.

The DP rotation had the minimum biomass breakeven price with the FMGGBNRA and FMGBNRA scenarios and the maximum biomass breakeven price with the FMGBNRAE and FMGGBNRAE scenarios. The scenarios differed by $0.01 per ton.

The SS rotation had the minimum biomass breakeven with the FMGBNRAE and FMGGBNRAE scenarios and the maximum biomass breakeven with the FMGGBNRA and FMGBNRA scenarios. The scenarios differed by $5.87 per ton.

The RC rotation had the minimum biomass breakeven with the FMGGBNRA and FMGBNRA scenarios and the maximum biomass breakeven with the FMGBNRAE and FMGGBNRAE scenarios. The scenarios differed by $0.13 per ton.

The CC rotation had the minimum biomass breakeven with the FMGGBNRAE and FMGBNRAE scenarios and the maximum biomass breakeven with the FMGBNRA and FMGGBNRA scenarios. The scenarios differed by $1.27 per ton.

Switchgrass had the minimum biomass breakeven price of $47.42 per ton with the FEP scenario and the maximum biomass breakeven price of $50.59 per ton with the FEPL scenario. The scenarios differed by $3.17 per ton.

Big bluestem had the minimum biomass breakeven with the FEP scenario and the maximum biomass breakeven with the FEPL scenario. The scenarios differed by $4.47 per ton.

Alfalfa had the minimum biomass breakeven with the FMGA scenario and the maximum biomass breakeven with the FMGAL scenario. The scenarios differed by $3.76 per ton.

Table 4.16 also shows that for the grain rotations the scenarios ending with A had the same biomass breakeven, and the scenarios ending with AE had the same biomass breakeven. For grain rotations there was no difference in the scenarios beginning with FMG's breakeven prices except through yield changes. The PS rotation had different yields and fertilizer usages between the scenarios ending in A and the scenarios ending in AE because the FMGBNRA and FMGBNRAE scenarios used the recommendations from O'Brien and Duncan (2012, b) as grain fertilizer input levels. In the PS rotation these grain fertilizer input levels were accrued to biomass production because there was no grain harvest. The FMGGBNRA and FMGGBNRAE scenarios used nutrient replacement for grain and biomass.

The PS rotation had the highest maximum biomass breakeven price, followed, by big bluestem, the GS rotation, and alfalfa in that order. The RC rotation had the lowest minimum biomass breakeven, followed by switchgrass, and the CC rotation, in that order.

4.8 Sensitivity Analysis

Because of the number of scenarios examined conducting and summarizing sensitivity analysis results for all of them is an overwhelming task. The FMGGBNRA scenario for the annual crops was selected for reporting the price and yield sensitivity results. This scenario was the most appropriate because it includes all available yield data, the most accurate nutrient replacement fertilizer costs, and more typical chemical usage for the region. The previous cross scenario comparisons illustrate this point. The FEPL and FMGAL scenarios were selected for the perennial crops for reporting the amortized net returns per ton sensitivity and establishment year net returns per ton sensitivity, because these scenarios include lime, like the annual crops do, and are accurate representations of the regional activities.

Price and yield sensitivity on net returns was performed on each crop rotation for the chosen scenarios. Grain yield and biomass yield were assumed to be perfectly correlated. Yields were varied at given grain and biomass price levels to estimate the yield impact on net returns. Biomass prices and grain prices were assumed to be perfectly correlated. Prices were varied at given grain yield and biomass yield levels to estimate the price impact on net return.

Prices and yields were varied by increasing and decreasing the values used in the original analysis by increments of 5%, 10% and 25%.

Appendix C contains the sensitivity analysis results for the FMGGBNRA, FEPL, and FMGAL scenarios. The labels on the tables contain the yields and prices for the increments in prices and yields from the original price or yield. Table 4.17 provides the alternative prices and the original prices used in the sensitivity analysis. Appendix D contains the FMGGBNRA, FEPL, and FMGAL scenario budgets for all crops and crop rotations.

Because the PS crop is considered a forage sorghum the price for these in the sensitivity analysis are for sorghum straw. Further, the 2013 sorghum sudangrass price from Hessman and Hruska (2013) was used in an alternative price sensitivity analysis. This price would only affect the biomass prices for the PS crop. These alternative price sensitivity results were compared to the results from the original prices and yields. Sensitivity results that result in negative net returns are noted.

Grain and biomass prices have become more volatile and higher over the period of the Propheter (2009) and Roozeboom et al. (2011) study. Using the relatively high 2013 prices may provide inaccurate net return results that are not indicative of what prices may be for farmers in the future. Average biomass prices from 2010 to 2013 for annuals and perennials from Pitcock (2013), and Hessman and Hruska (2013), respectively, were used in a price sensitivity analysis. Average grain prices from Dhuyvetter (2014) for 2010 to 2013 were used in this sensitivity analysis.

In the FEP and FEPL scenarios fertilizer applications were delayed until after the establishment year. Sensitivity analysis was performed to determine the impact of applying fertilizer in the year of establishment given the original prices and original yield.

The top two annual rotations for all six annual scenarios (using original prices and original yields) were the RC and DP rotations, in that order. Sensitivity analysis was performed, using the FMGGBNRA scenario to determine by how much yields or prices would have to change before the two rotations had roughly equal net returns.

The top two perennial crops for all four perennial scenarios (using original prices and original yields) were switchgrass and alfalfa. Sensitivity analysis was performed, using the FEPL and FMGAL scenarios to determine by how much yields or prices would have to change before the two rotations had roughly equal net returns, amortized and in the establishment year.

Perennial crops are not directly comparable to annual rotations due to differences in land rental rates. Perennial crops' land rental rates were set equal to annual rotations' land rental rates to facilitate a ranking comparison of all the crops and rotations in this study.

4.8.a FMGGBNRA Sensitivity Analysis

The DP and RC rotations have positive net returns over the whole range of prices and yields used in the sensitivity analysis. The GS and BMR rotations have negative net returns when prices and yields fall to 75% of the original prices and yields; for all other combinations of prices and yields the GS and BMR rotations have positive net returns.

When prices for the PS and SS rotations were 75% of the original prices, the PS and SS rotations had negative net returns for all yields that were less than 95% of the original yields. When prices for the CC rotation were 75% of the original price, the CC rotation had negative net returns for all yields less than 125% of the original yield. When yields for the CC rotation were 75% of the original yield, the CC rotation had negative net returns for all prices that were less than the original price. Appendix C.1 contains the sensitivity analysis results using the original prices and yields.

4.8.b FMGGBNRA Sorghum Sudangrass Sensitivity Analysis

With the 2013 sorghum sudangrass price of $127.30 per ton from Hessman and Hruska (2013) for the PS rotation, biomass prices resulted in net returns of $48.06 per acre of rotation for the PS rotations. The 2013 sorghum sudangrass price was $48.96/ton higher (a 63% increase in price) than the 2013 milo (sorghum) straw price. The sorghum sudangrass prices had net returns that were $256.47 per acre of rotation higher for the PS rotation. Over the whole range of prices and yields the PS rotation had positive net returns. If these prices, were used the PS rotation would have the highest net returns across all rotations, given that all other rotations except PS rotation, were using the original prices. The RC, DP, and GS rotations would follow, in that order. Appendix C.2 contains the sensitivity analysis results using the average 2013 sorghum sudangrass price for the PS rotation's biomass price.

4.8.c FMGGBNRA Average 2010 to 2013 Price Sensitivity Analysis

The RC rotation had positive net returns for the whole yield and price range used in the sensitivity analysis when the average price was based on the 2010 to 2013 average prices. When yields and prices for the DP and GS rotations were 75% of the original yield, the DP and GS rotations had negative returns.

When yields for the PS and SS rotations were 75% of the original yield, the PS and SS rotations had negative net returns for prices strictly less than 105% of the average prices. When prices for the PS and SS rotations were 75% of the average prices, the PS and SS rotations had negative net returns for all yields that were strictly less than 95% of the original yields.

When yields for the CC and BMR rotations were 75% of the original yield, the CC rotation had negative net returns for all prices strictly less than 125% of the average prices. Additionally, when prices for the BMR and CC rotations were 75% of the 2010 to 2013 average prices, the BMR and CC rotations had negative net returns for all yields strictly less than 105% of the original yield. Appendix C.3 contains the sensitivity analysis results using the average prices.

4.8.d FMGGBNRA RC versus DP Return Sensitivity

Table 4.18 contains the price and yield combinations that equate the net returns of the RC rotation and the DP rotation, as explained below.

4.8.d.i Original Prices and Yields

While holding the original prices constant, the DP rotation would require a yield that is between 105% and 110% of the original yield in order for the DP rotation's net returns to be approximately equal to the RC rotation's net returns at the original price and yield. While holding the original yield constant, the DP rotation would require a price that is approximately 110% of the original price in order for the DP net returns to be approximately equal the RC rotation's net returns at the original price and yield.

While holding prices constant, the RC rotation would require a yield that is between 95% and 90% of the original yield in order for the RC rotation's net returns to be approximately equal to the DP rotation's original price and yield net returns. While holding original yield constant, the RC rotation would require a price that is between 95% and 90% of the original yield in order for the RC rotation's net returns to be approximately equal to the DP rotation's net returns at the original price and yield.

4.8.d.ii 2010 to 2013 Average Prices and Original Yields

While holding the 2010 to 2013 average prices constant, the DP rotation would require a yield that is between 105% and 110% of the original yield in order for the DP rotation's net returns to be approximately equal to the RC rotation's net returns at the average price and original yield. While holding the original yield constant, the DP rotation would require a price that is between 110% and 125% of the 2010 to 2013 average price in order for the DP rotation's net returns to be approximately equal the RC rotation's net returns at the average price and original yield.

While holding prices constant, the RC rotation would require a yield that is between 95% and 90% of the original yield in order for the RC rotation's net returns to be approximately equal to the DP rotation's net returns at the average price and original yield. While holding original yield constant, the RC rotation would require a price that is between 90% and 75% of the original price in order for the RC rotation's net returns to be approximately equal to the DP rotation's net returns at the average price and original yield.

4.8.e FEPL and FMGAL Sensitivity Analysis

Appendix C.4 contains the sensitivity analysis using original prices and yields.

4.8.e.i FEPL and FMGAL Amortized Per Ton Sensitivity Analysis

Switchgrass and alfalfa had positive amortized net returns per ton over the whole range of prices and yields used in the sensitivity analysis. When prices for big bluestem were 75% of the original price, big bluestem had negative net returns when yield strictly less than 95% of the original yield.

4.8.e.ii FEPL and FMGAL Establishment Year Per Ton Sensitivity Analysis

Alfalfa was the only crop which had mostly positive net returns over the whole range of prices and yields. Alfalfa had negative net returns when the price and yield were 75% of the original price and yield. Big bluestem and switchgrass had negative returns for many price and yield combinations. Refer to Appendix C.4 for a complete list of these combinations.

4.8.f FEPL and FMGAL 2010 to 2013 Average Prices Sensitivity Analysis

Appendix C.5 contains the sensitivity analysis results using average prices.

4.8.f.i FEPL and FMGAL Amortized Per ton Sensitivity Analysis

Switchgrass and alfalfa had negative net returns when using the 2010 to 2013 average prices only when yields and prices were 75% of the original yields and average prices. Big bluestem had negative net returns for many yield and average price combinations. Refer to Appendix C.5 for a complete list of these combinations.

4.8.f.ii FEPL and FMGAL Establishment Year Per ton Sensitivity Analysis

When yields for alfalfa were 75% of the original yield, alfalfa had negative net returns for all prices that were strictly less than the average price. When prices for alfalfa were 75% of the average price, alfalfa had negative net returns for all yields strictly less than the original yield. Big bluestem and switchgrass had negative returns for most price and yield combinations. Refer to Appendix C for a complete list of these combinations.

4.8.g FEPL Fertilizer Application Impacts

Appendix C.6 contains the sensitivity analysis results using fertilizer applications in the establishment year and using the 2013 average prices.

4.8.g.i FEPL Amortized Net Returns

Switchgrass had positive net returns for the whole range of prices and yields used in the sensitivity analysis, using the original prices and yields, when fertilizer applications began in the establishment year. When big bluestem prices were 75% of the original price, big bluestem had negative amortized net returns for all yields strictly less than the original yield. When big bluestem yields were 75% of the original price, big bluestem had negative amortized net returns for all prices strictly less than 95% of the original price.

Amortized net returns were $1.81 per ton and $4.00 per ton less when fertilizer was applied in the establishment year for switchgrass and big bluestem, respectively. Refer to Appendix C.6 for a complete list of these combinations.

4.8.g.ii FEPL Establishment Year Net Returns

Switchgrass and big bluestem had negative net returns for the whole range of prices and yields when fertilizer applications began in the establishment year. Establishment year net returns were $118.71 per ton and $135.97 per ton less when fertilizer was applied in the establishment year for switchgrass and big bluestem, respectively.

4.8.h FEPL Switchgrass versus FMGAL Alfalfa Net Return Sensitivity

Per acre and per ton results provide the same analysis results. Table 4.19 contains the price and yield combinations that equate the net returns of alfalfa and switchgrass, as explained below.

4.8.h.i Amortized Net Returns

While holding the original prices constant, switchgrass would require yields that are between 110% and 125% of the original yield in order for switchgrass's net returns to be approximately equal to alfalfa's net returns. While holding original yields constant, switchgrass would require prices that are between 110% and 125% of the original yield for switchgrass's net returns to be approximately equal to alfalfa's net returns.

While holding the price constant, alfalfa would require a yield between 95% and 90% of the original yield in order for alfalfa's net returns to be approximately equal to switchgrass's net returns. While holding the yields constant, alfalfa would require a price approximately 90% of the original price in order for alfalfa's net returns to be approximately equal to switchgrass's net returns.

4.8.h.ii Establishment Net Returns

Switchgrass would require a price and yield greater than 125% of the original prices and yields in order for the establishment year switchgrass net returns to be approximately equal to the establishment year net returns. Alfalfa would require a prices and yields of approximately 75% of the original prices and yields in order for the establishment year net returns of alfalfa to be approximately equal to switchgrass's establishment year net returns.

4.8.i Annual Rotations versus Perennial Crops

Setting the land rental rates of the perennial crops equal to the land rental rates of the annual rotations allows the perennial crops amortized net returns per acre to be compared to the annual rotations net returns per acre of rotation. Appendix C.7 contains the sensitivity analysis of the perennial crops using the annual rotations' land rental rates and using the 2013 average prices. Appendix C.8 contains the sensitivity analysis of the perennial crops using the annual rotations' land rental rates and using the 2010 to 2013 average prices.

4.8.i.i Annual Rotations versus Perennial Crops Using 2013 Average Prices

Alfalfa had amortized net returns of $271.23 per acre when perennial land rental rates were equal to the annual rotation's land rental rates and when 2013 average prices were used. Alfalfa's net returns rank above the SS, RC, PS, and BMR rotations' net returns. Switchgrass and big bluestem had net amortized net returns of $204.53 per acre and $32.68 per acre, respectively. The big bluestem net returns were less than the net returns of all the annual rotations. Switchgrass had net returns that were greater than only the CC rotation.

Switchgrass did not make positive net returns until the third year of production, and big bluestem had negative net returns in year six when fertilizer was applied for the second time in the production horizon (refer to 3.3.c.ii Perennial Crops Fertilizer Costs for more information). Alfalfa had mostly positive net returns in the establishment year across the range of prices and yields used in sensitivity analysis. However, switchgrass and big bluestem had mostly negative net returns in the establishment year across the range of prices and yields used in the sensitivity analysis. Appendix C.7 contains a complete list of these net returns.

4.8.i.ii Annual Rotations versus Perennial Crops Using 2010 to 2013 Average Prices

Alfalfa had amortized net returns of $258.03 per acre when perennial land rental rates were equal to the annual rotation's land rental rates and 2010 to 2013 average prices were used.. Alfalfa's net returns rank above the SS, RC, PS, and BMR rotations' net returns. Switchgrass and big bluestem had net amortized net returns of $93.89 per acre and $(32.55) per acre, respectively. The switchgrass and big bluestem net returns were less than the net returns of all the annual rotations.

Switchgrass did not make positive net returns until the third year of production. Big bluestem had negative net returns in years one, two, three, five, and six when using the 2010 to 2013 average prices. Alfalfa had mostly positive net returns in the establishment year across the range of prices and yields used in sensitivity analysis. However, switchgrass and big bluestem had mostly negative net returns in the establishment year across the range of prices and yields used in the sensitivity analysis. Appendix C.8 contains a complete list of these net returns.

4.9 Overall Conclusions

4.9.a Annual Rotations Conclusions

The RC rotation has the highest net returns and, across the sensitivity analyses performed, generally has the highest net returns. However, if the PS rotation received the higher sorghum sudangrass price, it would have the highest net returns. The DP rotation was consistently behind the RC rotation and had the second highest net returns, if the sorghum sudangrass price was not received. If the sorghum sudangrass price was received for the PS rotation, the DP rotation would have the third highest net returns.

4.9.b Perennial Crops Conclusions

Alfalfa has positive establishment net returns over the majority of the sensitivity analyses, due to its high prices. Alfalfa has the highest amortized net returns as well. Switchgrass has the second highest amortized and establishment net returns, but had cash flow problems.

4.9.c Annual Rotations and Perennial Crops Conclusions

Annual rotations and perennial crops can't be directly compared to each other because of differences in land rental rates. These differences in land rental rates imply differences in land productivity, which helps drive yields.

Chapter 4: Tables and Figures

Table 4. 1: FEA Scenario Rotation Comparison

	GS	BMR	PS	DP	SS	RC	CC		Min	Max	Median	Average
Fertilizer and Chemicals- Grain per Acre									$ -	$ -	$ -	$ -
Fertilizer and Chemicals- Biomass per Acre									$ -	$ -	$ -	$ -
Total Fertilizer and Chemicals per Acre	$ 154.64	$ 154.64	$ 154.64	$ 154.64	$ 154.64	$ 175.44	$ 278.43		$ 154.64	$ 278.43	$ 154.64	$ 175.29
									$ -	$ -	$ -	$ -
Harvest Cost per Ton of Biomass	$ 35.59	$ 35.99	$ 34.73	$ 34.81	$ 34.47	$ 34.25	$ 34.79		$ 34.25	$ 35.99	$ 34.79	$ 34.95
Variable Cost per Ton of Biomass									$ -	$ -	$ -	$ -
Harvest-Grain per Acre	$ 42.00	$ 35.65	$ 21.50	$ 43.25	$ 34.40	$ 52.89	$ 49.08		$ 21.50	$ 52.89	$ 42.00	$ 39.83
Harvest-Biomass per Acre	$ 111.87	$ 115.90	$ 181.92	$ 150.71	$ 177.71	$ 125.40	$ 199.15		$ 111.87	$ 199.15	$ 150.71	$ 151.81
Total Harvest (Grain+Biomass) per Acre	$ 153.88	$ 151.56	$ 203.42	$ 193.96	$ 212.12	$ 178.30	$ 248.24		$ 151.56	$ 248.24	$ 193.96	$ 191.64
									$ -	$ -	$ -	$ -
Interest Grain per Acre									$ -	$ -	$ -	$ -
Interest Biomass per Acre									$ -	$ -	$ -	$ -
Total Interest per Acre	$ 11.54	$ 11.46	$ 13.15	$ 12.84	$ 13.43	$ 14.32	$ 20.76		$ 11.46	$ 20.76	$ 13.15	$ 13.93
									$ -	$ -	$ -	$ -
Total Cost Grain									$ -	$ -	$ -	$ -
Total Cost Biomass									$ -	$ -	$ -	$ -
Total Cost per Acre	$ 505.81	$ 503.42	$ 556.97	$ 547.20	$ 565.95	$ 594.06	$ 798.86		$ 503.42	$ 798.86	$ 556.97	$ 581.75
									$ -	$ -	$ -	$ -
Gross Return-Grain per Acre	$ 578.06	$ 490.08	$ 399.25	$ 594.86	$ 455.30	$ 797.94	$ 587.38		$ 399.25	$ 797.94	$ 578.06	$ 557.55
Gross Return-Biomass per Acre	$ 246.23	$ 252.29	$ 410.31	$ 339.18	$ 403.82	$ 222.97	$ 348.68		$ 222.97	$ 410.31	$ 339.18	$ 317.64
Gross Return per Acre	$ 824.29	$ 742.37	$ 809.55	$ 934.04	$ 859.12	$ 1,020.92	$ 936.05		$ 742.37	$ 1,020.92	$ 859.12	$ 875.19
									$ -	$ -	$ -	$ -
Net Return- Grain per Acre									$ -	$ -	$ -	$ -
Net Return - Biomass per Acre									$ -	$ -	$ -	$ -
Net Return per Acre	$ 318.48	$ 238.95	$ 252.58	$ 386.84	$ 293.17	$ 426.86	$ 137.19		$ 137.19	$ 426.86	$ 293.17	$ 293.44

Table 4. 2: FEAE Scenario Rotation Comparison

	GS	BMR	PS	DP	SS	RC	CC		Min	Max	Median	Average
Fertilizer and Chemicals- Grain per Acre									$ -	$ -	$ -	$ -
Fertilizer and Chemicals- Biomass per Acre									$ -	$ -	$ -	$ -
Total Fertilizer and Chemicals per Acre	$ 142.48	$ 142.48	$ 142.48	$ 142.48	$ 142.48	$ 163.28	$ 278.43		$ 142.48	$ 278.43	$ 142.48	$ 164.87
									$ -	$ -	$ -	$ -
Harvest Cost per Ton of Biomass	$ 35.55	$ 36.00	$ 34.49	$ 34.81	$ 34.07	$ 34.27	$ 34.60		$ 34.07	$ 36.00	$ 34.60	$ 34.83
Variable Cost per Ton of Biomass									$ -	$ -	$ -	$ -
Harvest-Grain per Acre	$ 46.85	$ 39.96	$ 21.50	$ 48.71	$ 35.75	$ 57.20	$ 57.91		$ 21.50	$ 57.91	$ 46.85	$ 43.98
Harvest-Biomass per Acre	$ 113.32	$ 115.35	$ 205.53	$ 150.66	$ 228.68	$ 124.29	$ 214.39		$ 113.32	$ 228.68	$ 150.66	$ 164.60
Total Harvest (Grain+Biomass) per Acre	$ 160.17	$ 155.31	$ 227.03	$ 199.37	$ 264.43	$ 181.49	$ 272.30		$ 155.31	$ 272.30	$ 199.37	$ 208.59
									$ -	$ -	$ -	$ -
Interest Grain per Acre									$ -	$ -	$ -	$ -
Interest Biomass per Acre									$ -	$ -	$ -	$ -
Total Interest per Acre	$ 11.35	$ 11.19	$ 13.52	$ 12.62	$ 14.74	$ 14.03	$ 21.55		$ 11.19	$ 21.55	$ 13.52	$ 14.14
									$ -	$ -	$ -	$ -
Total Cost Grain									$ -	$ -	$ -	$ -
Total Cost Biomass									$ -	$ -	$ -	$ -
Total Cost per Acre	$ 499.76	$ 494.74	$ 568.79	$ 540.23	$ 607.40	$ 584.80	$ 823.71		$ 494.74	$ 823.71	$ 568.79	$ 588.49
									$ -	$ -	$ -	$ -
Gross Return-Grain per Acre	$ 643.20	$ 550.64	$ 399.25	$ 668.08	$ 492.67	$ 863.95	$ 722.69		$ 399.25	$ 863.95	$ 643.20	$ 620.07
Gross Return-Biomass per Acre	$ 249.69	$ 250.96	$ 466.81	$ 339.07	$ 525.81	$ 220.88	$ 377.36		$ 220.88	$ 525.81	$ 339.07	$ 347.23
Gross Return per Acre	$ 892.89	$ 801.60	$ 866.06	$ 1,007.15	$ 1,018.49	$ 1,084.83	$ 1,100.05		$ 801.60	$ 1,100.05	$ 1,007.15	$ 967.30
									$ -	$ -	$ -	$ -
Net Return- Grain per Acre									$ -	$ -	$ -	$ -
Net Return - Biomass per Acre									$ -	$ -	$ -	$ -
Net Return per Acre	$ 393.13	$ 306.86	$ 297.27	$ 466.93	$ 411.08	$ 500.03	$ 276.35		$ 276.35	$ 500.03	$ 393.13	$ 378.81

Table 4. 3: FMGBNRA Scenario Rotation Comparison

	GS	BMR	PS	DP	SS	RC	CC	Min	Max	Median	Average
Fertilizer and Chemicals- Grain per Acre	$98.04	$98.04	$35.79	$98.04	$98.04	$121.57	$190.48	$35.79	$190.48	$98.04	$105.72
Fertilizer and Chemicals- Biomass per Acre	$73.55	$56.91	$171.41	$67.59	$117.25	$41.70	$78.84	$41.70	$171.41	$73.55	$86.75
Total Fertilizer and Chemicals per Acre	$171.59	$154.96	$207.21	$165.63	$215.30	$163.27	$269.32	$154.96	$269.32	$171.59	$192.47
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Harvest Cost per Ton of Biomass	$35.59	$35.99	$34.73	$34.81	$34.47	$34.25	$34.79	$34.25	$35.99	$34.79	$34.95
Variable Cost per Ton of Biomass	$60.90	$55.40	$73.03	$52.05	$59.08	$47.12	$50.13	$47.12	$73.03	$55.40	$56.82
Harvest-Grain per Acre	$42.00	$35.65	$21.50	$43.25	$34.40	$52.89	$49.08	$21.50	$52.89	$42.00	$39.83
Harvest-Biomass per Acre	$111.87	$115.90	$181.92	$150.71	$177.71	$125.40	$199.15	$111.87	$199.15	$150.71	$151.81
Total Harvest (Grain+Biomass) per Acre	$153.88	$151.56	$203.42	$193.96	$212.12	$178.30	$248.24	$151.56	$248.24	$193.96	$191.64
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Interest Grain per Acre	$6.21	$6.00	$2.96	$6.25	$5.96	$8.60	$11.43	$2.96	$11.43	$6.21	$6.77
Interest Biomass per Acre	$6.03	$5.62	$12.04	$7.09	$9.59	$5.43	$9.03	$5.43	$12.04	$7.09	$7.83
Total Interest per Acre	$12.24	$11.62	$15.00	$13.35	$15.55	$14.03	$20.47	$11.62	$20.47	$14.03	$14.61
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Cost Grain	$336.50	$329.95	$163.76	$337.79	$328.66	$412.28	$502.43	$163.76	$502.43	$336.50	$344.48
Total Cost Biomass	$191.45	$178.43	$452.12	$225.39	$304.55	$172.53	$287.03	$172.53	$452.12	$225.39	$258.79
Total Cost per Acre	$527.95	$508.38	$615.88	$563.18	$633.21	$584.81	$789.46	$508.38	$789.46	$584.81	$603.27
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gross Return-Grain per Acre	$578.06	$490.08	$399.25	$594.86	$455.30	$797.94	$587.38	$399.25	$797.94	$578.06	$557.55
Gross Return-Biomass per Acre	$246.23	$252.29	$410.31	$339.18	$403.82	$222.97	$348.68	$222.97	$410.31	$339.18	$317.64
Gross Return per Acre	$824.29	$742.37	$809.55	$934.04	$859.12	$1,020.92	$936.05	$742.37	$1,020.92	$859.12	$875.19
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Net Return- Grain per Acre	$241.56	$160.13	$235.49	$257.07	$126.65	$385.66	$84.95	$84.95	$385.66	$235.49	$213.07
Net Return - Biomass per Acre	$54.78	$73.85	$(41.81)	$113.79	$99.27	$50.44	$61.65	$(41.81)	$113.79	$61.65	$58.85
Net Return per Acre	$296.34	$233.99	$193.67	$370.86	$225.91	$436.11	$146.59	$146.59	$436.11	$233.99	$271.93

Table 4. 4: FMGBNRAE Scenario Rotation Comparison

	GS	BMR	PS	DP	SS	RC	CC	Min	Max	Median	Average
Fertilizer and Chemicals- Grain per Acre	$ 98.04	$ 98.04	$ 35.79	$ 98.04	$ 98.04	$ 121.57	$ 190.48	$ 35.79	$ 190.48	$ 98.04	$ 105.72
Fertilizer and Chemicals- Biomass per Acre	$ 73.55	$ 56.91	$ 171.41	$ 67.59	$ 117.25	$ 41.70	$ 78.84	$ 41.70	$ 171.41	$ 73.55	$ 86.75
Total Fertilizer and Chemicals per Acre	$ 171.59	$ 154.96	$ 207.21	$ 165.63	$ 215.30	$ 163.27	$ 269.32	$ 154.96	$ 269.32	$ 171.59	$ 192.47
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Harvest Cost per Ton of Biomass	$ 35.55	$ 36.00	$ 34.49	$ 34.81	$ 34.07	$ 34.27	$ 34.60	$ 34.07	$ 36.00	$ 34.60	$ 34.83
Variable Cost per Ton of Biomass	$ 60.53	$ 55.52	$ 68.28	$ 52.06	$ 53.21	$ 47.26	$ 48.86	$ 47.26	$ 68.28	$ 53.21	$ 55.10
Harvest-Grain per Acre	$ 46.85	$ 37.14	$ 21.50	$ 48.71	$ 35.75	$ 57.20	$ 57.91	$ 21.50	$ 57.91	$ 46.85	$ 43.58
Harvest-Biomass per Acre	$ 113.32	$ 115.35	$ 205.53	$ 150.66	$ 228.68	$ 124.29	$ 214.39	$ 113.32	$ 228.68	$ 150.66	$ 164.60
Total Harvest (Grain+Biomass) per Acre	$ 160.17	$ 152.49	$ 227.03	$ 199.37	$ 264.43	$ 181.49	$ 272.30	$ 152.49	$ 272.30	$ 199.37	$ 208.18
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Interest Grain per Acre	$ 6.37	$ 6.05	$ 2.96	$ 6.43	$ 6.01	$ 8.74	$ 11.72	$ 2.96	$ 11.72	$ 6.37	$ 6.90
Interest Biomass per Acre	$ 6.07	$ 5.60	$ 12.81	$ 7.09	$ 11.24	$ 5.39	$ 9.53	$ 5.39	$ 12.81	$ 7.09	$ 8.25
Total Interest per Acre	$ 12.44	$ 11.65	$ 15.77	$ 13.52	$ 17.25	$ 14.13	$ 21.25	$ 11.65	$ 21.25	$ 14.13	$ 15.15
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Cost Grain	$ 341.51	$ 331.48	$ 163.76	$ 343.42	$ 330.04	$ 416.73	$ 511.55	$ 163.76	$ 511.55	$ 341.51	$ 348.36
Total Cost Biomass	$ 192.94	$ 177.86	$ 476.49	$ 225.34	$ 357.18	$ 171.38	$ 302.75	$ 171.38	$ 476.49	$ 225.34	$ 271.99
Total Cost per Acre	$ 534.45	$ 509.35	$ 640.26	$ 568.76	$ 687.22	$ 588.11	$ 814.30	$ 509.35	$ 814.30	$ 588.11	$ 620.35
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gross Return-Grain per Acre	$ 643.20	$ 512.79	$ 399.25	$ 668.08	$ 492.67	$ 863.95	$ 722.69	$ 399.25	$ 863.95	$ 643.20	$ 614.66
Gross Return-Biomass per Acre	$ 249.69	$ 250.96	$ 466.81	$ 339.07	$ 525.81	$ 220.88	$ 377.36	$ 220.88	$ 525.81	$ 339.07	$ 347.23
Gross Return per Acre	$ 892.89	$ 763.75	$ 866.06	$ 1,007.15	$ 1,018.49	$ 1,084.83	$ 1,100.05	$ 763.75	$ 1,100.05	$ 1,007.15	$ 961.89
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Net Return- Grain per Acre	$ 301.69	$ 181.31	$ 235.49	$ 324.66	$ 162.63	$ 447.22	$ 211.15	$ 162.63	$ 447.22	$ 235.49	$ 266.31
Net Return - Biomass per Acre	$ 56.75	$ 73.10	$ (9.68)	$ 113.73	$ 168.63	$ 49.50	$ 74.61	$ (9.68)	$ 168.63	$ 73.10	$ 75.23
Net Return per Acre	$ 358.44	$ 254.41	$ 225.80	$ 438.39	$ 331.26	$ 496.72	$ 285.75	$ 225.80	$ 496.72	$ 331.26	$ 341.54

Table 4. 5: FMGGBNRA Scenario Rotation Comparison

	GS	BMR	PS	DP	SS	RC	CC	Min	Max	Median	Average
Fertilizer and Chemicals- Grain per Acre	$ 91.77	$ 83.52	$ 35.79	$ 93.87	$ 72.98	$ 109.93	$ 152.12	$ 35.79	$ 152.12	$ 91.77	$ 91.43
Fertilizer and Chemicals- Biomass per Acre	$ 73.55	$ 56.91	$ 134.69	$ 67.59	$ 117.25	$ 41.70	$ 78.84	$ 41.70	$ 134.69	$ 73.55	$ 81.50
Total Fertilizer and Chemicals per Acre	$ 165.31	$ 140.43	$ 170.48	$ 161.45	$ 190.23	$ 151.63	$ 230.95	$ 140.43	$ 230.95	$ 165.31	$ 172.93
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Harvest Cost per Ton of Biomass	$ 35.59	$ 35.99	$ 34.73	$ 34.81	$ 34.47	$ 34.25	$ 34.79	$ 34.25	$ 35.99	$ 34.79	$ 34.95
Variable Cost per Ton of Biomass	$ 60.90	$ 55.40	$ 65.79	$ 52.05	$ 59.08	$ 47.12	$ 50.13	$ 47.12	$ 65.79	$ 55.40	$ 55.78
Harvest-Grain per Acre	$ 42.00	$ 35.65	$ 21.50	$ 43.25	$ 34.40	$ 52.89	$ 49.08	$ 21.50	$ 52.89	$ 42.00	$ 39.83
Harvest-Biomass per Acre	$ 111.87	$ 115.90	$ 181.92	$ 150.71	$ 177.71	$ 125.40	$ 199.15	$ 111.87	$ 199.15	$ 150.71	$ 151.81
Total Harvest (Grain+Biomass) per Acre	$ 153.88	$ 151.56	$ 203.42	$ 193.96	$ 212.12	$ 178.30	$ 248.24	$ 151.56	$ 248.24	$ 193.96	$ 191.64
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Interest Grain per Acre	$ 6.01	$ 5.53	$ 2.96	$ 6.12	$ 5.15	$ 8.22	$ 10.39	$ 2.96	$ 10.39	$ 6.01	$ 6.34
Interest Biomass per Acre	$ 6.03	$ 5.62	$ 10.85	$ 7.09	$ 9.59	$ 5.43	$ 9.03	$ 5.43	$ 10.85	$ 7.09	$ 7.66
Total Interest per Acre	$ 12.03	$ 11.15	$ 13.81	$ 13.21	$ 14.74	$ 13.65	$ 19.43	$ 11.15	$ 19.43	$ 13.65	$ 14.00
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Cost Grain	$ 330.02	$ 314.95	$ 163.76	$ 333.48	$ 302.78	$ 400.35	$ 463.20	$ 163.76	$ 463.20	$ 330.02	$ 329.79
Total Cost Biomass	$ 191.45	$ 178.43	$ 414.20	$ 225.39	$ 304.55	$ 172.53	$ 287.03	$ 172.53	$ 414.20	$ 225.39	$ 253.37
Total Cost per Acre	$ 521.47	$ 493.39	$ 577.96	$ 558.87	$ 607.33	$ 572.88	$ 750.23	$ 493.39	$ 750.23	$ 572.88	$ 583.16
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Gross Return-Grain per Acre	$ 578.06	$ 490.08	$ 399.25	$ 594.86	$ 455.30	$ 797.94	$ 587.38	$ 399.25	$ 797.94	$ 578.06	$ 557.55
Gross Return-Biomass per Acre	$ 246.23	$ 252.29	$ 410.31	$ 339.18	$ 403.82	$ 222.97	$ 348.68	$ 222.97	$ 410.31	$ 339.18	$ 317.64
Gross Return per Acre	$ 824.29	$ 742.37	$ 809.55	$ 934.04	$ 859.12	$ 1,020.92	$ 936.05	$ 742.37	$ 1,020.92	$ 859.12	$ 875.19
	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Net Return- Grain per Acre	$ 248.04	$ 175.13	$ 235.49	$ 261.38	$ 152.52	$ 397.59	$ 124.17	$ 124.17	$ 397.59	$ 235.49	$ 227.76
Net Return - Biomass per Acre	$ 54.78	$ 73.85	$ (3.90)	$ 113.79	$ 99.27	$ 50.44	$ 61.65	$ (3.90)	$ 113.79	$ 61.65	$ 64.27
Net Return per Acre	$ 302.82	$ 248.98	$ 231.59	$ 375.17	$ 251.79	$ 448.03	$ 185.82	$ 185.82	$ 448.03	$ 251.79	$ 292.03

Table 4. 6: FMGGBNRAE Scenario Rotation Comparison

	GS	BMR	PS	DP	SS	RC	CC		Min	Max	Median	Average
Fertilizer and Chemicals- Grain per Acre	$ 91.77	$ 83.52	$ 35.79	$ 93.87	$ 72.98	$ 109.93	$ 152.12		$ 35.79	$ 152.12	$ 91.77	$ 91.43
Fertilizer and Chemicals- Biomass per Acre	$ 73.55	$ 56.91	$ 134.69	$ 67.59	$ 117.25	$ 41.70	$ 78.84		$ 41.70	$ 134.69	$ 73.55	$ 81.50
Total Fertilizer and Chemicals per Acre	$ 165.31	$ 140.43	$ 170.48	$ 161.45	$ 190.23	$ 151.63	$ 230.95		$ 140.43	$ 230.95	$ 165.31	$ 172.93
	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -	$ -	$ -
Harvest Cost per Ton of Biomass	$ 35.55	$ 36.00	$ 34.49	$ 34.81	$ 34.07	$ 34.27	$ 34.60		$ 34.07	$ 36.00	$ 34.60	$ 34.83
Variable Cost per Ton of Biomass	$ 60.53	$ 55.52	$ 61.92	$ 52.06	$ 53.21	$ 47.26	$ 48.86		$ 47.26	$ 61.92	$ 53.21	$ 54.19
Harvest-Grain per Acre	$ 46.85	$ 37.14	$ 21.50	$ 48.71	$ 35.75	$ 57.20	$ 57.91		$ 21.50	$ 57.91	$ 46.85	$ 43.58
Harvest-Biomass per Acre	$ 113.32	$ 115.35	$ 205.53	$ 150.66	$ 228.68	$ 124.29	$ 214.39		$ 113.32	$ 228.68	$ 150.66	$ 164.60
Total Harvest (Grain+Biomass) per Acre	$ 160.17	$ 152.49	$ 227.03	$ 199.37	$ 264.43	$ 181.49	$ 272.30		$ 152.49	$ 272.30	$ 199.37	$ 208.18
	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -	$ -	$ -
Interest Grain per Acre	$ 6.16	$ 5.58	$ 2.96	$ 6.29	$ 5.19	$ 8.36	$ 10.68		$ 2.96	$ 10.68	$ 6.16	$ 6.46
Interest Biomass per Acre	$ 6.07	$ 5.60	$ 11.61	$ 7.09	$ 11.24	$ 5.39	$ 9.53		$ 5.39	$ 11.61	$ 7.09	$ 8.08
Total Interest per Acre	$ 12.24	$ 11.18	$ 14.58	$ 13.39	$ 16.44	$ 13.75	$ 20.21		$ 11.18	$ 20.21	$ 13.75	$ 14.54
	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -	$ -	$ -
Total Cost Grain	$ 335.03	$ 316.49	$ 163.76	$ 339.11	$ 304.17	$ 404.80	$ 472.32		$ 163.76	$ 472.32	$ 335.03	$ 333.67
Total Cost Biomass	$ 192.94	$ 177.86	$ 438.58	$ 225.34	$ 357.18	$ 171.38	$ 302.75		$ 171.38	$ 438.58	$ 225.34	$ 266.58
Total Cost per Acre	$ 527.97	$ 494.35	$ 602.34	$ 564.45	$ 661.34	$ 576.18	$ 775.07		$ 494.35	$ 775.07	$ 576.18	$ 600.24
	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -	$ -	$ -
Gross Return-Grain per Acre	$ 643.20	$ 512.79	$ 399.25	$ 668.08	$ 492.67	$ 863.95	$ 722.69		$ 399.25	$ 863.95	$ 643.20	$ 614.66
Gross Return-Biomass per Acre	$ 249.69	$ 250.96	$ 466.81	$ 339.07	$ 525.81	$ 220.88	$ 377.36		$ 220.88	$ 525.81	$ 339.07	$ 347.23
Gross Return per Acre	$ 892.89	$ 763.75	$ 866.06	$ 1,007.15	$ 1,018.49	$ 1,084.83	$ 1,100.05		$ 763.75	$ 1,100.05	$ 1,007.15	$ 961.89
	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	$ -	$ -	$ -
Net Return- Grain per Acre	$ 308.17	$ 196.30	$ 235.49	$ 328.97	$ 188.51	$ 459.15	$ 250.37		$ 188.51	$ 459.15	$ 250.37	$ 280.99
Net Return - Biomass per Acre	$ 56.75	$ 73.10	$ 28.24	$ 113.73	$ 168.63	$ 49.50	$ 74.61		$ 28.24	$ 168.63	$ 73.10	$ 80.65
Net Return per Acre	$ 364.92	$ 269.40	$ 263.72	$ 442.70	$ 357.14	$ 508.64	$ 324.98		$ 263.72	$ 508.64	$ 357.14	$ 361.64

Table 4. 7: GS Rotation Cross Scenario Comparison

	FEA	FEAE	FMGBNRA	FMGBNRAE	FMGGBNRA	FMGGBNRAE		Min	Max	Difference	Median	Average	Std. Dev
Fertilizer and Chemicals- Grain per Acre			$ 98.04	$ 98.04	$ 91.77	$ 91.77		$ 91.77	$ 98.04	$ 6.28	$ 94.91	$ 94.91	$ 3.14
Fertilizer and Chemicals- Biomass per Acre			$ 73.55	$ 73.55	$ 73.55	$ 73.55		$ 73.55	$ 73.55	$ -	$ 73.55	$ 73.55	$ -
Total Fertilizer and Chemicals per Acre	$ 154.64	$ 142.48	$ 171.59	$ 171.59	$ 165.31	$ 165.31		$ 142.48	$ 171.59	$ 29.11	$ 165.31	$ 161.82	$ 10.34
Harvest Cost per Ton of Biomass	$ 35.59	$ 35.55	$ 35.59	$ 35.55	$ 35.59	$ 35.55		$ 35.55	$ 35.59	$ 0.04	$ 35.57	$ 35.57	$ 0.02
Variable Cost per Ton of Biomass			$ 60.90	$ 60.53	$ 60.90	$ 60.53		$ 60.53	$ 60.90	$ 0.38	$ 60.72	$ 60.72	$ 0.19
Harvest-Grain per Acre	$ 42.00	$ 46.85	$ 42.00	$ 46.85	$ 42.00	$ 46.85		$ 42.00	$ 46.85	$ 4.85	$ 44.43	$ 44.43	$ 2.43
Harvest-Biomass per Acre	$ 111.87	$ 113.32	$ 111.87	$ 113.32	$ 111.87	$ 113.32		$ 111.87	$ 113.32	$ 1.44	$ 112.60	$ 112.60	$ 0.72
Total Harvest (Grain+Biomass) per Acre	$ 153.88	$ 160.17	$ 153.88	$ 160.17	$ 153.88	$ 160.17		$ 153.88	$ 160.17	$ 6.29	$ 157.02	$ 157.02	$ 3.15
Interest Grain per Acre			$ 6.21	$ 6.37	$ 6.01	$ 6.16		$ 6.01	$ 6.37	$ 0.36	$ 6.19	$ 6.19	$ 0.13
Interest Biomass per Acre			$ 6.03	$ 6.07	$ 6.03	$ 6.07		$ 6.03	$ 6.07	$ 0.05	$ 6.05	$ 6.05	$ 0.02
Total Interest per Acre	$ 11.54	$ 11.35	$ 12.24	$ 12.44	$ 12.03	$ 12.24		$ 11.35	$ 12.44	$ 1.09	$ 12.13	$ 11.97	$ 0.40
Total Cost Grain			$ 336.50	$ 341.51	$ 330.02	$ 335.03		$ 330.02	$ 341.51	$ 11.49	$ 335.77	$ 335.77	$ 4.09
Total Cost Biomass			$ 191.45	$ 192.94	$ 191.45	$ 192.94		$ 191.45	$ 192.94	$ 1.49	$ 192.19	$ 192.19	$ 0.74
Total Cost per Acre	$ 505.81	$ 499.76	$ 527.95	$ 534.45	$ 521.47	$ 527.97		$ 499.76	$ 534.45	$ 34.69	$ 524.71	$ 519.57	$ 12.57
Gross Return-Grain per Acre	$ 578.06	$ 643.20	$ 578.06	$ 643.20	$ 578.06	$ 643.20		$ 578.06	$ 643.20	$ 65.14	$ 610.63	$ 610.63	$ 32.57
Gross Return-Biomass per Acre	$ 246.23	$ 249.69	$ 246.23	$ 249.69	$ 246.23	$ 249.69		$ 246.23	$ 249.69	$ 3.45	$ 247.96	$ 247.96	$ 1.73
Gross Return per Acre	$ 824.29	$ 892.89	$ 824.29	$ 892.89	$ 824.29	$ 892.89		$ 824.29	$ 892.89	$ 68.60	$ 858.59	$ 858.59	$ 34.30
Net Return- Grain per Acre			$ 241.56	$ 301.69	$ 248.04	$ 308.17		$ 241.56	$ 308.17	$ 66.61	$ 274.87	$ 274.87	$ 30.24
Net Return - Biomass per Acre			$ 54.78	$ 56.75	$ 54.78	$ 56.75		$ 54.78	$ 56.75	$ 1.96	$ 55.77	$ 55.77	$ 0.98
Net Return per Acre	$ 318.48	$ 393.13	$ 296.34	$ 358.44	$ 302.82	$ 364.92		$ 296.34	$ 393.13	$ 96.79	$ 338.46	$ 339.02	$ 35.43

Table 4. 8: BMR Rotation Cross Scenario Comparison

	FEA	FEAE	FMGBNRA	FMGBNRAE	FMGGBNRA	FMGGBNRAE		Min	Max	Difference	Median	Average	Std. Dev
Fertilizer and Chemicals- Grain per Acre			$ 98.04	$ 98.04	$ 83.52	$ 83.52		$ 83.52	$ 98.04	$ 14.52	$ 90.78	$ 90.78	$ 7.26
Fertilizer and Chemicals- Biomass per Acre			$ 56.91	$ 56.91	$ 56.91	$ 56.91		$ 56.91	$ 56.91	$ -	$ 56.91	$ 56.91	$ -
Total Fertilizer and Chemicals per Acre	$ 154.64	$ 142.48	$ 154.96	$ 154.96	$ 140.43	$ 140.43		$ 140.43	$ 154.96	$ 14.52	$ 148.56	$ 147.98	$ 6.90
Harvest Cost per Ton of Biomass	$ 35.99	$ 36.00	$ 35.99	$ 36.00	$ 35.99	$ 36.00		$ 35.99	$ 36.00	$ 0.02	$ 36.00	$ 36.00	$ 0.01
Variable Cost per Ton of Biomass			$ 55.40	$ 55.52	$ 55.40	$ 55.52		$ 55.40	$ 55.52	$ 0.11	$ 55.46	$ 55.46	$ 0.06
Harvest-Grain per Acre	$ 35.65	$ 39.96	$ 35.65	$ 37.14	$ 35.65	$ 37.14		$ 35.65	$ 39.96	$ 4.31	$ 36.40	$ 36.87	$ 1.53
Harvest-Biomass per Acre	$ 115.90	$ 115.35	$ 115.90	$ 115.35	$ 115.90	$ 115.35		$ 115.35	$ 115.90	$ 0.55	$ 115.63	$ 115.63	$ 0.28
Total Harvest (Grain+Biomass) per Acre	$ 151.56	$ 155.31	$ 151.56	$ 152.49	$ 151.56	$ 152.49		$ 151.56	$ 155.31	$ 3.75	$ 152.03	$ 152.50	$ 1.33
Interest Grain per Acre			$ 6.00	$ 6.05	$ 5.53	$ 5.58		$ 5.53	$ 6.05	$ 0.52	$ 5.79	$ 5.79	$ 0.24
Interest Biomass per Acre			$ 5.62	$ 5.60	$ 5.62	$ 5.60		$ 5.60	$ 5.62	$ 0.02	$ 5.61	$ 5.61	$ 0.01
Total Interest per Acre	$ 11.46	$ 11.19	$ 11.62	$ 11.65	$ 11.15	$ 11.18		$ 11.15	$ 11.65	$ 0.50	$ 11.33	$ 11.38	$ 0.21
Total Cost Grain			$ 329.95	$ 331.48	$ 314.95	$ 316.49		$ 314.95	$ 331.48	$ 16.53	$ 323.22	$ 323.22	$ 7.54
Total Cost Biomass			$ 178.43	$ 177.86	$ 178.43	$ 177.86		$ 177.86	$ 178.43	$ 0.57	$ 178.15	$ 178.15	$ 0.29
Total Cost per Acre	$ 503.42	$ 494.74	$ 508.38	$ 509.35	$ 493.39	$ 494.35		$ 493.39	$ 509.35	$ 15.96	$ 499.08	$ 500.60	$ 6.71
Gross Return-Grain per Acre	$ 490.08	$ 550.64	$ 490.08	$ 512.79	$ 490.08	$ 512.79		$ 490.08	$ 550.64	$ 60.56	$ 501.44	$ 507.74	$ 21.71
Gross Return-Biomass per Acre	$ 252.29	$ 250.96	$ 252.29	$ 250.96	$ 252.29	$ 250.96		$ 250.96	$ 252.29	$ 1.32	$ 251.63	$ 251.63	$ 0.66
Gross Return per Acre	$ 742.37	$ 801.60	$ 742.37	$ 763.75	$ 742.37	$ 763.75		$ 742.37	$ 801.60	$ 59.23	$ 753.06	$ 759.37	$ 21.17
Net Return- Grain per Acre			$ 160.13	$ 181.31	$ 175.13	$ 196.30		$ 160.13	$ 196.30	$ 36.17	$ 178.22	$ 178.22	$ 12.97
Net Return - Biomass per Acre			$ 73.85	$ 73.10	$ 73.85	$ 73.10		$ 73.10	$ 73.85	$ 0.75	$ 73.48	$ 73.48	$ 0.38
Net Return per Acre	$ 238.95	$ 306.86	$ 233.99	$ 254.41	$ 248.98	$ 269.40		$ 233.99	$ 306.86	$ 72.87	$ 251.69	$ 258.76	$ 24.32

Table 4. 9: PS Rotation Cross Scenario Comparison

	FEA	FEAE	FMGBNRA	FMGBNRAE	FMGGBNRA	FMGGBNRAE		Min	Max	Difference	Median	Average	Std. Dev
Fertilizer and Chemicals- Grain per Acre			$ 35.79	$ 35.79	$ 35.79	$ 35.79		$ 35.79	$ 35.79	$ -	$ 35.79	$ 35.79	$ -
Fertilizer and Chemicals- Biomass per Acre			$ 171.41	$ 171.41	$ 134.69	$ 134.69		$ 134.69	$ 171.41	$ 36.72	$ 153.05	$ 153.05	$ 18.36
Total Fertilizer and Chemicals per Acre	$ 154.64	$ 142.48	$ 207.21	$ 207.21	$ 170.48	$ 170.48		$ 142.48	$ 207.21	$ 64.73	$ 170.48	$ 175.42	$ 24.45
Harvest Cost per Ton of Biomass	$ 34.73	$ 34.49	$ 34.73	$ 34.49	$ 34.73	$ 34.49		$ 34.49	$ 34.73	$ 0.24	$ 34.61	$ 34.61	$ 0.12
Variable Cost per Ton of Biomass			$ 73.03	$ 68.28	$ 65.79	$ 61.92		$ 61.92	$ 73.03	$ 11.11	$ 67.03	$ 67.25	$ 4.03
Harvest-Grain per Acre	$ 21.50	$ 21.50	$ 21.50	$ 21.50	$ 21.50	$ 21.50		$ 21.50	$ 21.50	$ -	$ 21.50	$ 21.50	$ -
Harvest-Biomass per Acre	$ 181.92	$ 205.53	$ 181.92	$ 205.53	$ 181.92	$ 205.53		$ 181.92	$ 205.53	$ 23.61	$ 193.73	$ 193.73	$ 11.80
Total Harvest (Grain+Biomass) per Acre	$ 203.42	$ 227.03	$ 203.42	$ 227.03	$ 203.42	$ 227.03		$ 203.42	$ 227.03	$ 23.61	$ 215.23	$ 215.23	$ 11.80
Interest Grain per Acre			$ 2.96	$ 2.96	$ 2.96	$ 2.96		$ 2.96	$ 2.96	$ -	$ 2.96	$ 2.96	$ -
Interest Biomass per Acre			$ 12.04	$ 12.81	$ 10.85	$ 11.61		$ 10.85	$ 12.81	$ 1.96	$ 11.83	$ 11.83	$ 0.71
Total Interest per Acre	$ 13.15	$ 13.52	$ 15.00	$ 15.77	$ 13.81	$ 14.58		$ 13.15	$ 15.77	$ 2.62	$ 14.19	$ 14.31	$ 0.90
Total Cost Grain			$ 163.76	$ 163.76	$ 163.76	$ 163.76		$ 163.76	$ 163.76	$ -	$ 163.76	$ 163.76	$ -
Total Cost Biomass			$ 452.12	$ 476.49	$ 414.20	$ 438.58		$ 414.20	$ 476.49	$ 62.29	$ 445.35	$ 445.35	$ 22.54
Total Cost per Acre	$ 556.97	$ 568.79	$ 615.88	$ 640.26	$ 577.96	$ 602.34		$ 556.97	$ 640.26	$ 83.28	$ 590.15	$ 593.70	$ 28.73
Gross Return-Grain per Acre	$ 399.25	$ 399.25	$ 399.25	$ 399.25	$ 399.25	$ 399.25		$ 399.25	$ 399.25	$ -	$ 399.25	$ 399.25	$ -
Gross Return-Biomass per Acre	$ 410.31	$ 466.81	$ 410.31	$ 466.81	$ 410.31	$ 466.81		$ 410.31	$ 466.81	$ 56.51	$ 438.56	$ 438.56	$ 28.25
Gross Return per Acre	$ 809.55	$ 866.06	$ 809.55	$ 866.06	$ 809.55	$ 866.06		$ 809.55	$ 866.06	$ 56.51	$ 837.81	$ 837.81	$ 28.25
Net Return- Grain per Acre			$ 235.49	$ 235.49	$ 235.49	$ 235.49		$ 235.49	$ 235.49	$ -	$ 235.49	$ 235.49	$ -
Net Return - Biomass per Acre			$ (41.81)	$ (9.68)	$ (3.90)	$ 28.24		$ (41.81)	$ 28.24	$ 70.05	$ (6.79)	$ (6.79)	$ 24.85
Net Return per Acre	$ 252.58	$ 297.27	$ 193.67	$ 225.80	$ 231.59	$ 263.72		$ 193.67	$ 297.27	$ 103.60	$ 242.09	$ 244.11	$ 32.45

Table 4. 10: DP Rotation Cross Scenario Comparison

	FEA	FEAE	FMGBNRA	FMGBNRAE	FMGGBNRA	FMGGBNRAE	Min	Max	Difference	Median	Average	Std. Dev
Fertilizer and Chemicals- Grain per Acre			$ 98.04	$ 98.04	$ 98.04	$ 93.87	$ 93.87	$ 98.04	$ 4.18	$ 98.04	$ 97.00	$ 1.81
Fertilizer and Chemicals- Biomass per Acre			$ 67.59	$ 67.59	$ 67.59	$ 67.59	$ 67.59	$ 67.59	$ -	$ 67.59	$ 67.59	$ -
Total Fertilizer and Chemicals per Acre	$ 154.64	$ 142.48	$ 165.63	$ 165.63	$ 161.45	$ 161.45	$ 142.48	$ 165.63	$ 23.15	$ 161.45	$ 158.55	$ 8.07
Harvest Cost per Ton of Biomass	$ 34.81	$ 34.81	$ 34.81	$ 34.81	$ 34.81	$ 34.81	$ 34.81	$ 34.81	$ 0.00	$ 34.81	$ 34.81	$ 0.00
Variable Cost per Ton of Biomass			$ 52.05	$ 52.06	$ 52.05	$ 52.06	$ 52.05	$ 52.06	$ 0.01	$ 52.06	$ 52.06	$ 0.00
Harvest-Grain per Acre	$ 43.25	$ 48.71	$ 43.25	$ 48.71	$ 43.25	$ 48.71	$ 43.25	$ 48.71	$ 5.45	$ 45.98	$ 45.98	$ 2.73
Harvest-Biomass per Acre	$ 150.71	$ 150.66	$ 150.71	$ 150.66	$ 150.71	$ 150.66	$ 150.66	$ 150.71	$ 0.04	$ 150.68	$ 150.68	$ 0.02
Total Harvest (Grain+Biomass) per Acre	$ 193.96	$ 199.37	$ 193.96	$ 199.37	$ 193.96	$ 199.37	$ 193.96	$ 199.37	$ 5.41	$ 196.66	$ 196.66	$ 2.70
Interest Grain per Acre			$ 6.25	$ 6.43	$ 6.12	$ 6.29	$ 6.12	$ 6.43	$ 0.31	$ 6.27	$ 6.27	$ 0.11
Interest Biomass per Acre			$ 7.09	$ 7.09	$ 7.09	$ 7.09	$ 7.09	$ 7.09	$ 0.00	$ 7.09	$ 7.09	$ 0.00
Total Interest per Acre	$ 12.84	$ 12.62	$ 13.35	$ 13.52	$ 13.21	$ 13.39	$ 12.62	$ 13.52	$ 0.90	$ 13.28	$ 13.15	$ 0.32
Total Cost Grain			$ 337.79	$ 343.42	$ 333.48	$ 339.11	$ 333.48	$ 343.42	$ 9.94	$ 338.45	$ 338.45	$ 3.55
Total Cost Biomass			$ 225.39	$ 225.34	$ 225.39	$ 225.34	$ 225.34	$ 225.39	$ 0.05	$ 225.36	$ 225.36	$ 0.02
Total Cost per Acre	$ 547.20	$ 540.23	$ 563.18	$ 568.76	$ 558.87	$ 564.45	$ 540.23	$ 568.76	$ 28.54	$ 561.02	$ 557.11	$ 10.11
Gross Return-Grain per Acre	$ 594.86	$ 668.08	$ 594.86	$ 668.08	$ 594.86	$ 668.08	$ 594.86	$ 668.08	$ 73.22	$ 631.47	$ 631.47	$ 36.61
Gross Return-Biomass per Acre	$ 339.18	$ 339.07	$ 339.18	$ 339.07	$ 339.18	$ 339.07	$ 339.07	$ 339.18	$ 0.11	$ 339.12	$ 339.12	$ 0.05
Gross Return per Acre	$ 934.04	$ 1,007.15	$ 934.04	$ 1,007.15	$ 934.04	$ 1,007.15	$ 934.04	$ 1,007.15	$ 73.11	$ 970.60	$ 970.60	$ 36.56
Net Return- Grain per Acre			$ 257.07	$ 324.66	$ 261.38	$ 328.97	$ 257.07	$ 328.97	$ 71.90	$ 293.02	$ 293.02	$ 33.86
Net Return - Biomass per Acre			$ 113.79	$ 113.73	$ 113.79	$ 113.73	$ 113.73	$ 113.79	$ 0.06	$ 113.76	$ 113.76	$ 0.03
Net Return per Acre	$ 386.84	$ 466.93	$ 370.86	$ 438.39	$ 375.17	$ 442.70	$ 370.86	$ 466.93	$ 96.06	$ 412.62	$ 413.48	$ 37.25

Table 4. 11: SS Rotation Cross Scenario Comparison

	FEA	FEAE	FMGBNRA	FMGBNRAE	FMGGBNRA	FMGGBNRAE		Min	Max	Difference	Median	Average	Std. Dev
Fertilizer and Chemicals- Grain per Acre			$ 98.04	$ 98.04	$ 72.98	$ 72.98		$ 72.98	$ 98.04	$ 25.06	$ 85.51	$ 85.51	$ 12.53
Fertilizer and Chemicals- Biomass per Acre			$ 117.25	$ 117.25	$ 117.25	$ 117.25		$ 117.25	$ 117.25	$ -	$ 117.25	$ 117.25	$ -
Total Fertilizer and Chemicals per Acre	$ 154.64	$ 142.48	$ 215.30	$ 215.30	$ 190.23	$ 190.23		$ 142.48	$ 215.30	$ 72.82	$ 190.23	$ 184.70	$ 27.75
Harvest Cost per Ton of Biomass	$ 34.47	$ 34.07	$ 34.47	$ 34.07	$ 34.47	$ 34.07		$ 34.07	$ 34.47	$ 0.41	$ 34.27	$ 34.27	$ 0.20
Variable Cost per Ton of Biomass			$ 59.08	$ 53.21	$ 59.08	$ 53.21		$ 53.21	$ 59.08	$ 5.87	$ 56.14	$ 56.14	$ 2.93
Harvest-Grain per Acre	$ 34.40	$ 35.75	$ 34.40	$ 35.75	$ 34.40	$ 35.75		$ 34.40	$ 35.75	$ 1.34	$ 35.08	$ 35.08	$ 0.67
Harvest-Biomass per Acre	$ 177.71	$ 228.68	$ 177.71	$ 228.68	$ 177.71	$ 228.68		$ 177.71	$ 228.68	$ 50.97	$ 203.20	$ 203.20	$ 25.48
Total Harvest (Grain+Biomass) per Acre	$ 212.12	$ 264.43	$ 212.12	$ 264.43	$ 212.12	$ 264.43		$ 212.12	$ 264.43	$ 52.31	$ 238.27	$ 238.27	$ 26.16
Interest Grain per Acre			$ 5.96	$ 6.01	$ 5.15	$ 5.19		$ 5.15	$ 6.01	$ 0.86	$ 5.58	$ 5.58	$ 0.41
Interest Biomass per Acre			$ 9.59	$ 11.24	$ 9.59	$ 11.24		$ 9.59	$ 11.24	$ 1.66	$ 10.41	$ 10.41	$ 0.83
Total Interest per Acre	$ 13.43	$ 14.74	$ 15.55	$ 17.25	$ 14.74	$ 16.44		$ 13.43	$ 17.25	$ 3.82	$ 15.14	$ 15.36	$ 1.24
Total Cost Grain			$ 328.66	$ 330.04	$ 302.78	$ 304.17		$ 302.78	$ 330.04	$ 27.27	$ 316.41	$ 316.41	$ 12.96
Total Cost Biomass			$ 304.55	$ 357.18	$ 304.55	$ 357.18		$ 304.55	$ 357.18	$ 52.62	$ 330.87	$ 330.87	$ 26.31
Total Cost per Acre	$ 565.95	$ 607.40	$ 633.21	$ 687.22	$ 607.33	$ 661.34		$ 565.95	$ 687.22	$ 121.27	$ 620.31	$ 627.08	$ 39.46
Gross Return-Grain per Acre	$ 455.30	$ 492.67	$ 455.30	$ 492.67	$ 455.30	$ 492.67		$ 455.30	$ 492.67	$ 37.37	$ 473.99	$ 473.99	$ 18.69
Gross Return-Biomass per Acre	$ 403.82	$ 525.81	$ 403.82	$ 525.81	$ 403.82	$ 525.81		$ 403.82	$ 525.81	$ 121.99	$ 464.82	$ 464.82	$ 61.00
Gross Return per Acre	$ 859.12	$1,018.49	$ 859.12	$ 1,018.49	$ 859.12	$ 1,018.49		$ 859.12	$ 1,018.49	$ 159.36	$ 938.80	$ 938.80	$ 79.68
Net Return- Grain per Acre			$ 126.65	$ 162.63	$ 152.52	$ 188.51		$ 126.65	$ 188.51	$ 61.86	$ 157.58	$ 157.58	$ 22.16
Net Return - Biomass per Acre			$ 99.27	$ 168.63	$ 99.27	$ 168.63		$ 99.27	$ 168.63	$ 69.37	$ 133.95	$ 133.95	$ 34.68
Net Return per Acre	$ 293.17	$ 411.08	$ 225.91	$ 331.26	$ 251.79	$ 357.14		$ 225.91	$ 411.08	$ 185.17	$ 312.22	$ 311.73	$ 62.74

Table 4. 12: RC Rotation Cross Scenario Comparison

	FEA	FEAE	FMGBNRA	FMGBNRAE	FMGGBNRA	FMGGBNRAE		Min	Max	Difference	Median	Average	Std. Dev
Fertilizer and Chemicals- Grain per Acre			$ 121.57	$ 121.57	$ 121.57	$ 109.93		$ 109.93	$ 121.57	$ 11.64	$ 121.57	$ 118.66	$ 5.04
Fertilizer and Chemicals- Biomass per Acre			$ 41.70	$ 41.70	$ 41.70	$ 41.70		$ 41.70	$ 41.70	$ -	$ 41.70	$ 41.70	$ -
Total Fertilizer and Chemicals per Acre	$ 175.44	$ 163.28	$ 163.27	$ 163.27	$ 151.63	$ 151.63		$ 151.63	$ 175.44	$ 23.81	$ 163.27	$ 161.42	$ 8.15
Harvest Cost per Ton of Biomass	$ 34.25	$ 34.27	$ 34.25	$ 34.27	$ 34.25	$ 34.27		$ 34.25	$ 34.27	$ 0.02	$ 34.26	$ 34.26	$ 0.01
Variable Cost per Ton of Biomass			$ 47.12	$ 47.26	$ 47.12	$ 47.26		$ 47.12	$ 47.26	$ 0.13	$ 47.19	$ 47.19	$ 0.07
Harvest-Grain per Acre	$ 52.89	$ 57.20	$ 52.89	$ 57.20	$ 52.89	$ 57.20		$ 52.89	$ 57.20	$ 4.31	$ 55.05	$ 55.05	$ 2.15
Harvest-Biomass per Acre	$ 125.40	$ 124.29	$ 125.40	$ 124.29	$ 125.40	$ 124.29		$ 124.29	$ 125.40	$ 1.11	$ 124.85	$ 124.85	$ 0.56
Total Harvest (Grain+Biomass) per Acre	$ 178.30	$ 181.49	$ 178.30	$ 181.49	$ 178.30	$ 181.49		$ 178.30	$ 181.49	$ 3.20	$ 179.89	$ 179.89	$ 1.60
Interest Grain per Acre			$ 8.60	$ 8.74	$ 8.22	$ 8.36		$ 8.22	$ 8.74	$ 0.52	$ 8.48	$ 8.48	$ 0.20
Interest Biomass per Acre			$ 5.43	$ 5.39	$ 5.43	$ 5.39		$ 5.39	$ 5.43	$ 0.04	$ 5.41	$ 5.41	$ 0.02
Total Interest per Acre	$ 14.32	$ 14.03	$ 14.03	$ 14.13	$ 13.65	$ 13.75		$ 13.65	$ 14.32	$ 0.67	$ 14.03	$ 13.98	$ 0.22
Total Cost Grain			$ 412.28	$ 416.73	$ 400.35	$ 404.80		$ 400.35	$ 416.73	$ 16.37	$ 408.54	$ 408.54	$ 6.36
Total Cost Biomass			$ 172.53	$ 171.38	$ 172.53	$ 171.38		$ 171.38	$ 172.53	$ 1.15	$ 171.96	$ 171.96	$ 0.57
Total Cost per Acre	$ 594.06	$ 584.80	$ 584.81	$ 588.11	$ 572.88	$ 576.18		$ 572.88	$ 594.06	$ 21.18	$ 584.81	$ 583.47	$ 7.10
Gross Return-Grain per Acre	$ 797.94	$ 863.95	$ 797.94	$ 863.95	$ 797.94	$ 863.95		$ 797.94	$ 863.95	$ 66.00	$ 830.95	$ 830.95	$ 33.00
Gross Return-Biomass per Acre	$ 222.97	$ 220.88	$ 222.97	$ 220.88	$ 222.97	$ 220.88		$ 220.88	$ 222.97	$ 2.09	$ 221.93	$ 221.93	$ 1.05
Gross Return per Acre	$ 1,020.92	$ 1,084.83	$ 1,020.92	$ 1,084.83	$ 1,020.92	$ 1,084.83		$ 1,020.92	$ 1,084.83	$ 63.91	$ 1,052.87	$ 1,052.87	$ 31.96
Net Return- Grain per Acre			$ 385.66	$ 447.22	$ 397.59	$ 459.15		$ 385.66	$ 459.15	$ 73.48	$ 422.41	$ 422.41	$ 31.35
Net Return - Biomass per Acre			$ 50.44	$ 49.50	$ 50.44	$ 49.50		$ 49.50	$ 50.44	$ 0.95	$ 49.97	$ 49.97	$ 0.47
Net Return per Acre	$ 426.86	$ 500.03	$ 436.11	$ 496.72	$ 448.03	$ 508.64		$ 426.86	$ 508.64	$ 81.79	$ 472.38	$ 469.40	$ 33.16

Table 4. 13: CC Rotation Cross Scenario Comparison

	FEA	FEAE	FMGBNRA	FMGBNRAE	FMGGBNRA	FMGGBNRAE		Min	Max	Difference	Median	Average	Std. Dev
Fertilizer and Chemicals- Grain per Acre			$ 190.48	$ 190.48	$ 152.12	$ 152.12		$ 152.12	$ 190.48	$ 38.36	$ 171.30	$ 171.30	$ 19.18
Fertilizer and Chemicals- Biomass per Acre			$ 78.84	$ 78.84	$ 78.84	$ 78.84		$ 78.84	$ 78.84	$ -	$ 78.84	$ 78.84	$ -
Total Fertilizer and Chemicals per Acre	$ 278.43	$ 278.43	$ 269.32	$ 269.32	$ 230.95	$ 230.95		$ 230.95	$ 278.43	$ 47.47	$ 269.32	$ 259.57	$ 20.57
Harvest Cost per Ton of Biomass	$ 34.79	$ 34.60	$ 34.79	$ 34.60	$ 34.79	$ 34.60		$ 34.60	$ 34.79	$ 0.19	$ 34.69	$ 34.69	$ 0.09
Variable Cost per Ton of Biomass			$ 50.13	$ 48.86	$ 50.13	$ 48.86		$ 48.86	$ 50.13	$ 1.27	$ 49.50	$ 49.50	$ 0.64
Harvest-Grain per Acre	$ 49.08	$ 57.91	$ 49.08	$ 57.91	$ 49.08	$ 57.91		$ 49.08	$ 57.91	$ 8.83	$ 53.50	$ 53.50	$ 4.41
Harvest-Biomass per Acre	$ 199.15	$ 214.39	$ 199.15	$ 214.39	$ 199.15	$ 214.39		$ 199.15	$ 214.39	$ 15.23	$ 206.77	$ 206.77	$ 7.62
Total Harvest (Grain+Biomass) per Acre	$ 248.24	$ 272.30	$ 248.24	$ 272.30	$ 248.24	$ 272.30		$ 248.24	$ 272.30	$ 24.06	$ 260.27	$ 260.27	$ 12.03
Interest Grain per Acre			$ 11.43	$ 11.72	$ 10.39	$ 10.68		$ 10.39	$ 11.72	$ 1.33	$ 11.06	$ 11.06	$ 0.54
Interest Biomass per Acre			$ 9.03	$ 9.53	$ 9.03	$ 9.53		$ 9.03	$ 9.53	$ 0.50	$ 9.28	$ 9.28	$ 0.25
Total Interest per Acre	$ 20.76	$ 21.55	$ 20.47	$ 21.25	$ 19.43	$ 20.21		$ 19.43	$ 21.55	$ 2.12	$ 20.62	$ 20.61	$ 0.69
Total Cost Grain			$ 502.43	$ 511.55	$ 463.20	$ 472.32		$ 463.20	$ 511.55	$ 48.34	$ 487.37	$ 487.37	$ 20.14
Total Cost Biomass			$ 287.03	$ 302.75	$ 287.03	$ 302.75		$ 287.03	$ 302.75	$ 15.73	$ 294.89	$ 294.89	$ 7.86
Total Cost per Acre	$ 798.86	$ 823.71	$ 789.46	$ 814.30	$ 750.23	$ 775.07		$ 750.23	$ 823.71	$ 73.47	$ 794.16	$ 791.94	$ 24.45
Gross Return-Grain per Acre	$ 587.38	$ 722.69	$ 587.38	$ 722.69	$ 587.38	$ 722.69		$ 587.38	$ 722.69	$ 135.32	$ 655.03	$ 655.03	$ 67.66
Gross Return-Biomass per Acre	$ 348.68	$ 377.36	$ 348.68	$ 377.36	$ 348.68	$ 377.36		$ 348.68	$ 377.36	$ 28.68	$ 363.02	$ 363.02	$ 14.34
Gross Return per Acre	$ 936.05	$ 1,100.05	$ 936.05	$ 1,100.05	$ 936.05	$ 1,100.05		$ 936.05	$ 1,100.05	$ 164.00	$ 1,018.05	$ 1,018.05	$ 82.00
Net Return- Grain per Acre			$ 84.95	$ 211.15	$ 124.17	$ 250.37		$ 84.95	$ 250.37	$ 165.43	$ 167.66	$ 167.66	$ 66.08
Net Return - Biomass per Acre			$ 61.65	$ 74.61	$ 61.65	$ 74.61		$ 61.65	$ 74.61	$ 12.96	$ 68.13	$ 68.13	$ 6.48
Net Return per Acre	$ 137.19	$ 276.35	$ 146.59	$ 285.75	$ 185.82	$ 324.98		$ 137.19	$ 324.98	$ 187.79	$ 231.08	$ 226.11	$ 72.70

Table 4. 14: FEP and FMGA Scenarios Cross Crop Comparison in $/acre and $/ton

	Amortized Cost and Returns ($/acre)			Establisment Cost and Returns ($/acre)		
	FEP	FEP	FMGA	FEP	FEP	FMGA
	Switchgrass	Big bluestem	Alfalfa	Switchgrass	Big bluestem	Alfalfa
Fertilizer, Chemical, and Seed Cost	$ 71.33	$ 75.87	$ 70.63	$ 53.23	$ 91.18	$ 80.06
Field Operations	$ 7.72	$ 8.34	$ 7.73	$ 17.99	$ 17.99	$ 23.38
Total Input Cost	$ 79.05	$ 84.21	$ 78.36	$ 71.22	$ 109.17	$ 103.44
Harvest Costs	$ 167.27	$ 127.93	$ 165.77	$ 90.43	$ 91.53	$ 117.00
Total Variable Cost	$ 246.33	$ 212.15	$ 244.13	$ 161.65	$ 200.70	$ 220.44
Total Costs	$ 332.91	$ 297.62	$ 330.64	$ 242.90	$ 283.22	$ 303.61
Gross Returns	$ 619.80	$ 442.66	$ 684.23	$ 279.74	$ 284.11	$ 541.90
Net Returns	$ 286.89	$ 145.04	$ 353.59	$ 36.84	$ 0.89	$ 238.29
	Amortized Cost and Returns ($/ton)			Establisment Cost and Returns ($/ton)		
	FEP	FEP	FMGA	FEP	FEP	FMGA
	Switchgrass	Big bluestem	Alfalfa	Switchgrass	Big bluestem	Alfalfa
Fertilizer, Chemical, and Seed Cost	$ 13.73	$ 20.60	$ 16.11	$ 26.69	$ 44.93	$ 26.63
Field Operations	$ 1.49	$ 2.26	$ 1.76	$ 9.02	$ 8.86	$ 7.78
Total Input Cost	$ 15.22	$ 22.86	$ 17.87	$ 35.71	$ 53.80	$ 34.41
Harvest Costs	$ 32.20	$ 34.73	$ 37.81	$ 45.34	$ 45.10	$ 38.92
Total Variable Cost	$ 47.42	$ 57.59	$ 55.68	$ 81.06	$ 98.90	$ 73.33
Total Costs	$ 64.09	$ 80.80	$ 75.41	$ 121.80	$ 139.56	$ 101.00
Gross Returns	$ 119.32	$ 120.18	$ 156.05	$ 140.27	$ 140.00	$ 180.27
Net Returns	$ 55.23	$ 39.38	$ 80.64	$ 18.47	$ 0.44	$ 79.27
Total Tons (10 years)	43.42	30.79	36.65	1.99	2.03	3.01
Average Tons per Year	4.34	3.08	3.67			

Table 4. 15: FEPL and FMGAL Scenarios Cross Crop Comparison in $/acre and $/ton

	Amortized Cost and Returns ($/acre)			Establisment Cost and Returns ($/acre)		
	FEPL	FEPL	FMGAL	FEPL	FEPL	FMGAL
	Switchgrass	Big bluestem	Alfalfa	Switchgrass	Big bluestem	Alfalfa
	Per Acre Costs Amortized					
Fertilizer, Chemical, and Seed Cost	$ 87.81	$ 92.35	$ 87.11	$ 69.16	$ 107.12	$ 96.00
Field Operations	$ 7.72	$ 8.34	$ 7.73	$ 17.99	$ 17.99	$ 23.38
Total Input Cost	$ 95.53	$ 100.69	$ 94.83	$ 87.15	$ 125.10	$ 119.38
Harvest Costs	$ 167.27	$ 127.93	$ 165.77	$ 90.43	$ 91.53	$ 117.00
Total Variable Cost	$ 262.80	$ 228.62	$ 260.60	$ 177.58	$ 216.63	$ 236.38
Total Costs	$ 349.93	$ 314.63	$ 347.65	$ 259.35	$ 299.67	$ 320.06
Gross Returns	$ 619.80	$ 442.66	$ 684.23	$ 279.74	$ 284.11	$ 541.90
Net Returns	$ 269.88	$ 128.03	$ 336.57	$ 20.39	$ (15.56)	$ 221.84
	Amortized Cost and Returns ($/ton)			Establisment Cost and Returns ($/ton)		
	FEPL	FEPL	FMGAL	FEPL	FEPL	FMGAL
	Switchgrass	Big bluestem	Alfalfa	Switchgrass	Big bluestem	Alfalfa
Fertilizer, Chemical, and Seed Cost	$ 16.90	$ 25.07	$ 19.87	$ 34.68	$ 52.78	$ 31.94
Field Operations	$ 1.49	$ 2.26	$ 1.76	$ 9.02	$ 8.86	$ 7.78
Total Input Cost	$ 18.39	$ 27.34	$ 21.63	$ 43.70	$ 61.65	$ 39.71
Harvest Costs	$ 32.20	$ 34.73	$ 37.81	$ 45.34	$ 45.10	$ 38.92
Total Variable Cost	$ 50.59	$ 62.07	$ 59.43	$ 89.05	$ 106.75	$ 78.63
Total Costs	$ 67.37	$ 85.42	$ 79.29	$ 130.05	$ 147.67	$ 106.47
Gross Returns	$ 119.32	$ 120.18	$ 156.05	$ 140.27	$ 140.00	$ 180.27
Net Returns	$ 51.96	$ 34.76	$ 76.76	$ 10.22	$ (7.67)	$ 73.80
Total Tons (10 years)	43.42	30.79	36.65	1.99	2.03	3.01
Average Tons per Year	4.34	3.08	3.67			

Table 4. 16 Breakeven Analysis

	GS	BMR	PS	DP	SS	RC	CC	Switchgrass	Big Bluestem	Alfalfa	Min	Max	Average
Maximum $/ton	$ 60.90	$ 55.52	$ 73.03	$ 52.06	$ 59.08	$ 47.26	$ 50.13	$ 50.59	$ 62.07	$ 59.43	$ 47.26	$ 73.03	$ 57.01
Highest Scenario(s)	FMGBNRA	FMGGBNRAE	FMGBNRA	FMGBNRAE	FMGGBNRA	FMGBNRAE	FMGBNRA	FEPL	FEPL	FMGAL			
	FMGGBNRA	FMGBNRAE		FMGGBNRAE	FMGBNRA	FMGGBNRAE	FMGGBNRA						
Minimum $/ton	$ 60.53	$ 55.40	$ 61.92	$ 52.05	$ 53.21	$ 47.12	$ 48.86	$ 47.42	$ 57.59	$ 55.68	$ 47.12	$ 61.92	$ 53.98
Lowest Scenario(s)	FMGGBNRAE	FMGBNRA	FMGGBNRAE	FMGGBNRA	FMGBNRAE	FMGGBNRA	FMGGBNRAE	FEP	FEP	FMGA			
	FMGBNRAE	FMGGBNRA		FMGBNRA	FMGGBNRAE	FMGBNRA	FMGBNRAE						
Difference in Price	$ 0.38	$ 0.11	$ 11.11	$ 0.01	$ 5.87	$ 0.13	$ 1.27	$ 3.17	$ 4.47	$ 3.76	$ 0.01	$ 11.11	$ 3.03

Table 4. 17 Alternative Prices for Sensitivity Analysis

	2013 Soybean$/bu	2010-2013 Soybean $/bu	Difference
125%	$ 17.15	$ 15.71	$ 1.44
110%	$ 15.09	$ 13.82	$ 1.27
105%	$ 14.41	$ 13.19	$ 1.21
100%	$ 13.72	$ 12.57	$ 1.15
95%	$ 13.03	$ 11.94	$ 1.10
90%	$ 12.35	$ 11.31	$ 1.04
75%	$ 10.29	$ 9.42	$ 0.87

	2013 Sorghum $/bu	2010-2013 Sorghum $/bu	Difference
125%	$ 6.68	$ 6.60	$ 0.08
110%	$ 5.87	$ 5.81	$ 0.07
105%	$ 5.61	$ 5.54	$ 0.07
100%	$ 5.34	$ 5.28	$ 0.06
95%	$ 5.07	$ 5.01	$ 0.06
90%	$ 4.81	$ 4.75	$ 0.06
75%	$ 4.01	$ 3.96	$ 0.05

	2013 Corn $/bu	2010-2013 Corn $/bu	Difference
125%	$ 7.36	$ 7.21	$ 0.15
110%	$ 6.47	$ 6.34	$ 0.13
105%	$ 6.18	$ 6.05	$ 0.12
100%	$ 5.88	$ 5.77	$ 0.12
95%	$ 5.59	$ 5.48	$ 0.11
90%	$ 5.30	$ 5.19	$ 0.11
75%	$ 4.41	$ 4.32	$ 0.09

	2013 Sorghum $/ton	2010-2013 Sorghum $/ton	Difference
125%	$ 97.92	$ 91.24	$ 6.68
110%	$ 86.17	$ 80.29	$ 5.88
105%	$ 82.25	$ 76.64	$ 5.61
100%	$ 78.33	$ 72.99	$ 5.34
95%	$ 74.42	$ 69.34	$ 5.08
90%	$ 70.50	$ 65.69	$ 4.81
75%	$ 58.75	$ 54.74	$ 4.01

	2013 Sorghum Sudangrass $/ton	2013 Sorghum $/ton	Difference
125%	$ 159.12	$ 97.92	$ 61.20
110%	$ 140.03	$ 86.17	$ 53.86
105%	$ 133.66	$ 82.25	$ 51.41
100%	$ 127.30	$ 78.33	$ 48.96
95%	$ 120.93	$ 74.42	$ 46.52
90%	$ 114.57	$ 70.50	$ 44.07
75%	$ 95.47	$ 58.75	$ 36.72

	2013 Corn $/ton	2010-2013 Corn $/ton	Difference
125%	$ 76.13	$ 72.41	$ 3.72
110%	$ 66.99	$ 63.72	$ 3.27
105%	$ 63.95	$ 60.83	$ 3.12
100%	$ 60.90	$ 57.93	$ 2.97
95%	$ 57.86	$ 55.03	$ 2.82
90%	$ 54.81	$ 52.14	$ 2.67
75%	$ 45.68	$ 43.45	$ 2.23

	2013 Switchgrass $/ton	2010-2013 Switchgrass $/ton	Difference
125%	$ 140.27	$ 144.04	$ (3.77)
110%	$ 123.44	$ 126.76	$ (3.32)
105%	$ 117.83	$ 120.99	$ (3.17)
100%	$ 112.22	$ 115.23	$ (3.02)
95%	$ 106.61	$ 109.47	$ (2.86)
90%	$ 101.00	$ 103.71	$ (2.71)
75%	$ 84.16	$ 86.42	$ (2.26)

	2013 Big bluestem $/ton	2010-2013 Big bluestem $/ton	Difference
125%	$ 140.00	$ 137.35	$ 2.65
110%	$ 123.20	$ 120.87	$ 2.33
105%	$ 117.60	$ 115.37	$ 2.23
100%	$ 112.00	$ 109.88	$ 2.12
95%	$ 106.40	$ 104.39	$ 2.01
90%	$ 100.80	$ 98.89	$ 1.91
75%	$ 84.00	$ 82.41	$ 1.59

	2013 Alfalfa $/ton	2010-2013 Alfalfa $/ton	Difference
125%	$ 180.27	$ 179.46	$ 0.82
110%	$ 158.64	$ 157.92	$ 0.72
105%	$ 151.43	$ 150.74	$ 0.69
100%	$ 144.22	$ 143.57	$ 0.65
95%	$ 137.01	$ 136.39	$ 0.62
90%	$ 129.80	$ 129.21	$ 0.59
75%	$ 108.16	$ 107.67	$ 0.49

Table 4. 18 FMGGBNRA RC vs. DP, Changes in Prices or Yields Required for Equal Net Returns

Price Regime	Changing	Percent Change	Soybean (bu/acre)	Grain (bu/acre)	Biomass (ton/acre)
2013 DP	Yield	108%	62.74	78.97	9.34
2010-2013 DP	Yield	109%	63.48	79.90	9.44
Original DP	Yield	100%	58.20	73.25	8.66
2013 RC	Yield	93%	54.05	142.75	7.27
2010-2013 RC	Yield	92%	53.43	141.13	7.18
Original RC	Yield	100%	58.20	153.72	7.83
	Changing	**Percent Change**	**Soybean ($/bu)**	**Grain ($/bu)**	**Biomass ($/ton)**
2013 DP	Price	110%	$15.03	$5.85	$85.83
2013 DP	Price	100%	$13.72	$5.34	$78.33
2010-2013 DP	Price	111%	$13.99	$5.87	$81.24
2010-2013 DP	Price	100%	$12.57	$5.28	$72.99
2013 RC	Price	92%	$12.56	$5.39	$55.74
2013 RC	Price	100%	$13.72	$5.88	$60.90
2010-2013 RC	Price	82%	$10.31	$4.73	$47.54
2010-2013 RC	Price	100%	$12.57	$5.77	$57.93

Table 4. 19 FMGAL Alfalfa vs. FEPL Switchgrass, Changes in Prices or Yields for Equal Net Returns

Price Regime	Changing	Percent Change	Biomass ($/ton)
Switchgrass 2013	Price	121%	$169.43
Switchgrass 2013 Establishment Year	Price	145%	$203.85
Switchgrass 2013 Original	Price	100%	$140.27
Switchgrass 2010-2013	Price	115%	$132.08
Switchgrass 2010-2013 Establishment Year	Price	145%	$167.14
Switchgrass 2010-2013 Original	Price	100%	$115.23
Alfalfa 2013	Price	84%	$151.62
Alfalfa 2013 Establishment Year	Price	65%	$116.69
Alfalfa 2013 Original	Price	100%	$180.27
Alfalfa 2010-2013	Price	88%	$127.02
Alfalfa 2010-2013 Establishment Year	Price	64%	$91.65
Alfalfa 2010-2013 Original	Price	100%	$143.57
	Changing	**Percent Change**	**Biomass (tons/acre)**
Switchgrass 2013	Yield	265%	114.90
Switchgrass 2010-2013	Yield	156%	67.79
Switchgrass Original	Yield	100%	43.42
Switchgrass 2013 Establishment Year	Yield	286%	5.71
Switchgrass 2010-2013 Establishment Year	Yield	213%	4.25
Switchgrass Original Establishment Year	Yield	100%	1.99
Alfalfa 2013	Yield	71%	26.14
Alfalfa 2010-2013	Yield	81%	29.74
Alfalfa Original	Yield	100%	36.65
Alfalfa 2013 Establishment Year	Yield	63%	1.88
Alfalfa 2010-2013 Establishment Year	Yield	67%	2.02
Alfalfa Original Establishment Year	Yield	100%	3.01

Figure 4. 1 The FEA Scenario Crop Rotation Comparison

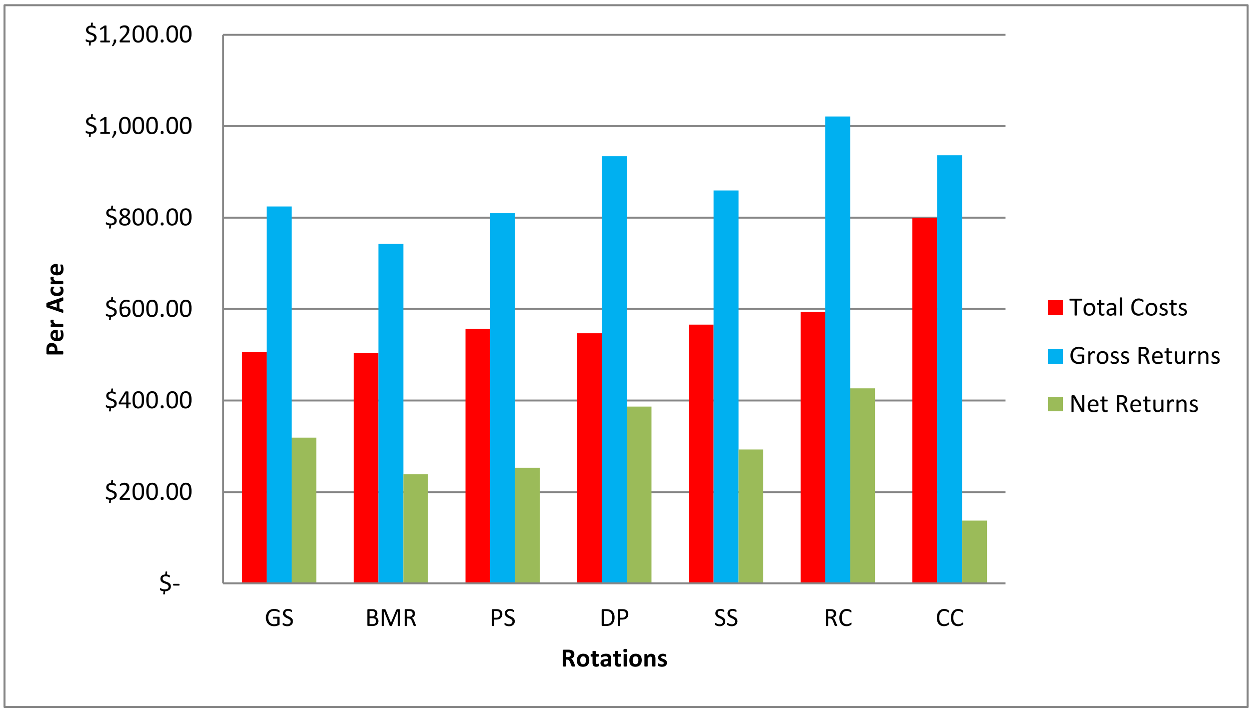


Figure 4. 2 The FEAE Scenario Crop Rotation Comparison

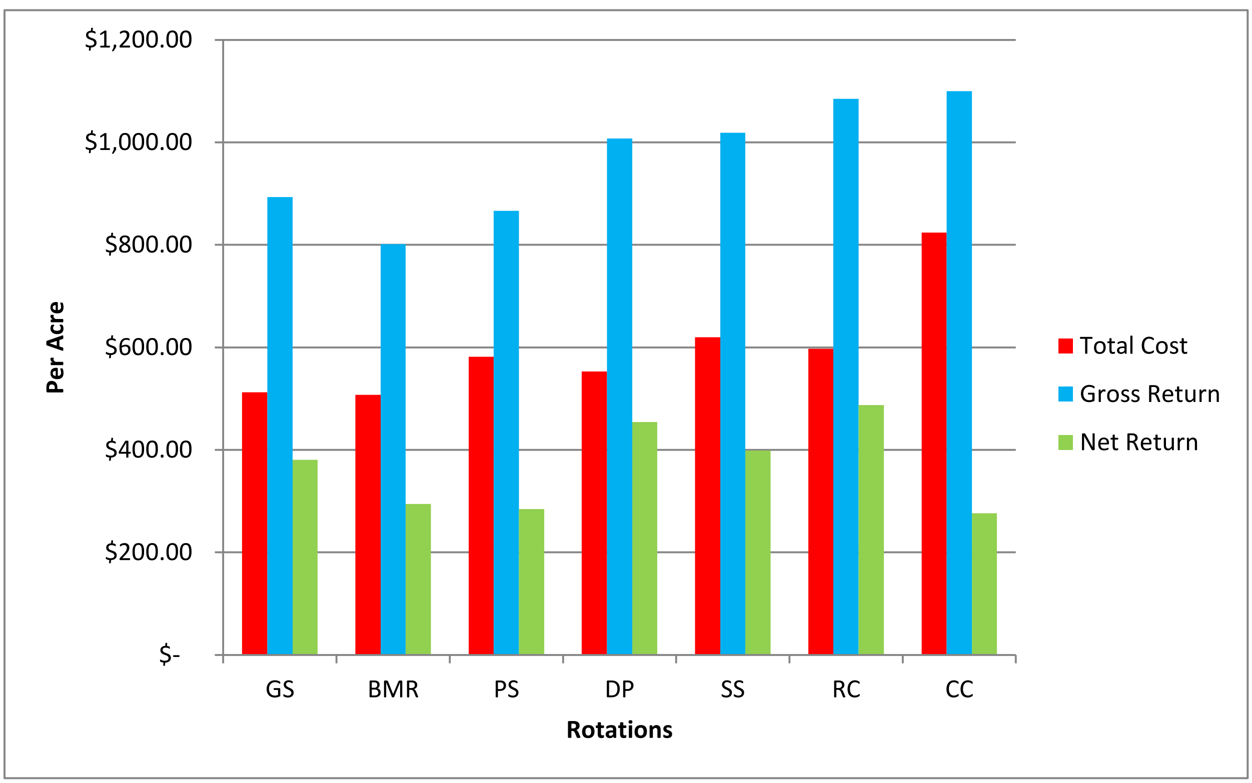


Figure 4. 3 The FMGBNRA Scenario Crop Rotation Comparison

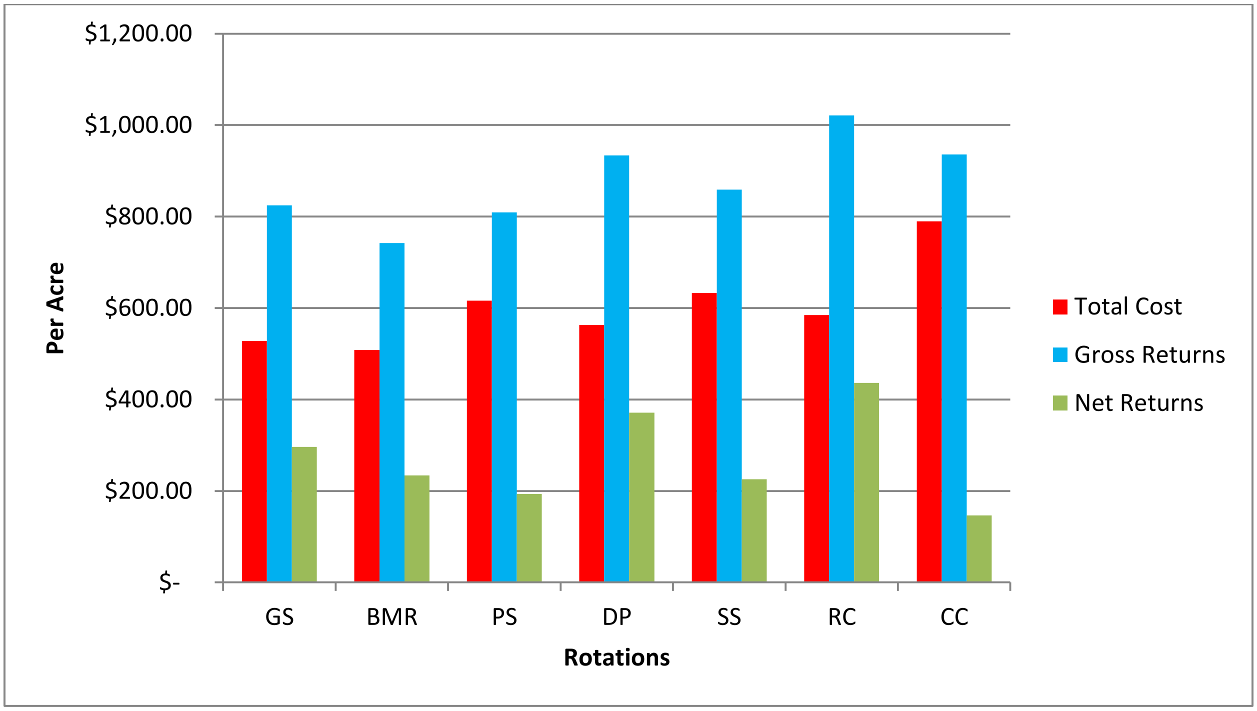


Figure 4. 4 The FMGBNRAE Scenario Crop Rotation Comparison

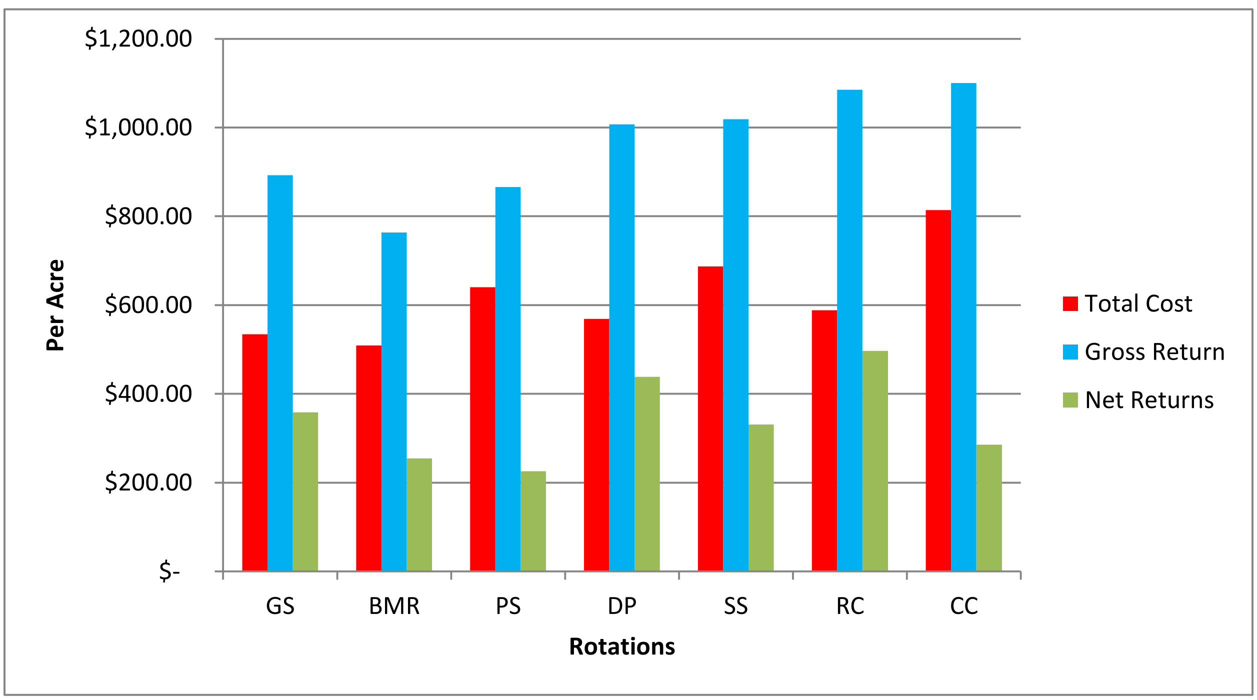


Figure 4. 5 The FMGGBNRA Scenario Crop Rotation Comparison

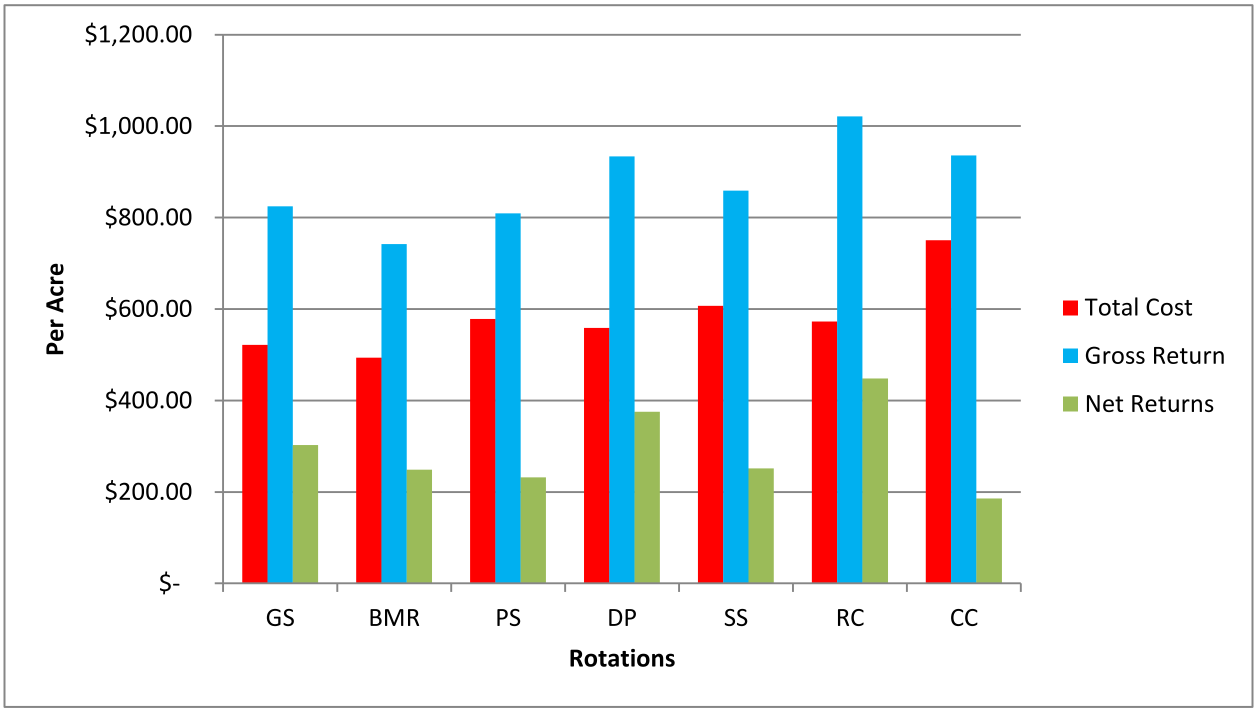


Figure 4. 6 The FMGGBNRAE Scenario Crop Rotation Scenario

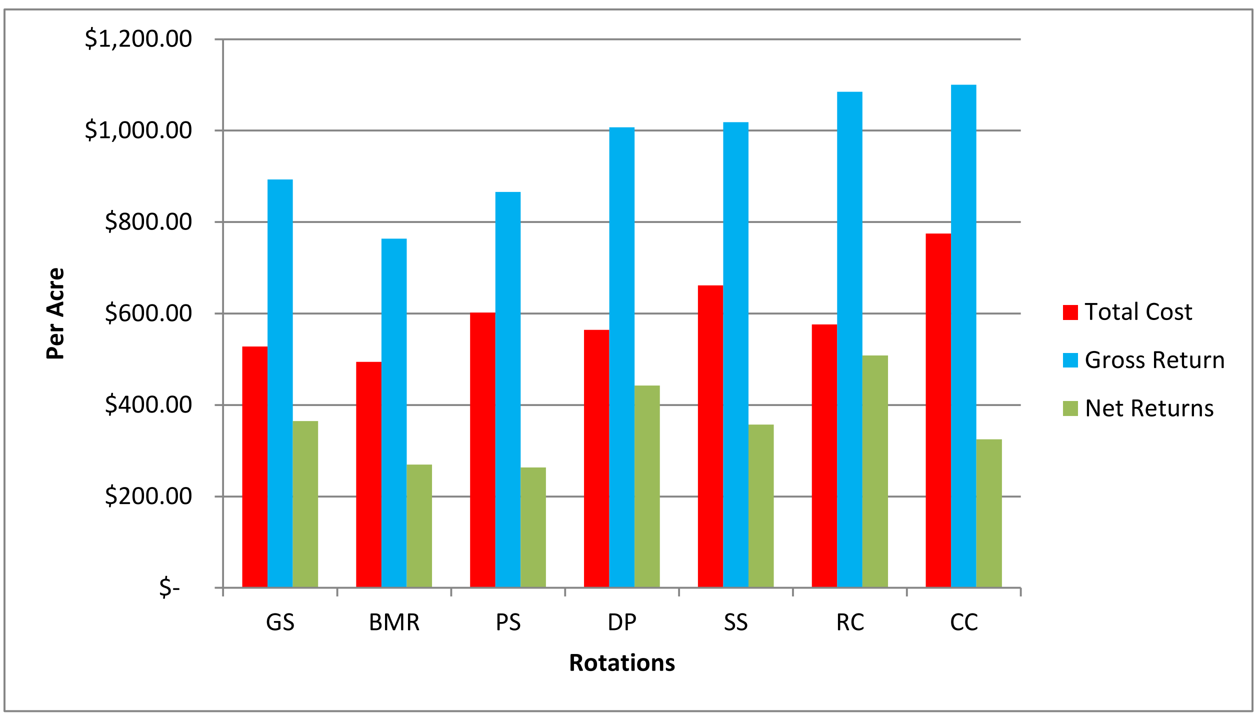


Figure 4. 7 The GS Rotation Cross Scenario Comparison

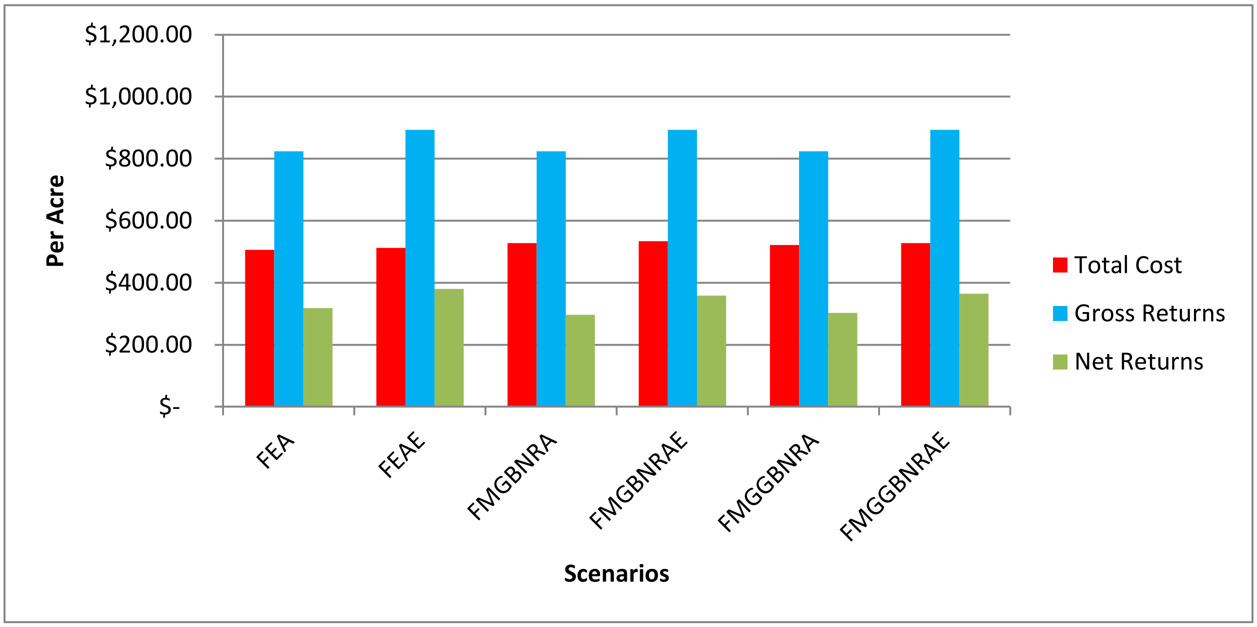


Figure 4. 8 The BMR Rotation Cross Scenario Comparison

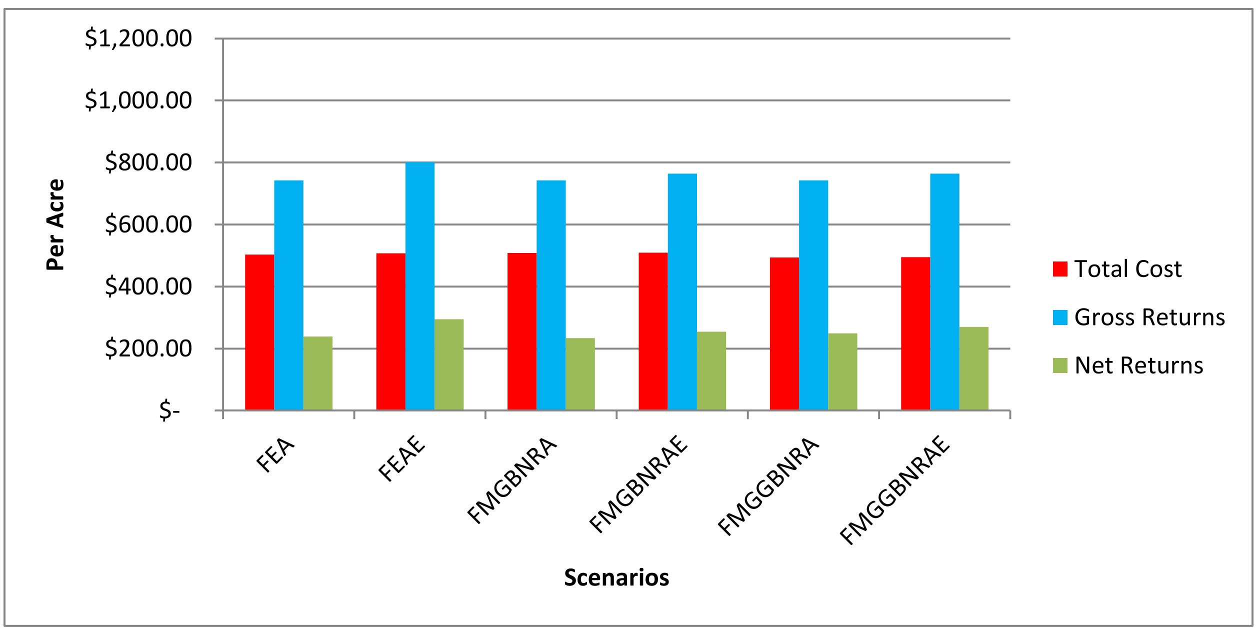


Figure 4. 9 The PS Rotation Cross Scenario Comparison

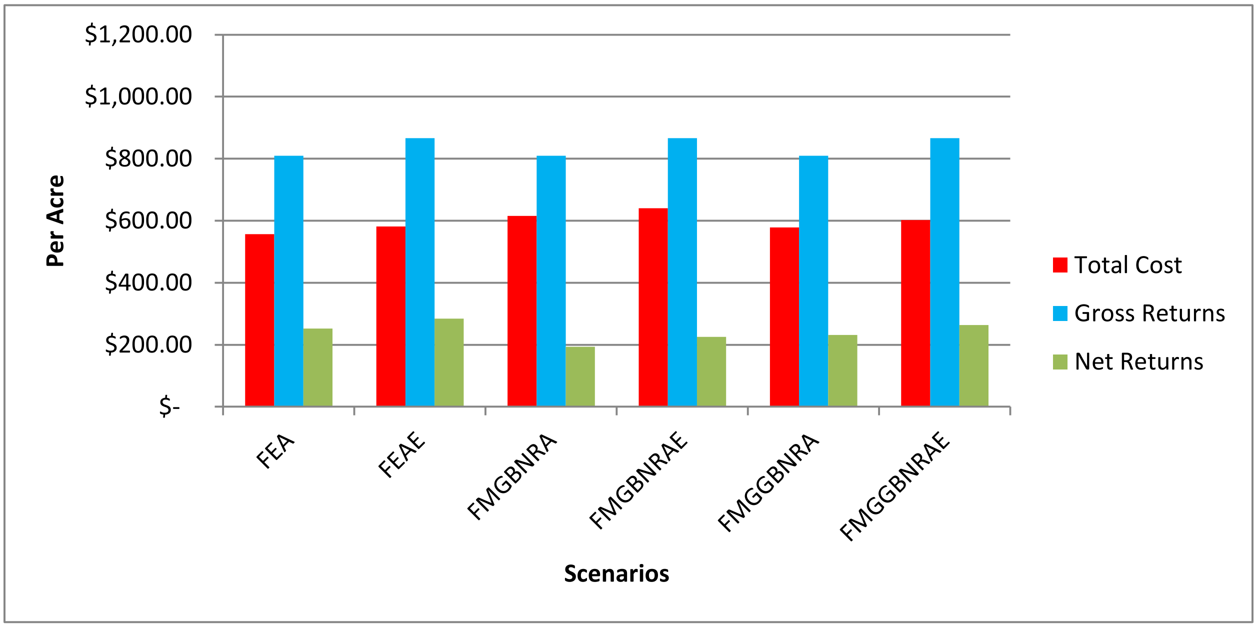


Figure 4. 10 The DP Rotation Cross Scenario Comparison

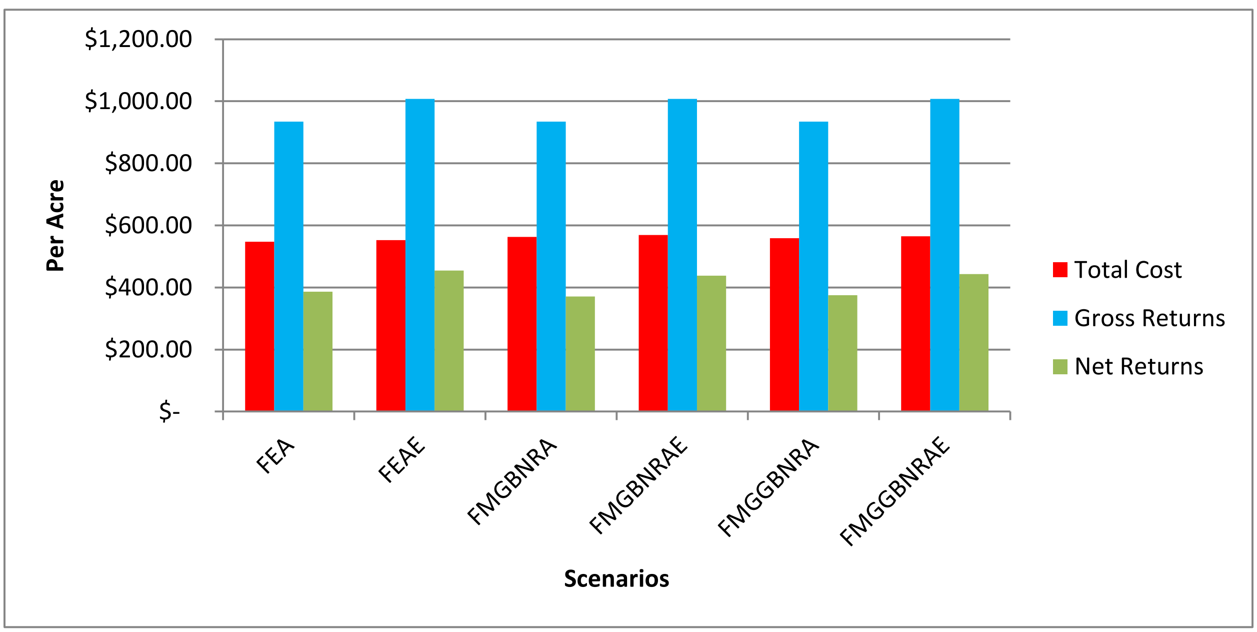


Figure 4. 11 The SS Rotation Cross Scenario Comparison

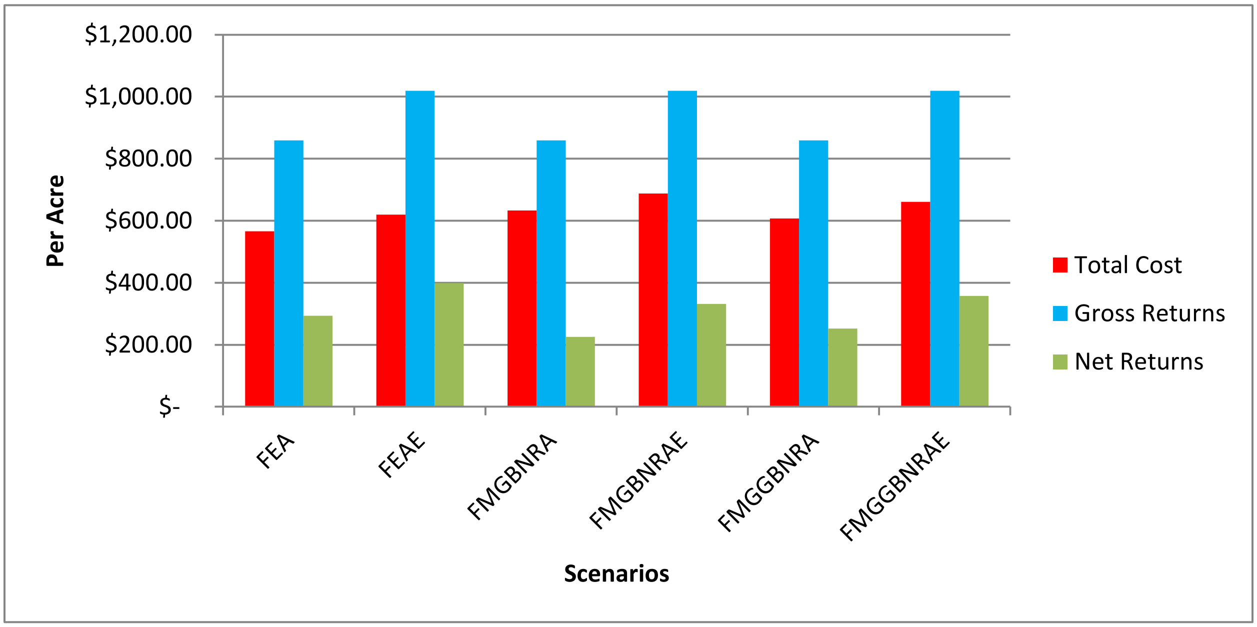


Figure 4. 12 The RC Rotation Cross Scenario Comparison

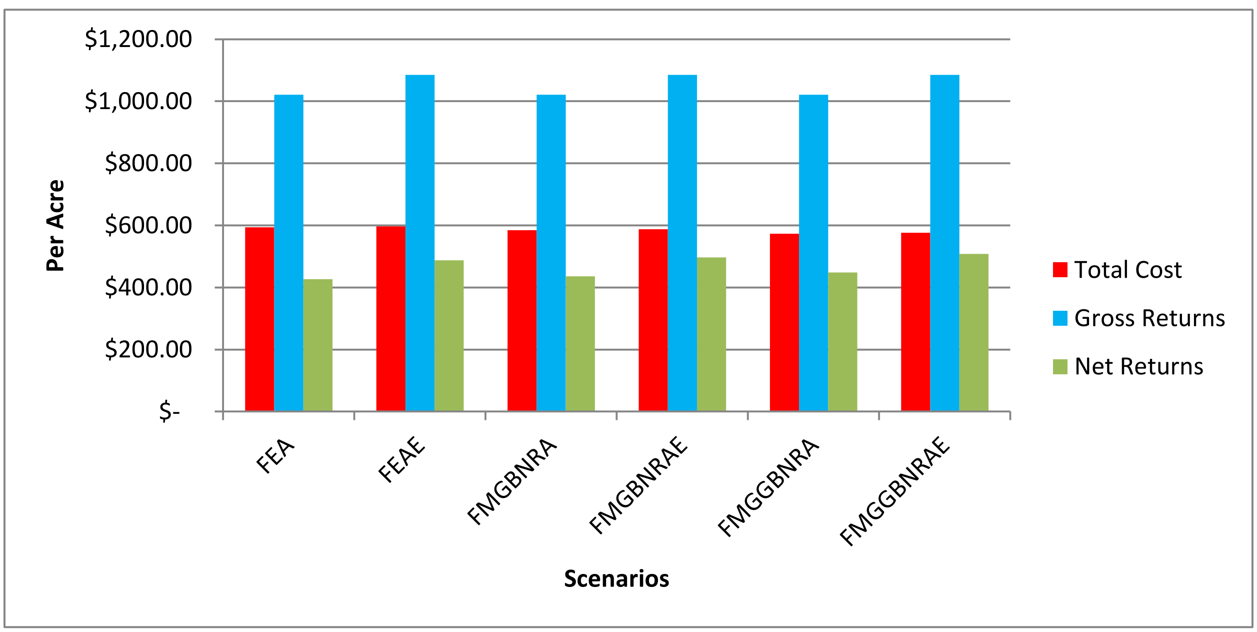


Figure 4. 13 The CC Rotation Cross Scenario Comparison

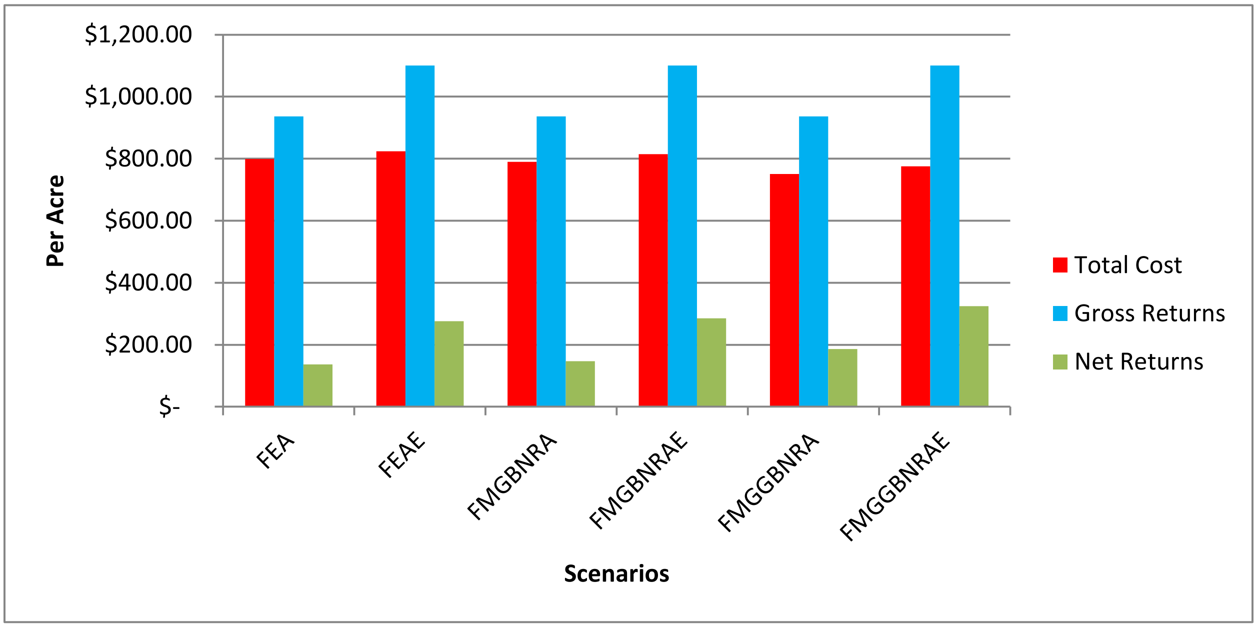


Figure 4. 14 FEP and FMGA Scenarios Crop Comparison (Amortized)

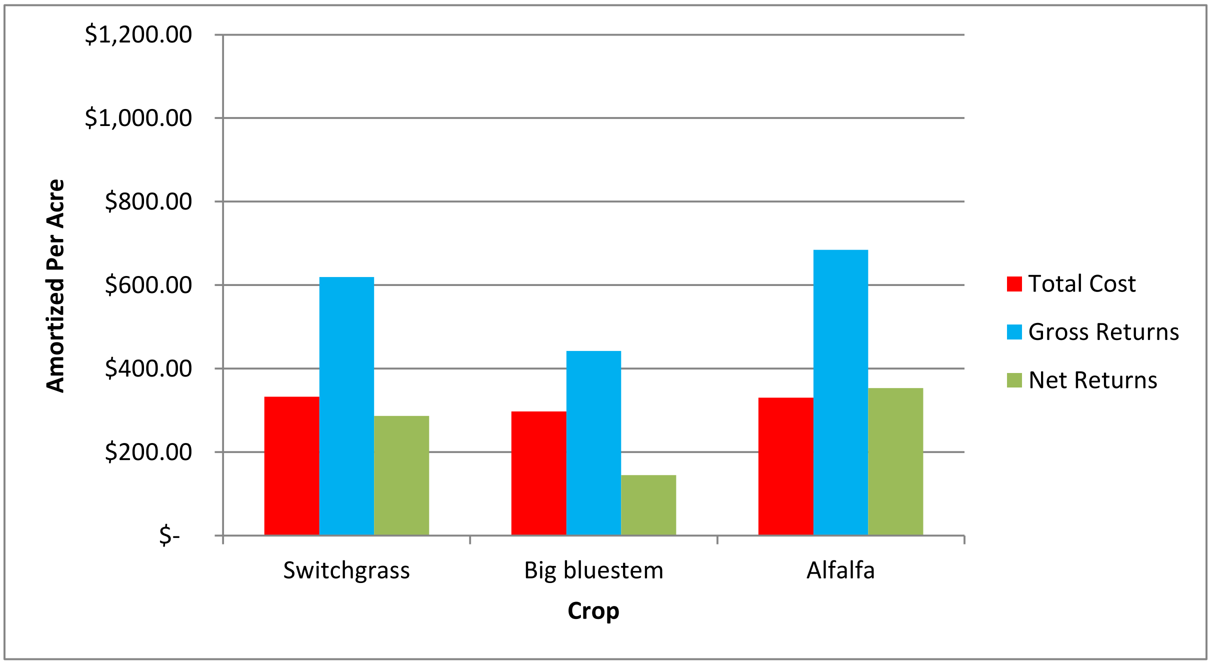


Figure 4. 15 FEP and FMGA Crop Comparison (Establishment Year)

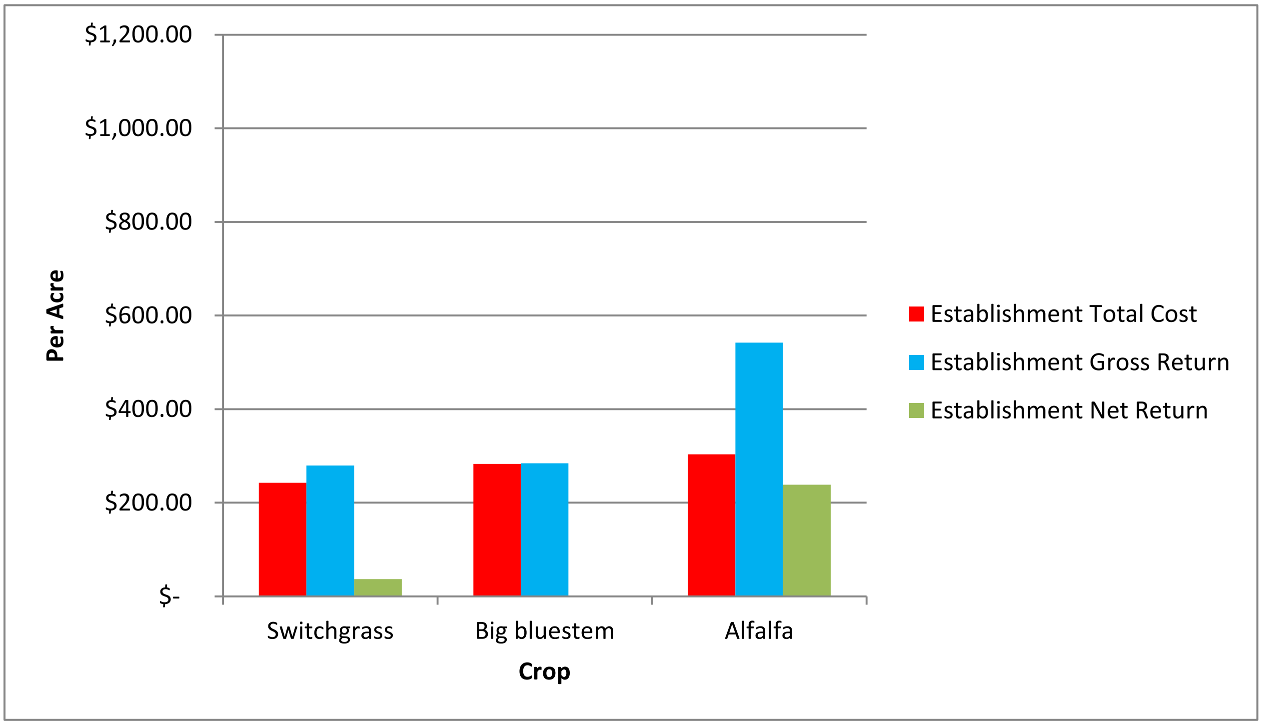


Figure 4. 16 FEPL and FMGAL Scenario Crop Comparison (Amortized)

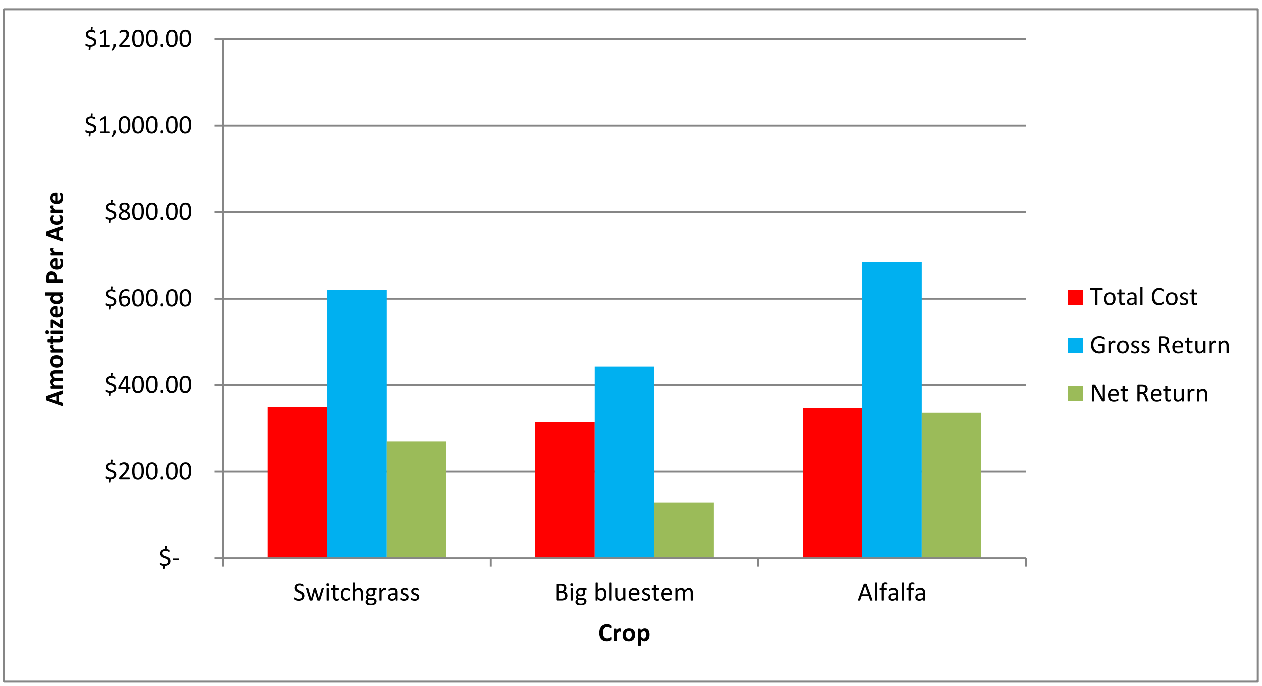
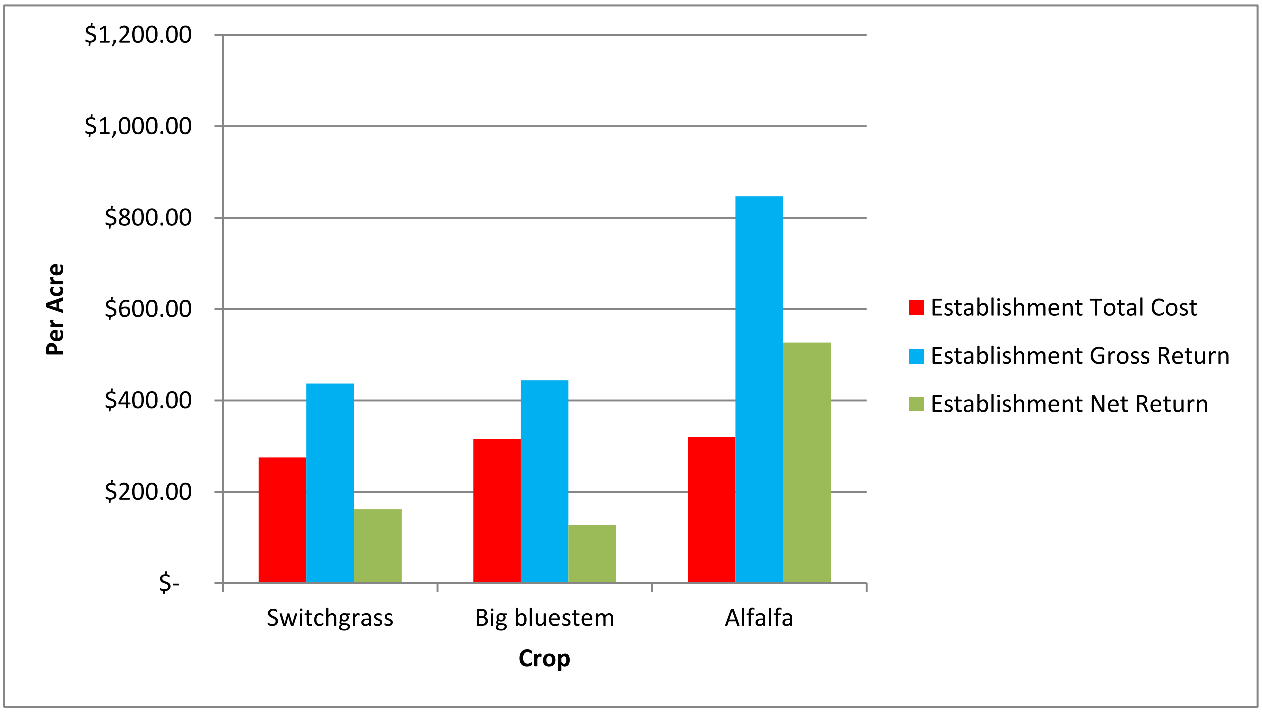


Figure 4. 17 FEPL and FMGAL Scenario Crop Comparison (Establishment Year)



Chapter 5 - Summary and Conclusions

5.1 Summary

For each of the seven annual crop rotations (GS, BMR, PS, DP, SS, RC, and CC), six different management scenarios were analyzed. Enterprise budgets were created for each rotation in each scenario. In the FEA and FEAE scenarios, input rates were determined by the field experiment of Propheter (2009) and Roozeboom et al. (2011). In the FMGBNRA and FMGBNRAE scenarios, input rates were from O'Brien and Duncan (2012, a, b, and c), and biomass nutrients were replaced, as a supplement to the O'Brien and Duncan (2012, a, b, and c) rates, following Propheter (2009). In the FMGGBNRA and FMGGBNRAE scenarios, grain and biomass nutrients were replaced following Propheter (2009), and all other inputs were from O'Brien and Duncan (2012, a, b, and c). In the scenarios ending with AE, 2009 and 2011 yield data were removed due to incomplete data points in these years.

For each of the two perennial grasses (switchgrass and big bluestem), two different management scenarios were analyzed. The FEP scenario followed the field experiment of Propheter (2009) and Roozeboom et al. (2011). The FEPL scenario was the same as the FEP scenario with the addition of lime application. Alfalfa also had two management scenarios, FMGA and FMGAL. Alfalfa used inputs from Dumler and Shoup (2012). The FMGAL scenario included lime, while the FMGA scenario did not include lime. Perennial enterprise budgets were created for a 10 year growing horizon; costs and returns were then amortized on a per ton and per acre basis.

The annual rotations were then compared to each other within each scenario. For each rotation, all annual scenarios were compared to each other. This allowed for the evaluation of the most realistic scenario, and for the robustness of results. Perennial crops were then compared using amortized per acre and amortized per ton metrics. Because perennial crops may encounter cash flow problems with high establishment costs, the perennial crops were compared to each other in the establishment year.

Sensitivity of net returns due to yields and prices used in the scenarios was performed. Prices and yields were changed by increasing and decreasing the original prices and yields by increments of 5%, 10%, and 25%. Further, the average 2010 to 2013 biomass and grain prices for perennials and annuals were used as an alternative price to test the robustness of the results. Additionally, the biomass price of the PS crop may be different from those used in the analysis, and the 2013 sorghum sudangrass price was used as another alternative price. The 2013 average sorghum sudangrass price was $71.67 / ton higher than the 2013 average sorghum stover price. The average 2010 to 2013 biomass and grain prices were lower than the average 2013 grain and biomass prices for all annual rotations and perennial crops.

5.2 Conclusions

5.2.a Annual Crops

The RC rotation had the highest net returns per acre across all annual crop scenarios. When the 2010 to 2013 average prices were used, the RC rotation had the highest net returns over the whole range of prices and yields. Only when the 2013 sorghum sudangrass price was used for the PS rotation did the RC rotation not have the highest net returns. The DP rotation had the second highest net returns per acre across all scenarios using the original prices, and when using the average 2010-2013 prices. The RC and DP rotations had high grain net returns, and low to average biomass production costs. The RC and DP rotations had costs similar to the other annual rotations, excluding the CC rotation, but had gross returns that were significantly higher than the other annual rotations, excluding the CC rotation.

Across all annual crop scenarios, the CC or PS rotations had the lowest net returns, and generally the CC rotation had the lowest net returns. When 2010 to 2013 average prices were used, both rotations still had the lowest net returns. The PS rotation had no grain harvest for the PS crop. When the 2013 sorghum sudangrass prices were used, the PS rotation had net returns that were larger than the net returns of the RC rotation. The 2013 sorghum sudangrass prices were 63% higher than the 2013 sorghum (milo) straw prices used in the original scenarios. The CC rotation had relatively high gross returns, but had consistently the highest costs. The PS and BMR rotations had relatively low costs, but also had the lowest gross returns.

5.2.b Perennial Crops

Alfalfa had the highest amortized net returns in the FEP and FMGA, and FEPL and FMGAL scenarios. Alfalfa had high net returns amortized and in the establishment year due to it having a much higher price that drove alfalfa to having the highest gross returns. In the establishment year, the high alfalfa price and alfalfa having the highest establishment year yield allowed it to have mostly positive net returns. When sensitivity was conducted on prices and yields, alfalfa had positive amortized net returns for the 10 year production horizon for the whole range of prices and yields. This was also true when only the establishment was considered. When the average 2010 to 2013 prices were used, alfalfa had the highest amortized net returns for the 10 year production horizon across the whole range of prices and yields used in sensitivity analysis. The establishment year net returns were mostly positive, but always larger than the perennial grasses.

Big bluestem had the lowest amortized 10 year production horizon and establishment year net returns. This is due to big bluestem having low yields. When the average 2010 to 2013 average prices were used, big bluestem still had the lowest amortized 10 year production horizon and establishment year net returns. Establishment year net returns for switchgrass and big bluestem had mostly negative net returns over the range of prices and yields used in sensitivity. Changing the timing of fertilizer applications for switchgrass and big bluestem had little effect on amortized net returns, but caused all establishment year net returns to become negative over the whole range of prices and yields used in the sensitivity analysis.

5.3 Price and Cost Scenarios Implications

The average 2010 to 2013 prices used for sensitivity were lower than the 2013 prices used in the original scenarios, excluding switchgrass. The annual and perennial scenarios that had positive net returns continued to have positive net returns when the average prices from 2010 to 2013 were used. With commodity prices expected to be lower in 2014 than prices were in 2013, the rotations and crops that were profitable will continue to be profitable, just less profitable than in 2013 (Russel, 2013). Appendix C contains the sensitivity analysis for the most realistic scenarios (FMGGBNRA, FEPL, and FMAL) which show what is expected to happen to net returns when prices and yields change.

Big bluestem is a native grass and the goal of the CRP program was to return marginal land to native grasses. To avoid high establishment, costs the existing CRP stands could be moved into biomass production as the CRP contacts expire. These stands should exhibit the same yields and costs as the big bluestem crop, but management strategies for maintaining the stand would have to be undertaken. This study did not examine how costly long term management strategies would be, or how they would affect yields.

5.4 Limitations of the Study

This study is based on a field experiment conducted at Kansas State University (Propheter, 2009; Roozeboom et al., 2011; Roozeboom 2013). Agronomic field experiments seek to examine how crops, soils, and management practices affect yields; they do not however design them for economic analysis. This study has attempted to take into account the fact that the agronomic field experiments may not use typical practices. The shortfall in this study's method of accounting for these inconsistencies is that this study assumes that yields do not change when the management practices change. No environmental factors were considered in this study.

Because nutrient removal data was only available for 2007 and 2008 (Propheter, 2009) fertilizer use in the scenarios beginning with FMG did not vary in the 2009, 2010, and 2011 years (Roozeboom et al., 2011). Fertilizer use in the scenarios beginning with FMG used the nutrient replacement data as a supplement to the Kansas State University farm management guides (O'Brien and Duncan, 2012, a , b, and c) or as the entire required amount of fertilizer. In the scenarios ending with AE yield data from 2009 and 2011 was excluded, due to missing data points. These exclusions changed the average yields but did not change the average quantity of fertilizer required. Yields should drive the quantity of fertilizer removed by harvesting both grain and biomass. In the sensitivity analysis, fertilizer use was not tied to yield but was held at the average removal from Propheter (2009). Fixing fertilizer use and cost to yield would have restricted the range of net returns for all crops.

In sensitivity analysis this study assumed that grain and biomass yields were perfectly correlated. When severe to extreme droughts occur it is likely that the crop will not produce grain. This study avoided these scenarios by restricting the range of yield changes.

This study did not examine alternative biomass harvest methods, namely round bales. While round bales are a common production practice, they are often only used for the producers other enterprises, or sold and transported a small geographical distance. Square bales offer a larger transportation range and use less space to store. Storage costs were not specifically considered in this study by assuming that bales were only stored at the edge of the field until the next crop was planted. In reality, bales may be stored on site for several years and will take acres out of production (generally storage occurs on productive acres near to road entrances) and may require specialized storage materials (tarps) and additional management time to maintain the stored biomass.

The alfalfa crop was directly seeded. Tanner (2005) recommends that alfalfa be seeded with a companion crop. While direct seeding is not uncommon, it is uncommon in no-till rotations. If a companion crop were included, it would increase the price of establishment because an additional planting operation and seed would be required. Generally the companion crop is oats. Using a companion crop would increase the yield in the year of establishment, but would require a different pricing structure to market the alfalfa companion crop cutting and each subsequent pure alfalfa cutting.

Alfalfa prices were restricted due to this study's assumption that all alfalfa cuttings would be of the lowest quality. This restricted the price that alfalfa received. In reality, each cutting would have a different price based on its relative feed value (RFV).

5.5 Future Research

In the sensitivity analysis grain and biomass prices were assumed to be perfectly correlated. There is no literature examining how these cash markets move in relation to each other. Synthetic hedges may provide a basis for examining how the biomass and grain markets interact.

Switchgrass is not currently grown and sold on a commercial level. Using the RFV of switchgrass and comparing it to other currently marketed crops would provide a price per RFV. Literature on the RFV of switchgrass is lacking, but literature on the ethanol production capabilities of switchgrass is prevalent. While not directly an economic issue, studying the RFV of bioenergy crops and the ethanol output of roughages and forages should lead to more accurate pricing for both the livestock and ethanol industries.

Soil quality changes from the removal of biomass need to have economic values beside fertilizer replacement. Because removing biomass reduces soil organic matter long term biomass removal may result in long term yields falling (Andrews, 2006). In future analysis, a long term model of the soil characteristics should be undertaken.

If large acreages are harvested for biomass, increased fertilizer use and reduced soil cover may cause further environmental problems due to eutrophication and nitrogen runoff. Currently, biomass production's only focus in on farm level decisions and impacts but what happens when whole states move toward biomass production. Additionally, these nutrients are mined and imported from developing nations hold vast reserves. Research into how long these reserves may sustain the increased demand and the impact that the increased demand would have on producing countries should be undertaken. The environmental impact of increased mining in developing nations, which may lack adequate environmental, workforce safety, and transportation infrastructure, legal or otherwise, should also be examined.

Analysis of how the market structure of these macronutrients functions and if an increased demand (due to large quantities of biomass produced) would produce a structural break is a possible future research area. The social benefits and costs of producing large quantities of biomass should be further researched. The cost-benefit analysis of cellulosic ethanol should also be compared to the cost-benefit analysis of continued use of fossil fuels.

The biomass markets also need to be studied. Biomass markets are highly local, and while there have been some instances of biomass markets integrating into each other there is little research into how these markets work. The biggest complication biomass market studies face is the lack of quantity data.

5.6 Criticism of Existing Literature

Wolfe, Downing and Hoagland (2012) make the case that perennial biomass crops behave differently than existing perennial crops. The distinction between woody plants and existing perennial crops (miscanthus and tree like plants) is extremely relevant but lumping woody plants into a category switchgrass, big bluestem, and other "energy" perennial grasses is a disservice to the farmers. By lumping the woody plants and "energy" perennial grasses into one category gives farmers a false sense of uncertainty to the grasses. Woody plant production is uncertain in the United States and to some extent Europe. Grasses, however, are ubiquitously a known quantity. Establishing and growing a warm season grass is for all intents and purposes the same and establishing and growing a cool season grass is also the same.

Marra et al. (2012) point to education as influencing farmers' opinions and willingness to produce switchgrass. While switchgrass is new in the sense that it hasn't been grown explicitly for biomass harvesting, switchgrass and its relatives are currently found on pasture, rangeland, CRP, and farming acres. Economists' publications on switchgrass' novelty for bioenergy have glossed over, or fully ignored its close relation to other grasses which are also native to and grown in the Western U.S. This removes the tacit knowledge which farmers possess about growing grasses. At the least, economists should find crops that are related, in species or growth behavior, to the "new" energy crop being proposed and use this as background knowledge when conducting research and when presenting results to farmers about these energy crops.

Also, the BMR and PS crops in animal science and agronomy circles are regarded as animal feed, while the economics profession seeks to make them a separate class of annual forage crops, which they are not. Sorghum for animal feed is grown relatively infrequently in the West but is produced in the region. It should not be a "new" phenomenon just because a new intended use has come to light, but instead, new uses should be viewed as structural changes in the existing markets.

Epplin et al. (2007) contends spot markets for biomass do not exist. If this was the case, feedlots, diary operations, and other animal production facilities would be unable to source feedstocks for animal production (Karlin, 2010). Spot markets for genuinely new crops, like the woody plants, may have a very niche market that would have a structural break if and when cellulosic ethanol production comes into existence commercially. Spot markets, like those seen in grain markets, do not exist but spot markets for roughages and forages do exist, as evidenced by state specific hay price reports (Pitcock, 2013; Hessman and Hruska, 2013). Larson et al. (2005), instead of using existing price data for the region of that study, used a synthetic price which set the price for biomass as a an energy substitute, ignoring the other common uses which would provide an inaccurate price.

Marra et al. (2012) asked farmers if the "ability to use switchgrass as a feed for livestock" and "concern that the market for switchgrass as an energy crop is not developed enough yet" were an important trait, farmers responded that they both were "somewhat" of an issue. Fewell et al. (2013) found that pricing and markets were a major factor in farmers willingness to produce bioenergy crops. The false distinction between perennial bioenergy crops and existing perennial grasses produces further unwarranted uncertainty about the ability to market and the availability of price information by failing to realize markets do exist for animal feed and that bioenergy is just another use for animal feed.

Epplin et al. (2007) and Larson et al. (2005) proposed several forms of securing biomass feedstock for bioenergy production. Again, overlooking the similarities of bioenergy crops and perennial crops grown has resulted in missing, or overlooking current market structures in the livestock industries that secure feedstocks for animal feed. The dairy industry, especially the organic dairy industry, have already put into place several of the contracting options Epplin et al. (2007) and Larson et al. (2005) proposed. Dairies and feedlots make a wide variety of contracts withindividual producers, groups of producers, and brokers for delivery of a set quality and quantity over a set time frame. The cellulosic ethanol facilities would then compete with the livestock industry over the regional biomass available and alter prices. Cellulosic ethanol facilities venturing into custom harvesting, buying land, or other contract forms would only be undertaken if the cellulosic ethanol facility is unable to compete with the existing forage and roughage market that is fairly efficient.

Starch ethanol co-products help make feeding cheap forages and roughages more efficient (Donkin, Doane, and Cecava, 2013; Morrow et al. 2013). When corn prices drastically increased in late 2012 and starch ethanol plants were shutting down or curtailing production, many producers were left seeking starch ethanol co-product substitutes. In light of the "Food vs. Fuel" argument, cellulosic ethanol's effects on the supply of roughages and forages should be examined. If cellulosic ethanol production becomes wide spread, it could affect the bottom lines of livestock producers and divert biomass from food production to energy production. With starch ethanol production, livestock producers have access to a co-product that makes their rations cheaper, and helps animals utilize feed more efficiently. It is yet to be seen if cellulosic ethanol produces a co-product that the livestock industry can take advantage of.

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Appendix A - Average Annual Yields per Crop

Table A. 1 Average Annual Yields for Annual Crops[6]

Year	Crop	Grain Yield (bushels/acre)	Biomass Yield (tons/acre)
2007	GS	104.45	4.59
2008	GS	98.50	7.45
2009	GS	51.94	6.18
2010	GS	71.12	7.08
2011	GS	8.80	6.13
2007	BMR	72.87	5.86
2008	BMR	49.84	5.78
2009	BMR	-	6.49
2010	BMR	47.37	7.58
2011	BMR	-	6.49
2007	PS	-	13.74
2008	PS	-	11.37
2009	PS	-	5.82
2010	PS	-	10.65
2011	PS	-	10.81
2007	DP	124.87	7.21
2008	DP	93.98	8.40
2009	DP	43.04	6.42
2010	DP	83.18	10.36
2011	DP	21.21	10.91
2007	SS	28.10	12.61
2008	SS	39.97	15.77
2009	SS	-	0.70
2010	SS	36.88	11.90
2011	SS	-	10.58
2007	RC	187.32	7.87
2008	RC	185.28	7.43
2009	RC	141.02	9.54
2010	RC	101.27	6.46
2011	RC	62.71	5.31
2007	CC	163.57	8.35
2008	CC	152.83	6.52
2009	CC	89.06	6.56
2010	CC	52.07	3.72
2011	CC	41.59	3.48
2007	Soybeans	61.00	
2008	Soybeans	64.00	
2009	Soybeans	55.00	
2010	Soybeans	50.00	
2011	Soybeans	61.00	

[6] Grain yields for BMR and SS in 2009 and 2011are missing completely. In 2011 grain yields for GS are missing in two of the four observations.

Appendix B - Specific Rates and Costs of Fertilizer Application

B.1 Specific Rates of Fertilizer Application Across Annual Rotation Scenarios

Table B. 1 The GS Rotations Fertilizer Applications Across Scenarios[7]

The GS Rotation	FEA and FEAE	FMGBNRA and FMGBNRAE	FMGGBNRA and FMGGBNRAE
Pounds of N per Acre for Grain		43.00	36.08
Pounds of N per Acre for Biomass		63.40	63.40
Pounds of N per Acre Total	158.06	106.40	99.49
Pounds of P_2O_5 per Acre for Grain		76.00	49.29
Pounds of P_2O_5 per Acre for Biomass		9.38	9.38
Pounds of P_2O_5 per Acre Total	67.42	85.38	58.66
Pounds of K_2O per Acre for Grain			19.20
Pounds of K_2O per Acre for Biomass		200.48	200.48
Pounds of K_2O per Acre Total	150.02	200.48	219.68

Table B. 2 The BMR Rotations Fertilizer Applications Across Scenarios

The BMR Rotation	FEA and FEAE	FMGBNRA and FMGBNRAE	FMGGBNRA and FMGGBNRAE
Pounds of N per Acre for Grain		43.00	20.01
Pounds of N per Acre for Biomass		50.90	50.90
Pounds of N per Acre Total	158.06	93.90	70.91
Pounds of P_2O_5 per Acre for Grain		76.00	44.82
Pounds of P_2O_5 per Acre for Biomass		10.72	10.72
Pounds of P_2O_5 per Acre Total	67.42	86.72	55.54
Pounds of K_2O per Acre for Grain			12.50
Pounds of K_2O per Acre for Biomass		148.24	148.24
Pounds of K_2O per Acre Total	150.02	148.24	160.74

[7] Refer to 3.3.c Fertilizer Costs for determining how fertilizer rates were determined. The scenarios beginning with FMG had soybean N credits for all rotations except the CC rotation, which caused some grain N application rates in the FMGGBNRA and FMGGBNRAE scenarios to be negative.

Table B. 3 The PS Rotations Fertilizer Applications Across Scenarios

The PS Rotation	FEA and FEAE	FMGBNRA and FMGBNRAE	FMGGBNRA and FMGGBNRAE
Pounds of N per Acre for Grain		43.00	-30
Pounds of N per Acre for Biomass		99.12	99.123
Pounds of N per Acre Total	158.06	142.12	69.123
Pounds of P_2O_5 per Acre for Grain		76.00	35
Pounds of P_2O_5 per Acre for Biomass		21.43	21.432
Pounds of P_2O_5 per Acre Total	67.42	97.43	56.432
Pounds of K_2O per Acre for Grain			
Pounds of K_2O per Acre for Biomass		281.30	281.295
Pounds of K_2O per Acre Total	150.02	281.30	281.295

Table B. 4 The DP Rotations Fertilizer Applications Across Scenarios

The DP Rotation	FEA and FEAE	FMGBNRA and FMGBNRAE	FMGGBNRA and FMGGBNRAE
Pounds of N per Acre for Grain		43.00	39.65
Pounds of N per Acre for Biomass		54.47	54.47
Pounds of N per Acre Total	158.06	97.47	94.13
Pounds of P_2O_5 per Acre for Grain		76.00	50.18
Pounds of P_2O_5 per Acre for Biomass		9.38	9.38
Pounds of P_2O_5 per Acre Total	67.42	85.38	59.56
Pounds of K_2O per Acre for Grain			21.88
Pounds of K_2O per Acre for Biomass		187.98	187.98
Pounds of K_2O per Acre Total	150.02	187.98	209.86

Table B. 5 The SS Rotations Fertilizer Applications Across Scenarios

The SS Rotation	FEA and FEAE	FMGBNRA and FMGBNRAE	FMGGBNRA and FMGGBNRAE
Pounds of N per Acre for Grain		43.00	(5.00)
Pounds of N per Acre for Biomass		137.08	137.08
Pounds of N per Acre Total	158.06	180.08	132.08
Pounds of P_2O_5 per Acre for Grain		76.00	41.25
Pounds of P_2O_5 per Acre for Biomass		15.18	15.18
Pounds of P_2O_5 per Acre Total	67.42	91.18	56.43
Pounds of K_2O per Acre for Grain			6.70
Pounds of K_2O per Acre for Biomass		274.15	274.15
Pounds of K_2O per Acre Total	150.02	274.15	280.85

Table B. 6 The RC Rotations Fertilizer Applications Across Scenarios

The RC Rotation	FEA and FEAE	FMGBNRA and FMGBNRAE	FMGGBNRA and FMGGBNRAE
Pounds of N per Acre for Grain		97.00	68.23
Pounds of N per Acre for Biomass		44.65	44.65
Pounds of N per Acre Total	158.06	141.65	112.88
Pounds of P_2O_5 per Acre for Grain		92.00	59.11
Pounds of P_2O_5 per Acre for Biomass		6.70	6.70
Pounds of P_2O_5 per Acre Total	67.42	98.70	65.81
Pounds of K_2O per Acre for Grain			33.49
Pounds of K_2O per Acre for Biomass		100.91	100.91
Pounds of K_2O per Acre Total	150.02	100.91	134.40

Table B. 7 The CC Rotations Fertilizer Applications Across Scenarios

The CC Rotation	FEA and FEAE	FMGBNRA and FMGBNRAE	FMGGBNRA and FMGGBNRAE
Pounds of N per Acre for Grain		127.00	78.58
Pounds of N per Acre for Biomass		40.63	40.63
Pounds of N per Acre Total	158.06	167.63	119.22
Pounds of P_2O_5 per Acre for Grain		57.00	21.43
Pounds of P_2O_5 per Acre for Biomass		6.70	6.70
Pounds of P_2O_5 per Acre Total	67.42	63.70	28.13
Pounds of K_2O per Acre for Grain			31.70
Pounds of K_2O per Acre for Biomass		96.89	96.89
Pounds of K_2O per Acre Total	150.02	96.89	128.59

B.2 Specific Costs of Nutrient Replacement for Annual Crops

Table B. 8 Nutrient Replacement Costs Using 2007 to 2011 Yield Data[8]

Cost	The GS Crop	The BMR Crop	The PS Crop	The DP Crop	The SS Crop	The RC Crop	The CC Crop
Grain N Replacement $/bu	$0.34	$0.37	$0.00	$0.34	-$0.15	$0.32	$0.50
Grain P_2O_5 Replacement $/bu	$0.14	$0.19	$0.00	$0.14	$0.20	$0.12	$0.14
Grain K_2O Replacement $/bu	$0.14	$0.18	$0.00	$0.15	$0.16	$0.12	$0.16
Total Grain Replacement $/bu	$0.63	$0.75	$0.00	$0.63	$0.21	$0.56	$0.80
Biomass N Replacement $/ton	$6.36	$4.99	$5.97	$3.97	$8.39	$3.85	$4.48
Biomass P_2O_5 Replacement $/ton	$1.00	$1.11	$1.37	$0.72	$0.98	$0.61	$0.78
Biomass K_2O Replacement $/ton	$16.04	$11.57	$13.50	$10.92	$13.37	$6.93	$8.51
Total Biomass Replacement $/ton	$23.40	$17.67	$20.84	$15.61	$22.74	$11.39	$13.77

[8] Refer to 3.3.c Fertilizer Costs. The FMGGBNRA and FMGGBNRAE scenarios, and FMGBNRA and FMGBNRAE scenarios share the same biomass nutrient replacement costs, but the FMGGBNRA and FMGGBNRAE scenarios have grain nutrient replacement and are used for the grain nutrient replacement costs here.

Table B. 9 Nutrient Replacement Costs Using 2007 to 2008 Yield Data

Cost	The GS Crop	The BMR Crop	The PS Crop	The DP Crop	The SS Crop	The RC Crop	The CC Crop
Grain N Replacement $/bu	$0.22	$0.21	$0.00	$0.23	-$0.09	$0.23	$0.31
Grain P_2O_5 Replacement $/bu	$0.09	$0.11	$0.00	$0.09	$0.12	$0.09	$0.09
Grain K_2O Replacement $/bu	$0.10	$0.10	$0.00	$0.10	$0.10	$0.09	$0.10
Total Grain Replacement $/bu	$0.41	$0.42	$0.00	$0.42	$0.13	$0.41	$0.50
Biomass N Replacement $/ton	$6.64	$5.52	$4.98	$4.40	$6.10	$3.68	$3.45
Biomass P_2O_5 Replacement $/ton	$1.04	$1.23	$1.14	$0.80	$0.71	$0.58	$0.60
Biomass K_2O Replacement $/ton	$16.75	$12.80	$11.27	$12.11	$9.72	$6.63	$6.56
Total Biomass Replacement $/ton	$24.43	$19.55	$17.39	$17.32	$16.53	$10.90	$10.61

B.2 Fertilizer Applications for Perennials across the 10 Year Production Horizon

Table B. 10 Fertilizer Applications for Switchgrass and Big Bluestem (per acre)[9]

Fertilizer	Urea N	Phosphorus P	Potassium K	Lime
Year 1				333.00
Year 2	40.19	58.85	249.07	333.00
Year 3	50.00			333.00
Year 4	50.00			333.00
Year 5	50.00			333.00
Year 6	50.00	58.85	249.07	333.00
Year 7	50.00			333.00
Year 8	50.00			333.00
Year 9	50.00			333.00
Year 10	50.00			333.00

[9] The FEP scenario excludes the application of lime, but N, P, and K are the same across the FEP and FEPL scenarios.

Table B. 11 Fertilizer Applications for Alfalfa (per acre)[10]

Fertilizer	Urea N	Phosphorus P	Potassium K	Lime
Year 1		40	60	333
Year 2		40	60	333
Year 3		40	60	333
Year 4		40	60	333
Year 5		40	60	333
Year 6		40	60	333
Year 7		40	60	333
Year 8		40	60	333
Year 9		40	60	333
Year 10		40	60	333

[10] The FMGA scenario excludes the application of lime, but N, P, and K are the same across the FMGA and FMGAL scenarios.

Appendix C - Sensitivity Analysis[11]

[11] When comparing figures to each other please note that differences in the vertical axis scale will change the interpretations and conclusions.

C.1 Annual Rotations Original Price and Yield Sensitivity Analysis ($/acre)

Table C. 1 The GS Rotation's Net Returns Sensitivity Analysis

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	Grain Sorghum Bushels per Acre				83.70	73.66	70.31	66.96	63.61	60.27	50.22
	Grain Sorghum Tons per Acre				7.86	6.92	6.60	6.29	5.97	5.66	4.72
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 302.82	125%	110%	105%	100%	95%	90%	75%
	$ 17.15	$ 6.68	$ 97.92	125%	$ 733.63	$ 598.79	$ 553.84	$ 508.89	$ 463.95	$ 419.00	$ 284.16
	$ 15.09	$ 5.87	$ 86.17	110%	$ 579.07	$ 462.78	$ 424.02	$ 385.25	$ 346.49	$ 307.72	$ 191.43
	$ 14.41	$ 5.61	$ 82.25	105%	$ 527.55	$ 417.44	$ 380.74	$ 344.04	$ 307.33	$ 270.63	$ 160.52
	$ 13.72	$ 5.34	$ 78.33	100%	$ 476.04	$ 372.11	$ 337.46	$ 302.82	$ 268.18	$ 233.54	$ 129.61
	$ 13.03	$ 5.07	$ 74.42	95%	$ 424.52	$ 326.77	$ 294.19	$ 261.61	$ 229.03	$ 196.44	$ 98.70
	$ 12.35	$ 4.81	$ 70.50	90%	$ 373.00	$ 281.44	$ 250.91	$ 220.39	$ 189.87	$ 159.35	$ 67.79
	$ 10.29	$ 4.01	$ 58.75	75%	$ 218.44	$ 145.43	$ 121.09	$ 96.75	$ 72.41	$ 48.07	$ (24.95)

Figure C. 1 The GS Rotation's Net Returns Sensitivity Analysis

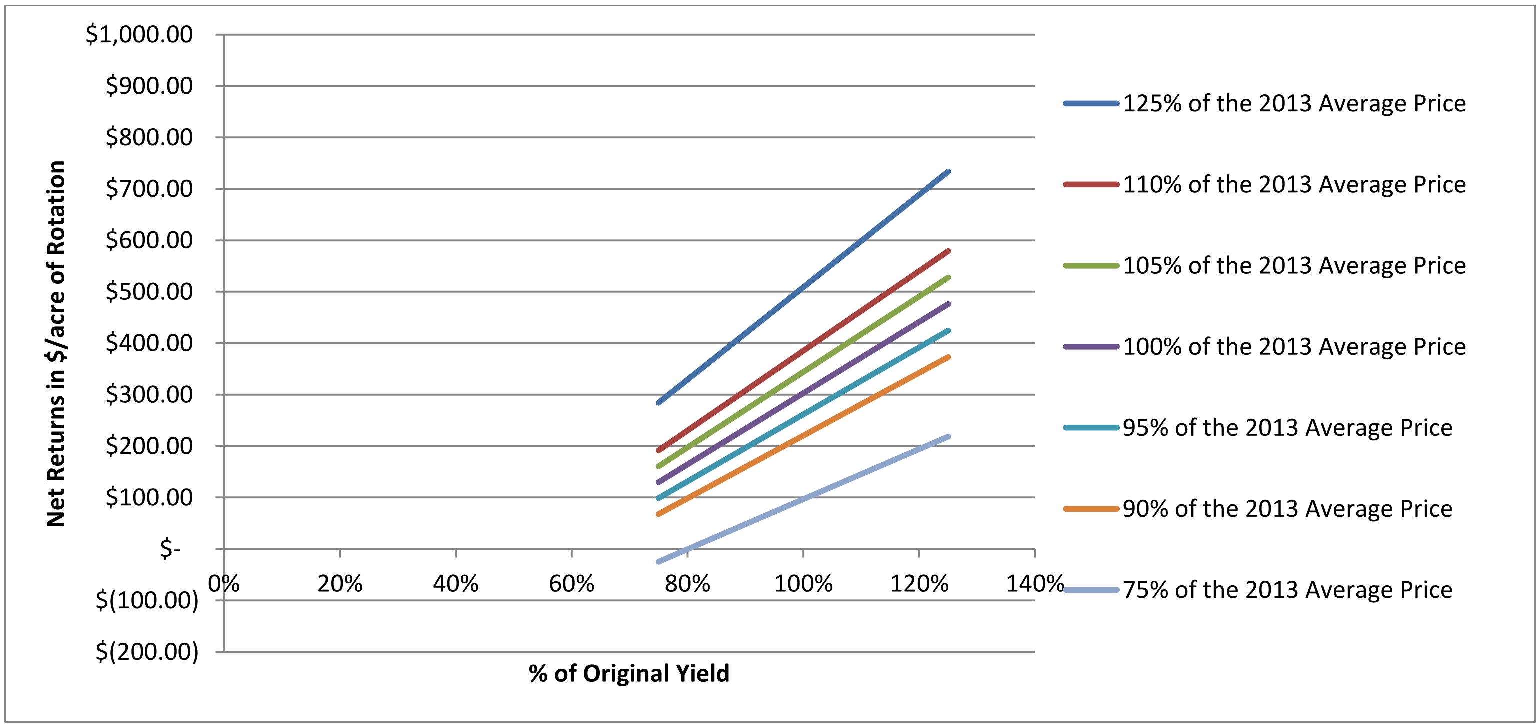


Table C. 2 The BMR Rotation's Net Returns Sensitivity Analysis

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	BMR Sorghum Bushels per Acre				42.52	37.42	35.72	34.02	32.31	30.61	25.51
	BMR Sorghum Tons per Acre				8.05	7.09	6.76	6.44	6.12	5.80	4.83
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 248.98	125%	110%	105%	100%	95%	90%	75%
	$ 17.15	$ 6.68	$ 97.92	125%	$ 634.95	$ 514.85	$ 474.79	$ 434.57	$ 394.36	$ 354.15	$ 233.50
	$ 15.09	$ 5.87	$ 86.17	110%	$ 495.76	$ 392.36	$ 357.87	$ 323.22	$ 288.57	$ 253.93	$ 149.99
	$ 14.41	$ 5.61	$ 82.25	105%	$ 449.36	$ 351.53	$ 318.89	$ 286.10	$ 253.31	$ 220.52	$ 122.15
	$ 13.72	$ 5.34	$ 78.33	100%	$ 402.96	$ 310.70	$ 279.92	$ 248.98	$ 218.05	$ 187.11	$ 94.31
	$ 13.03	$ 5.07	$ 74.42	95%	$ 356.57	$ 269.87	$ 240.94	$ 211.86	$ 182.78	$ 153.71	$ 66.47
	$ 12.35	$ 4.81	$ 70.50	90%	$ 310.17	$ 229.04	$ 201.97	$ 174.74	$ 147.52	$ 120.30	$ 38.63
	$ 10.29	$ 4.01	$ 58.75	75%	$ 170.97	$ 106.55	$ 85.04	$ 63.39	$ 41.73	$ 20.08	$ (44.89)

Figure C. 2 The BMR Rotation's Net Returns Sensitivity Analysis

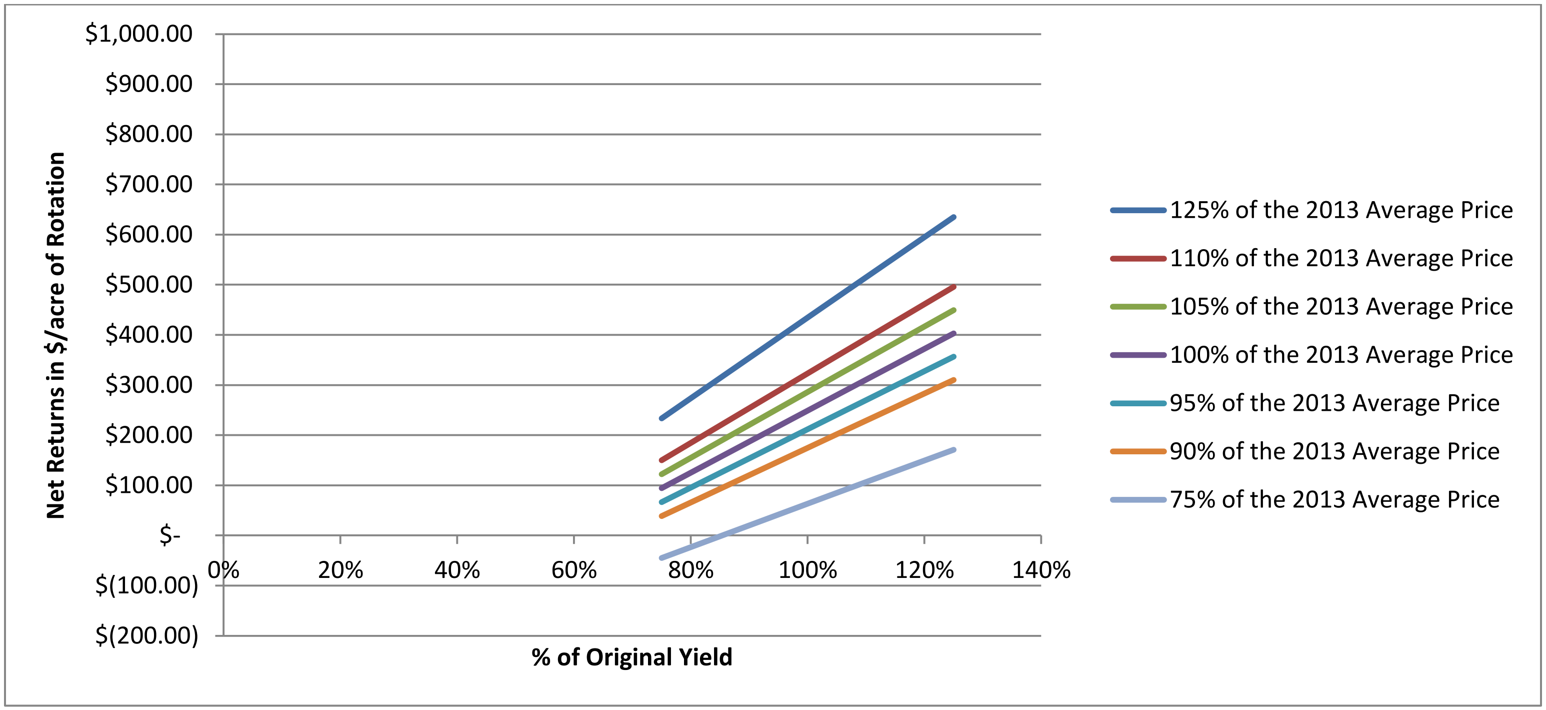


Table C. 3 The PS Rotation's Net Returns Sensitivity Analysis

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	PS Sorghum Bushels per Acre				-	-	-	-	-	-	-
	PS Sorghum Tons per Acre				13.09	11.52	11.00	10.48	9.95	9.43	7.86
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 231.59	125%	110%	105%	100%	95%	90%	75%
	$ 17.15	$ 6.68	$ 97.92	125%	$ 639.85	$ 516.33	$ 475.15	$ 433.98	$ 392.80	$ 351.63	$ 228.11
	$ 15.09	$ 5.87	$ 86.17	110%	$ 488.06	$ 382.75	$ 347.65	$ 312.55	$ 277.44	$ 242.34	$ 137.03
	$ 14.41	$ 5.61	$ 82.25	105%	$ 437.46	$ 338.22	$ 305.15	$ 272.07	$ 238.99	$ 205.91	$ 106.68
	$ 13.72	$ 5.34	$ 78.33	100%	$ 386.86	$ 293.70	$ 262.64	$ 231.59	$ 200.54	$ 169.48	$ 76.32
	$ 13.03	$ 5.07	$ 74.42	95%	$ 336.26	$ 249.17	$ 220.14	$ 191.11	$ 162.08	$ 133.05	$ 45.96
	$ 12.35	$ 4.81	$ 70.50	90%	$ 285.67	$ 204.65	$ 177.64	$ 150.63	$ 123.63	$ 96.62	$ 15.60
	$ 10.29	$ 4.01	$ 58.75	75%	$ 133.88	$ 71.07	$ 50.14	$ 29.20	$ 8.27	$ (12.67)	$ (75.47)

Figure C. 3 The PS Rotation's Net Returns Sensitivity Analysis

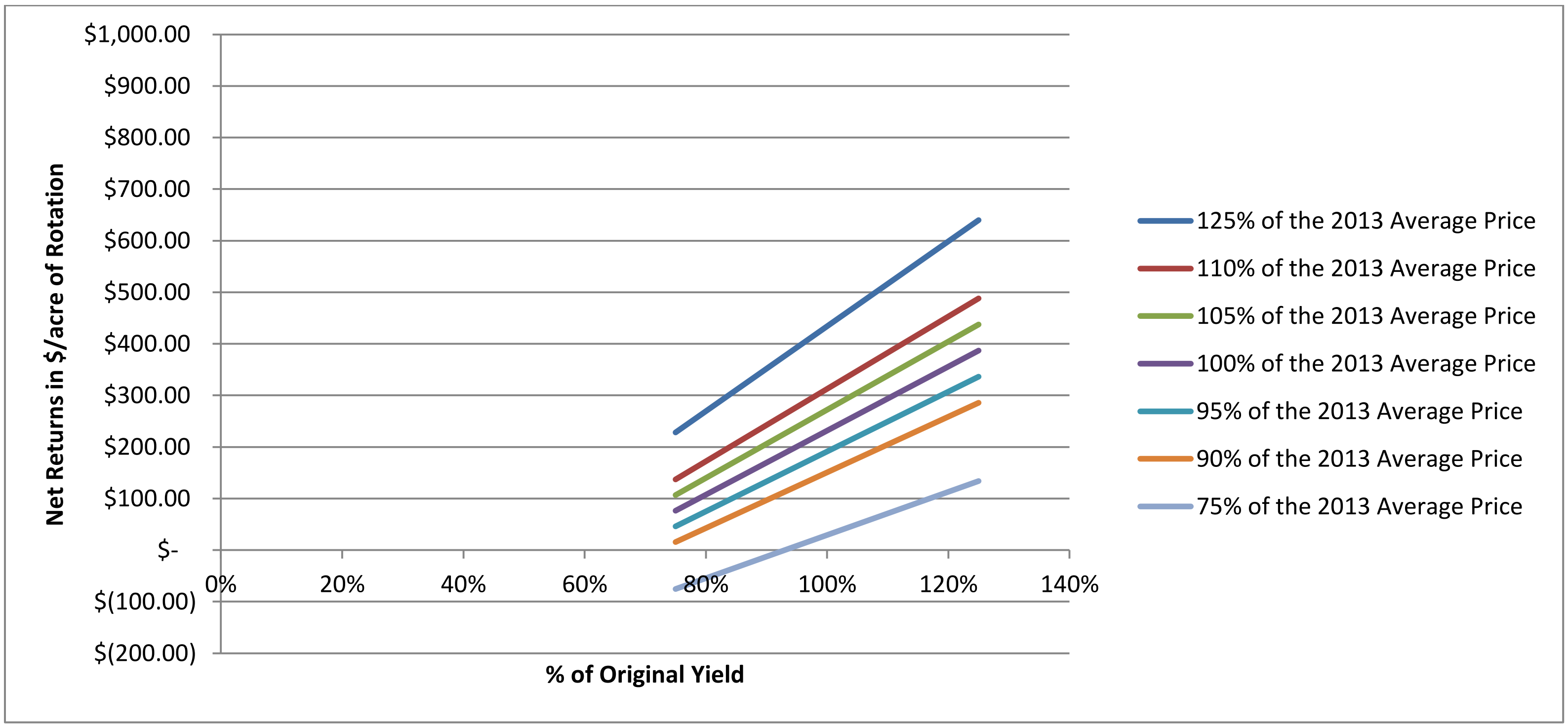


Table C. 4 The DP Rotation's Net Returns Sensitivity Analysis

					Grain and Biomass Yield Range					
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	Dual Sorghum Bushels per Acre				91.57	80.58	76.92	73.25	69.59	65.93	54.94
	Dual Sorghum Tons per Acre				10.82	9.53	9.09	8.66	8.23	7.79	6.49
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 375.17	125%	110%	105%	100%	95%	90%	75%
	$ 17.15	$ 6.68	$ 97.92	125%	$ 857.37	$ 708.16	$ 658.42	$ 608.68	$ 558.95	$ 509.21	$ 360.00
	$ 15.09	$ 5.87	$ 86.17	110%	$ 682.23	$ 554.04	$ 511.31	$ 468.58	$ 425.85	$ 383.12	$ 254.92
	$ 14.41	$ 5.61	$ 82.25	105%	$ 623.86	$ 502.67	$ 462.27	$ 421.88	$ 381.48	$ 341.08	$ 219.90
	$ 13.72	$ 5.34	$ 78.33	100%	$ 565.48	$ 451.30	$ 413.23	$ 375.17	$ 337.11	$ 299.05	$ 184.87
	$ 13.03	$ 5.07	$ 74.42	95%	$ 507.10	$ 399.92	$ 364.20	$ 328.47	$ 292.75	$ 257.02	$ 149.84
	$ 12.35	$ 4.81	$ 70.50	90%	$ 448.72	$ 348.55	$ 315.16	$ 281.77	$ 248.38	$ 214.99	$ 114.82
	$ 10.29	$ 4.01	$ 58.75	75%	$ 273.59	$ 194.43	$ 168.05	$ 141.66	$ 115.28	$ 88.89	$ 9.74

Figure C. 4 The DP Rotation's Net Returns Sensitivity Analysis

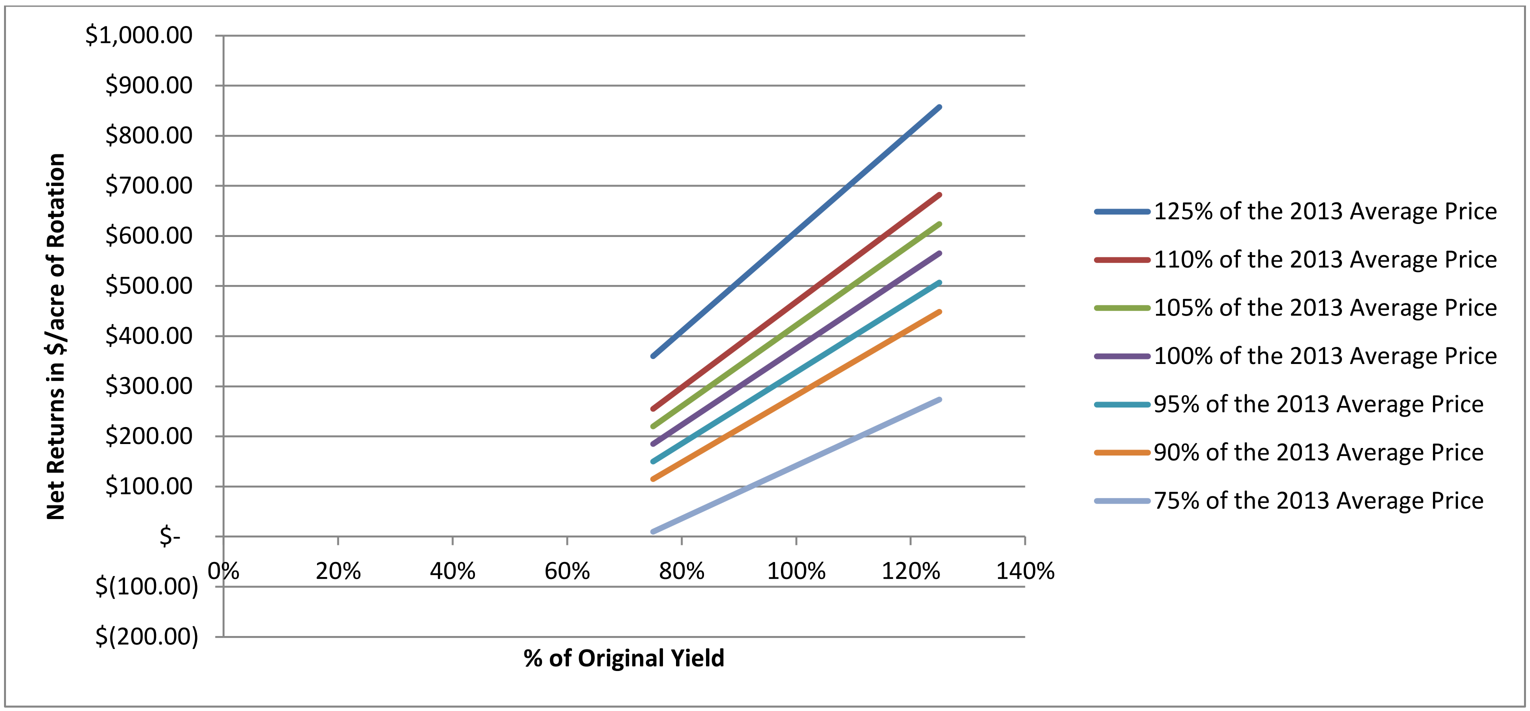


Table C. 5 The SS Rotation's Net Returns Sensitivity Analysis

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	Sweet Sorghum Bushels per Acre				26.24	23.09	22.04	20.99	19.94	18.89	15.74
	Sweet Sorghum Tons per Acre				12.89	11.34	10.83	10.31	9.79	9.28	7.73
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 251.79	125%	110%	105%	100%	95%	90%	75%
	$ 17.15	$ 6.68	$ 97.92	125%	$ 688.11	$ 555.19	$ 510.88	$ 466.57	$ 422.26	$ 377.96	$ 245.03
	$ 15.09	$ 5.87	$ 86.17	110%	$ 527.02	$ 413.43	$ 375.57	$ 337.70	$ 299.84	$ 261.97	$ 148.38
	$ 14.41	$ 5.61	$ 82.25	105%	$ 473.33	$ 366.18	$ 330.46	$ 294.75	$ 259.03	$ 223.31	$ 116.16
	$ 13.72	$ 5.34	$ 78.33	100%	$ 419.63	$ 318.93	$ 285.36	$ 251.79	$ 218.22	$ 184.65	$ 83.95
	$ 13.03	$ 5.07	$ 74.42	95%	$ 365.94	$ 271.68	$ 240.26	$ 208.83	$ 177.41	$ 145.99	$ 51.73
	$ 12.35	$ 4.81	$ 70.50	90%	$ 312.24	$ 224.42	$ 195.15	$ 165.88	$ 136.61	$ 107.33	$ 19.51
	$ 10.29	$ 4.01	$ 58.75	75%	$ 151.16	$ 82.67	$ 59.84	$ 37.01	$ 14.18	$ (8.65)	$ (77.14)

Figure C. 5 The SS Rotation's Net Returns Sensitivity Analysis

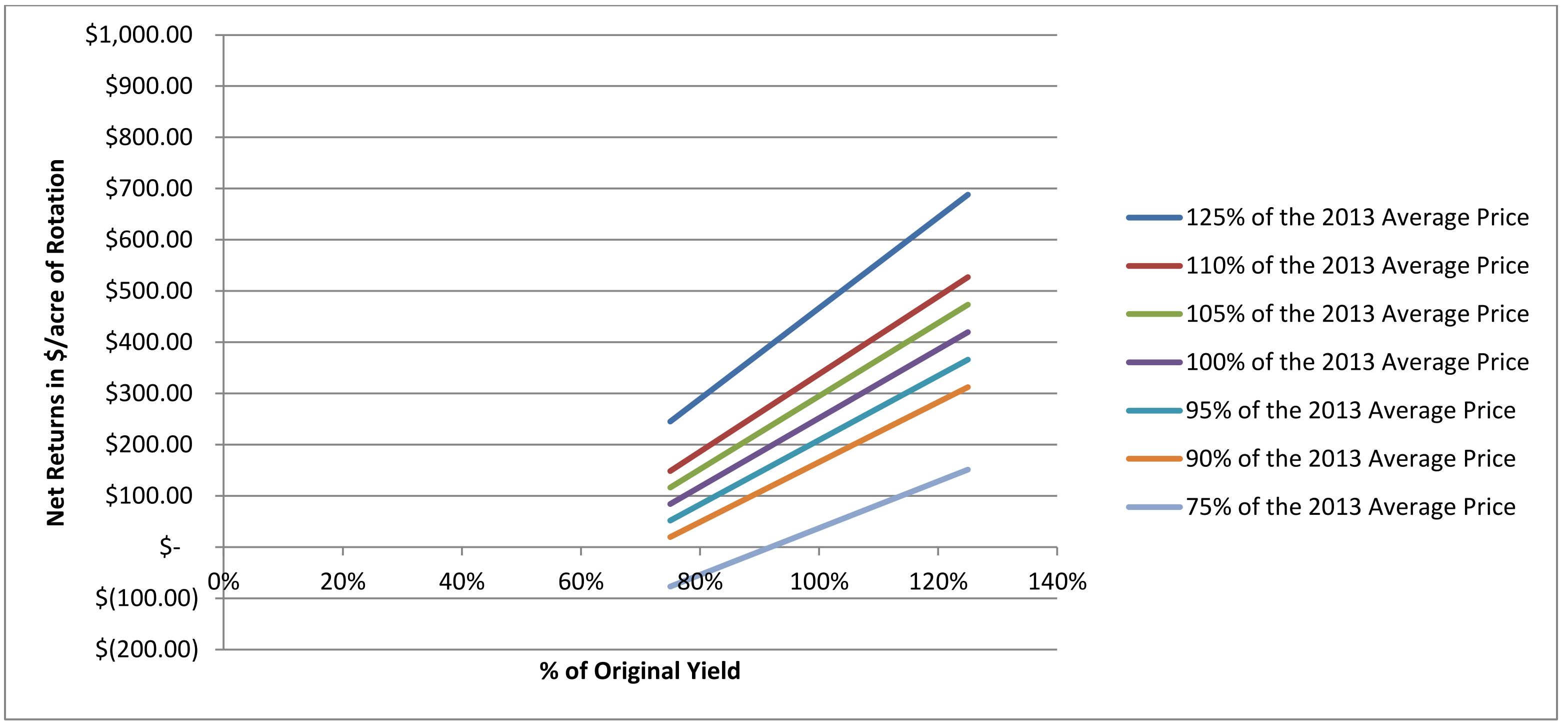


Table C. 6 The RC Rotation's Net Returns Sensitivity Analysis

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	Rotated Corn Bushels per Acre				192.15	169.09	161.41	153.72	146.03	138.35	115.29
	Rotated Corn Tons per Acre				9.78	8.61	8.22	7.83	7.43	7.04	5.87
Grain and Biomass Price Range	Soybean Price per Bushel	Corn Price per Bushel	Biomass Price per Ton	$ 448.03	125%	110%	105%	100%	95%	90%	75%
	$ 17.15	$ 7.36	$ 76.13	125%	$ 982.15	$ 814.82	$ 759.04	$ 703.26	$ 647.48	$ 591.71	$ 424.37
	$ 15.09	$ 6.47	$ 66.99	110%	$ 790.73	$ 646.37	$ 598.25	$ 550.12	$ 502.00	$ 453.88	$ 309.52
	$ 14.41	$ 6.18	$ 63.95	105%	$ 726.92	$ 590.22	$ 544.65	$ 499.08	$ 453.51	$ 407.94	$ 271.23
	$ 13.72	$ 5.88	$ 60.90	100%	$ 663.12	$ 534.07	$ 491.05	$ 448.03	$ 405.02	$ 362.00	$ 232.95
	$ 13.03	$ 5.59	$ 57.86	95%	$ 599.31	$ 477.92	$ 437.45	$ 396.99	$ 356.52	$ 316.06	$ 194.66
	$ 12.35	$ 5.30	$ 54.81	90%	$ 535.50	$ 421.77	$ 383.85	$ 345.94	$ 308.03	$ 270.12	$ 156.38
	$ 10.29	$ 4.41	$ 45.68	75%	$ 344.08	$ 253.31	$ 223.06	$ 192.80	$ 162.55	$ 132.29	$ 41.53

Figure C. 6 The RC Rotation's Net Returns Sensitivity Analysis

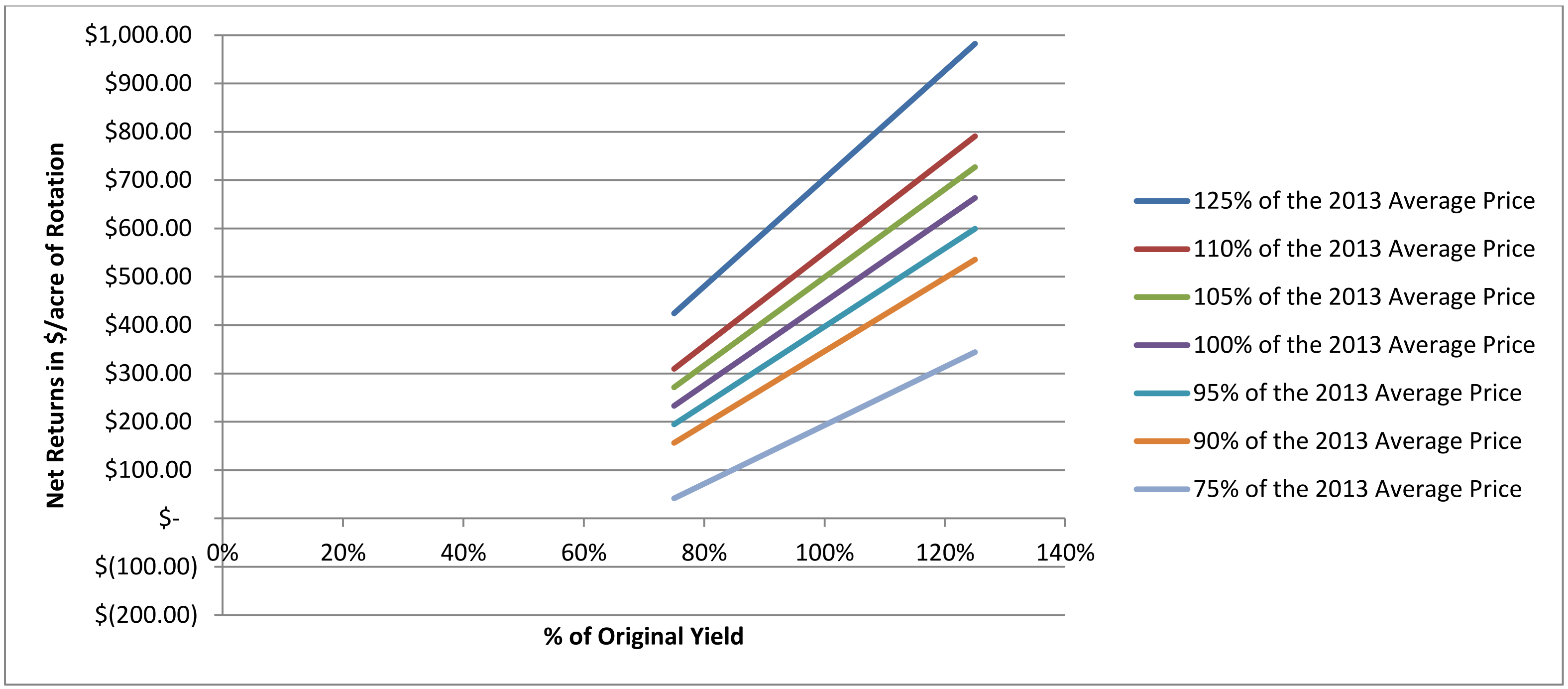
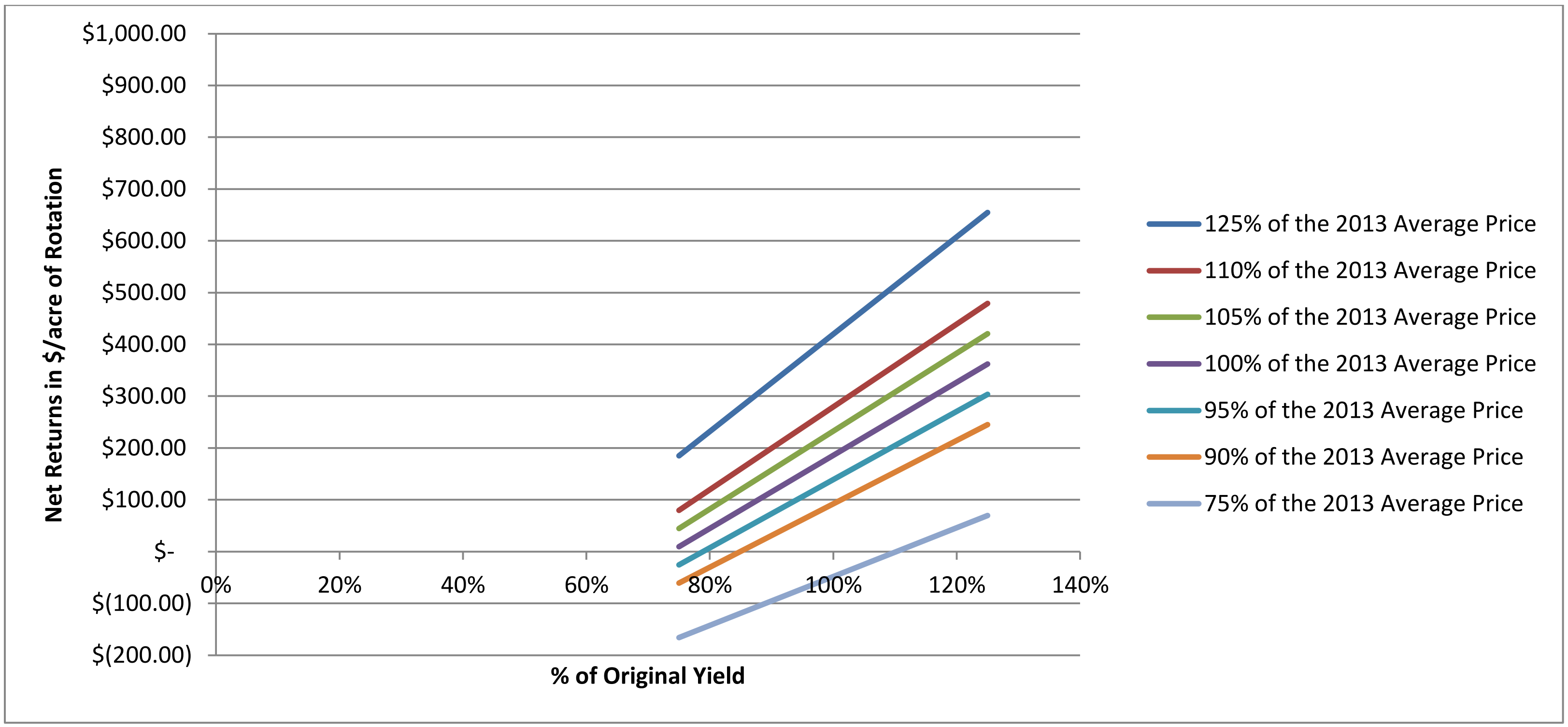


Table C. 7 The CC Rotation’s Net Returns Sensitivity Analysis

Grain and Biomass Price Range				Grain and Biomass Yield Range						
	Continous Corn Bushels per Acre			142.98	125.82	120.10	114.38	108.66	102.94	85.79
	Continious Corn Tons per Acre			7.86	6.92	6.60	6.29	5.97	5.66	4.72
	Corn Price per Bushel	Biomass Price per Ton	$ 185.82	125%	110%	105%	100%	95%	90%	75%
	$ 7.36	$ 76.13	125%	$ 654.66	$ 513.76	$ 466.80	$ 419.83	$ 372.87	$ 325.90	$ 184.97
	$ 6.18	$ 63.95	105%	$ 420.65	$ 307.83	$ 270.23	$ 232.62	$ 195.02	$ 157.41	$ 44.57
	$ 5.88	$ 60.90	100%	$ 362.15	$ 256.35	$ 221.09	$ 185.82	$ 150.55	$ 115.29	$ 9.46
	$ 5.59	$ 57.86	95%	$ 303.64	$ 204.87	$ 171.94	$ 139.02	$ 106.09	$ 73.17	$ (25.64)
	$ 5.30	$ 54.81	90%	$ 245.14	$ 153.38	$ 122.80	$ 92.21	$ 61.63	$ 31.04	$ (60.74)
	$ 4.41	$ 45.68	75%	$ 69.63	$ (1.06)	$ (24.63)	$ (48.19)	$ (71.76)	$ (95.32)	$ (166.05)

Figure C. 7 The CC Rotation’s Net Returns Sensitivity Analysis

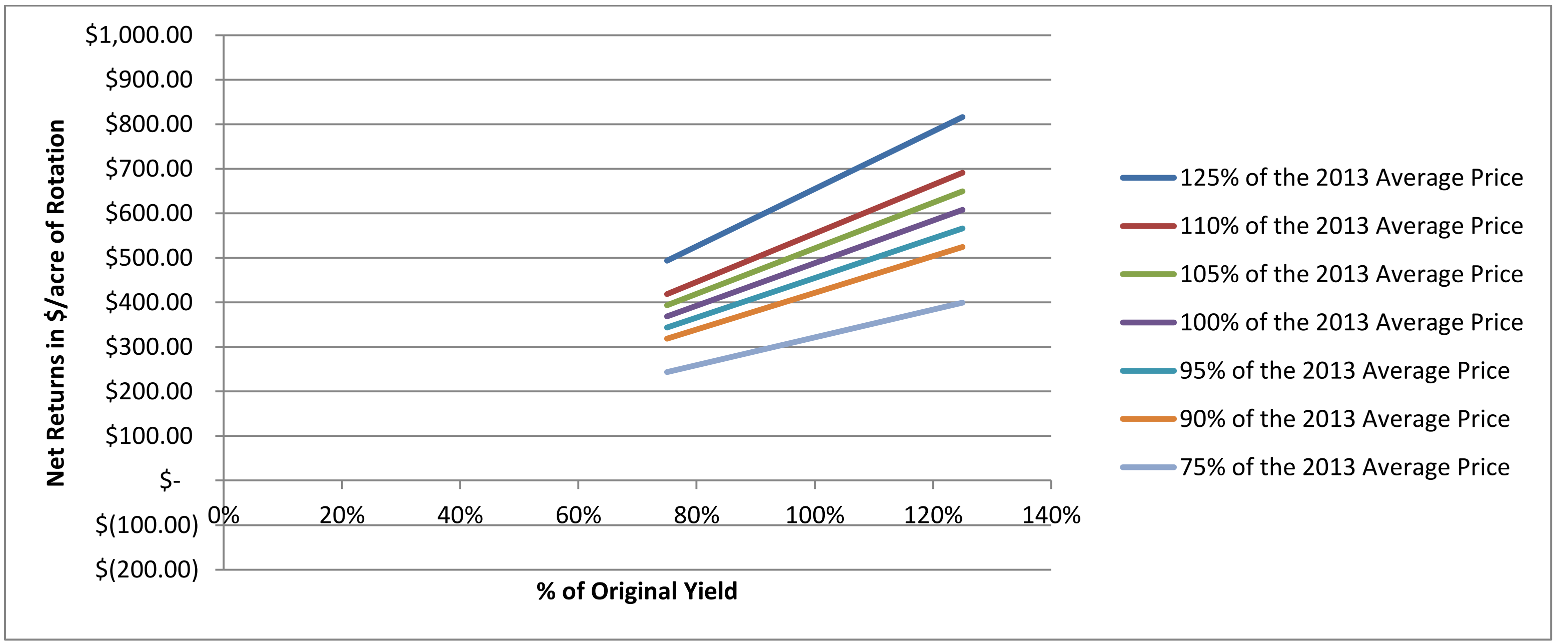


C.2 Alternative PS Price Using the 2013 Average Sorghum Sudangrass

Table C. 8 The PS Rotation's Net Returns Sensitivity Analysis Using Sorghum Sudangrass Price

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	PS Sorghum Bushels per Acre				-	-	-	-	-	-	-
	PS Sorghum Tons per Acre				13.09	11.52	11.00	10.48	9.95	9.43	7.86
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 488.06	125%	110%	105%	100%	95%	90%	75%
	$ 17.15	$ 6.68	$ (60.24)	125%	$ 816.01	$ 719.26	$ 687.01	$ 654.76	$ 622.51	$ 590.26	$ 493.50
	$ 15.09	$ 5.87	$ (53.01)	110%	$ 690.99	$ 609.24	$ 581.99	$ 554.74	$ 527.49	$ 500.24	$ 418.49
	$ 14.41	$ 5.61	$ (50.60)	105%	$ 649.31	$ 572.57	$ 546.98	$ 521.40	$ 495.82	$ 470.24	$ 393.49
	$ 13.72	$ 5.34	$ (48.19)	100%	$ 607.64	$ 535.89	$ 511.98	$ 488.06	$ 464.15	$ 440.23	$ 368.48
	$ 13.03	$ 5.07	$ (45.78)	95%	$ 565.97	$ 499.22	$ 476.97	$ 454.72	$ 432.47	$ 410.23	$ 343.48
	$ 12.35	$ 4.81	$ (43.37)	90%	$ 524.29	$ 462.55	$ 441.97	$ 421.38	$ 400.80	$ 380.22	$ 318.48
	$ 10.29	$ 4.01	$ (36.14)	75%	$ 399.27	$ 352.53	$ 336.95	$ 321.37	$ 305.79	$ 290.21	$ 243.46

Figure C. 8 The PS Rotation's Net Returns Sensitivity Analysis Using Sorghum Sudangrass Price



C.3 Annual Rotations Sensitivity Analysis Using 2010-2013 Average Prices

Table C. 9 The GS Rotation's Net Returns Sensitivity Using Average Prices

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	Grain Sorghum Bushels per Acre				83.70	73.66	70.31	66.96	63.61	60.27	50.22
	Grain Sorghum Tons per Acre				7.86	6.92	6.60	6.29	5.97	5.66	4.72
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 250.38	125%	110%	105%	100%	95%	90%	75%
	$ 15.71	$ 6.60	$ 91.24	125%	$ 651.68	$ 526.67	$ 485.00	$ 443.34	$ 401.67	$ 360.00	$ 234.99
	$ 13.82	$ 5.81	$ 80.29	110%	$ 506.96	$ 399.32	$ 363.44	$ 327.56	$ 291.68	$ 255.80	$ 148.16
	$ 13.19	$ 5.54	$ 76.64	105%	$ 458.72	$ 356.87	$ 322.92	$ 288.97	$ 255.02	$ 221.07	$ 119.22
	$ 12.57	$ 5.28	$ 72.99	100%	$ 410.48	$ 314.42	$ 282.40	$ 250.38	$ 218.36	$ 186.34	$ 90.27
	$ 11.94	$ 5.01	$ 69.34	95%	$ 362.24	$ 271.96	$ 241.87	$ 211.78	$ 181.69	$ 151.60	$ 61.33
	$ 11.31	$ 4.75	$ 65.69	90%	$ 314.00	$ 229.51	$ 201.35	$ 173.19	$ 145.03	$ 116.87	$ 32.39
	$ 9.42	$ 3.96	$ 54.74	75%	$ 169.28	$ 102.16	$ 79.79	$ 57.41	$ 35.04	$ 12.67	$ (54.45)

Figure C. 9 The GS Rotation's Net Returns Sensitivity Using Average Prices

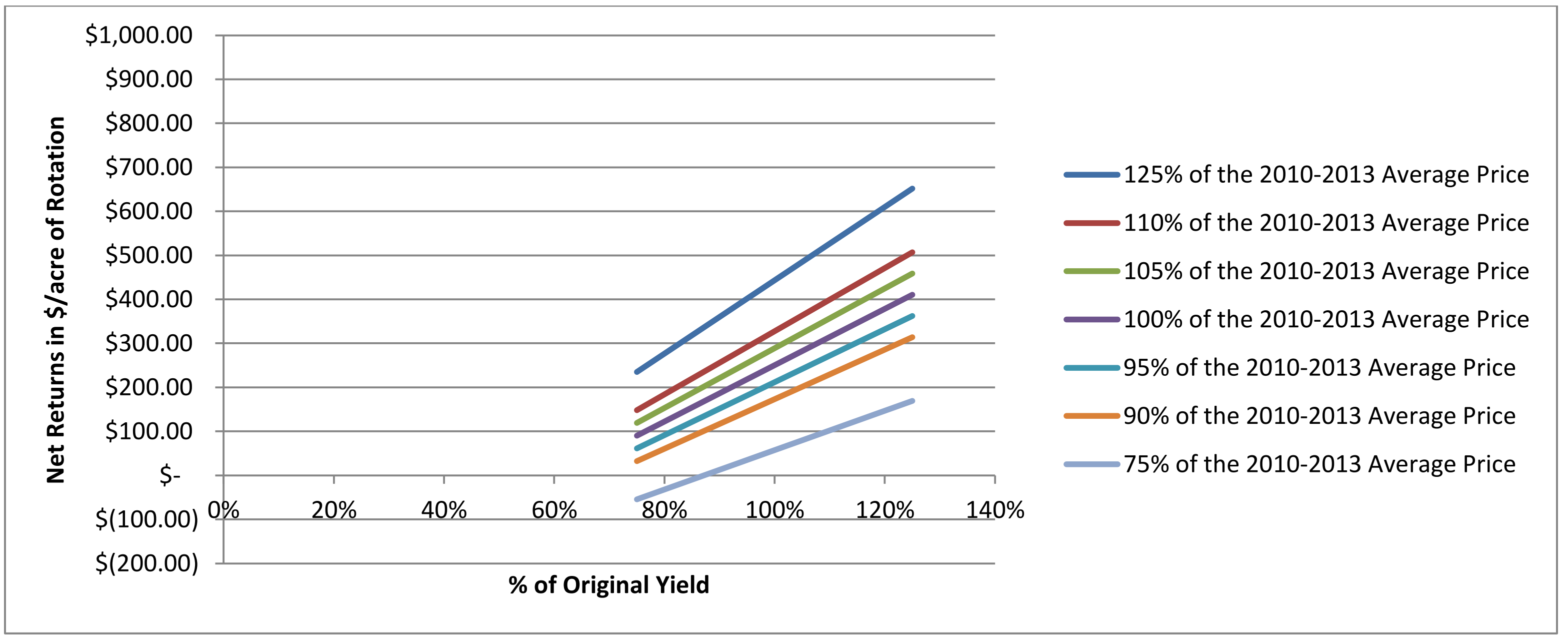


Table C. 10 The BMR Rotation's Net Returns Sensitivity Analysis Using Average Prices

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	BMR Sorghum Bushels per Acre				42.52	37.42	35.72	34.02	32.31	30.61	25.51
	BMR Sorghum Tons per Acre				8.05	7.09	6.76	6.44	6.12	5.80	4.83
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 107.37	125%	110%	105%	100%	95%	90%	75%
	$ 15.71	$ 6.60	$ 91.24	125%	$ 413.68	$ 320.13	$ 288.92	$ 257.56	$ 226.19	$ 194.83	$ 100.74
	$ 13.82	$ 5.81	$ 80.29	110%	$ 301.04	$ 221.01	$ 194.30	$ 167.44	$ 140.58	$ 113.73	$ 33.15
	$ 13.19	$ 5.54	$ 76.64	105%	$ 263.49	$ 187.97	$ 162.76	$ 137.40	$ 112.05	$ 86.69	$ 10.63
	$ 12.57	$ 5.28	$ 72.99	100%	$ 225.94	$ 154.92	$ 131.22	$ 107.37	$ 83.51	$ 59.66	$ (11.90)
	$ 11.94	$ 5.01	$ 69.34	95%	$ 188.40	$ 121.88	$ 99.68	$ 77.33	$ 54.98	$ 32.63	$ (34.43)
	$ 11.31	$ 4.75	$ 65.69	90%	$ 150.85	$ 88.84	$ 68.14	$ 47.29	$ 26.44	$ 5.59	$ (56.96)
	$ 9.42	$ 3.96	$ 54.74	75%	$ 38.21	$ (10.28)	$ (26.48)	$ (42.82)	$ (59.17)	$ (75.51)	$ (124.54)

Figure C. 10 The BMR Rotation's Net Returns Sensitivity Analysis Using Average Prices

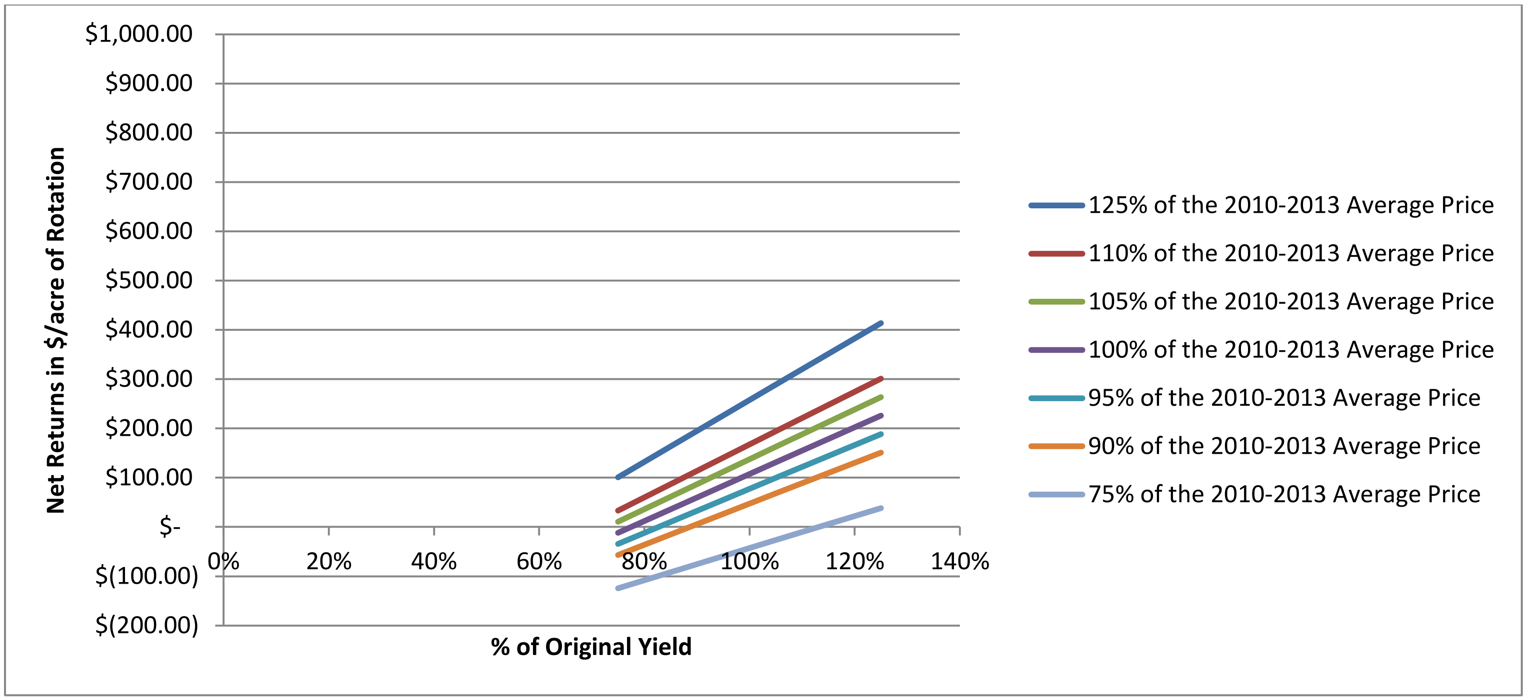


Table C. 11 The PS Rotation's Net Returns Sensitivity Analysis Using Average Prices

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	PS Sorghum Bushels per Acre				-	-	-	-	-	-	-
	PS Sorghum Tons per Acre				13.09	11.52	11.00	10.48	9.95	9.43	7.86
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 170.03	125%	110%	105%	100%	95%	90%	75%
	$ 15.71	$ 6.60	$ 91.24	125%	$ 543.66	$ 431.68	$ 394.36	$ 357.03	$ 319.70	$ 282.38	$ 170.40
	$ 13.82	$ 5.81	$ 80.29	110%	$ 403.41	$ 308.26	$ 276.55	$ 244.83	$ 213.11	$ 181.40	$ 86.25
	$ 13.19	$ 5.54	$ 76.64	105%	$ 356.66	$ 267.12	$ 237.28	$ 207.43	$ 177.58	$ 147.74	$ 58.20
	$ 12.57	$ 5.28	$ 72.99	100%	$ 309.91	$ 225.98	$ 198.01	$ 170.03	$ 142.05	$ 114.08	$ 30.15
	$ 11.94	$ 5.01	$ 69.34	95%	$ 263.16	$ 184.84	$ 158.74	$ 132.63	$ 106.52	$ 80.42	$ 2.10
	$ 11.31	$ 4.75	$ 65.69	90%	$ 216.41	$ 143.70	$ 119.47	$ 95.23	$ 70.99	$ 46.76	$ (25.95)
	$ 9.42	$ 3.96	$ 54.74	75%	$ 76.16	$ 20.28	$ 1.66	$ (16.97)	$ (35.59)	$ (54.22)	$ (110.10)

Figure C. 11 The PS Rotation's Net Returns Sensitivity Analysis Using Average Prices

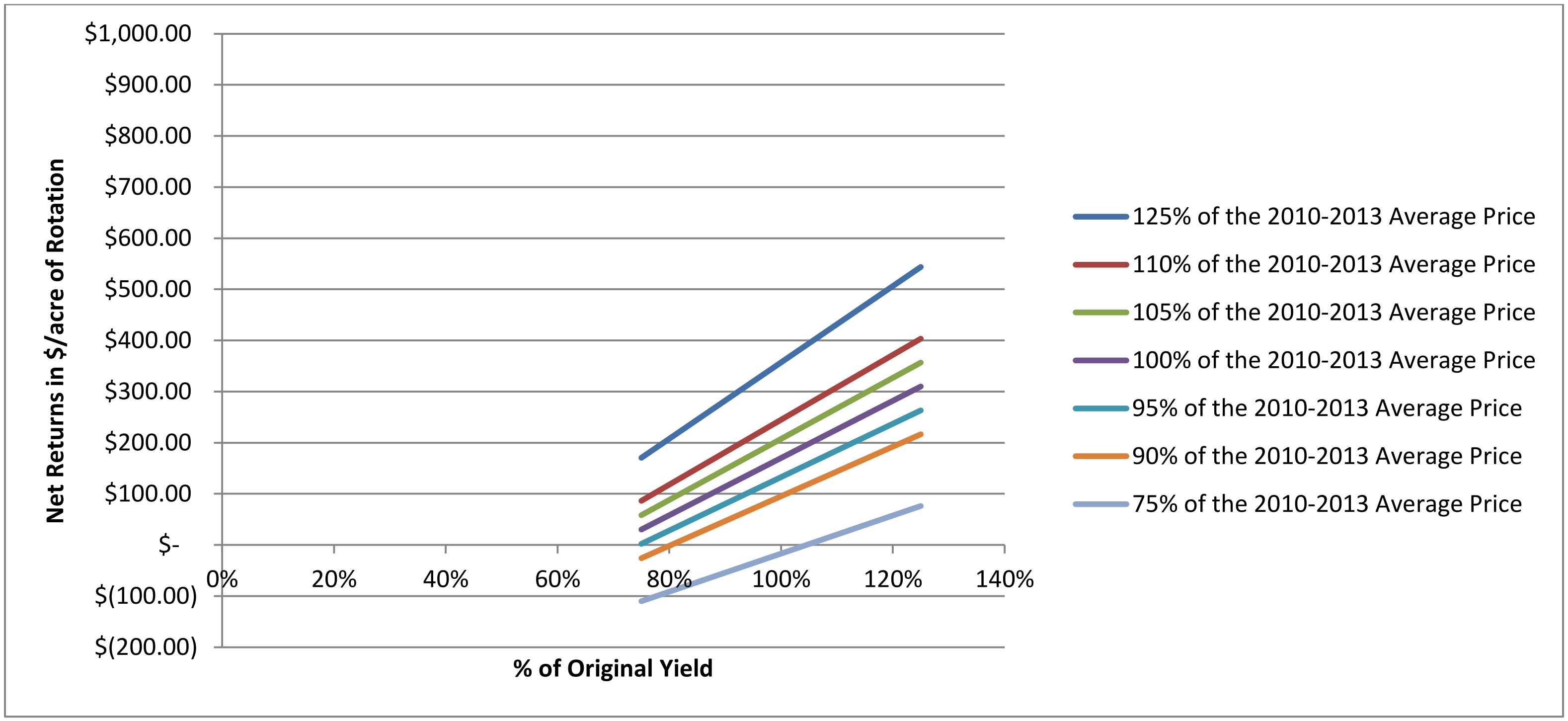


Table C. 12 The DP Rotation's Net Returns Sensitivity Analysis Using Average Prices

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	Dual Sorghum Bushels per Acre				91.57	80.58	76.92	73.25	69.59	65.93	54.94
	Dual Sorghum Tons per Acre				10.82	9.53	9.09	8.66	8.23	7.79	6.49
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 316.19	125%	110%	105%	100%	95%	90%	75%
	$ 15.71	$ 6.60	$ 91.24	125%	$ 765.21	$ 627.06	$ 581.01	$ 534.96	$ 488.91	$ 442.86	$ 304.71
	$ 13.82	$ 5.81	$ 80.29	110%	$ 601.13	$ 482.67	$ 443.19	$ 403.70	$ 364.21	$ 324.72	$ 206.26
	$ 13.19	$ 5.54	$ 76.64	105%	$ 546.44	$ 434.54	$ 397.24	$ 359.95	$ 322.65	$ 285.35	$ 173.45
	$ 12.57	$ 5.28	$ 72.99	100%	$ 491.75	$ 386.42	$ 351.30	$ 316.19	$ 281.08	$ 245.97	$ 140.63
	$ 11.94	$ 5.01	$ 69.34	95%	$ 437.06	$ 338.29	$ 305.36	$ 272.44	$ 239.52	$ 206.59	$ 107.82
	$ 11.31	$ 4.75	$ 65.69	90%	$ 382.37	$ 290.16	$ 259.42	$ 228.69	$ 197.95	$ 167.21	$ 75.00
	$ 9.42	$ 3.96	$ 54.74	75%	$ 218.29	$ 145.77	$ 121.60	$ 97.43	$ 73.25	$ 49.08	$ (23.44)

Figure C. 12 The DP Rotation's Net Returns Sensitivity Analysis Using Average Prices

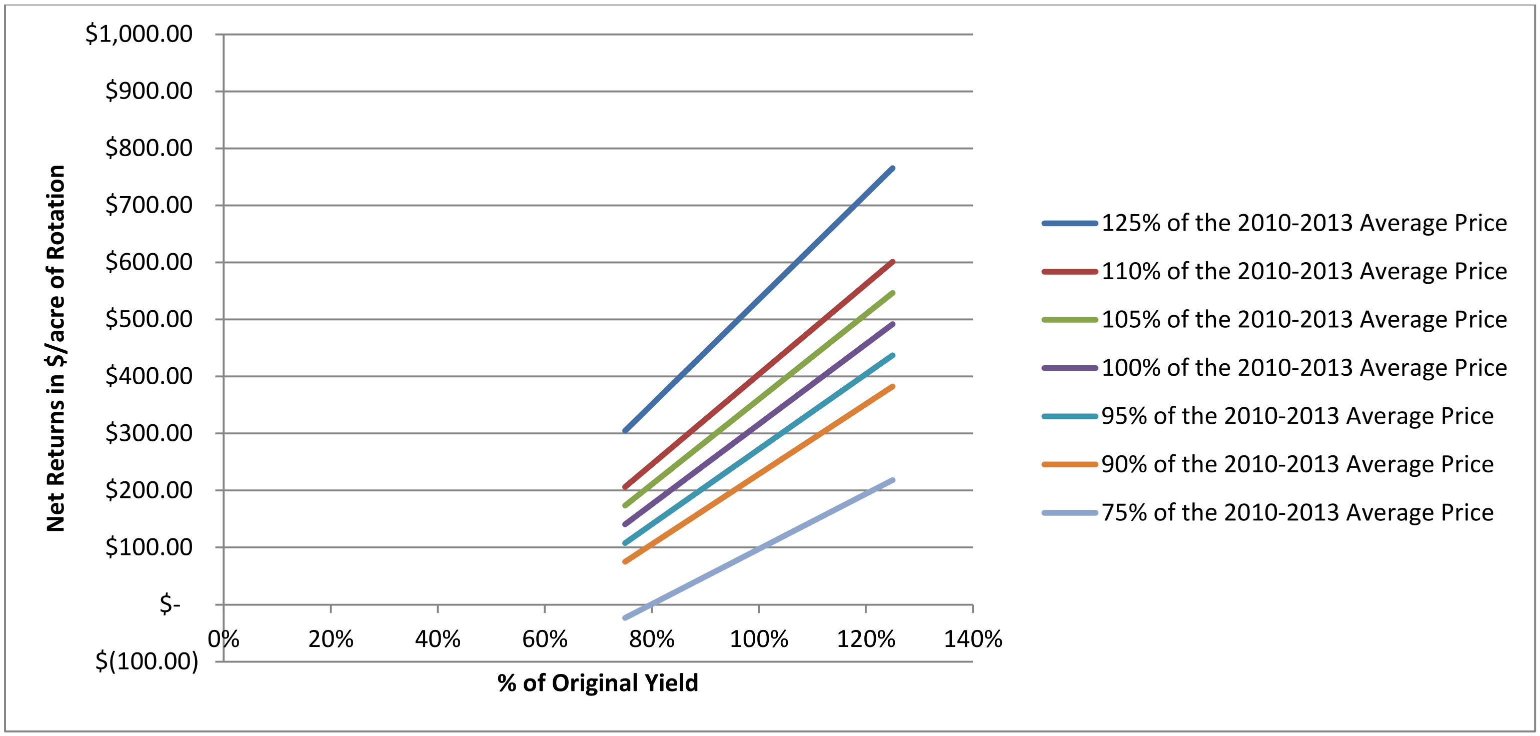


Table C. 13 The SS Rotation's Net Returns Sensitivity Analysis Using Average Prices

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	Dual Sorghum Bushels per Acre				26.24	23.09	22.04	20.99	19.94	18.89	15.74
	Dual Sorghum Tons per Acre				12.89	11.34	10.83	10.31	9.79	9.28	7.73
Grain and Biomass Price Range	Soybean Price per Bushel	Sorghum Price per Bushel	Biomass Price per Ton	$ 190.02	125%	110%	105%	100%	95%	90%	75%
	$ 15.71	$ 6.60	$ 91.24	125%	$ 765.21	$ 627.06	$ 581.01	$ 534.96	$ 488.91	$ 442.86	$ 304.71
	$ 13.82	$ 5.81	$ 80.29	110%	$ 601.13	$ 482.67	$ 443.19	$ 403.70	$ 364.21	$ 324.72	$ 206.26
	$ 13.19	$ 5.54	$ 76.64	105%	$ 546.44	$ 434.54	$ 397.24	$ 359.95	$ 322.65	$ 285.35	$ 173.45
	$ 12.57	$ 5.28	$ 72.99	100%	$ 491.75	$ 386.42	$ 351.30	$ 316.19	$ 281.08	$ 245.97	$ 140.63
	$ 11.94	$ 5.01	$ 69.34	95%	$ 437.06	$ 338.29	$ 305.36	$ 272.44	$ 239.52	$ 206.59	$ 107.82
	$ 11.31	$ 4.75	$ 65.69	90%	$ 382.37	$ 290.16	$ 259.42	$ 228.69	$ 197.95	$ 167.21	$ 75.00
	$ 9.42	$ 3.96	$ 54.74	75%	$ 218.29	$ 145.77	$ 121.60	$ 97.43	$ 73.25	$ 49.08	$ (23.44)

Figure C. 13 The SS Rotation's Net Returns Sensitivity Analysis Using Average Prices

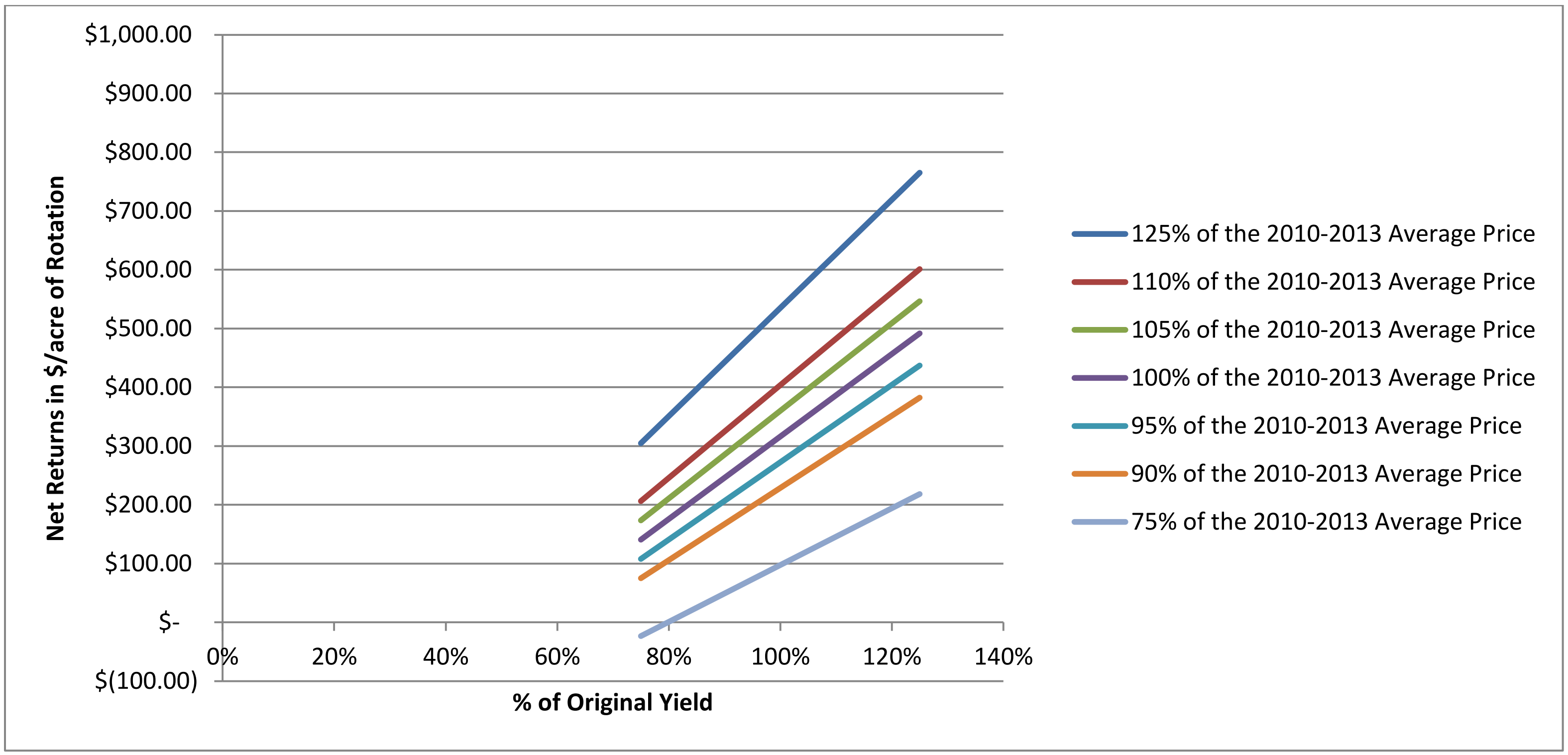


Table C. 14 The RC Rotation's Net Returns Sensitivity Analysis Using Average Prices

					Grain and Biomass Yield Range						
	Soybean Bushels per Acre				72.75	64.02	61.11	58.20	55.29	52.38	43.65
	Rotated Corn Bushels per Acre				192.15	169.09	161.41	153.72	146.03	138.35	115.29
	Rotated Corn Tons per Acre				9.78	8.61	8.22	7.83	7.43	7.04	5.87
Grain and Biomass Price Range	Soybean Price per Bushel	Corn Price per Bushel	Biomass Price per Ton	$ 395.53	125%	110%	105%	100%	95%	90%	75%
	$ 15.71	$ 7.21	$ 72.41	125%	$ 785.84	$ 696.92	$ 667.28	$ 637.63	$ 607.99	$ 578.35	$ 489.42
	$ 13.82	$ 6.34	$ 63.72	110%	$ 617.98	$ 542.61	$ 517.49	$ 492.37	$ 467.25	$ 442.13	$ 366.76
	$ 13.19	$ 6.05	$ 60.83	105%	$ 562.02	$ 491.18	$ 467.56	$ 443.95	$ 420.34	$ 396.72	$ 325.88
	$ 12.57	$ 5.77	$ 57.93	100%	$ 506.07	$ 439.75	$ 417.64	$ 395.53	$ 373.42	$ 351.31	$ 284.99
	$ 11.94	$ 5.48	$ 55.03	95%	$ 450.11	$ 388.31	$ 367.71	$ 347.11	$ 326.51	$ 305.91	$ 244.10
	$ 11.31	$ 5.19	$ 52.14	90%	$ 394.16	$ 336.88	$ 317.78	$ 298.69	$ 279.59	$ 260.50	$ 203.22
	$ 9.42	$ 4.32	$ 43.45	75%	$ 226.29	$ 182.57	$ 168.00	$ 153.43	$ 138.85	$ 124.28	$ 80.56

Figure C. 14 The RC Rotation's Net Returns Sensitivity Analysis Using Average Prices

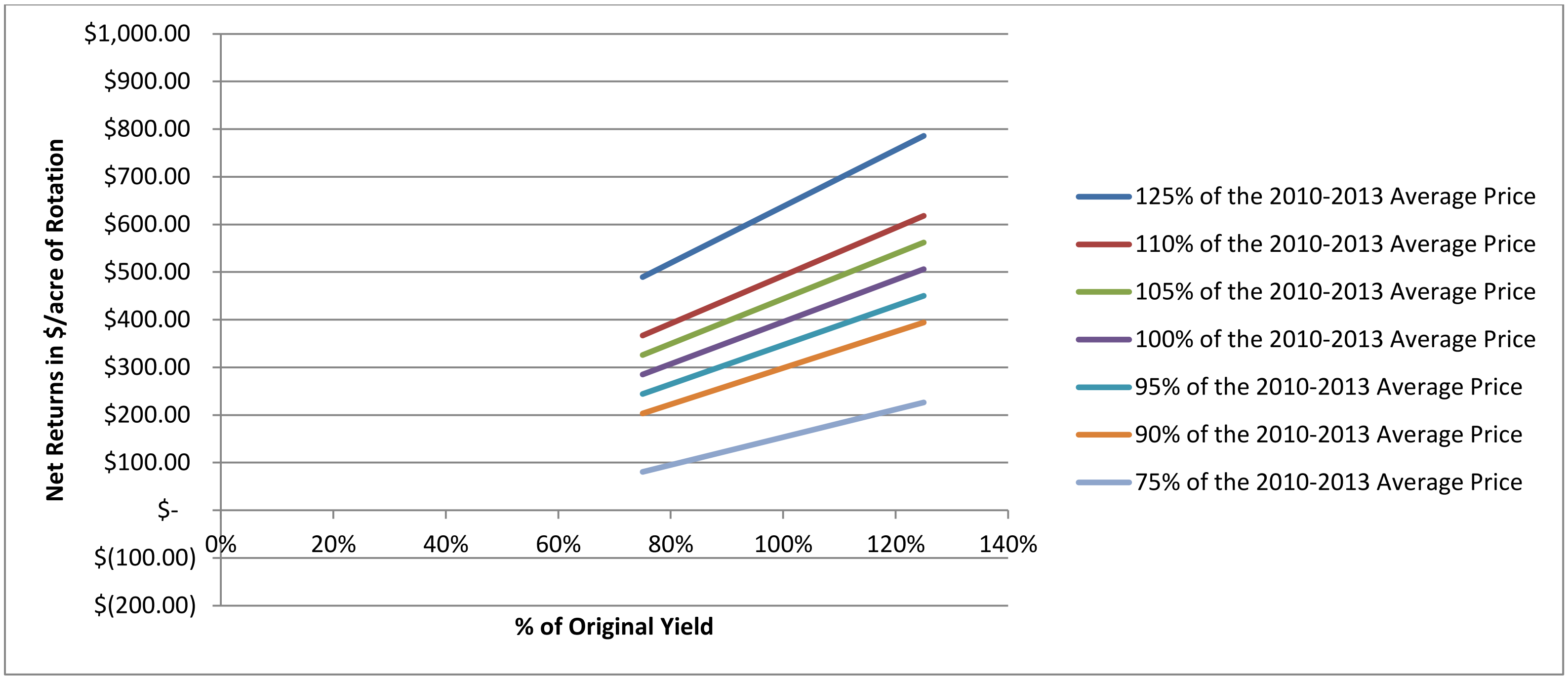
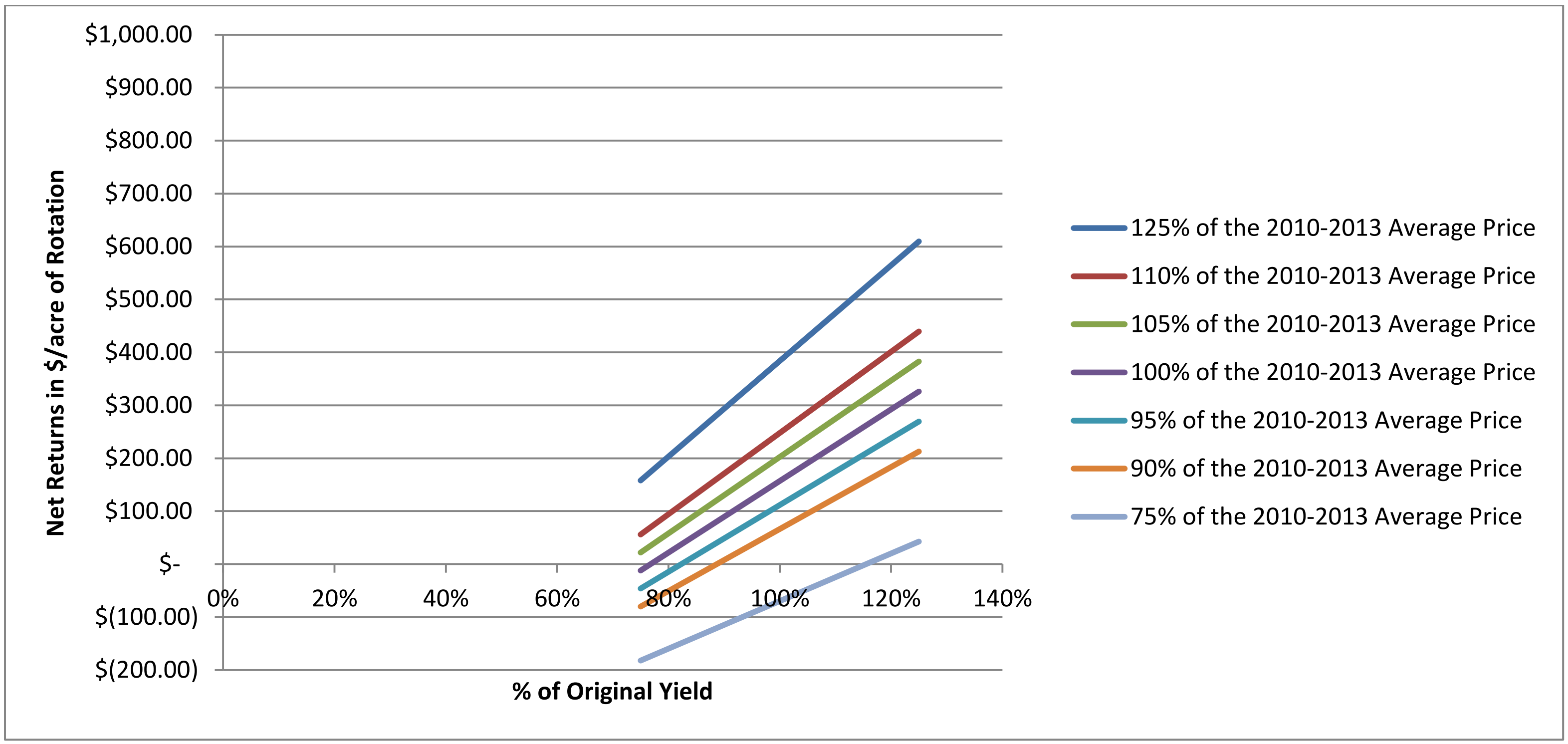


Table C. 15 The CC Rotation's Net Returns Sensitivity Analysis Using Average Prices

				Grain and Biomass Yield Range						
Continous Corn Bushels per Acre				142.98	125.82	120.10	114.38	108.66	102.94	85.79
Continious Corn Tons per Acre				7.86	6.92	6.60	6.29	5.97	5.66	4.72
Grain and Biomass Price Range	Corn Price per Bushel	Biomass Price per Ton	$ 156.94	125%	110%	105%	100%	95%	90%	75%
	$ 7.21	$ 72.41	125%	$ 609.55	$ 474.06	$ 428.90	$ 383.74	$ 338.58	$ 293.42	$ 157.90
	$ 6.34	$ 63.72	110%	$ 439.45	$ 324.38	$ 286.02	$ 247.66	$ 209.30	$ 170.95	$ 55.85
	$ 6.05	$ 60.83	105%	$ 382.75	$ 274.48	$ 238.39	$ 202.30	$ 166.21	$ 130.12	$ 21.83
	$ 5.77	$ 57.93	100%	$ 326.05	$ 224.59	$ 190.77	$ 156.94	$ 123.12	$ 89.30	$ (12.19)
	$ 5.48	$ 55.03	95%	$ 269.35	$ 174.69	$ 143.14	$ 111.59	$ 80.03	$ 48.48	$ (46.21)
	$ 5.19	$ 52.14	90%	$ 212.66	$ 124.80	$ 95.51	$ 66.23	$ 36.94	$ 7.66	$ (80.23)
	$ 4.32	$ 43.45	75%	$ 42.56	$ (24.89)	$ (47.37)	$ (69.85)	$ (92.33)	$ (114.81)	$ (182.29)

Figure C. 15 The CC Rotation's Net Returns Sensitivity Analysis Using Average Prices



C.4 Perennial Sensitivity Analysis Using Original Prices and Yields ($/ton)

Table C. 16 Switchgrass Amortized Net Returns Sensitivity Analysis

Switchgrass		Amortized Per Ton Net Returns	Biomass Price Range						
		Price Per Ton	$ 175.34	$ 154.30	$ 147.29	$ 140.27	$ 133.26	$ 126.25	$ 105.20
	Total Tons per Acre	$ 51.96	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	54.28	125%	$ 89.76	$ 71.86	$ 65.90	$ 59.93	$ 53.96	$ 48.00	$ 30.10
	47.76	110%	$ 85.41	$ 67.51	$ 61.55	$ 55.58	$ 49.61	$ 43.65	$ 25.75
	45.59	105%	$ 83.69	$ 65.79	$ 59.82	$ 53.86	$ 47.89	$ 41.92	$ 24.02
	43.42	100%	$ 81.79	$ 63.89	$ 57.92	**$ 51.96**	$ 45.99	$ 40.02	$ 22.13
	41.25	95%	$ 79.69	$ 61.79	$ 55.82	$ 49.86	$ 43.89	$ 37.93	$ 20.03
	39.08	90%	$ 77.36	$ 59.46	$ 53.49	$ 47.53	$ 41.56	$ 35.59	$ 17.70
	32.57	75%	$ 68.50	$ 50.60	$ 44.63	$ 38.67	$ 32.70	$ 26.73	$ 8.83

Figure C. 16 Switchgrass Amortized Net Returns Sensitivity Analysis

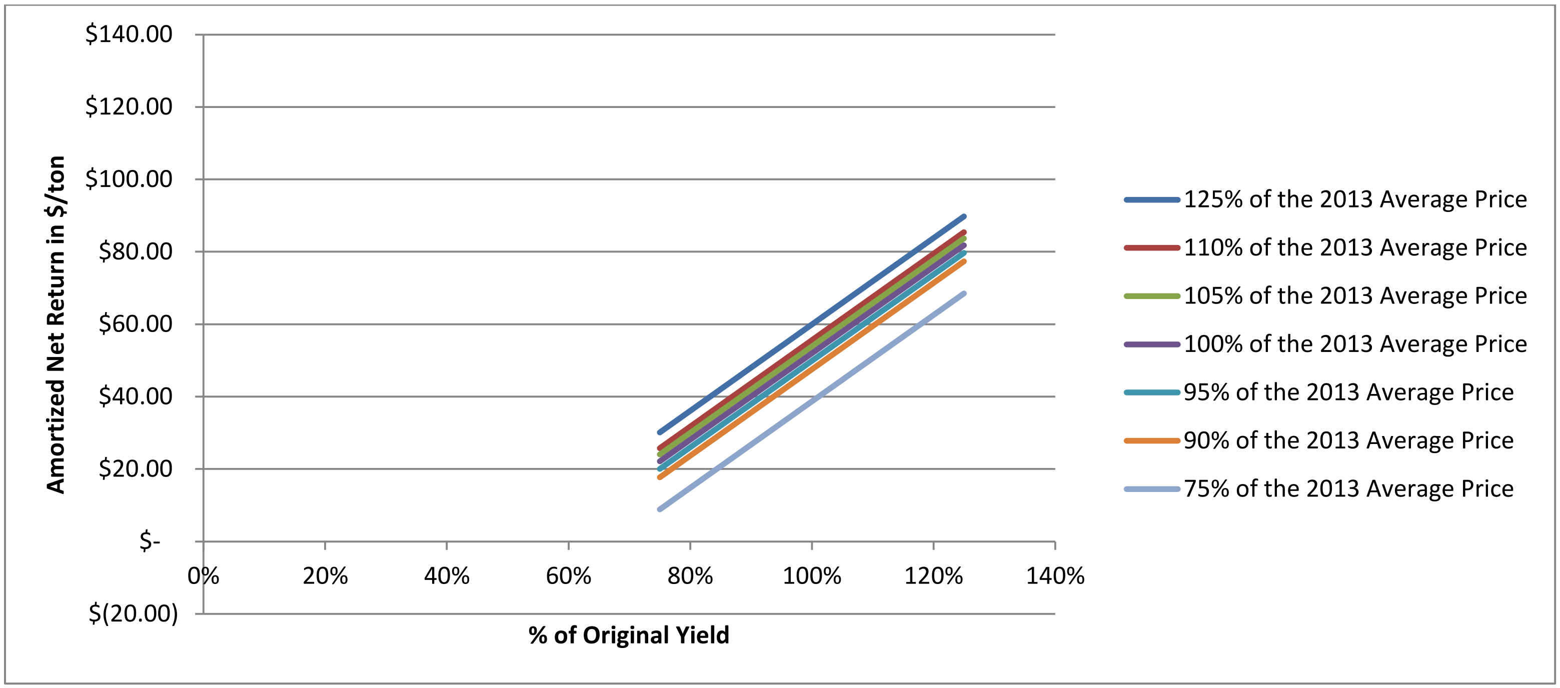


Table C. 17 Big Bluestem Amortized Net Returns Sensitivity Analysis

Big Bluestem		Amortized Per Ton Net Returns	Biomass Price Range						
			$ 175.00	$ 154.00	$ 147.00	$ 140.00	$ 133.00	$ 126.00	$ 105.00
	Total Tons per Acre	$ 34.76	125%	110%	105%	100%	95%	90%	75%
	38.49	125%	$ 76.34	$ 58.31	$ 52.30	$ 46.29	$ 40.28	$ 34.28	$ 16.25
	33.87	110%	$ 70.05	$ 52.02	$ 46.01	$ 40.00	$ 33.99	$ 27.98	$ 9.96
	32.33	105%	$ 67.55	$ 49.52	$ 43.51	$ 37.51	$ 31.50	$ 25.49	$ 7.46
Biomass Yield Range	30.79	100%	$ 64.80	$ 46.78	$ 40.77	**$ 34.76**	$ 28.75	$ 22.74	$ 4.71
	29.25	95%	$ 61.77	$ 43.74	$ 37.73	$ 31.72	$ 25.71	$ 19.71	$ 1.68
	27.71	90%	$ 58.40	$ 40.37	$ 34.36	$ 28.35	$ 22.34	$ 16.33	$ (1.69)
	23.09	75%	$ 45.58	$ 27.55	$ 21.54	$ 15.53	$ 9.53	$ 3.52	$ (14.51)

Figure C. 17 Big Bluestem Amortized Net Returns Sensitivity Analysis

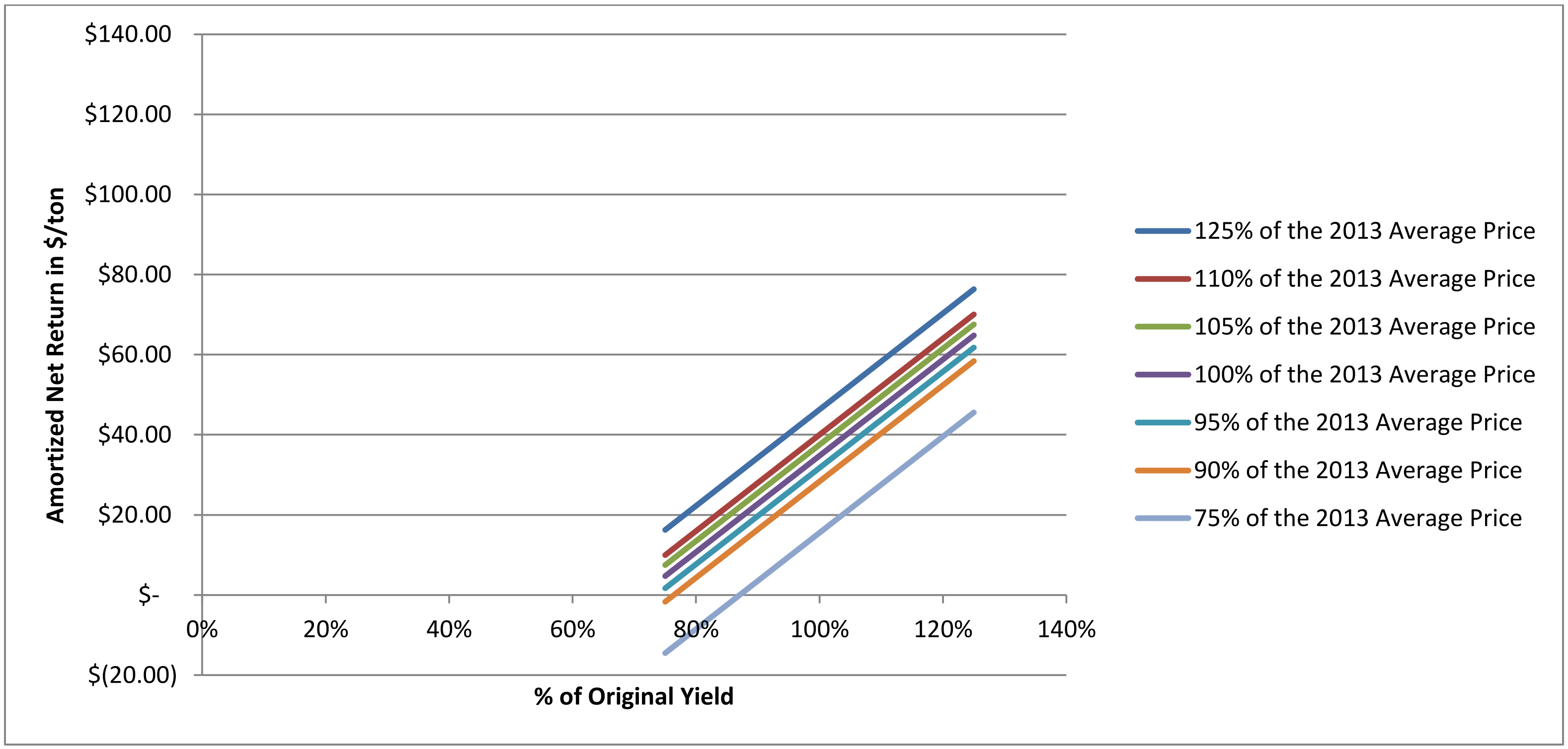


Table C. 18 Alfalfa Amortized Net Returns Sensitivity Analysis

Alfalfa		Amortized Per Ton Net Returns	Biomass Price Range						
			$ 225.34	$ 198.30	$ 189.29	$ 180.27	$ 171.26	$ 162.25	$ 135.20
	Total Tons per Acre	$ 76.76	125%	110%	105%	100%	95%	90%	75%
	45.82	125%	$ 128.10	$ 104.69	$ 96.89	$ 89.09	$ 81.29	$ 73.48	$ 50.08
	40.32	110%	$ 121.38	$ 97.97	$ 90.17	$ 82.36	$ 74.56	$ 66.76	$ 43.35
	38.49	105%	$ 118.71	$ 95.30	$ 87.50	$ 79.70	$ 71.89	$ 64.09	$ 40.68
Biomass Yield Range	36.65	100%	$ 115.77	$ 92.37	$ 84.56	**$ 76.76**	$ 68.96	$ 61.16	$ 37.75
	34.82	95%	$ 112.53	$ 89.12	$ 81.32	$ 73.52	$ 65.72	$ 57.91	$ 34.51
	32.99	90%	$ 108.93	$ 85.52	$ 77.72	$ 69.91	$ 62.11	$ 54.31	$ 30.90
	27.49	75%	$ 95.23	$ 71.82	$ 64.02	$ 56.22	$ 48.41	$ 40.61	$ 17.20

Figure C. 18 Alfalfa Amortized Net Returns Sensitivity Analysis

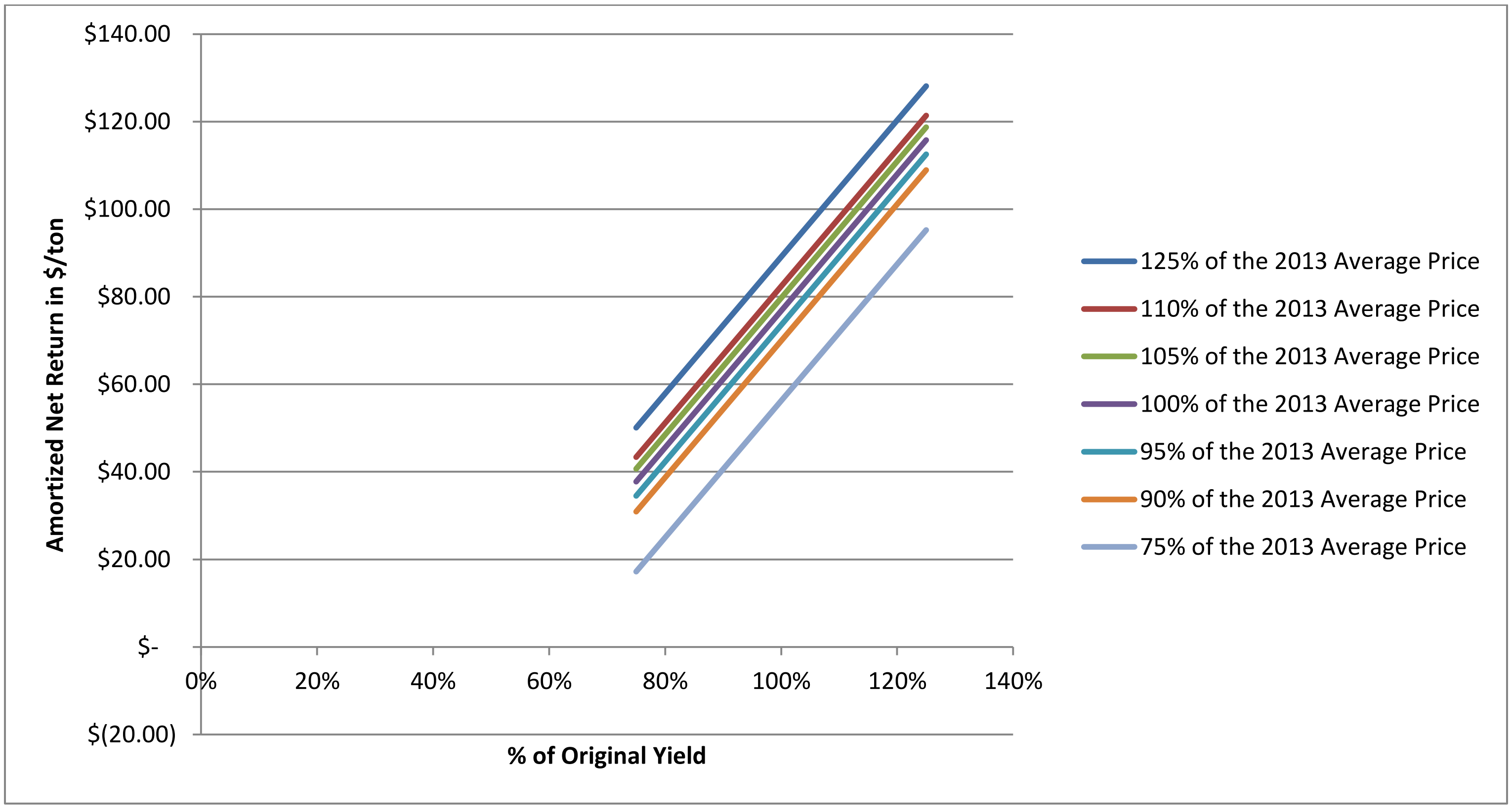


Table C. 19 Switchgrass Establishment Year Net Returns Sensitivity Analysis

Switchgrass		Establishment Per Ton Net Return	Biomass Price Range						
		Price Per Ton	$ 175.34	$ 154.30	$ 147.29	$ 140.27	$ 133.26	$ 126.25	$ 105.20
	Est. Year Tons per Acre	$ 10.22	125%	110%	105%	100%	95%	90%	75%
	2.49	125%	$ 64.84	$ 43.80	$ 36.78	$ 29.77	$ 22.76	$ 15.74	$ (5.30)
	2.19	110%	$ 54.18	$ 33.14	$ 26.12	$ 19.11	$ 12.09	$ 5.08	$ (15.96)
	2.09	105%	$ 49.95	$ 28.90	$ 21.89	$ 14.88	$ 7.86	$ 0.85	$ (20.19)
Biomass Yield Range	1.99	100%	$ 45.29	$ 24.25	$ 17.24	**$ 10.22**	$ 3.21	$ (3.80)	$ (24.84)
	1.89	95%	$ 40.15	$ 19.11	$ 12.09	$ 5.08	$ (1.93)	$ (8.95)	$ (29.99)
	1.79	90%	$ 34.43	$ 13.39	$ 6.38	$ (0.63)	$ (7.65)	$ (14.66)	$ (35.70)
	1.50	75%	$ 12.72	$ (8.32)	$ (15.34)	$ (22.35)	$ (29.37)	$ (36.38)	$ (57.42)

Figure C. 19 Switchgrass Establishment Year Net Returns Sensitivity Analysis

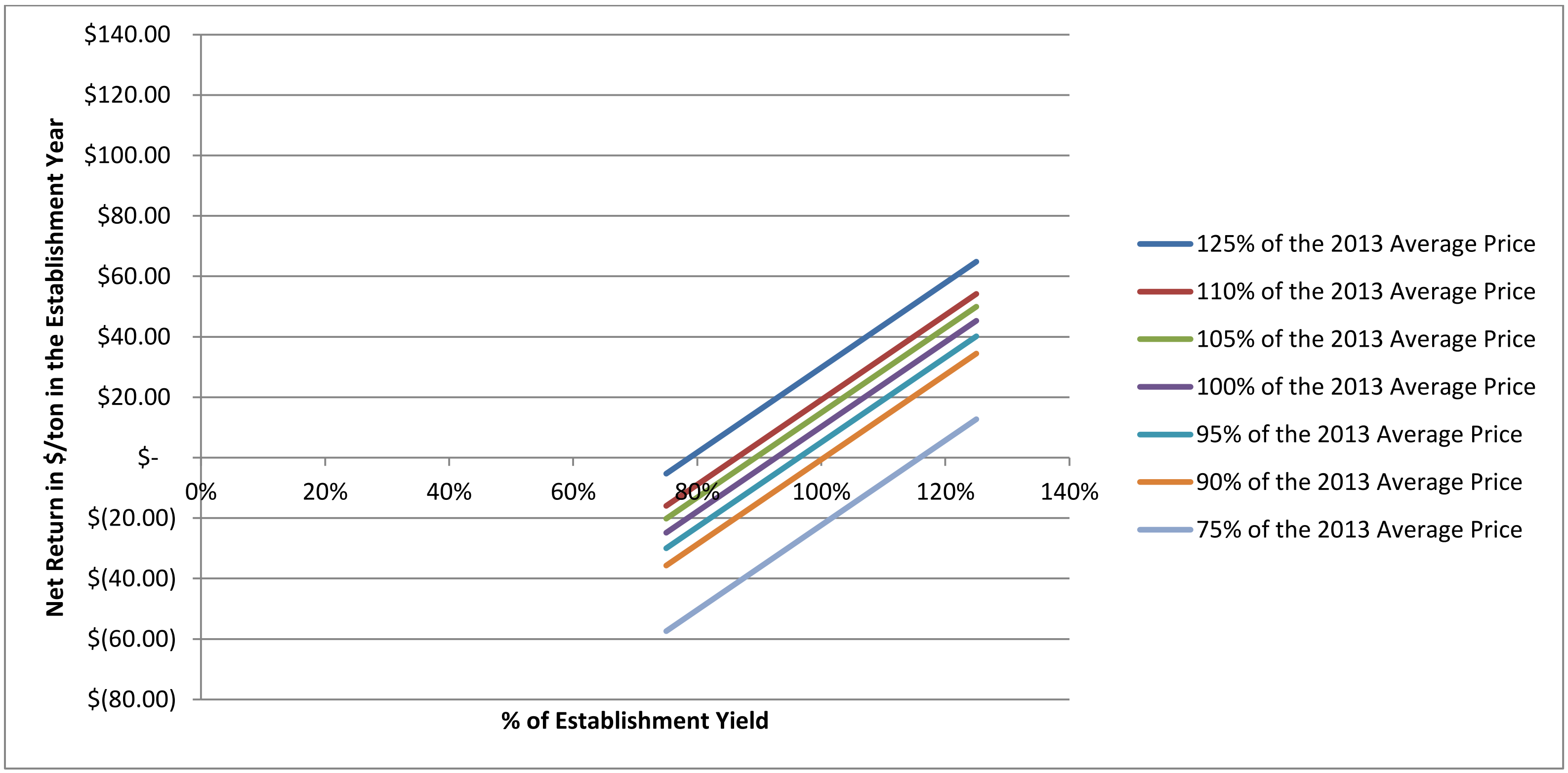


Table C. 20 Big Bluestem Establishment Year Net Returns Sensitivity Analysis

Big Bluestem		Establishment Per Ton Net Return		Biomass Price Range						
				$ 175.00	$ 154.00	$ 147.00	$ 140.00	$ 133.00	$ 126.00	$ 105.00
	Est. Year Tons per Acre	$	(7.67)	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	2.54		125%	$ 50.40	$ 29.40	$ 22.40	$ 15.40	$ 8.40	$ 1.40	$ (19.60)
	2.23		110%	$ 37.82	$ 16.82	$ 9.82	$ 2.82	$ (4.18)	$ (11.18)	$ (32.18)
	2.13		105%	$ 32.82	$ 11.82	$ 4.82	$ (2.18)	$ (9.18)	$ (16.18)	$ (37.18)
	2.03		100%	$ 27.33	$ 6.33	$ (0.67)	**$ (7.67)**	$ (14.67)	$ (21.67)	$ (42.67)
	1.93		95%	$ 21.26	$ 0.26	$ (6.74)	$ (13.74)	$ (20.74)	$ (27.74)	$ (48.74)
	1.83		90%	$ 14.51	$ (6.49)	$ (13.49)	$ (20.49)	$ (27.49)	$ (34.49)	$ (55.49)
	1.52		75%	$ (11.12)	$ (32.12)	$ (39.12)	$ (46.12)	$ (53.12)	$ (60.12)	$ (81.12)

Figure C. 20 Big Bluestem Establishment Year Net Returns Sensitivity Analysis

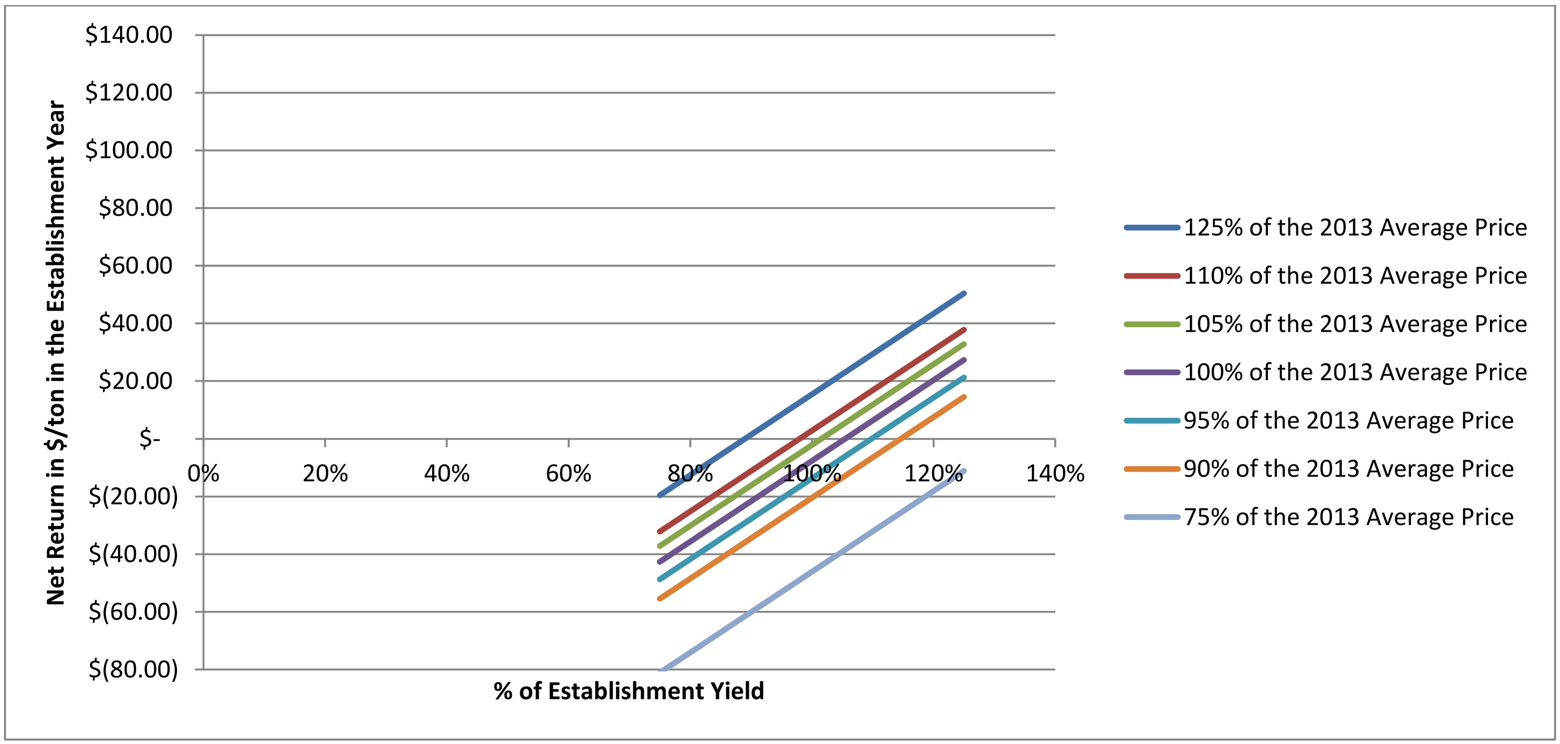
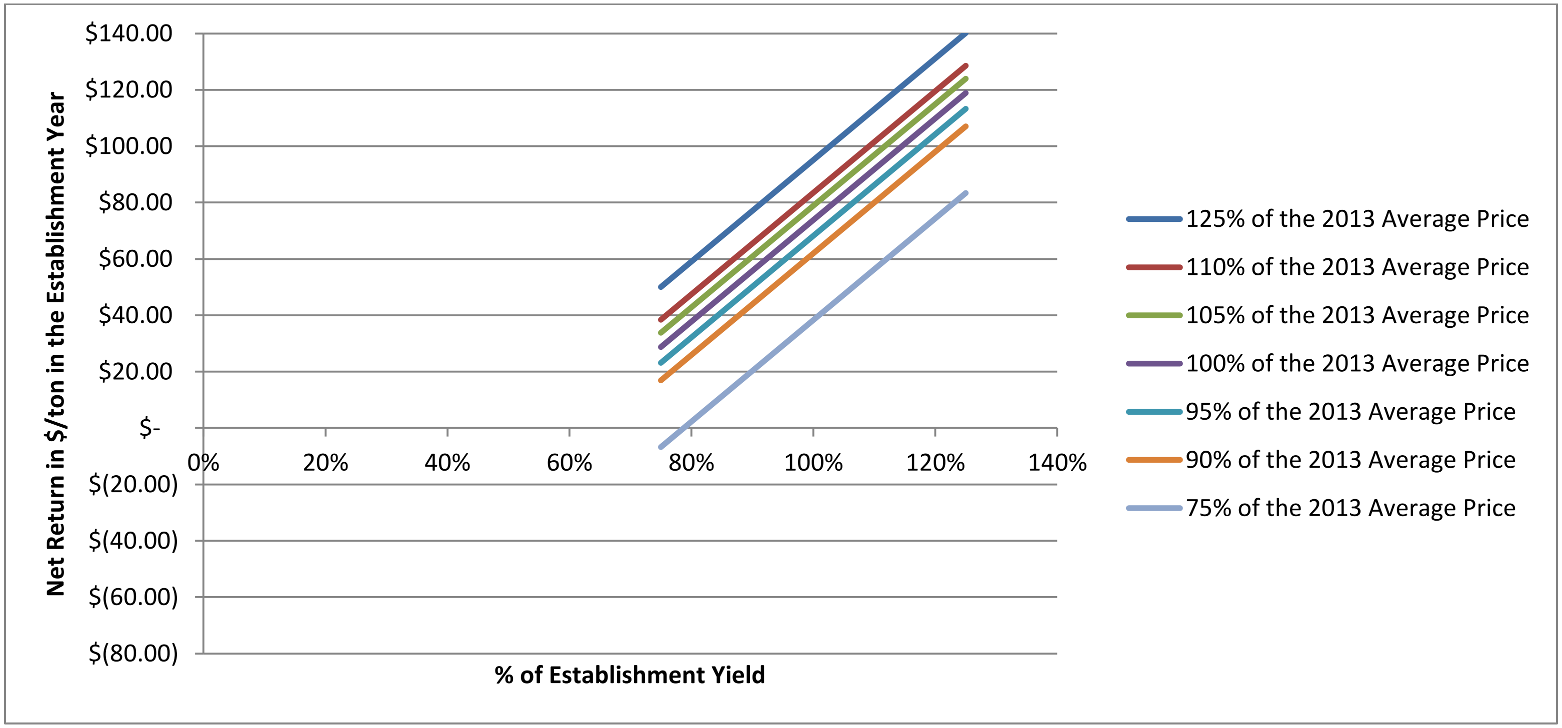


Table C. 21 Alfalfa Establishment Year Net Returns Sensitivity Analysis

Alfalfa		Establishment Per Ton Net Return	Biomass Price Range						
			$ 225.34	$ 198.30	$ 189.29	$ 180.27	$ 171.26	$ 162.25	$ 135.20
	Est. Year Tons per Acre	$ 73.80	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	3.76	125%	$ 140.16	$ 113.12	$ 104.11	$ 95.09	$ 86.08	$ 77.07	$ 50.03
	3.31	110%	$ 128.55	$ 101.51	$ 92.49	$ 83.48	$ 74.47	$ 65.45	$ 38.41
	3.16	105%	$ 123.94	$ 96.90	$ 87.88	$ 78.87	$ 69.86	$ 60.84	$ 33.80
	3.01	100%	$ 118.87	$ 91.83	$ 82.81	**$ 73.80**	$ 64.79	$ 55.77	$ 28.73
	2.86	95%	$ 113.26	$ 86.22	$ 77.21	$ 68.20	$ 59.18	$ 50.17	$ 23.13
	2.71	90%	$ 107.04	$ 80.00	$ 70.98	$ 61.97	$ 52.96	$ 43.94	$ 16.90
	2.25	75%	$ 83.38	$ 56.34	$ 47.32	$ 38.31	$ 29.29	$ 20.28	$ (6.76)

Figure C. 21 Alfalfa Establishment Year Net Returns Sensitivity Analysis



C.5 Perennial Sensitivity Analysis Using the 2010 to 2013 Average Prices ($/ton)

Table C. 22 Switchgrass Amortized Net Returns Sensitivity Analysis Using Average Prices

Switchgrass		Amortized Per Ton Net Returns	Biomass Price Range						
			$ 144.04	$ 126.76	$ 120.99	$ 115.23	$ 109.47	$ 103.71	$ 86.42
	Total Tons per Acre	$ 30.66	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	54.28	125%	$ 63.14	$ 48.43	$ 43.53	$ 38.63	$ 33.73	$ 28.83	$ 14.13
	47.76	110%	$ 58.79	$ 44.08	$ 39.18	$ 34.28	$ 29.38	$ 24.48	$ 9.78
	45.59	105%	$ 57.06	$ 42.36	$ 37.46	$ 32.56	$ 27.65	$ 22.75	$ 8.05
	43.42	100%	$ 55.16	$ 40.46	$ 35.56	**$ 30.66**	$ 25.76	$ 20.85	$ 6.15
	41.25	95%	$ 53.06	$ 38.36	$ 33.46	$ 28.56	$ 23.66	$ 18.76	$ 4.05
	39.08	90%	$ 50.73	$ 36.03	$ 31.13	$ 26.23	$ 21.33	$ 16.42	$ 1.72
	32.57	75%	$ 41.87	$ 27.17	$ 22.27	$ 17.37	$ 12.46	$ 7.56	$ (7.14)

Figure C. 22 Switchgrass Amortized Net Returns Sensitivity Analysis Using Average Prices

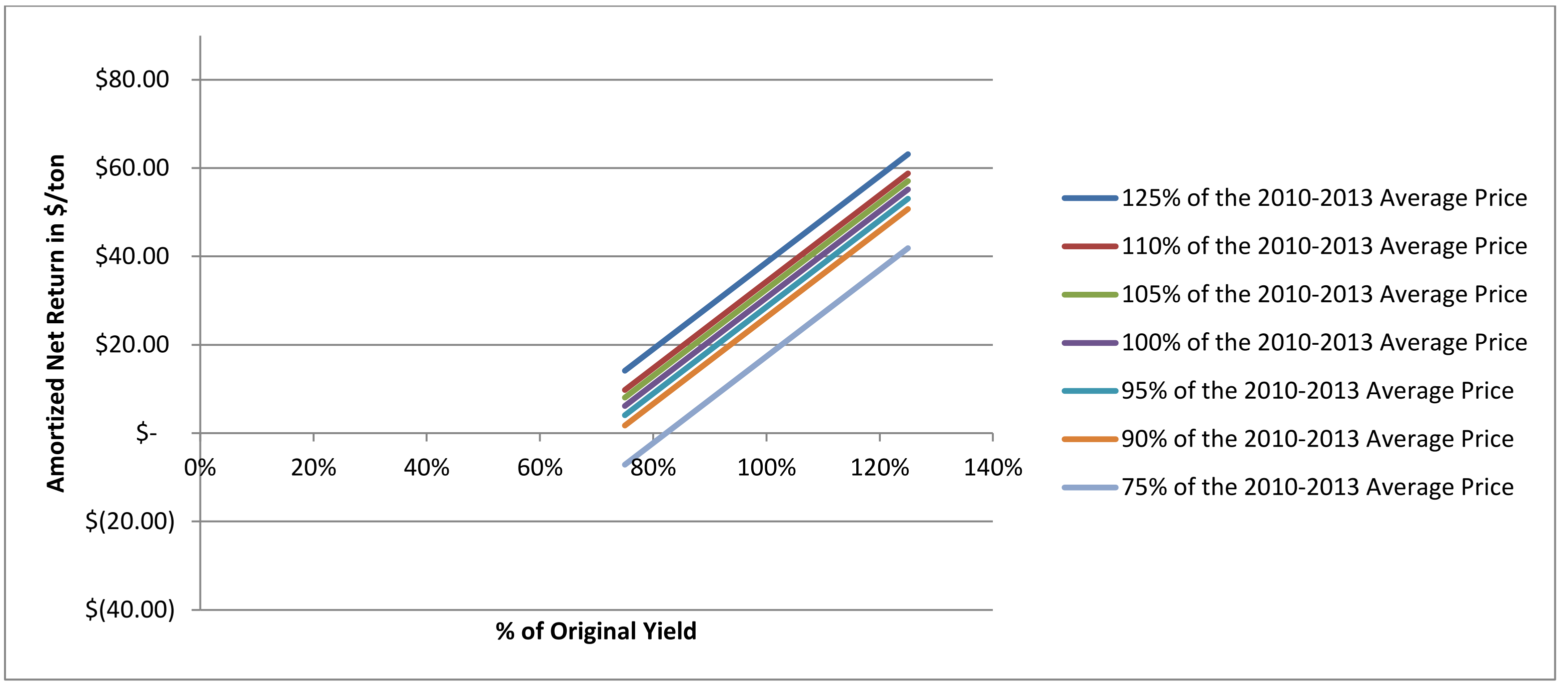


Table C. 23 Big Bluestem Amortized Net Returns Sensitivity Analysis Using Average Prices

Big Bluestem		Amortized Per Ton Net Returns	Biomass Price Range						
			$ 137.35	$ 120.87	$ 115.37	$ 109.88	$ 104.39	$ 98.89	$ 82.41
	Total Tons per Acre	$ 8.90	125%	110%	105%	100%	95%	90%	75%
	38.49	125%	$ 44.02	$ 29.87	$ 25.15	$ 20.44	$ 15.72	$ 11.01	$ (3.14)
	33.87	110%	$ 37.73	$ 23.58	$ 18.86	$ 14.15	$ 9.43	$ 4.71	$ (9.43)
	32.33	105%	$ 35.23	$ 21.08	$ 16.37	$ 11.65	$ 6.93	$ 2.22	$ (11.93)
Biomass Yield Range	30.79	100%	$ 32.48	$ 18.34	$ 13.62	**$ 8.90**	$ 4.19	$ (0.53)	$ (14.68)
	29.25	95%	$ 29.45	$ 15.30	$ 10.58	$ 5.87	$ 1.15	$ (3.56)	$ (17.71)
	27.71	90%	$ 26.08	$ 11.93	$ 7.21	$ 2.50	$ (2.22)	$ (6.94)	$ (21.09)
	23.09	75%	$ 13.26	$ (0.89)	$ (5.61)	$ (10.32)	$ (15.04)	$ (19.75)	$ (33.90)

Figure C. 23 Big Bluestem Amortized Net Returns Sensitivity Analysis Using Average Prices

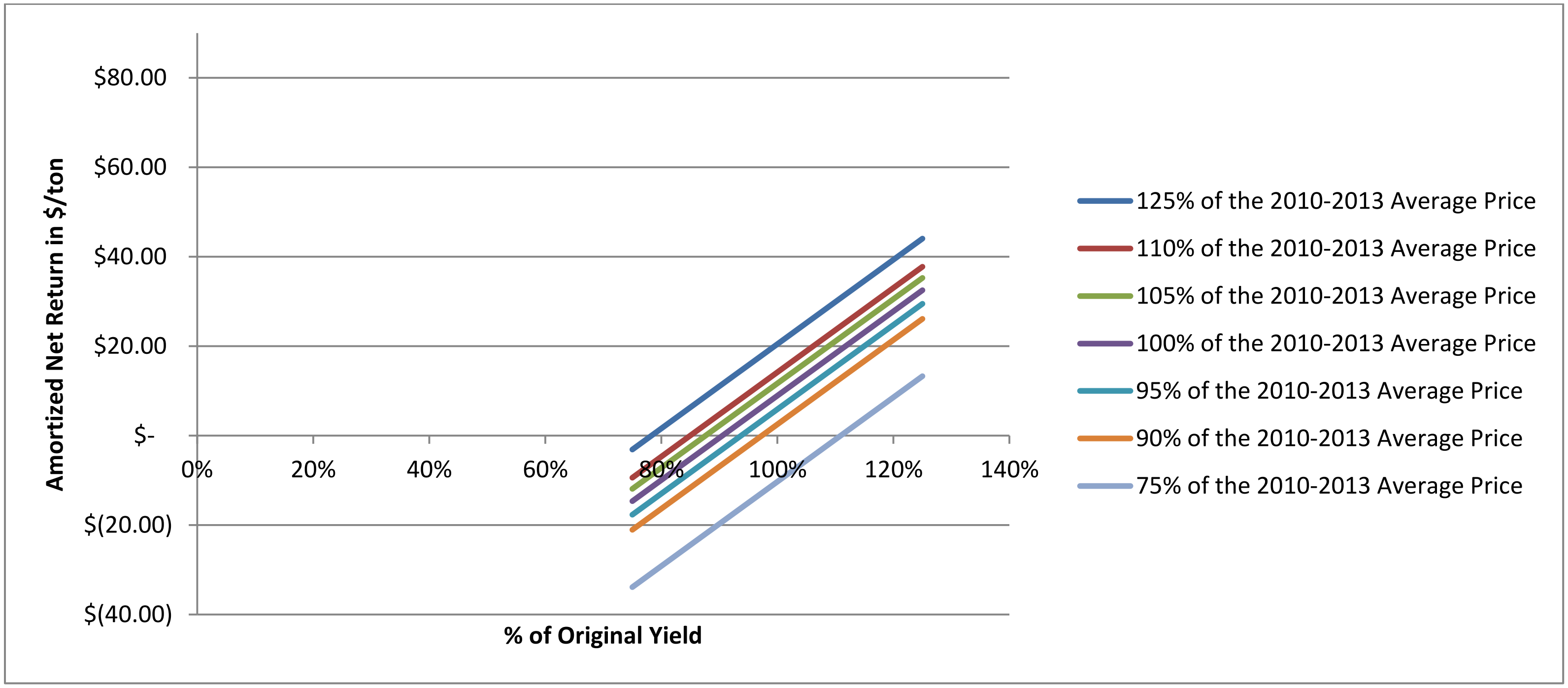


Table C. 24 Alfalfa Amortized Net Returns Sensitivity Analysis Using Average Prices

Alfalfa		Amortized Per Ton Net Returns	Biomass Price Range						
			$ 179.46	$ 157.92	$ 150.74	$ 143.57	$ 136.39	$ 129.21	$ 107.67
	Total Tons per Acre	$ 44.99	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	45.82	125%	$ 88.38	$ 69.74	$ 63.53	$ 57.31	$ 51.10	$ 44.89	$ 26.24
	40.32	110%	$ 81.66	$ 63.02	$ 56.80	$ 50.59	$ 44.38	$ 38.16	$ 19.52
	38.49	105%	$ 78.99	$ 60.35	$ 54.14	$ 47.92	$ 41.71	$ 35.49	$ 16.85
	36.65	100%	$ 76.06	$ 57.41	$ 51.20	**$ 44.99**	$ 38.77	$ 32.56	$ 13.92
	34.82	95%	$ 72.81	$ 54.17	$ 47.96	$ 41.74	$ 35.53	$ 29.31	$ 10.67
	32.99	90%	$ 69.21	$ 50.57	$ 44.35	$ 38.14	$ 31.92	$ 25.71	$ 7.07
	27.49	75%	$ 55.51	$ 36.87	$ 30.66	$ 24.44	$ 18.23	$ 12.01	$ (6.63)

Figure C. 24 Alfalfa Amortized Net Returns Sensitivity Analysis Using Average Prices

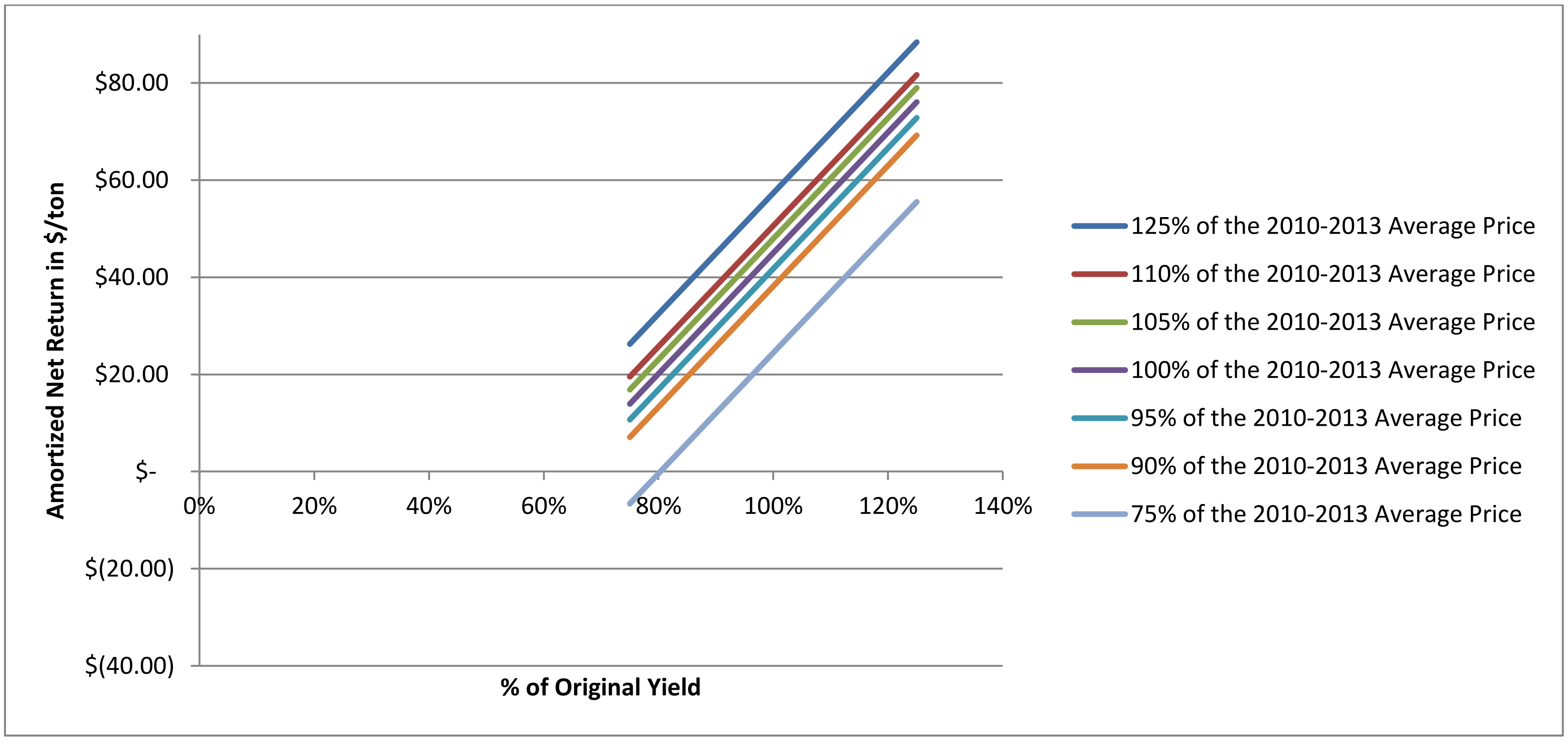


Table C. 25 Switchgrass Establishment Year Net Returns Sensitivity Analysis Using Average Prices

Switchgrass		Establishment Per Ton Net Return	Biomass Price Range						
			$ 144.04	$ 126.76	$ 120.99	$ 115.23	$ 109.47	$ 103.71	$ 86.42
	Est. Year Tons per Acre	$ (14.82)	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	4.80	125%	$ 33.54	$ 16.25	$ 10.49	$ 4.73	$ (1.03)	$ (6.79)	$ (24.08)
	2.19	110%	$ 22.88	$ 5.59	$ (0.17)	$ (5.93)	$ (11.69)	$ (17.45)	$ (34.74)
	2.09	105%	$ 18.65	$ 1.36	$ (4.40)	$ (10.16)	$ (15.92)	$ (21.69)	$ (38.97)
	1.99	100%	$ 13.99	$ (3.29)	$ (9.05)	**$ (14.82)**	$ (20.58)	$ (26.34)	$ (43.62)
	1.89	95%	$ 8.85	$ (8.44)	$ (14.20)	$ (19.96)	$ (25.72)	$ (31.48)	$ (48.77)
	1.79	90%	$ 3.13	$ (14.15)	$ (19.91)	$ (25.67)	$ (31.44)	$ (37.20)	$ (54.48)
	1.50	75%	$ (18.58)	$ (35.87)	$ (41.63)	$ (47.39)	$ (53.15)	$ (58.91)	$ (76.20)

Figure C. 25 Switchgrass Establishment Year Net Returns Sensitivity Analysis Using Average Prices

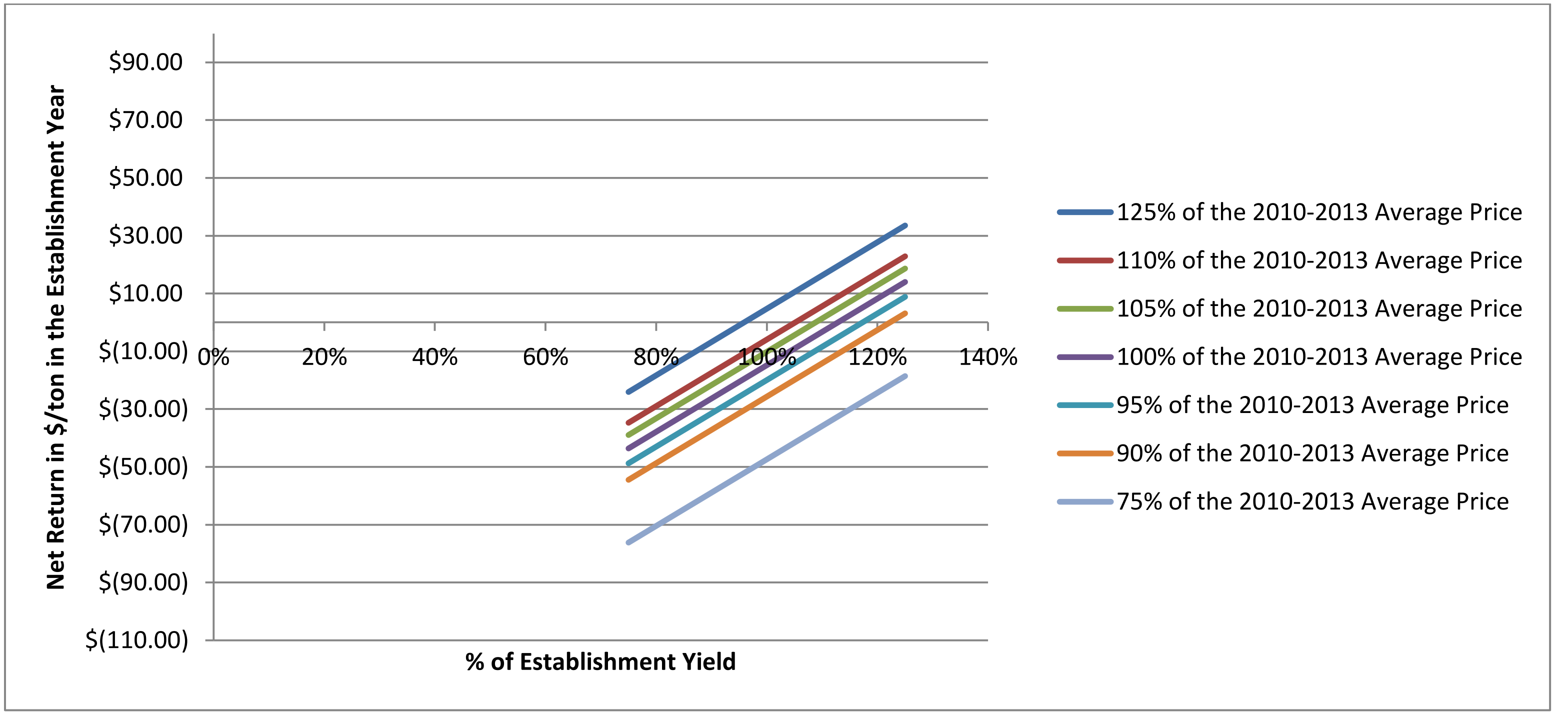


Table C. 26 Big Bluestem Establishment Year Net Returns Sensitivity Analysis Using Average Prices

Big Bluestem		Establishment Per Ton Net Return	Biomass Price Range						
			$ 137.35	$ 120.87	$ 115.37	$ 109.88	$ 104.39	$ 98.89	$ 82.41
	Est. Year Tons per Acre	$ (37.79)	125%	110%	105%	100%	95%	90%	75%
	2.54	125%	$ 12.75	$ (3.73)	$ (9.23)	$ (14.72)	$ (20.21)	$ (25.71)	$ (42.19)
	2.23	110%	$ 0.17	$ (16.31)	$ (21.81)	$ (27.30)	$ (32.80)	$ (38.29)	$ (54.77)
	2.13	105%	$ (4.83)	$ (21.31)	$ (26.80)	$ (32.30)	$ (37.79)	$ (43.28)	$ (59.77)
Biomass Yield Range	2.03	100%	$ (10.32)	$ (26.80)	$ (32.30)	**$ (37.79)**	$ (43.28)	$ (48.78)	$ (65.26)
	1.93	95%	$ (16.39)	$ (32.87)	$ (38.37)	$ (43.86)	$ (49.35)	$ (54.85)	$ (71.33)
	1.83	90%	$ (23.14)	$ (39.62)	$ (45.11)	$ (50.61)	$ (56.10)	$ (61.59)	$ (78.08)
	1.52	75%	$ (48.77)	$ (65.25)	$ (70.74)	$ (76.24)	$ (81.73)	$ (87.23)	$ (103.71)

Figure C. 26 Big Bluestem Establishment Year Net Returns Sensitivity Analysis Using Average Prices

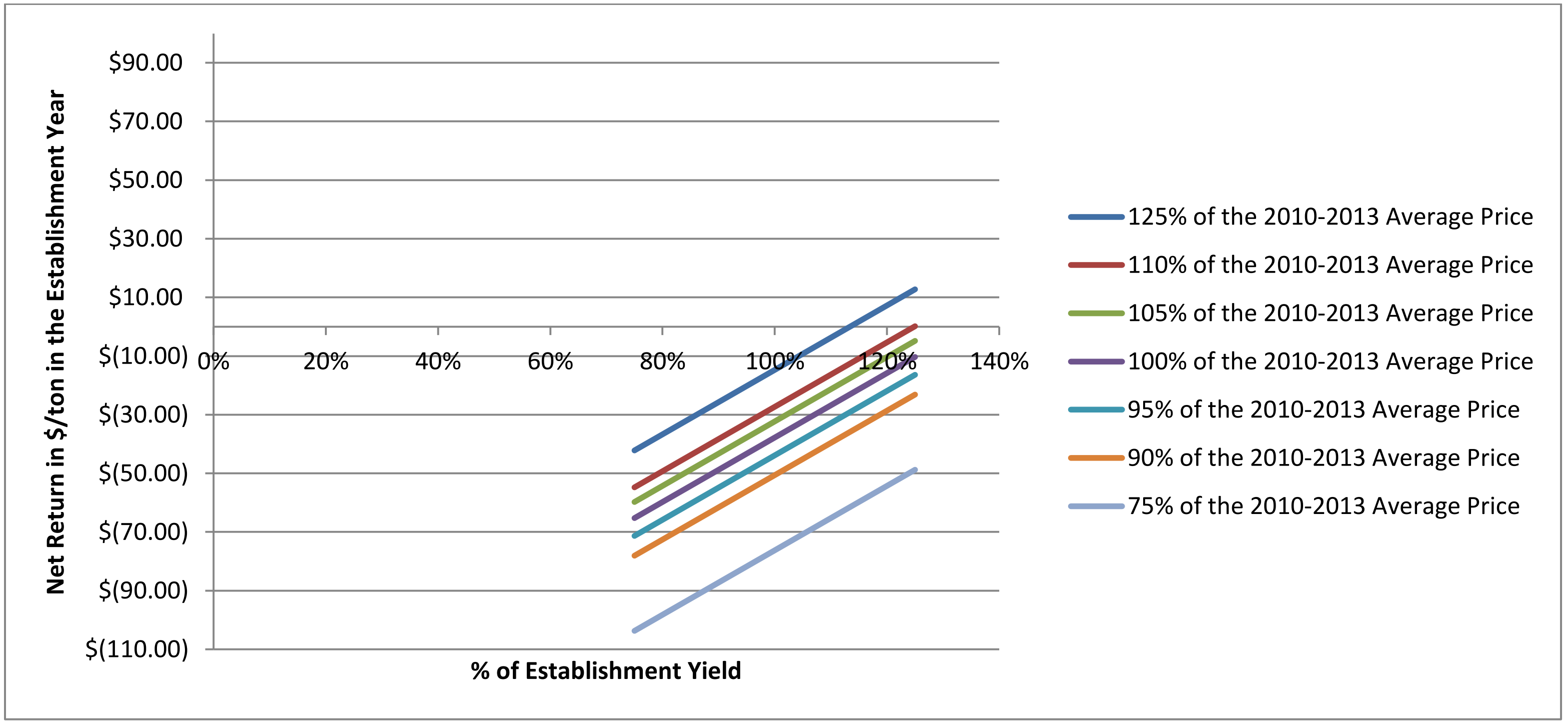
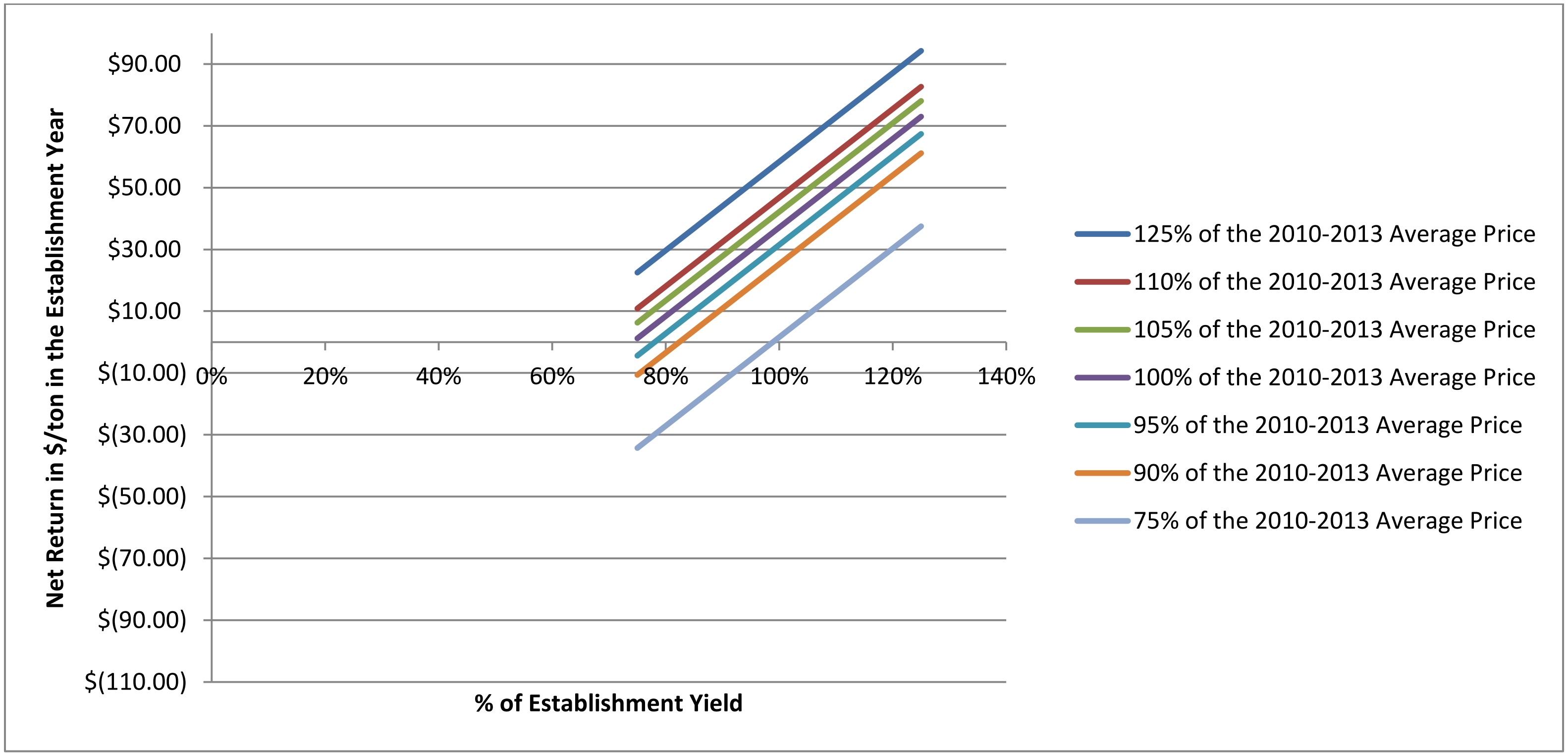


Table C. 27 Alfalfa Establishment Year Net Returns Sensitivity Analysis Using Average Prices

Alfalfa		Establishment Per Ton Net Return	Biomass Price Range						
			$ 179.46	$ 157.92	$ 150.74	$ 143.57	$ 136.39	$ 129.21	$ 107.67
	Est. Year Tons per Acre	$ 37.09	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	3.76	125%	$ 94.28	$ 72.74	$ 65.56	$ 58.39	$ 51.21	$ 44.03	$ 22.50
	3.31	110%	$ 82.66	$ 61.13	$ 53.95	$ 46.77	$ 39.59	$ 32.41	$ 10.88
	3.16	105%	$ 78.05	$ 56.52	$ 49.34	$ 42.16	$ 34.98	$ 27.81	$ 6.27
	3.01	100%	$ 72.98	$ 51.45	$ 44.27	**$ 37.09**	$ 29.91	$ 22.74	$ 1.20
	2.86	95%	$ 67.38	$ 45.84	$ 38.67	$ 31.49	$ 24.31	$ 17.13	$ (4.40)
	2.71	90%	$ 61.15	$ 39.62	$ 32.44	$ 25.26	$ 18.08	$ 10.91	$ (10.63)
	2.25	75%	$ 37.49	$ 15.96	$ 8.78	$ 1.60	$ (5.58)	$ (12.76)	$ (34.29)

Figure C. 27 Alfalfa Establishment Year Net Returns Sensitivity Analysis Using Average Prices



C.6 Perennial Sensitivity Analysis Using Fertilizer Application in the Establishment Year ($/ton) and Using 2013 Average Prices

Table C. 28 Switchgrass Amortized Net Returns Sensitivity Analysis Using Establishment Year Fertilizer Application

Switchgrass		Amortized Per Ton Net Returns	Biomass Price Range						
		Price Per Ton	$ 175.34	$ 154.30	$ 147.29	$ 140.27	$ 133.26	$ 126.25	$ 105.20
	Total Tons per Acre	$ 50.15	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	54.28	125%	$ 88.31	$ 70.42	$ 64.45	$ 58.48	$ 52.52	$ 46.55	$ 28.65
	47.76	110%	$ 83.77	$ 65.87	$ 59.90	$ 53.94	$ 47.97	$ 42.00	$ 24.10
	45.59	105%	$ 81.96	$ 64.06	$ 58.10	$ 52.13	$ 46.17	$ 40.20	$ 22.30
	43.42	100%	$ 79.98	$ 62.08	$ 56.11	**$ 50.15**	$ 44.18	$ 38.21	$ 20.32
	41.25	95%	$ 77.78	$ 59.88	$ 53.92	$ 47.95	$ 41.99	$ 36.02	$ 18.12
	39.08	90%	$ 75.35	$ 57.45	$ 51.48	$ 45.52	$ 39.55	$ 33.58	$ 15.68
	32.57	75%	$ 66.08	$ 48.18	$ 42.22	$ 36.25	$ 30.29	$ 24.32	$ 6.42

Figure C. 28 Switchgrass Amortized Net Returns Sensitivity Analysis Using Establishment Year Fertilizer Application

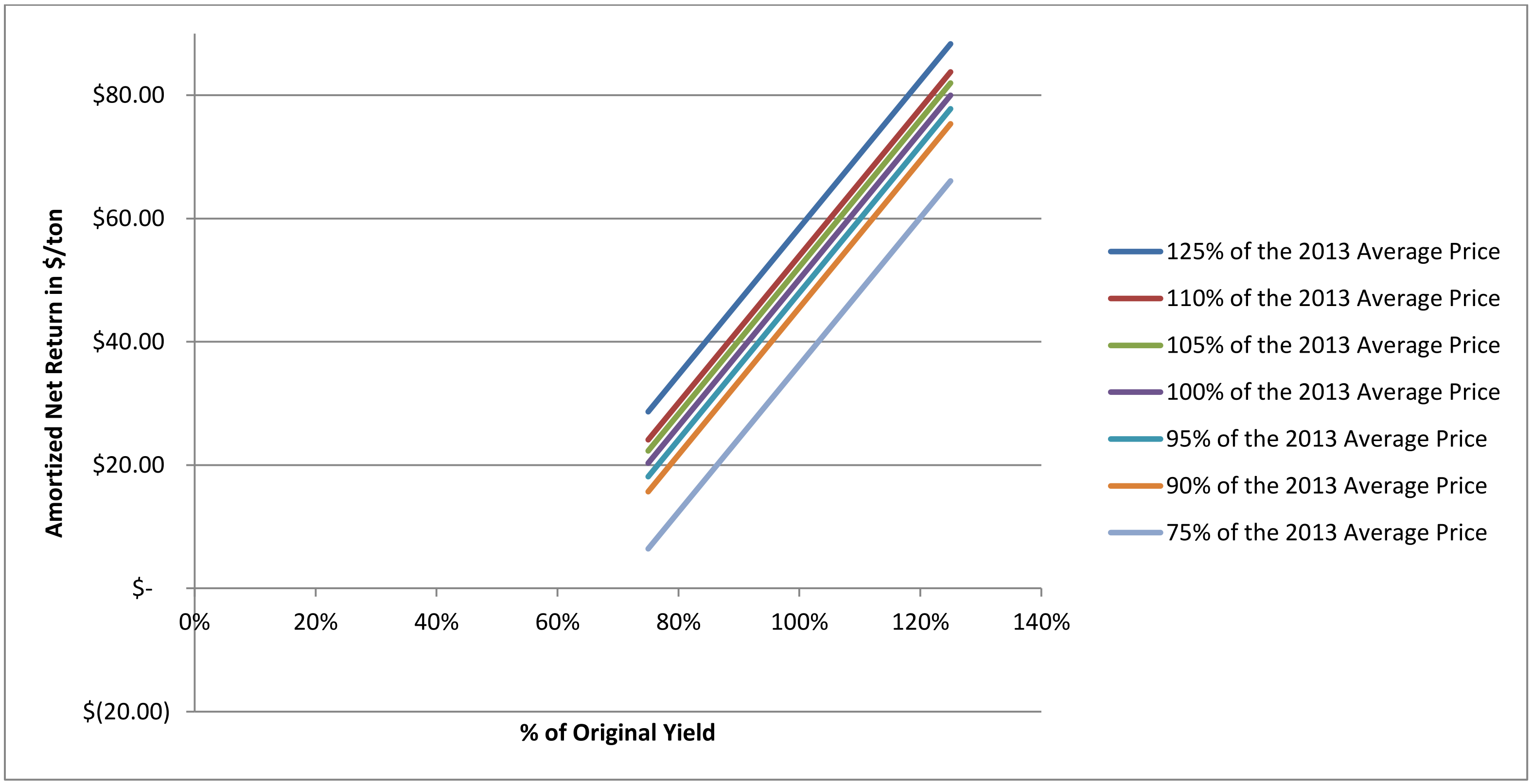


Table C. 29 Big Bluestem Amortized Net Returns Sensitivity Analysis Using Establishment Year Fertilizer Application

Big Bluestem		Amortized Per Ton Net Returns	Biomass Price Range						
		Price Per Ton	$ 175.00	$ 154.00	$ 147.00	$ 140.00	$ 133.00	$ 126.00	$ 105.00
	Total Tons per Acre	$ 30.76	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	38.49	125%	$ 73.14	$ 55.12	$ 49.11	$ 43.10	$ 37.09	$ 31.08	$ 13.05
	33.87	110%	$ 66.41	$ 48.39	$ 42.38	$ 36.37	$ 30.36	$ 24.35	$ 6.33
	32.33	105%	$ 63.74	$ 45.72	$ 39.71	$ 33.70	$ 27.69	$ 21.68	$ 3.66
	30.79	100%	$ 60.81	$ 42.78	$ 36.77	**$ 30.76**	$ 24.75	$ 18.75	$ 0.72
	29.25	95%	$ 57.56	$ 39.54	$ 33.53	$ 27.52	$ 21.51	$ 15.50	$ (2.53)
	27.71	90%	$ 53.96	$ 35.93	$ 29.92	$ 23.91	$ 17.90	$ 11.89	$ (6.13)
	23.09	75%	$ 40.25	$ 22.22	$ 16.22	$ 10.21	$ 4.20	$ (1.81)	$ (19.84)

Figure C. 29 Big Bluestem Amortized Net Returns Sensitivity Analysis Using Establishment Year Fertilizer Application

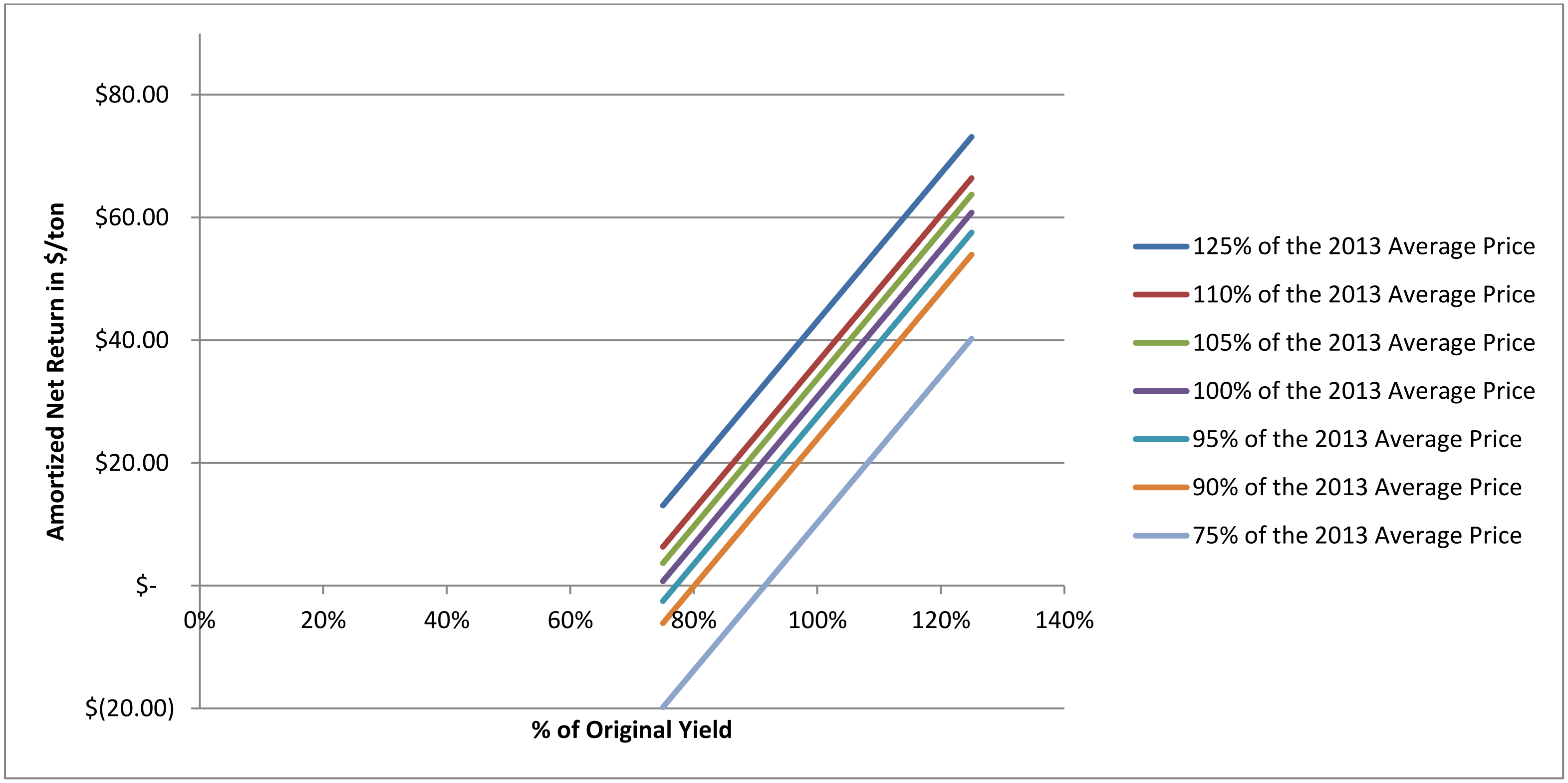


Table C. 30 Switchgrass Establishment Year Net Returns Sensitivity Analysis Using Establishment Year Fertilizer Application

Switchgrass		Est. Year Per Ton Sensitivity	Biomass Price Range						
		Price Per Ton	$ 175.34	$ 154.30	$ 147.29	$ 140.27	$ 133.26	$ 126.25	$ 105.20
	Est. Year Tons per Acre	$ (108.49)	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	2.49	125%	$ (30.13)	$ (51.17)	$ (58.19)	$ (65.20)	$ (72.21)	$ (79.23)	$ (100.27)
	2.19	110%	$ (53.74)	$ (74.78)	$ (81.80)	$ (88.81)	$ (95.82)	$(102.84)	$ (123.88)
	2.09	105%	$ (63.11)	$ (84.15)	$ (91.17)	$ (98.18)	$(105.19)	$(112.21)	$ (133.25)
	1.99	100%	$ (73.42)	$ (94.46)	$(101.47)	**$ (108.49)**	$(115.50)	$(122.51)	$ (143.56)
	1.89	95%	$ (84.81)	$(105.85)	$(112.87)	$ (119.88)	$(126.89)	$(133.91)	$ (154.95)
	1.79	90%	$ (97.47)	$(118.51)	$(125.52)	$ (132.54)	$(139.55)	$(146.56)	$ (167.60)
	1.50	75%	$(145.57)	$(166.61)	$(173.62)	$ (180.63)	$(187.65)	$(194.66)	$ (215.70)

Figure C. 30 Switchgrass Establishment Year Net Returns Sensitivity Analysis Using Establishment Year Fertilizer Application

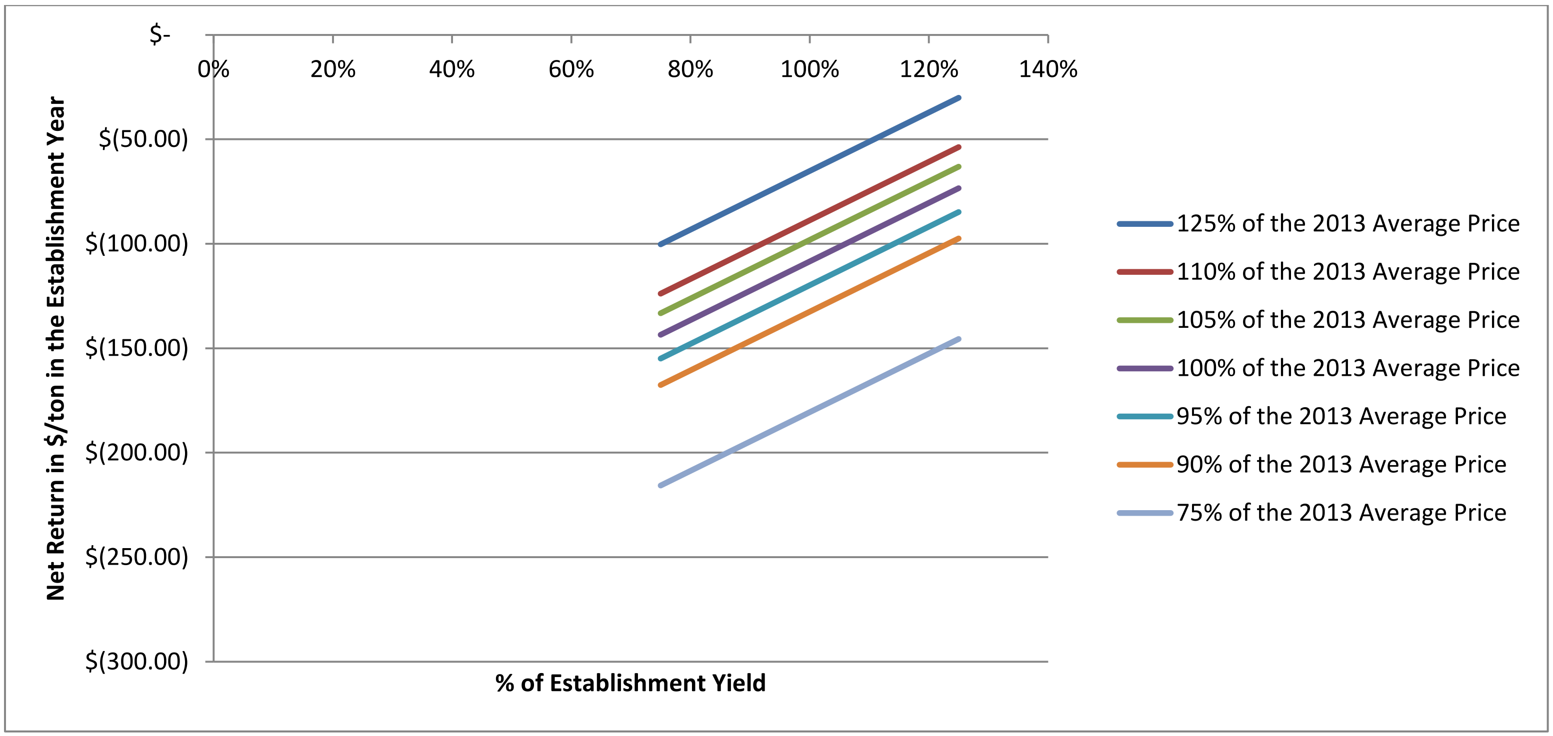
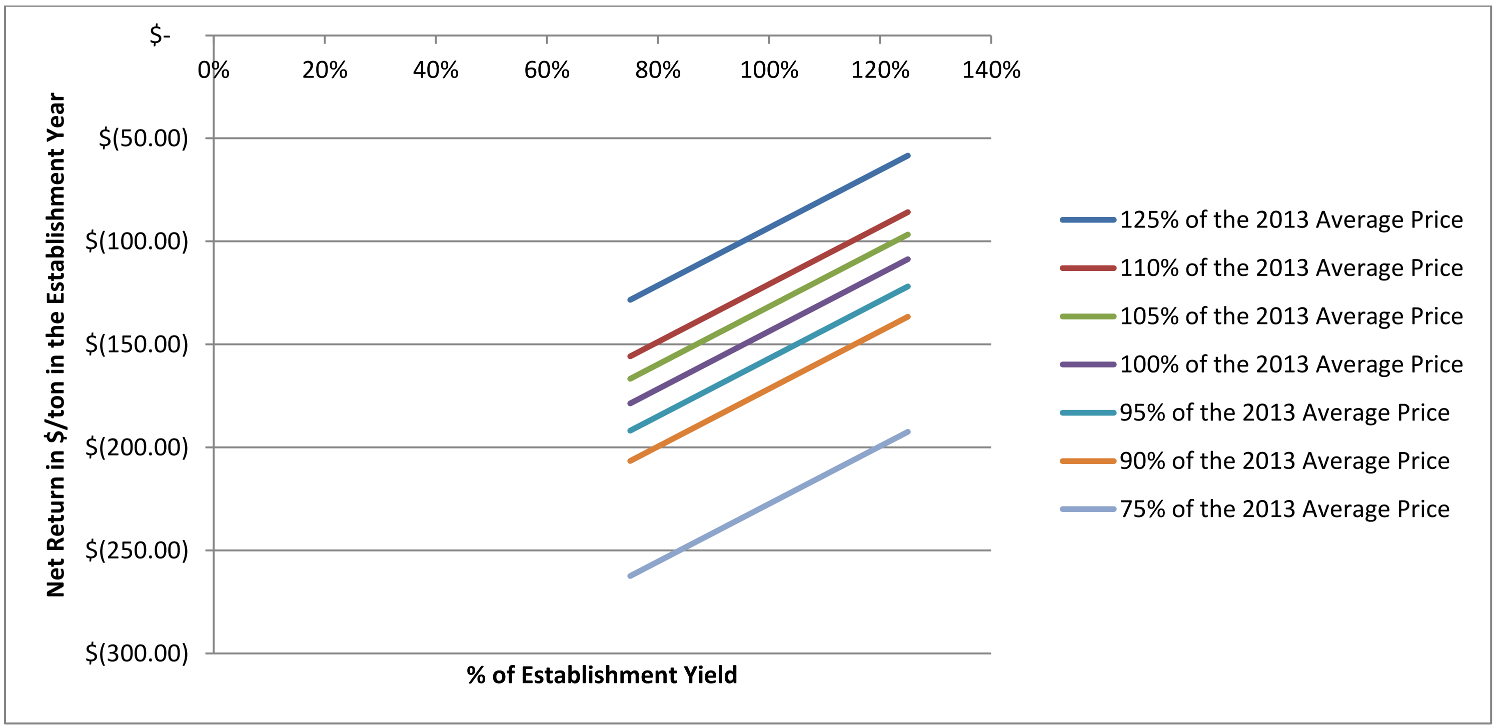


Table C. 31 Big Bluestem Establishment Year Net Returns Sensitivity Analysis Using Establishment Year Fertilizer Application

Big Bluestem		Est. Year Per Ton Sensitivity	Biomass Price Range						
		Price Per Ton	$ 175.00	$ 154.00	$ 147.00	$ 140.00	$ 133.00	$ 126.00	$ 105.00
	Est. Year Tons per Acre	$ (143.64)	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	2.54	125%	$ (58.37)	$ (79.37)	$ (86.37)	$ (93.37)	$(100.37)	$(107.37)	$(128.37)
	2.23	110%	$ (85.79)	$(106.79)	$(113.79)	$ (120.79)	$(127.79)	$(134.79)	$(155.79)
	2.13	105%	$ (96.67)	$(117.67)	$(124.67)	$ (131.67)	$(138.67)	$(145.67)	$(166.67)
	2.03	100%	$(108.64)	$(129.64)	$(136.64)	**$ (143.64)**	$(150.64)	$(157.64)	$(178.64)
	1.93	95%	$(121.86)	$(142.86)	$(149.86)	$ (156.86)	$(163.86)	$(170.86)	$(191.86)
	1.83	90%	$(136.56)	$(157.56)	$(164.56)	$ (171.56)	$(178.56)	$(185.56)	$(206.56)
	1.52	75%	$(192.41)	$(213.41)	$(220.41)	$ (227.41)	$(234.41)	$(241.41)	$(262.41)

Figure C. 3132 Big Bluestem Establishment Year Net Returns Sensitivity Analysis Using Establishment Year Fertilizer Application



C.7 Perennial Crops versus Annual Rotations Using Average 2013 Prices

Table C. 33 Switchgrass Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

Switchgrass		Amortized Per Acre Net Returns	Biomass Price Range						
		Price Per Ton	$ 175.34	$ 154.30	$ 147.29	$ 140.27	$ 133.26	$ 126.25	$ 105.20
	Total Tons per Acre	$ 204.53	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	54.28	125%	$ 517.47	$ 401.25	$ 362.52	$ 323.78	$ 285.04	$ 246.30	$ 130.09
	47.76	110%	$ 422.68	$ 320.41	$ 286.32	$ 252.23	$ 218.14	$ 184.05	$ 81.78
	45.59	105%	$ 391.08	$ 293.46	$ 260.92	$ 228.38	$ 195.84	$ 163.30	$ 65.68
	43.42	100%	$ 359.48	$ 266.51	$ 235.52	**$ 204.53**	$ 173.54	$ 142.55	$ 49.58
	41.25	95%	$ 327.89	$ 239.56	$ 210.12	$ 180.68	$ 151.24	$ 121.80	$ 33.48
	39.08	90%	$ 296.29	$ 212.62	$ 184.72	$ 156.83	$ 128.94	$ 101.05	$ 17.38
	32.57	75%	$ 201.50	$ 131.77	$ 108.53	$ 85.28	$ 62.04	$ 38.80	$ (30.93)

Figure C. 32 Switchgrass Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

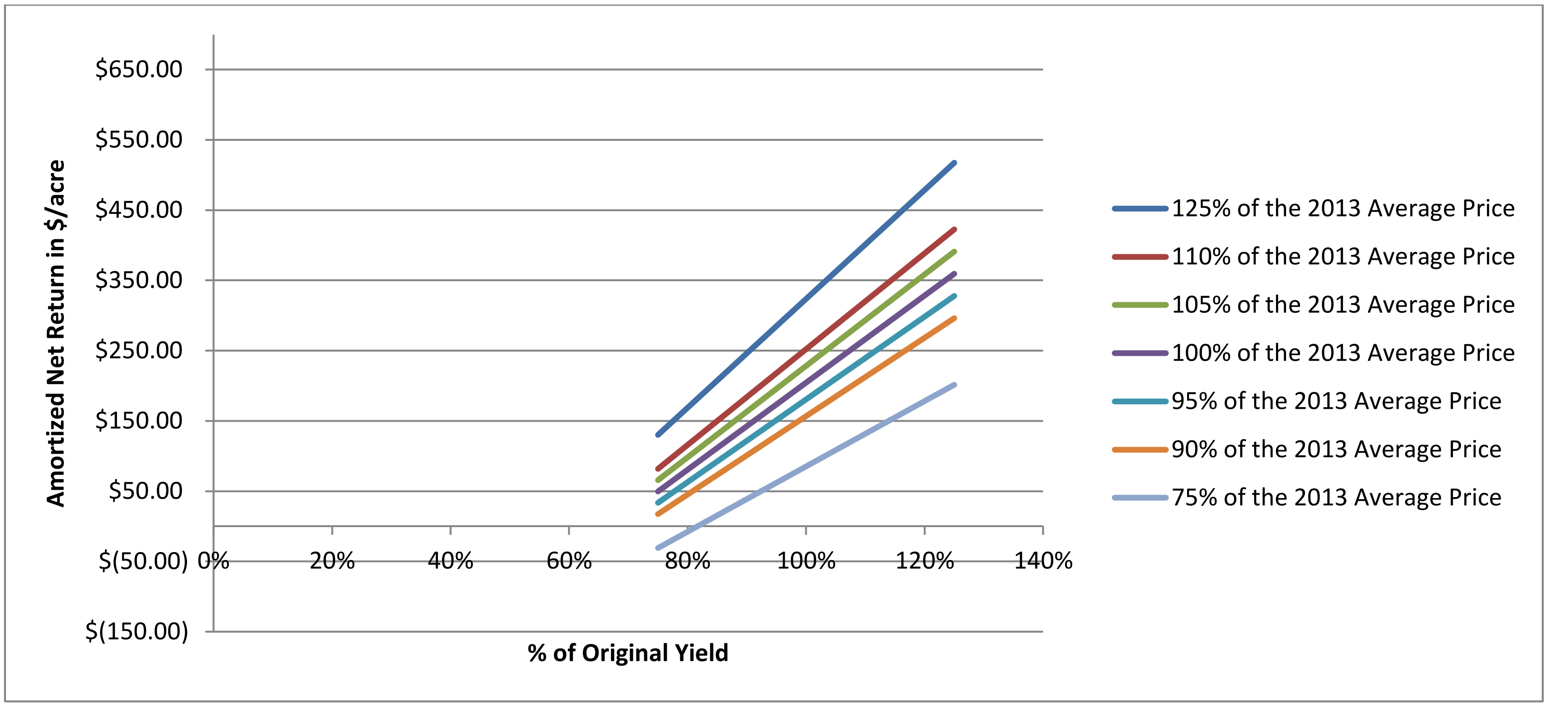


Table C. 34 Big Bluestem Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

Big Bluestem	Amortized Per Acre Net Returns		Biomass Price Range						
			$ 175.00	$ 154.00	$ 147.00	$ 140.00	$ 133.00	$ 126.00	$ 105.00
	Total Tons per Acr	$ 62.68	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	38.49	125%	$ 286.13	$ 203.13	$ 175.47	$ 147.80	$ 120.13	$ 92.47	$ 9.47
	33.87	110%	$ 218.46	$ 145.42	$ 121.08	$ 96.73	$ 72.38	$ 48.04	$ (25.00)
	32.33	105%	$ 195.91	$ 126.19	$ 102.95	$ 79.71	$ 56.47	$ 33.23	$ (36.49)
	30.79	100%	$ 173.35	$ 106.95	$ 84.82	**$ 62.68**	$ 40.55	$ 18.42	$ (47.98)
	29.25	95%	$ 150.79	$ 87.71	$ 66.69	$ 45.66	$ 24.63	$ 3.61	$ (59.47)
	27.71	90%	$ 128.24	$ 68.48	$ 48.56	$ 28.64	$ 8.72	$ (11.20)	$ (70.96)
	23.09	75%	$ 60.57	$ 10.77	$ (5.83)	$ (22.43)	$ (39.03)	$ (55.63)	$ (105.43)

Figure C. 33 Big Bluestem Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

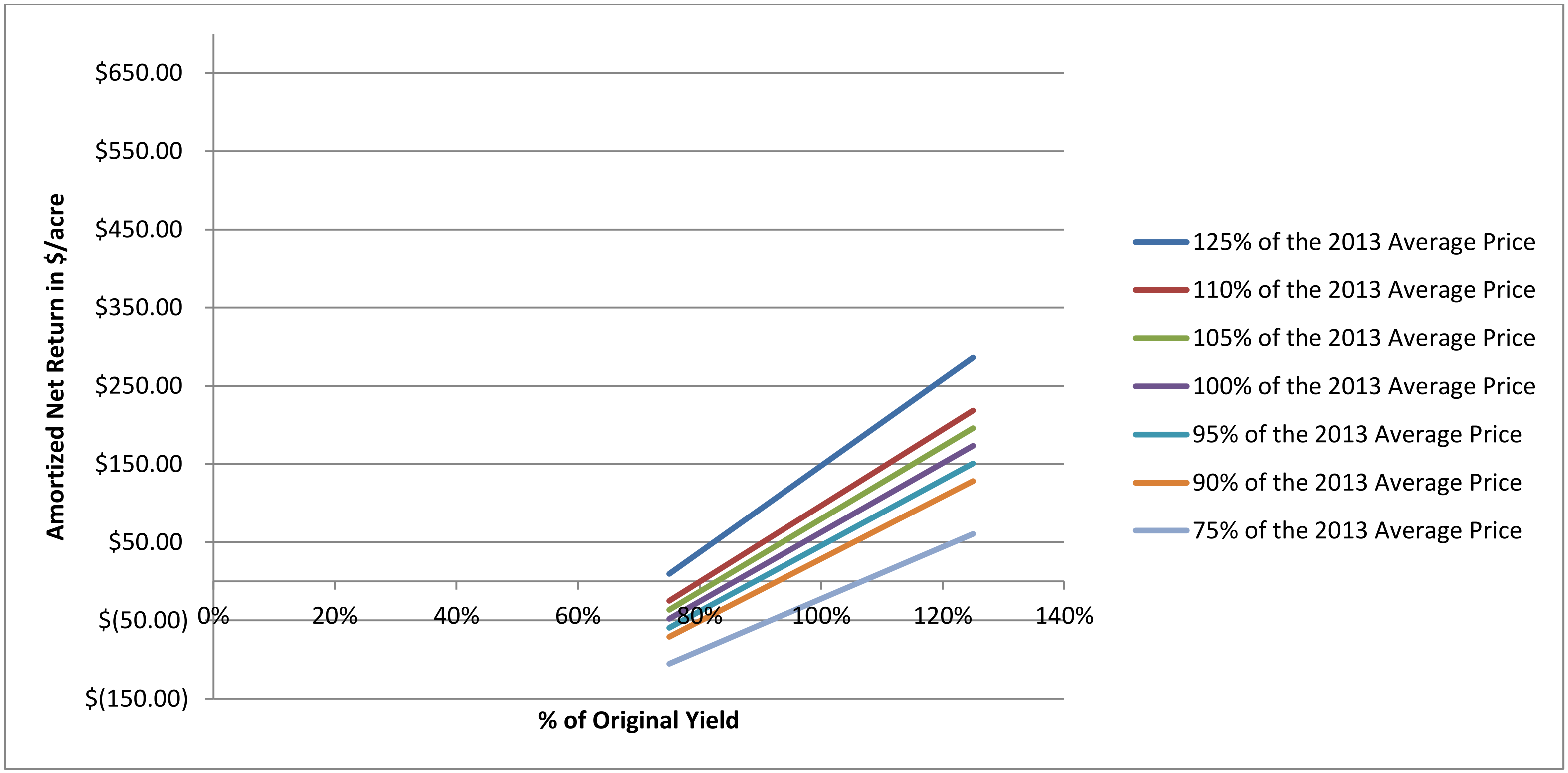


Table C. 35 Alfalfa Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

Alfalfa		Amortized Per Acre Net Returns	Biomass Price Range						
			$ 225.34	$ 198.30	$ 189.29	$ 180.27	$ 171.26	$ 162.25	$ 135.20
	Total Tons per Acre	$ 271.23	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	45.82	125%	$ 636.76	$ 508.46	$ 465.70	$ 422.93	$ 380.17	$ 337.41	$ 209.11
	40.32	110%	$ 520.07	$ 407.18	$ 369.54	$ 331.91	$ 294.28	$ 256.64	$ 143.75
	38.49	105%	$ 481.18	$ 373.41	$ 337.49	$ 301.57	$ 265.65	$ 229.72	$ 121.96
	36.65	100%	$ 442.28	$ 339.65	$ 305.44	**$ 271.23**	$ 237.02	$ 202.80	$ 100.17
	34.82	95%	$ 403.39	$ 305.89	$ 273.39	$ 240.89	$ 208.38	$ 175.88	$ 78.38
	32.99	90%	$ 364.50	$ 272.13	$ 241.33	$ 210.54	$ 179.75	$ 148.96	$ 56.59
	27.49	75%	$ 247.81	$ 170.84	$ 145.18	$ 119.52	$ 93.86	$ 68.20	$ (8.77)

Figure C. 34 Alfalfa Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

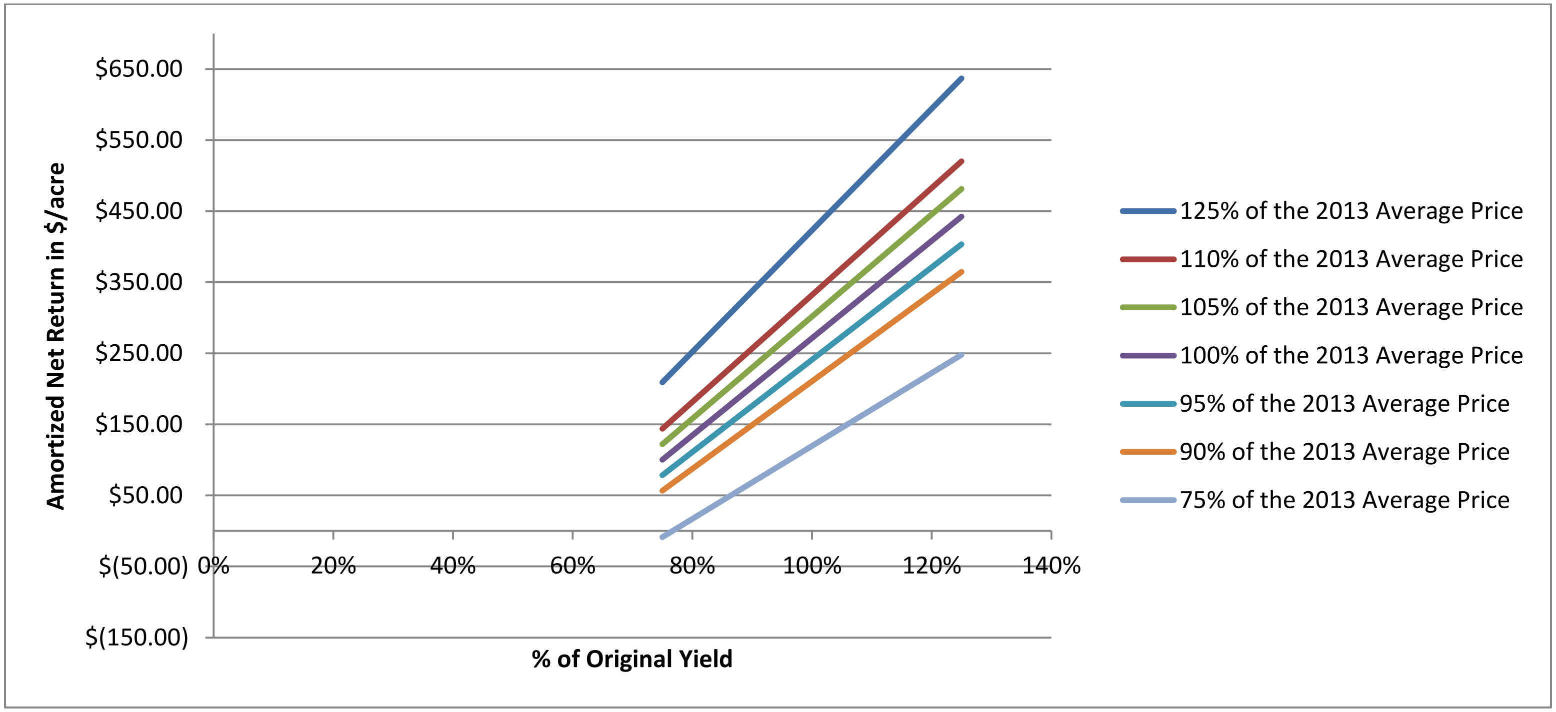


Table C. 36 Switchgrass Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

Switchgrass		Establishment Year Per Acre	Biomass Price Range						
		Price Per Ton	$ 175.34	$ 154.30	$ 147.29	$ 140.27	$ 133.26	$ 126.25	$ 105.20
	Est. Year Tons per Acre	$ (42.81)	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	2.49	125%	$ 98.43	$ 45.98	$ 28.49	$ 11.01	$ (6.47)	$ (23.96)	$ (76.41)
	2.19	110%	$ 55.65	$ 9.49	$ (5.90)	$ (21.28)	$ (36.67)	$ (52.05)	$ (98.21)
	2.09	105%	$ 41.38	$ (2.67)	$ (17.36)	$ (32.05)	$ (46.73)	$ (61.42)	$ (105.48)
	1.99	100%	$ 27.12	$ (14.84)	$ (28.82)	**$ (42.81)**	$ (56.80)	$ (70.79)	$ (112.75)
	1.89	95%	$ 12.86	$ (27.00)	$ (40.29)	$ (53.58)	$ (66.86)	$ (80.15)	$ (120.01)
	1.79	90%	$ (1.40)	$ (39.16)	$ (51.75)	$ (64.34)	$ (76.93)	$ (89.52)	$ (127.28)
	1.50	75%	$ (44.18)	$ (75.65)	$ (86.14)	$ (96.63)	$ (107.12)	$ (117.61)	$ (149.08)

Figure C. 35 Switchgrass Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

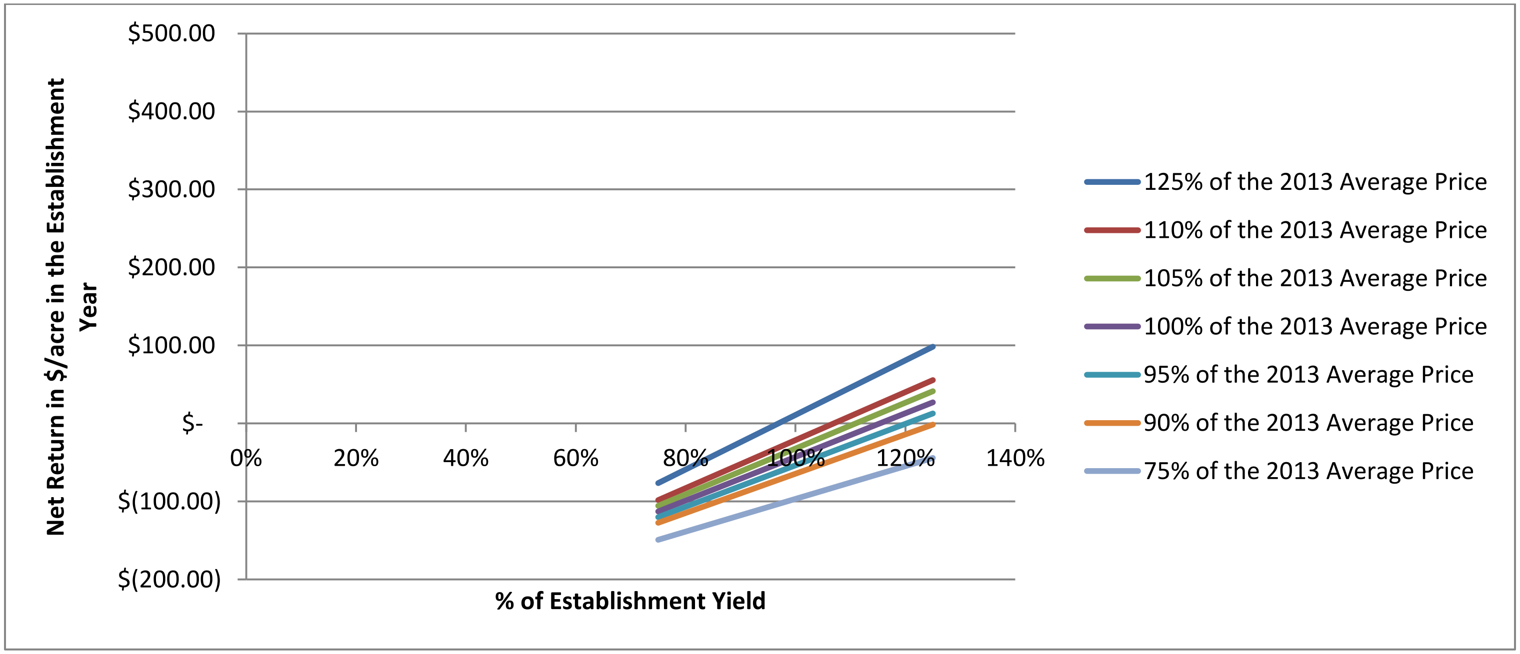


Table C. 37 Big Bluestem Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

Big Bluestem		Establishment Year Per Acre	Biomass Price Range						
		Price Per Ton	$ 175.00	$ 154.00	$ 147.00	$ 140.00	$ 133.00	$ 126.00	$ 105.00
	Est. Year Tons per Acre	$ (78.76)	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	2.54	125%	$ 64.65	$ 11.38	$ (6.38)	$ (24.13)	$ (41.89)	$ (59.65)	$ (112.92)
	2.23	110%	$ 21.22	$ (25.66)	$ (41.29)	$ (56.91)	$ (72.54)	$ (88.16)	$ (135.04)
	2.13	105%	$ 6.74	$ (38.01)	$ (52.92)	$ (67.84)	$ (82.75)	$ (97.67)	$ (142.42)
	2.03	100%	$ (7.74)	$ (50.35)	$ (64.56)	**$ (78.76)**	$ (92.97)	$ (107.17)	$ (149.79)
	1.93	95%	$ (22.21)	$ (62.70)	$ (76.19)	$ (89.69)	$ (103.18)	$ (116.68)	$ (157.16)
	1.83	90%	$ (36.69)	$ (75.04)	$ (87.83)	$ (100.61)	$ (113.40)	$ (126.18)	$ (164.54)
	1.52	75%	$ (80.12)	$ (112.08)	$ (122.74)	$ (133.39)	$ (144.05)	$ (154.70)	$ (186.66)

Figure C. 36 Big Bluestem Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

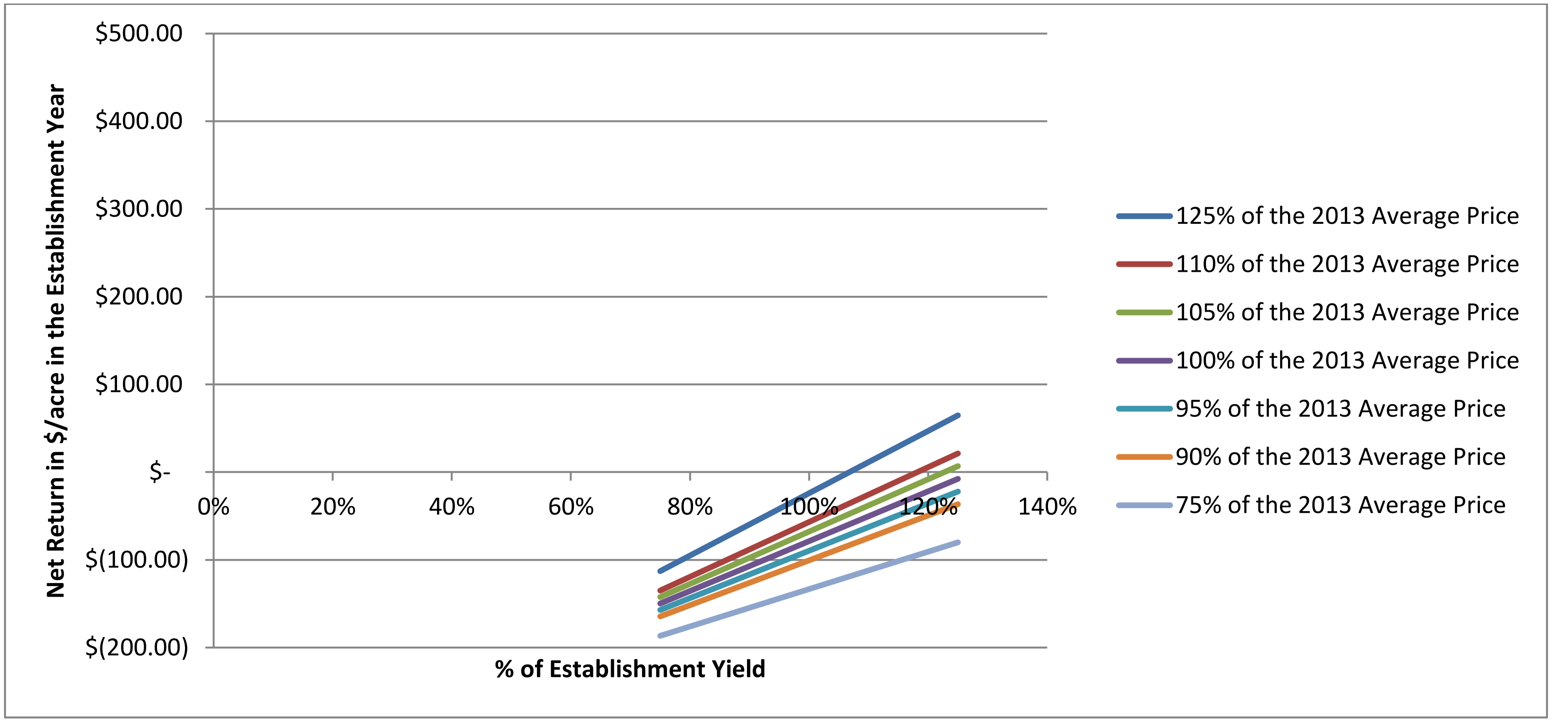
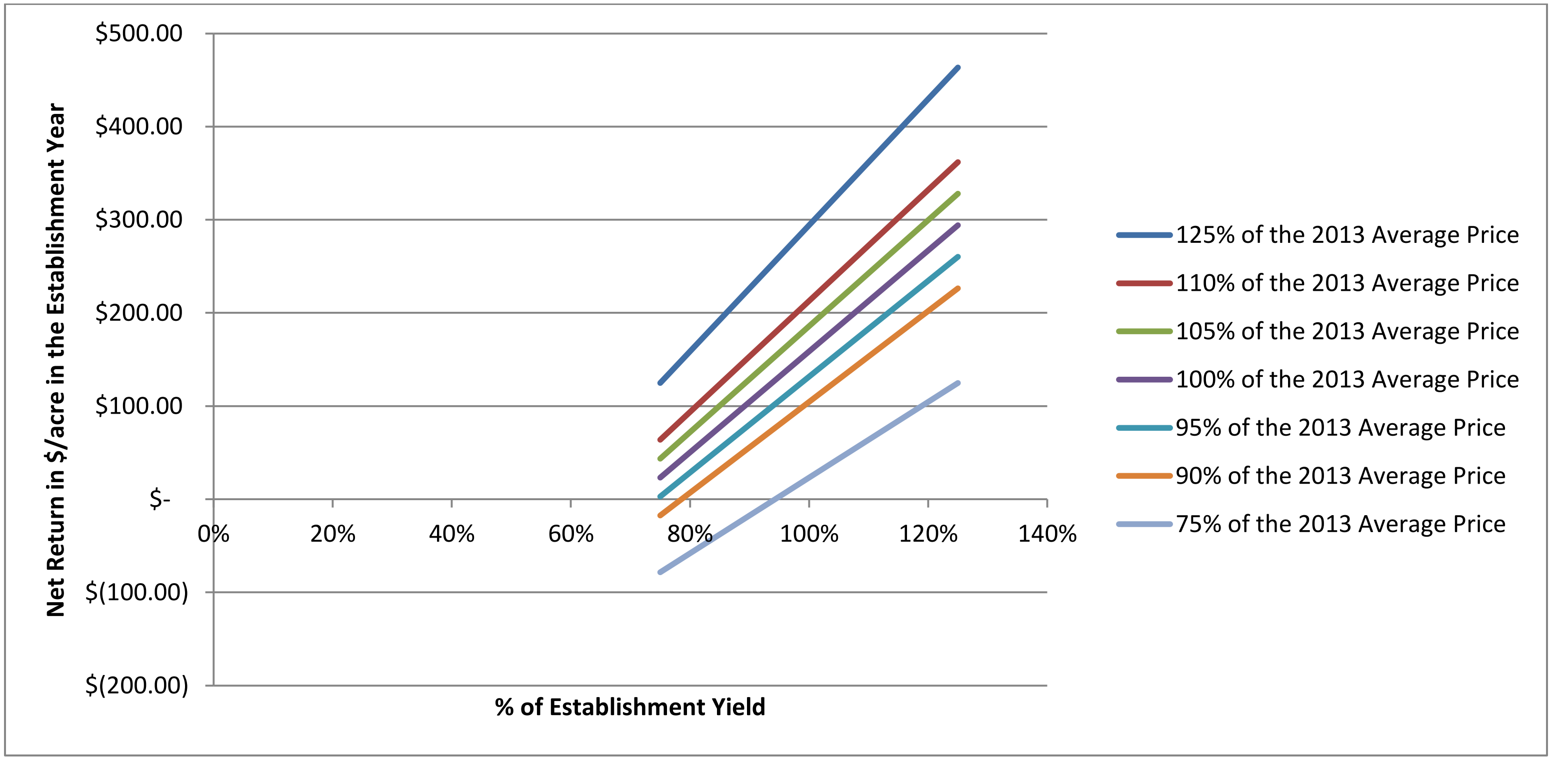


Table C. 38 Alfalfa Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

Alfalfa		Establishment Year Per Acre	Biomass Price Range						
		Price Per Ton	$ 225.34	$ 198.30	$ 189.29	$ 180.27	$ 171.26	$ 162.25	$ 135.20
	Est. Year Tons per Acre	$ 158.64	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	3.76	125%	$ 463.46	$ 361.85	$ 327.98	$ 294.12	$ 260.25	$ 226.38	$ 124.77
	3.31	110%	$ 361.85	$ 272.44	$ 242.64	$ 212.83	$ 183.03	$ 153.22	$ 63.81
	3.16	105%	$ 327.98	$ 242.64	$ 214.19	$ 185.74	$ 157.29	$ 128.84	$ 43.49
	3.01	100%	$ 294.12	$ 212.83	$ 185.74	**$ 158.64**	$ 131.55	$ 104.45	$ 23.17
	2.86	95%	$ 260.25	$ 183.03	$ 157.29	$ 131.55	$ 105.81	$ 80.07	$ 2.84
	2.71	90%	$ 226.38	$ 153.22	$ 128.84	$ 104.45	$ 80.07	$ 55.68	$ (17.48)
	2.25	75%	$ 124.77	$ 63.81	$ 43.49	$ 23.17	$ 2.84	$ (17.48)	$ (78.44)

Figure C. 37 Alfalfa Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)



C.8 Perennial Crops versus Annual Rotations Using Average 2010 to 2013 Prices

Table C. 39 Switchgrass Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

Switchgrass		Amortized Per Acre	Biomass Price Range						
			$ 144.04	$ 126.76	$ 120.99	$ 115.23	$ 109.47	$ 103.71	$ 86.42
		$ 93.89	125%	110%	105%	100%	95%	90%	75%
	54.28	125%	$ 344.59	$ 249.13	$ 217.30	$ 185.48	$ 153.66	$ 121.83	$ 26.37
	47.76	110%	$ 270.55	$ 186.54	$ 158.53	$ 130.53	$ 102.52	$ 74.52	$ (9.49)
	45.59	105%	$ 245.87	$ 165.67	$ 138.94	$ 112.21	$ 85.48	$ 58.75	$ (21.45)
Biomass Yield Range	43.42	100%	$ 221.18	$ 144.81	$ 119.35	**$ 93.89**	$ 68.43	$ 42.98	$ (33.40)
	41.25	95%	$ 196.50	$ 123.95	$ 99.76	$ 75.58	$ 51.39	$ 27.20	$ (45.35)
	39.08	90%	$ 171.82	$ 103.08	$ 80.17	$ 57.26	$ 34.35	$ 11.43	$ (57.30)
	32.57	75%	$ 97.77	$ 40.49	$ 21.40	$ 2.31	$ (16.79)	$ (35.88)	$ (93.16)

Figure C. 38 Switchgrass Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

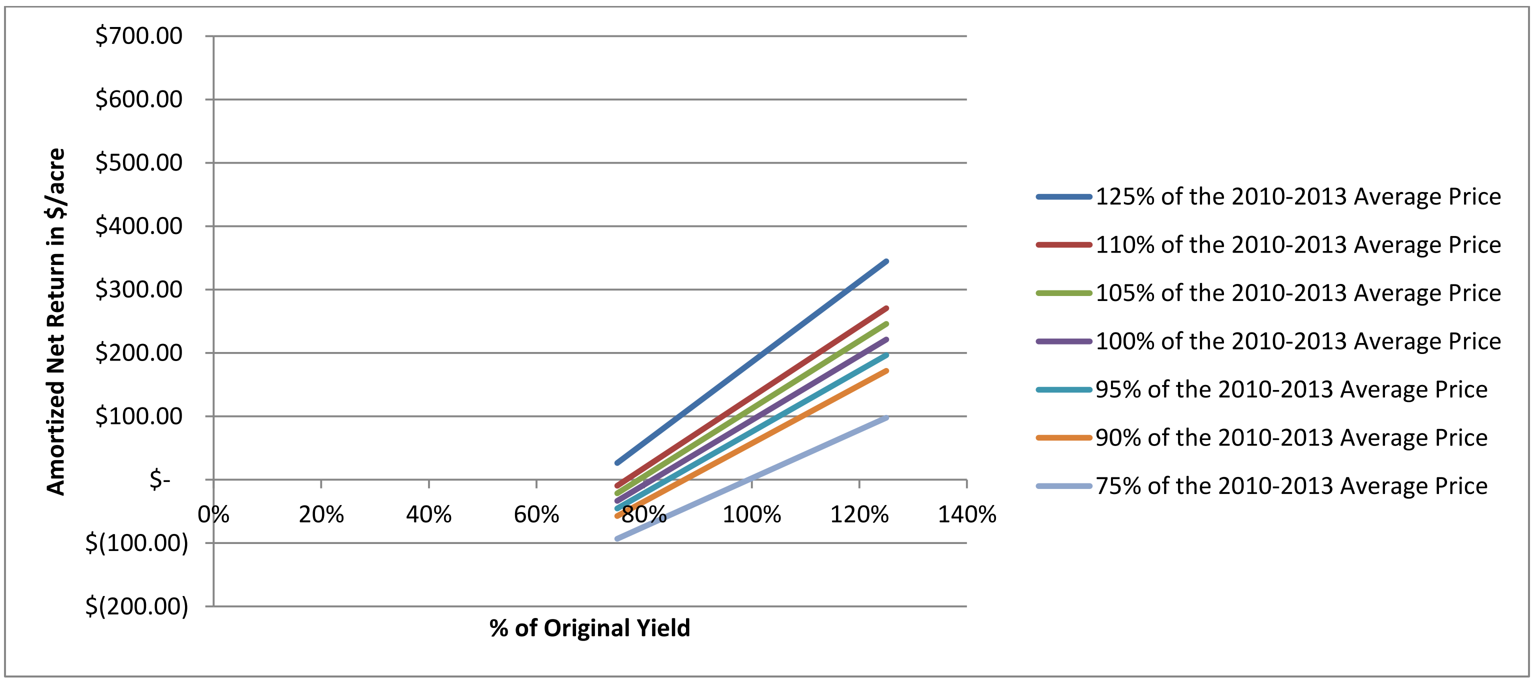


Table C. 40 Big Bluestem Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

Big Bluestem		Amortized Per Acre	Biomass Price Range						
			$ 137.35	$ 120.87	$ 115.37	$ 109.88	$ 104.39	$ 98.89	$ 82.41
		$ (32.55)	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	38.49	125%	$ 137.33	$ 72.18	$ 50.47	$ 28.75	$ 7.04	$ (14.67)	$ (79.82)
	33.87	110%	$ 87.51	$ 30.19	$ 11.08	$ (8.03)	$ (27.14)	$ (46.25)	$ (103.57)
	32.33	105%	$ 70.91	$ 16.19	$ (2.05)	$ (20.29)	$ (38.53)	$ (56.77)	$ (111.49)
	30.79	100%	$ 54.30	$ 2.19	$ (15.18)	**$ (32.55)**	$ (49.92)	$ (67.30)	$ (119.41)
	29.25	95%	$ 37.70	$ (11.81)	$ (28.31)	$ (44.81)	$ (61.32)	$ (77.82)	$ (127.33)
	27.71	90%	$ 21.10	$ (25.81)	$ (41.44)	$ (57.08)	$ (72.71)	$ (88.34)	$ (135.25)
	23.09	75%	$ (28.72)	$ (67.80)	$ (80.83)	$ (93.86)	$ (106.89)	$ (119.92)	$ (159.00)

Figure C. 39 Big Bluestem Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

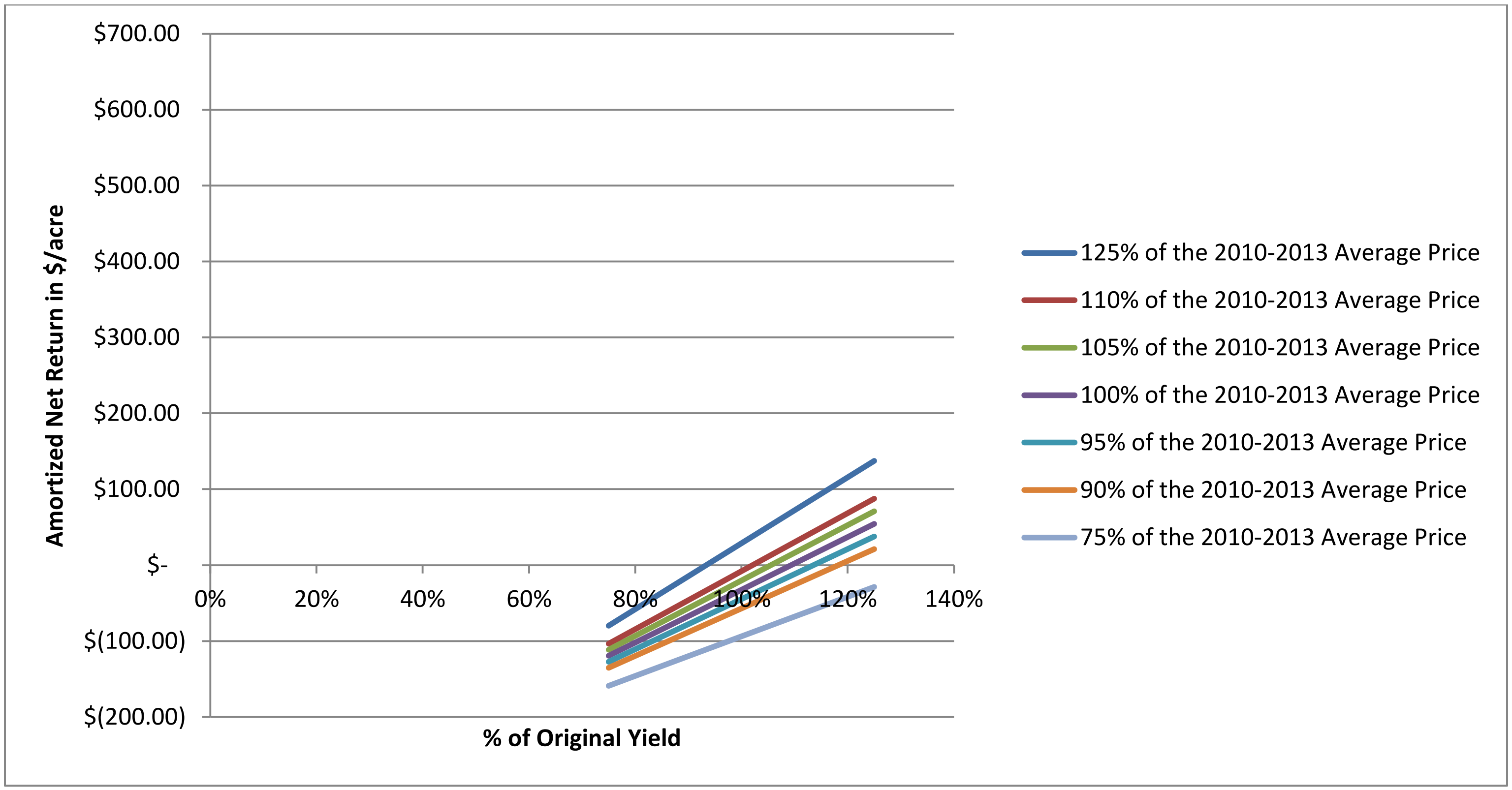


Table C. 41 Alfalfa Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

Alfalfa		Amortized Per Acre	Biomass Price Range						
			$ 179.46	$ 157.92	$ 150.74	$ 143.57	$ 136.39	$ 129.21	$ 107.67
		$ 258.03	125%	110%	105%	100%	95%	90%	75%
	45.82	125%	$ 616.13	$ 490.31	$ 448.37	$ 406.43	$ 364.50	$ 322.56	$ 196.74
	40.32	110%	$ 501.92	$ 391.20	$ 354.30	$ 317.39	$ 280.48	$ 243.58	$ 132.86
	38.49	105%	$ 463.85	$ 358.17	$ 322.94	$ 287.71	$ 252.48	$ 217.25	$ 111.56
Biomass Yield Range	36.65	100%	$ 425.78	$ 325.13	$ 291.58	**$ 258.03**	$ 224.48	$ 190.92	$ 90.27
	34.82	95%	$ 387.72	$ 292.09	$ 260.22	$ 228.35	$ 196.47	$ 164.60	$ 68.98
	32.99	90%	$ 349.65	$ 259.06	$ 228.86	$ 198.66	$ 168.47	$ 138.27	$ 47.68
	27.49	75%	$ 235.44	$ 159.95	$ 134.78	$ 109.62	$ 84.46	$ 59.29	$ (16.20)

Figure C. 40 Alfalfa Perennial Land Rental Rate Sensitivity Analysis (Amortized $/acre)

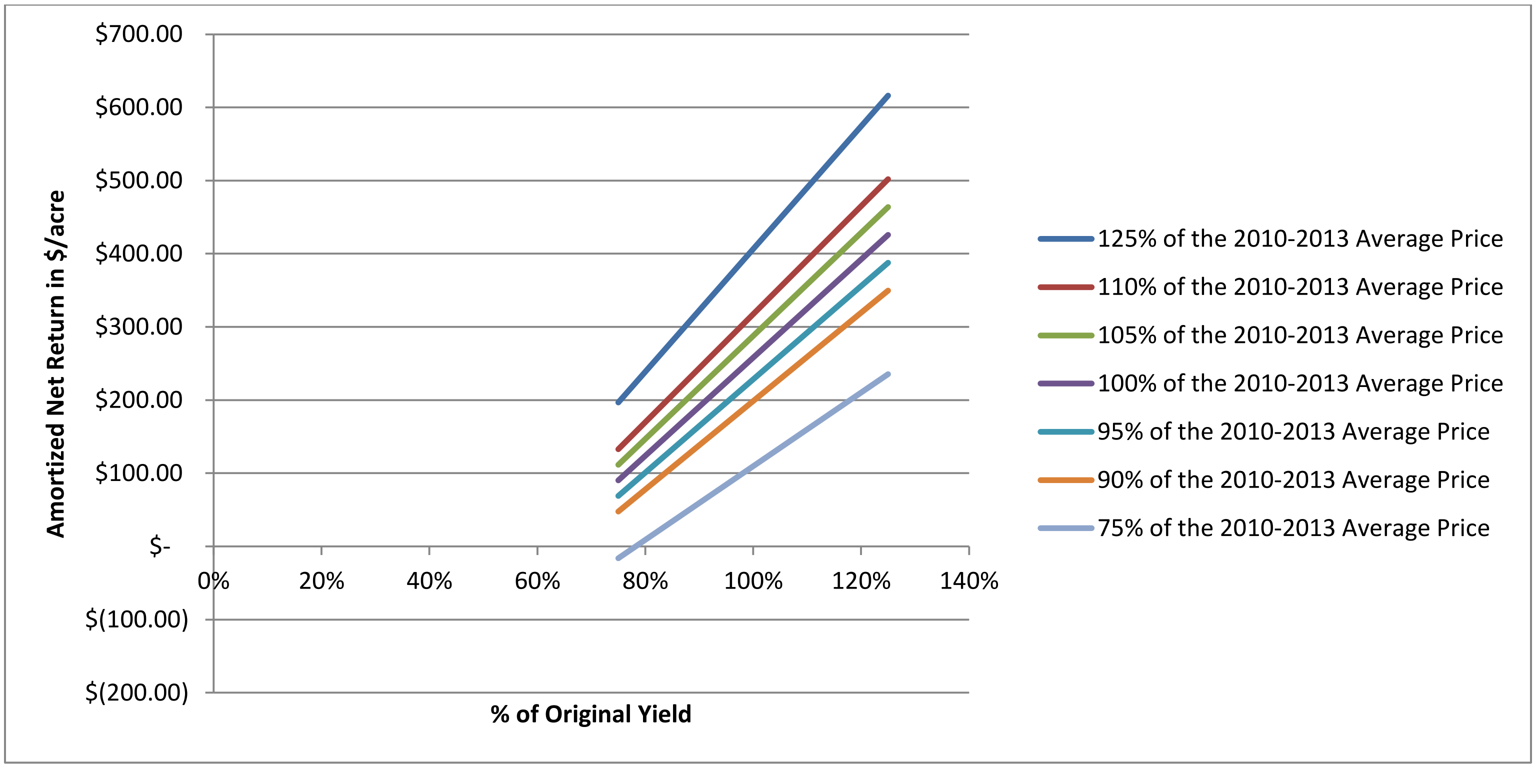


Table C. 42 Switchgrass Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

Switchgrass	Establishment Year Per Acre		Biomass Price Range						
		Price per Ton	$ 144.04	$ 126.76	$ 120.99	$ 115.23	$ 109.47	$ 103.71	$ 86.42
	Establishment Ton/	$ (92.75)	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	2.49	125%	$ 20.40	$ (22.68)	$ (37.05)	$ (51.41)	$ (65.77)	$ (80.14)	$ (123.22)
	2.19	110%	$ (13.02)	$ (50.93)	$ (63.57)	$ (76.21)	$ (88.85)	$ (101.49)	$ (139.41)
	2.09	105%	$ (24.16)	$ (60.35)	$ (72.41)	$ (84.48)	$ (96.54)	$ (108.61)	$ (144.80)
	1.99	100%	$ (35.30)	$ (69.77)	$ (81.26)	**$ (92.75)**	$ (104.24)	$ (115.73)	$ (150.20)
	1.89	95%	$ (46.44)	$ (79.18)	$ (90.10)	$ (101.01)	$ (111.93)	$ (122.85)	$ (155.59)
	1.79	90%	$ (57.58)	$ (88.60)	$ (98.94)	$ (109.28)	$ (119.62)	$ (129.96)	$ (160.99)
	1.50	75%	$ (90.99)	$ (116.85)	$ (125.47)	$ (134.08)	$ (142.70)	$ (151.32)	$ (177.17)

Figure C. 41 Switchgrass Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

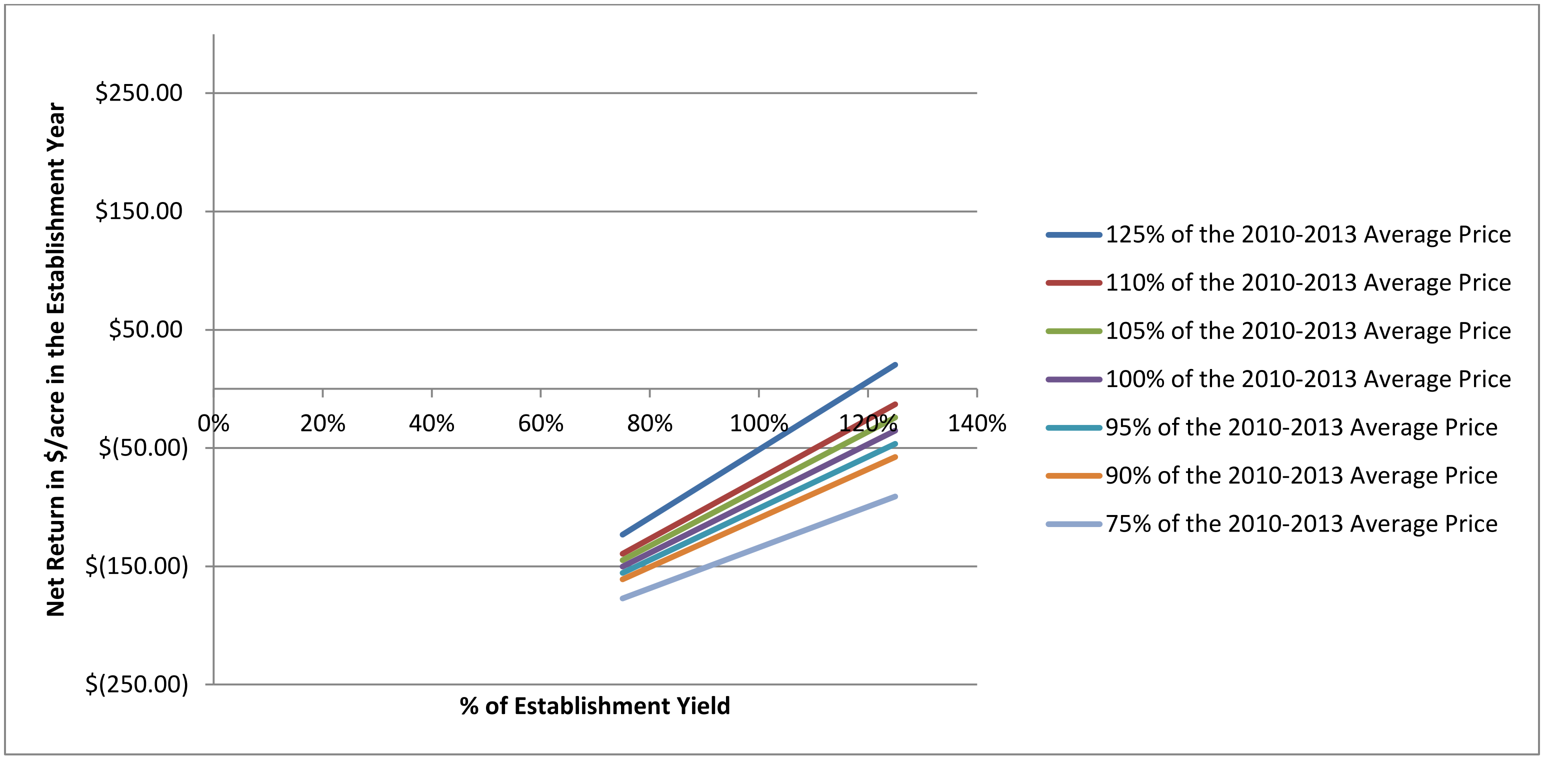


Table C. 43 Big Bluestem Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

Big Bluestem	Establishment Year Per Acre		Biomass Price Range						
		Price per Ton	$ 137.35	$ 154.00	$ 147.00	$ 109.88	$ 133.00	$ 126.00	$ 105.00
	Establishment Ton/	$ (139.89)	125%	110%	105%	100%	95%	90%	75%
Biomass Yield Range	2.54	125%	$ (30.86)	$ (72.67)	$ (86.60)	$ (100.54)	$ (114.48)	$ (128.41)	$ (170.22)
	2.23	110%	$ (62.83)	$ (99.62)	$ (111.88)	$ (124.15)	$ (136.41)	$ (148.68)	$ (185.47)
	2.13	105%	$ (73.48)	$ (108.60)	$ (120.31)	$ (132.02)	$ (143.72)	$ (155.43)	$ (190.55)
	2.03	100%	$ (84.14)	$ (117.59)	$ (128.74)	**$ (139.89)**	$ (151.04)	$ (162.19)	$ (195.63)
	1.93	95%	$ (94.80)	$ (126.57)	$ (137.17)	$ (147.76)	$ (158.35)	$ (168.94)	$ (200.72)
	1.83	90%	$ (105.45)	$ (135.56)	$ (145.59)	$ (155.63)	$ (165.66)	$ (175.70)	$ (205.80)
	1.52	75%	$ (137.43)	$ (162.51)	$ (170.87)	$ (179.24)	$ (187.60)	$ (195.96)	$ (221.05)

Figure C. 42 Big Bluestem Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

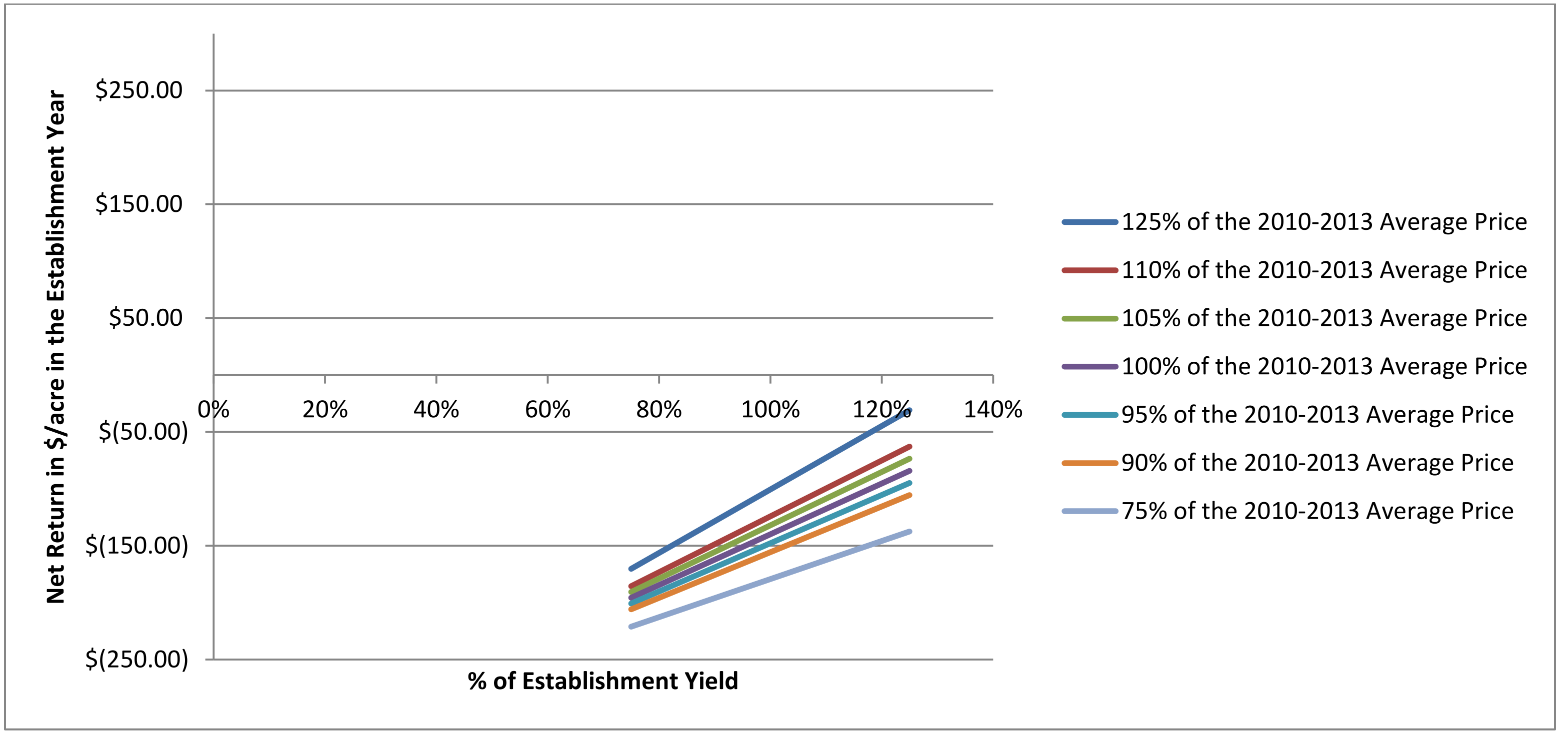
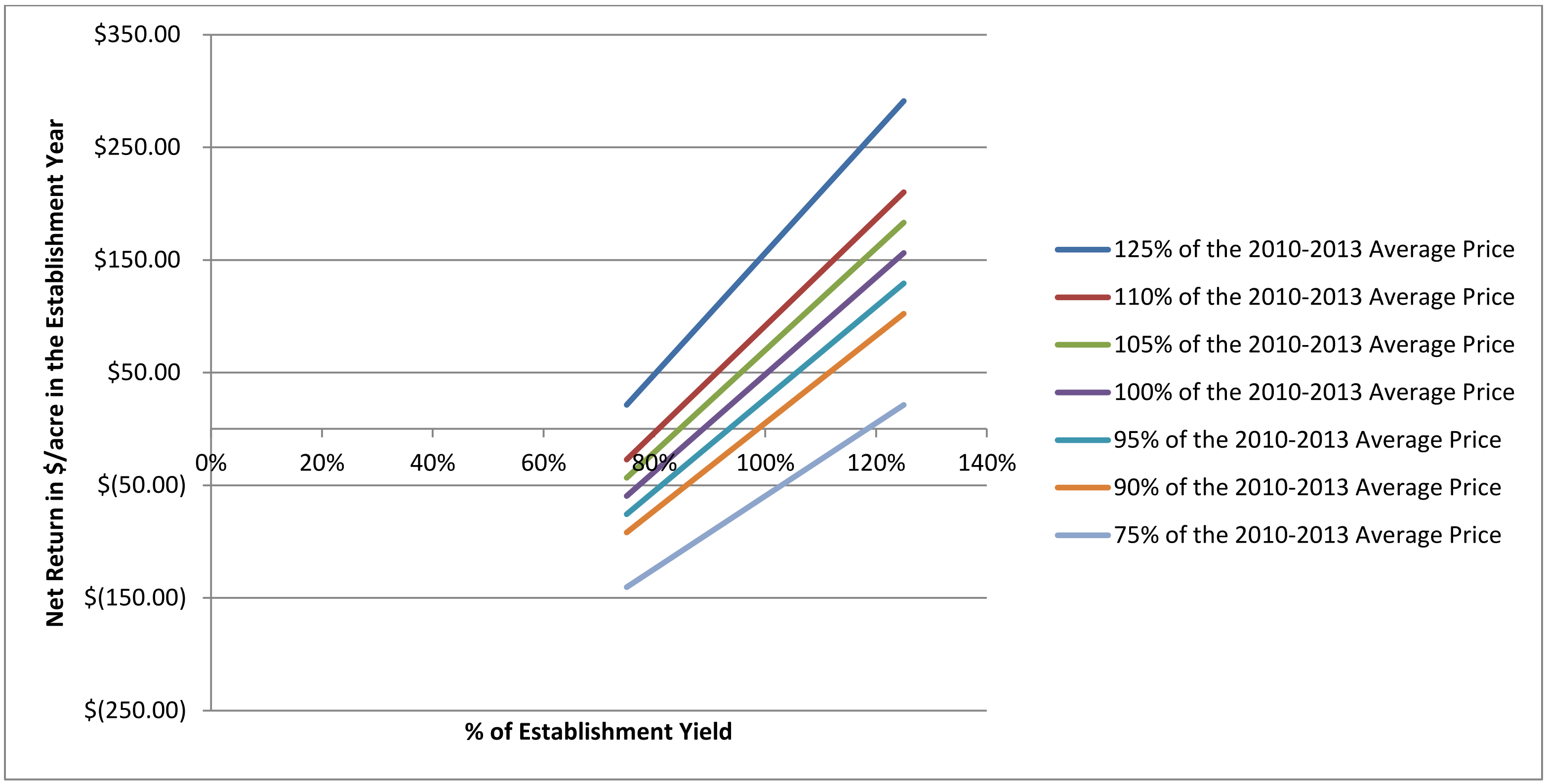


Table C. 44 Alfalfa Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)

Alfalfa	Establishment Year Per Acre		Biomass Price Range						
		Price per Ton	$ 179.46	$ 198.30	$ 189.29	$ 143.57	$ 171.26	$ 162.25	$ 135.20
	Establishment Ton/	$ 48.30	125%	110%	105%	100%	95%	90%	75%
	3.76	125%	$ 291.05	$ 210.13	$ 183.16	$ 156.19	$ 129.22	$ 102.24	$ 21.33
	3.31	110%	$ 210.13	$ 138.93	$ 115.19	$ 91.45	$ 67.72	$ 43.98	$ (27.22)
	3.16	105%	$ 183.16	$ 115.19	$ 92.53	$ 69.88	$ 47.22	$ 24.56	$ (43.41)
Biomass Yield Range	3.01	100%	$ 156.19	$ 91.45	$ 69.88	**$ 48.30**	$ 26.72	$ 5.14	$ (59.59)
	2.86	95%	$ 129.22	$ 67.72	$ 47.22	$ 26.72	$ 6.22	$ (14.28)	$ (75.77)
	2.71	90%	$ 102.24	$ 43.98	$ 24.56	$ 5.14	$ (14.28)	$ (33.70)	$ (91.96)
	2.25	75%	$ 21.33	$ (27.22)	$ (43.41)	$ (59.59)	$ (75.77)	$ (91.96)	$ (140.51)

Figure C. 43 Alfalfa Perennial Land Rental Rate Sensitivity Analysis (Establishment Year $/acre)



Appendix D - Sensitivity Enterprise Budgets

D.1 FMGGBNRA Scenario, Enterprise Budgets[12]

[12] Rows highlighted in blue are not included in the cost calculations; these are merely for additional information if the biomass transport costs were to be included in cost calculations.

Table D. 1 The GS Rotation Enterprise Budget

NT Soybean (Sorghum)						
Soybean						
		Cost				
	Application and Rates		**Prices**		**Cost**	
Herbacide- #1	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	24	fl oz	$ 0.11	fl oz	$ 2.64	
AMS	1.5	lb	$ 0.34	lb	$ 0.51	
						$ 8.68
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Urea (46-0-0)	0	lb of N	$ 0.63	$/lb. of actual N	$ -	
TSP (0-46-0)	35	lbs of P	$ 0.67	$/lb. of actual P	$ 23.38	
						$ 28.77
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting-Notill (Corn Planter)	1	application	$ 16.01	acres	$ 16.01	
Soybean Seed	140	1000 seeds	$ 0.37	$/1000 seeds	$ 51.80	
						$ 67.81
Herbacide- #2	1	application	$ 5.53	acres	$ 5.53	
Roundup Weather Max	22		$ 0.19	fl oz	$ 4.18	
AMS	1.5		$ 0.34	lb	$ 0.51	
						$ 10.22
Harvest	1	application	$ 26.41	acres	$ 26.41	
above 28 bu/ac	30.20		$ 0.20	bushels	$ 6.08	
haul (w/in 16 miles)	58.20		$ 0.18	bushels	$ 10.51	
						$ 43.00
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 5.93
Total Variable Cost per Acre						**$ 188.32**
		Revenue				
Grain Revenue (yield*$/bu)	58.20	bu/ac	$ 13.72	bushel	$ 798.49	
Return per Acre						**$ 610.17**
		Fixed Costs				
Land Rent/Charge	1	acre	$ 139.20	per acre	$ 139.20	
Net Return per Acre						**$ 470.97**
Grain Sorghum (Milo)						
		Costs				
	Application and Rates		**Prices**		**Cost**	
Herbacide #1	1	application	$ 5.53	acre	$ 5.53	
Bicep II Magnum	1.6	qt/ac	$ 10.58	qt	$ 16.93	
						$ 22.46
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Fertalizer Grain						
Urea (46-0-0)	36.082	lb of N	$ 0.63	$/lb. of actual N	$ 22.77	
TSP (0-46-0)	14.288	lbs of P	$ 0.67	$/lb. of actual P	$ 9.54	
						$ 37.70
Fertalizer Biomass						
Urea (46-0-0)	63.403	lb of N	$ 0.63	$/lb. of actual N	$ 40.01	
TSP (0-46-0)	9.3765	lbs of P	$ 0.67	$/lb. of actual P	$ 6.26	
						$ 46.27
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting Notill (Corn Planter)	1	application	$ 17.47	acres	$ 17.47	
GS Seed	4.67	lbs/ac	$ 3.60	$/lbs	$ 16.81	
Fertalizer Grain						
Potash (0-060)	19.1995	lbs of K	$ 0.50	$/lb. of actual K	$ 9.66	
Fertalizer Biomass						$ 43.94
Potash (0-060)	200.4785	lbs of K	$ 0.50	$/lb. of actual K	$ 100.82	
						$ 100.82
Herbacide #2	1	application	$ 5.53	acre	$ 5.53	
Buctril + Atrazine	2	pt/ac	$ 6.34	pint	$ 12.68	
						$ 18.21
Harvest	1	application	$ 21.77	acre	$ 21.77	
above 36 bu/ac	30.96	bu/ac	$ 0.21	bu	$ 6.37	
hauling (w/in 15 miles)	66.96	bu	$ 0.19	bu	$ 12.86	
						$ 41.00
Harvest (Biomass)	1	application				
Swath	1	acre	$ 18.00	acre	$ 18.00	
Rake	0	acre	$ 7.00	bale	$ -	
Bale (Lrg Sqr @ approx 1100 lbs)	11.43046984	bale	$ 14.00	acre	$ 160.03	
Stacking	11.43	bale	$ 4.00	bale	$ 45.72	
Loading	6.29	ton	$ 2.00	bale	$ 12.57	
Haul	6.29	ton	$ 2.33	$/ton CS,S,CRP	$ 34.88	
						$ 223.75
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 18.14
Interest Grain	6.5%	per annum	$ 0.50	% of year financed		$ 6.09
Interest Biomass	6.5%	per annum	$ 0.50	% of year financed		$ 12.05
Total Variable Cost per Acre						**$ 576.21**
Total Variable Cost per Acre Grain						**$ 250.20**
Total Variable Cost per Acre Biomass						**$ 382.89**
Revenue						
Grain Revenue (yield*$/bu)	66.96	bu/ac	$ 5.34	bu	$ 357.62	
Biomass Revenue (yield*$/ton)	6.29	ton/ac	$ 78.33	$/ton	$ 492.46	
					$ 850.09	
Return Per Acre						**$ 273.87**
Return Per Acre Grain						**$ 107.42**
Return Per Acre Biomass						**$ 109.57**
		Fixed Costs				
Land Rent/Charge	1	acre	$ 139.20	per acre	$ 139.20	
Net Return per Acre						**$ 134.67**
Net Return per Acre Grain						**$ (31.78)**
Net Return per Acre Biomass						**$ (29.63)**
Net Return on Rotation	With Biomass	Excluding Land Rent/Charge				$ 442.02
		Including Land Rent/Charge				$ 302.82
	Without Biomass	Excluding Land Rent/Charge				$ 358.80
		Including Land Rent/Charge				$ 219.60

Table D. 2 The BMR Rotation Enterprise Budget

NT Soybean (Sorghum)						
Soybean						
		Cost				
	Application and Rates		**Prices**		**Cost**	
Herbacide- #1	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	24	fl oz	$ 0.11	fl oz	$ 2.64	
AMS	1.5	lb	$ 0.34	lb	$ 0.51	
						$ 8.68
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Urea (46-0-0)	0	lb of N	$ 0.63	$/lb. of actual N	$ -	
TSP (0-46-0)	35	lbs of P	$ 0.67	$/lb. of actual P	$ 23.38	
						$ 28.77
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting-Notill (Corn Planter)	1	application	$ 16.01	acres	$ 16.01	
Soybean Seed	140	1000 seeds	$ 0.37	$/1000 seeds	$ 51.80	
						$ 67.81
Herbacide- #2	1	application	$ 5.53	acres	$ 5.53	
Roundup Weather Max	22		$ 0.19	fl oz	$ 4.18	
AMS	1.5		$ 0.34	lb	$ 0.51	
						$ 10.22
Harvest	1	application	$ 26.41	acres	$ 26.41	
above 28 bu/ac	30.20		$ 0.20	bushels	$ 6.08	
haul (w/in 16 miles)	58.20		$ 0.18	bushels	$ 10.51	
						$ 43.00
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 5.93
Total Variable Cost per Acre						**$ 188.32**
		Revenue				
Grain Revenue (yield*$/bu)	58.20	bu/ac	$ 13.72	bushel	$ 798.49	
Return per Acre						**$ 610.17**
		Fixed Costs				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 470.97**
BMR Sorghum						
		Costs				
	Application and Rates		**Prices**		**Cost**	
Herbacide #1	1	application	$ 5.53	acre	$ 5.53	
Bicep II Magnum	1.6	qt/ac	$ 10.58	qt	$ 16.93	
						$ 22.46
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Fertalizer Grain						
Urea (46-0-0)	20.008	lb of N	$ 0.63	$/lb. of actual N	$ 12.62	
TSP (0-46-0)	9.823	lbs of P	$ 0.67	$/lb. of actual P	$ 6.56	
						$ 24.58
Fertalizer Biomass						
Urea (46-0-0)	50.901	lb of N	$ 0.63	$/lb. of actual N	$ 32.12	
TSP (0-46-0)	10.716	lbs of P	$ 0.67	$/lb. of actual P	$ 7.16	
						$ 39.28
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting Notill (Corn Planter)	1	application	$ 17.47	acres	$ 17.47	
BMR Seed	4.67	lbs/ac	$ 3.60	$/lbs	$ 16.81	
Fertalizer Grain						
Potash (0-060)	12.502	lbs of K	$ 0.50	$/lb. of actual K	$ 6.29	
Fertalizer Biomass						$ 40.57
Potash (0-060)	148.238	lbs of K	$ 0.50	$/lb. of actual K	$ 74.55	
						$ 74.55
Herbacide #2	1	application	$ 5.53	acre	$ 5.53	
Buctril + Atrazine	2	pt/ac	$ 6.34	pint	$ 12.68	
						$ 18.21
Harvest	1	application	$ 21.77	acre	$ 21.77	
above 36 bu/ac	-	bu/ac	$ 0.21	bu	$ -	
hauling (w/in 15 miles)	34.02	bu	$ 0.19	bu	$ 6.53	
						$ 28.31
Harvest (Biomass)	1	application				
Swath	1	acre	$ 14.00	acre	$ 14.00	
Rake	1	acre	$ 7.00	bale	$ 7.00	
Bale (Lrg Sqr @ approx 1100 lbs)	11.71165652	bale	$ 14.00	acre	$ 163.96	
Stacking	11.71	bale	$ 4.00	bale	$ 46.85	
Loading	6.44	ton	$ 2.00	bale	$ 12.88	
Haul	6.44	ton	$ 2.33	$/ton CS,S,CRP	$ 34.88	
						$ 231.81
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 16.37
Interest Grain	6.5%	per annum	$ 0.50	% of year financed		$ 5.14
Interest Biomass	6.5%	per annum	$ 0.50	% of year financed		$ 11.23
Total Variable Cost per Acre						**$ 520.05**
Total Variable Cost per Acre Grain						**$ 197.16**
Total Variable Cost per Acre Biomass						**$ 356.87**
Revenue						
Grain Revenue (yield*$/bu)	34.02	bu/ac	$ 5.34	bu	$ 181.67	
Biomass Revenue (yield*$/ton)	6.44	ton/ac	$ 78.33	$/ton	$ 504.58	
					$ 686.25	
Return Per Acre						**$ 166.19**
Return Per Acre Grain						**$ (15.49)**
Return Per Acre Biomass						**$ 147.71**
		Fixed Costs				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 26.99**
Net Return per Acre Grain						**$ (154.69)**
Net Return per Acre Biomass						**$ 8.51**
Net Return on Rotation	With Biomass	Excluding Land Rent/Charge				$ 388.18
		Including Land Rent/Charge				$ 248.98
	Without Biomass	Excluding Land Rent/Charge				$ 297.34
		Including Land Rent/Charge				$ 158.14

Table D. 3 The PS Rotation Enterprise Budget

NT Soybean (Sorghum)						
Soybean						
		Cost				
	Application and Rates		**Prices**		**Cost**	
Herbacide- #1	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	24	fl oz	$ 0.11	fl oz	$ 2.64	
AMS	1.5	lb	$ 0.34	lb	$ 0.51	
						$ 8.68
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Urea (46-0-0)	0	lb of N	$ 0.63	$/lb. of actual N	$ -	
TSP (0-46-0)	35	lbs of P	$ 0.67	$/lb. of actual P	$ 23.38	
						$ 28.77
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting-Notill (Corn Planter)	1	application	$ 16.01	acres	$ 16.01	
Soybean Seed	140	1000 seeds	$ 0.37	$/1000 seeds	$ 51.80	
						$ 67.81
Herbacide- #2	1	application	$ 5.53	acres	$ 5.53	
Roundup Weather Max	22		$ 0.19	fl oz	$ 4.18	
AMS	1.5		$ 0.34	lb	$ 0.51	
						$ 10.22
Harvest	1	application	$ 26.41	acres	$ 26.41	
above 28 bu/ac	30.20		$ 0.20	bushels	$ 6.08	
haul (w/in 16 miles)	58.20		$ 0.18	bushels	$ 10.51	
						$ 43.00
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 5.93
Total Variable Cost per Acre						**$ 188.32**
		Revenue				
Grain Revenue (yield*$/bu)	58.20	bu/ac	$ 13.72	bushel	$ 798.49	
Return per Acre						**$ 610.17**
		Fixed Costs				
Land Rent/Charge	1	acre	$ 139.20	per acre	$ 139.20	
Net Return per Acre						**$ 470.97**
Photosensitive Sorghum						
		Costs				
	Application and Rates		**Prices**		**Cost**	
Herbacide #1	1	application	$ 5.53	acre	$ 5.53	
Bicep II Magnum	1.6	qt/ac	$ 10.58	qt	$ 16.93	
						$ 22.46
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Fertalizer Grain						
Urea (46-0-0)	-30	lb of N	$ 0.63	$/lb. of actual N	$ (18.93)	
TSP (0-46-0)	0	lbs of P	$ 0.67	$/lb. of actual P	$ -	
						$ (13.54)
Fertalizer Biomass						
Urea (46-0-0)	99.123	lb of N	$ 0.63	$/lb. of actual N	$ 62.54	
TSP (0-46-0)	21.432	lbs of P	$ 0.67	$/lb. of actual P	$ 14.32	
						$ 76.86
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting Notill (Corn Planter)	1	application	$ 17.47	acres	$ 17.47	
PS Seed	4.67	lbs/ac	$ 3.60	$/lbs	$ 16.81	
Fertalizer Grain						
Potash (0-060)	0	lbs of K	$ 0.50	$/lb. of actual K	$ -	
Fertalizer Biomass						$ 34.28
Potash (0-060)	281.295	lbs of K	$ 0.50	$/lb. of actual K	$ 141.47	
						$ 141.47
Herbacide #2	1	application	$ 5.53	acre	$ 5.53	
Buctril + Atrazine	2	pt/ac	$ 6.34	pint	$ 12.68	
						$ 18.21
Harvest	1	application	$ 21.77	acre	$ 21.77	
above 36 bu/ac	-	bu/ac	$ 0.21	bu	$ -	
hauling (w/in 15 miles)	-	bu	$ 0.19	bu	$ -	
						$ -
Harvest (Biomass)	1	application				
Swath	1	acre	$ 14.00	acre	$ 14.00	
Rake	1	acre	$ 7.00	bale	$ 7.00	
Bale (Lrg Sqr @ approx 1100 lbs)	19.04715034	bale	$ 14.00	acre	$ 266.66	
Stacking	19.05	bale	$ 4.00	bale	$ 76.19	
Loading	10.48	ton	$ 2.00	bale	$ 20.95	
Haul	10.48	ton	$ 2.33	$/ton CS,S,CRP	$ 34.88	
						$ 363.85
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 21.69
Interest Grain	6.5%	per annum	$ 0.50	% of year financed		$ -
Interest Biomass	6.5%	per annum	$ 0.50	% of year financed		$ 21.69
Total Variable Cost per Acre						**$ 689.21**
Total Variable Cost per Acre Grain						**$ -**
Total Variable Cost per Acre Biomass						**$ 689.21**
Revenue						
Grain Revenue (yield*$/bu)	-	bu/ac	$ 5.34	bu	$ -	
Biomass Revenue (yield*$/ton)	10.48	ton/ac	$ 78.33	$/ton	$ 820.61	
					$ 820.61	
Return Per Acre						**$ 131.41**
Return Per Acre Grain						**$ -**
Return Per Acre Biomass						**$ 131.41**
		Fixed Costs				
Land Rent/Charge	1	acre	$ 139.20	per acre	$ 139.20	
Net Return per Acre						**$ (7.79)**
Net Return per Acre Grain						**$ (139.20)**
Net Return per Acre Biomass						**$ (7.79)**
Net Return on Rotation	With Biomass	Excluding Land Rent/Charge				$ 370.79
		Including Land Rent/Charge				$ 231.59
	Without Biomass	Excluding Land Rent/Charge				$ 305.09
		Including Land Rent/Charge				$ 165.89

Table D. 4 The DP Rotation Enterprise Budget

NT Soybean (Sorghum)						
Soybean						
		Cost				
	Application and Rates		Prices		Cost	
Herbacide- #1	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	24	fl oz	$ 0.11	fl oz	$ 2.64	
AMS	1.5	lb	$ 0.34	lb	$ 0.51	
						$ 8.68
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Urea (46-0-0)	0	lb of N	$ 0.63	$/lb. of actual N	$ -	
TSP (0-46-0)	35	lbs of P	$ 0.67	$/lb. of actual P	$ 23.38	
						$ 28.77
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting-Notill (Corn Planter)	1	application	$ 16.01	acres	$ 16.01	
Soybean Seed	140	1000 seeds	$ 0.37	$/1000 seeds	$ 51.80	
						$ 67.81
Herbacide- #2	1	application	$ 5.53	acres	$ 5.53	
Roundup Weather Max	22		$ 0.19	fl oz	$ 4.18	
AMS	1.5		$ 0.34	lb	$ 0.51	
						$ 10.22
Harvest	1	application	$ 26.41	acres	$ 26.41	
above 28 bu/ac	30.20		$ 0.20	bushels	$ 6.08	
haul (w/in 16 miles)	58.20		$ 0.18	bushels	$ 10.51	
						$ 43.00
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 5.93
Total Variable Cost per Acre						**$ 188.32**
		Revenue				
Grain Revenue (yield*$/bu)	58.20	bu/ac	$ 13.72	bushel	$ 798.49	
Return per Acre						**$ 610.17**
		Fixed Costs				
Land Rent/Charge	1	acre	$ 139.20	per acre	$ 139.20	
Net Return per Acre						**$ 470.97**
Photosensitive Sorghum						
		Costs				
	Application and Rates		Prices		Cost	
Herbacide #1	1	application	$ 5.53	acre	$ 5.53	
Bicep II Magnum	1.6	qt/ac	$ 10.58	qt	$ 16.93	
						$ 22.46
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Fertalizer Grain						
Urea (46-0-0)	39.654	lb of N	$ 0.63	$/lb. of actual N	$ 25.02	
TSP (0-46-0)	15.181	lbs of P	$ 0.67	$/lb. of actual P	$ 10.14	
						$ 40.55
Fertalizer Biomass						
Urea (46-0-0)	54.473	lb of N	$ 0.63	$/lb. of actual N	$ 34.37	
TSP (0-46-0)	9.3765	lbs of P	$ 0.67	$/lb. of actual P	$ 6.26	
						$ 40.63
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting Notill (Corn Planter)	1	application	$ 17.47	acres	$ 17.47	
DS Seed	4.67	lbs/ac	$ 3.60	$/lbs	$ 16.81	
Fertalizer Grain						
Potash (0-060)	21.8785	lbs of K	$ 0.50	$/lb. of actual K	$ 11.00	
Fertalizer Biomass						$ 45.29
Potash (0-060)	187.9765	lbs of K	$ 0.50	$/lb. of actual K	$ 94.54	
						$ 94.54
Herbacide #2	1	application	$ 5.53	acre	$ 5.53	
Buctril + Atrazine	2	pt/ac	$ 6.34	pint	$ 12.68	
						$ 18.21
Harvest	1	application	$ 21.77	acre	$ 21.77	
above 36 bu/ac	37.25	bu/ac	$ 0.21	bu	$ 7.66	
hauling (w/in 15 miles)	73.25	bu	$ 0.19	bu	$ 14.07	
						$ 43.51
Harvest (Biomass)	1	application				
Swath	1	acre	$ 18.00	acre	$ 18.00	
Rake	0	acre	$ 7.00	bale	$ -	
Bale (Lrg Sqr @ approx 1100 lbs)	15.74517076	bale	$ 14.00	acre	$ 220.43	
Stacking	15.75	bale	$ 4.00	bale	$ 62.98	
Loading	8.66	ton	$ 2.00	bale	$ 17.32	
Haul	8.66	ton	$ 2.33	$/ton CS,S,CRP	$ 34.88	
						$ 301.41
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 20.49
Interest Grain	6.5%	per annum	$ 0.50	% of year financed		$ 6.30
Interest Biomass	6.5%	per annum	$ 0.50	% of year financed		$ 14.19
Total Variable Cost per Acre						**$ 651.01**
Total Variable Cost per Acre Grain						**$ 249.49**
Total Variable Cost per Acre Biomass						**$ 450.77**
Revenue						
Grain Revenue (yield*$/bu)	73.25	bu/ac	$ 5.34	bu	$ 391.23	
Biomass Revenue (yield*$/ton)	8.66	ton/ac	$ 78.33	$/ton	$ 678.35	
					$ 1,069.59	
Return Per Acre						**$ 418.58**
Return Per Acre Grain						**$ 141.75**
Return Per Acre Biomass						**$ 227.58**
		Fixed Costs				
Land Rent/Charge	1	acre	$ 139.20	per acre	$ 139.20	
Net Return per Acre						**$ 279.38**
Net Return per Acre Grain						**$ 2.55**
Net Return per Acre Biomass						**$ 88.38**
Net Return on Rotation	With Biomass	Excluding Land Rent/Charge				$ 514.37
		Including Land Rent/Charge				$ 375.17
	Without Biomass	Excluding Land Rent/Charge				$ 375.96
		Including Land Rent/Charge				$ 236.76

Table D. 5 The SS Rotation Enterprise Budget

NT Soybean (Sorghum)						
Soybean						
		Cost				
	Application and Rates		**Prices**		**Cost**	
Herbacide- #1	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	24	fl oz	$ 0.11	fl oz	$ 2.64	
AMS	1.5	lb	$ 0.34	lb	$ 0.51	
						$ 8.68
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Urea (46-0-0)	0	lb of N	$ 0.63	$/lb. of actual N	$ -	
TSP (0-46-0)	35	lbs of P	$ 0.67	$/lb. of actual P	$ 23.38	
						$ 28.77
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting-Notill (Corn Planter)	1	application	$ 16.01	acres	$ 16.01	
Soybean Seed	140	1000 seeds	$ 0.37	$/1000 seeds	$ 51.80	
						$ 67.81
Herbacide- #2	1	application	$ 5.53	acres	$ 5.53	
Roundup Weather Max	22		$ 0.19	fl oz	$ 4.18	
AMS	1.5		$ 0.34	lb	$ 0.51	
						$ 10.22
Harvest	1	application	$ 26.41	acres	$ 26.41	
above 28 bu/ac	30.20		$ 0.20	bushels	$ 6.08	
haul (w/in 16 miles)	58.20		$ 0.18	bushels	$ 10.51	
						$ 43.00
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 5.93
Total Variable Cost per Acre						**$ 188.32**
		Revenue				
Grain Revenue (yield*$/bu)	58.20	bu/ac	$ 13.72	bushel	$ 798.49	
Return per Acre						**$ 610.17**
		Fixed Costs				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 470.97**
Photosensitive Sorghum						
		Costs				
	Application and Rates		**Prices**		**Cost**	
Herbacide #1	1	application	$ 5.53	acre	$ 5.53	
Bicep II Magnum	1.6	qt/ac	$ 10.58	qt	$ 16.93	
						$ 22.46
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Fertalizer Grain						
Urea (46-0-0)	-4.996	lb of N	$ 0.63	$/lb. of actual N	$ (3.15)	
TSP (0-46-0)	6.251	lbs of P	$ 0.67	$/lb. of actual P	$ 4.18	
						$ 6.41
Fertalizer Biomass						
Urea (46-0-0)	137.0755	lb of N	$ 0.63	$/lb. of actual N	$ 86.49	
TSP (0-46-0)	15.181	lbs of P	$ 0.67	$/lb. of actual P	$ 10.14	
						$ 96.63
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting Notill (Corn Planter)	1	application	$ 17.47	acres	$ 17.47	
SS Seed	4.67	lbs/ac	$ 3.60	$/lbs	$ 16.81	
Fertalizer Grain						
Potash (0-060)	6.6975	lbs of K	$ 0.50	$/lb. of actual K	$ 3.37	
Fertalizer Biomass						$ 37.65
Potash (0-060)	274.151	lbs of K	$ 0.50	$/lb. of actual K	$ 137.88	
						$ 137.88
Herbacide #2	1	application	$ 5.53	acre	$ 5.53	
Buctril + Atrazine	2	pt/ac	$ 6.34	pint	$ 12.68	
						$ 18.21
Harvest	1	application	$ 21.77	acre	$ 21.77	
above 36 bu/ac	-	bu/ac	$ 0.21	bu	$ -	
hauling (w/in 15 miles)	20.99	bu	$ 0.19	bu	$ 4.03	
						$ 25.81
Harvest (Biomass)	1	application				
Swath	1	acre	$ 18.00	acre	$ 18.00	
Rake	0	acre	$ 7.00	bale	$ -	
Bale (Lrg Sqr @ approx 1100 lbs)	18.74593552	bale	$ 14.00	acre	$ 262.44	
Stacking	18.75	bale	$ 4.00	bale	$ 74.98	
Loading	10.31	ton	$ 2.00	bale	$ 20.62	
Haul	10.31	ton	$ 2.33	$/ton CS,S,CRP	$ 34.88	
						$ 355.43
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 23.54
Interest Grain	6.5%	per annum	$ 0.50	% of year financed		$ 4.37
Interest Biomass	6.5%	per annum	$ 0.50	% of year financed		$ 19.17
Total Variable Cost per Acre						**$ 747.94**
Total Variable Cost per Acre Grain						**$ 239.05**
Total Variable Cost per Acre Biomass						**$ 609.11**
Revenue						
Grain Revenue (yield*$/bu)	20.99	bu/ac	$ 5.34	bu	$ 112.11	
Biomass Revenue (yield*$/ton)	10.31	ton/ac	$ 78.33	$/ton	$ 807.64	
					$ 919.75	
Return Per Acre						**$ 171.81**
Return Per Acre Grain						**$ (126.94)**
Return Per Acre Biomass						**$ 198.53**
		Fixed Costs				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 32.61**
Net Return per Acre Grain						**$ (266.14)**
Net Return per Acre Biomass						**$ 59.33**
Net Return on Rotation	With Biomass	Excluding Land Rent/Charge				$ 390.99
		Including Land Rent/Charge				$ 251.79
	Without Biomass	Excluding Land Rent/Charge				$ 241.61
		Including Land Rent/Charge				$ 102.41

Table D. 6 The RC Rotation Enterprise Budget

NT Soybean Corn						
Soybean						
		Cost				
	Application and Rates		**Prices**		**Cost**	
Herbacide- #1	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	24	fl oz	$ 0.11	fl oz	$ 2.64	
AMS	1.5	lb	$ 0.34	lb	$ 0.51	
						$ 8.68
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Urea (46-0-0)	0	lb of N	$ 0.63	$/lb. of actual N	$ -	
TSP (0-46-0)	35	lbs of P	$ 0.67	$/lb. of actual P	$ 23.38	
						$ 28.77
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting-Notill (Corn Planter)	1	application	$ 16.01	acres	$ 16.01	
Soybean Seed	140	1000 seeds	$ 0.37	$/1000 seeds	$ 51.80	
						$ 67.81
Herbacide- #2	1	application	$ 5.53	acres	$ 5.53	
Roundup Weather Max	22		$ 0.19	fl oz	$ 4.18	
AMS	1.5		$ 0.34	lb	$ 0.51	
						$ 10.22
Harvest	1	application	$ 26.41	acres	$ 26.41	
above 28 bu/ac	30.20		$ 0.20	bushels	$ 6.08	
haul (w/in 16 miles)	58.20		$ 0.18	bushels	$ 10.51	
						$ 43.00
Interest Total	6.5%	per annum	50.0%	% of year financed		$ 5.93
Total Variable Cost per Acre						**$ 188.32**
Revenue						
Grain Revenue (yield*$/bu)	58.20	bu/ac	$ 13.72	bushel	$ 798.49	
Return per Acre						**$ 610.17**
		Fixed Costs				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 470.97**
Corn						
		Costs				
	Application and Rates		**Prices**		**Cost**	
Herbacide #1	1	application	$ 5.53	acre	$ 5.53	
Bicep II Magnum +Glyphosat + AMS	1	acre	$ 27.87	acre	$ 27.87	
						$ 33.40
Fertalizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Fertalizer Grain						
Urea (46-0-0)	68.23	lb of N	$ 0.63	$/lb. of actual N	$ 43.05	
TSP (0-46-0)	24.111	lbs of P	$ 0.67	$/lb. of actual P	$ 16.10	
						$ 64.55
Fertalizer Biomass						
Urea (46-0-0)	44.65	lb of N	$ 0.63	$/lb. of actual N	$ 28.17	
TSP (0-46-0)	6.6975	lbs of P	$ 0.67	$/lb. of actual P	$ 4.47	
						$ 32.65
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting Notill (Corn Planter)	1	application	$ 17.64	acres	$ 17.64	
Corn Seed	27	1000 seeds	$ 3.51	$/1000 seeds	$ 94.77	
Fertalizer Grain						
Potash (0-060)	33.4875	lbs of K	$ 0.50	$/lb. of actual K	$ 16.84	
Fertalizer Biomass						$ 129.25
Potash (0-060)	100.909	lbs of K	$ 0.50	$/lb. of actual K	$ 50.75	
						$ 50.75
Herbacide #2	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	32	oz/ac	$ 0.11	fl oz	$ 3.52	
AMS	1.5	lb/ac	$ 0.34	lb	$ 0.51	
						$ 9.56
Harvest	1	application	$ 26.36	acre	$ 26.36	
above 74 bu/ac	60.52	bu/ac	$ 0.21	bu	$ 12.59	
hauling (w/in 15 miles)	135.52	bu	$ 0.18	bu	$ 23.84	
						$ 62.79
Harvest (Biomass)	1	application				
Stalk Chop	1	acre	$ 14.00	acre	$ 14.00	
Bale (Lrg Sqr @ approx 1500 lbs)	12.46348932	bale	$ 15.00	bale	$ 186.95	
Stacking	12.46	bale	$ 4.00	bale	$ 49.85	
Loading	7.322299975	ton	$ 2.00	bale	$ 14.64	
Haul	7.322299975	ton	$ 2.33	$/ton CS,S,CRP	$ 17.02	
						$ 250.81
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 21.37
Interest Grain	6.5%	per annum	$ 0.50	% of year financed		$ 10.51
Interest Biomass	6.5%	per annum	$ 0.50	% of year financed		$ 10.86
Total Variable Cost per Acre						**$ 679.04**
Total Variable Cost per Acre Grain						**$ 333.98**
Total Variable Cost per Acre Biomass						**$ 345.06**
Revenue						
Grain Revenue (yield*$/bu)	135.52	bu/ac	$ 5.88	bu	$ 797.39	
Biomass Revenue (yield*$/ton)	7.32	ton/ac	$ 60.90	$/ton	$ 445.95	
					$ 1,243.34	
Return Per Acre						**$ 564.29**
Return Per Acre Grain						**$ 463.41**
Return Per Acre Biomass						**$ 100.88**
		Fixed Costs				
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 425.09**
Net Return per Acre Grain						**$ 324.21**
Net Return per Acre Biomass						**$ (38.32)**
Net Return on Rotation	With Biomass	Excluding Land Rent/Charge				$ 587.23
		Including Land Rent/Charge				$ 448.03
	Without Biomass	Excluding Land Rent/Charge				$ 536.79
		Including Land Rent/Charge				$ 397.59

Table D. 7 The CC Rotation Enterprise Budget

NT Corn-Corn						
Corn						
			Cost			
	Application and Rates		**Prices**		**Cost**	
Herbicide #1	1	application	$ 5.53	acre	$ 5.53	
Bicep II Magnum +Glyphosate + AMS	1	acre	$ 27.87	acre	$ 27.87	
						$ 33.40
Fertilizer-Broadcast	1	application	$ 5.39	acre	$ 5.39	
Fertalizer Grain						
Urea (46-0-0)	78.584	lb of N	$ 0.63	$/lb. of actual N	$ 49.58	
TSP	21.432	lbs of P	$ 0.67	$/lb. of actual P	$ 14.32	
						$ 69.29
Fertalizer Biomass						
Urea (46-0-0)	40.6315	lb of N	$ 0.63	$/lb. of actual N	$ 25.64	
TSP	6.6975	lbs of P	$ 0.67	$/lb. of actual P	$ 4.47	
						$ 30.11
Lime	500	lbs	$ 0.05	$/lbs	$ 23.93	
						$ 23.93
Planting Notill (Corn Planter)	1	application	$ 17.64	acres	$ 17.64	
Corn Seed	27	1000 seeds	$ 3.51	$/1000 seeds	$ 94.77	
Fertalizer Grain						
Potash (0-060)	31.7015	lbs of K	$ 0.50	$/lb. of actual K	$ 15.94	
						$ 128.36
Fertalizer Biomass						
Potash (0-060)	96.8905	lbs of K	$ 0.50	$/lb. of actual K	$ 48.73	
						$ 48.73
Herbicide #2	1	application	$ 5.53	acre	$ 5.53	
Glyphosate	32	oz/ac	$ 0.11	fl oz	$ 3.52	
AMS	1.5	lb/ac	$ 0.34	lb	$ 0.51	
						$ 9.56
Harvest	1	application	$ 26.36	acre	$ 26.36	
above 74 bu/ac	24.83	bu/ac	$ 0.21	bu	$ 5.16	
hauling (w/in 15 miles)	99.83	bu	$ 0.18	bu	$ 17.56	
						$ 49.08
Harvest (Biomass)	1	application				
Stalk Chop	1	acre	$ 14.00	acre	$ 14.00	
Bale (Lrg Sqr @ approx 1500 lbs)	9.744944942	bale	$ 15.00	bale	$ 146.17	
Stacking	9.74	bale	$ 4.00	bale	$ 38.98	
Loading	5.73	ton	$ 2.00	bale	$ 11.45	
Haul	5.73	ton	$ 2.33	$/ton CS,S,CRP	$ 13.31	
						$ 199.15
Interest Total	6.5%	per annum	$ 0.50	% of year financed		$ 19.23
Interest Grain	6.5%	per annum	$ 0.50	% of year financed		$ 10.39
Interest Biomass	6.5%	per annum	$ 0.50	% of year financed		$ 9.03
Total Variable Cost per Acre						**$ 610.83**
Total Variable Cost per Acre Grain						**$ 324.00**
Total Variable Cost per Acre Biomass						**$ 287.03**
			Revenue			
Grain Revenue (yield*$/bu)	99.83	bu/ac	$ 5.88	bu	$ 587.38	
Biomass Revenue (yield*$/ton)	5.73	ton/ac	$ 60.90	$/ton	$ 348.68	
					$ 936.05	
Return Per Acre						**$ 325.22**
Return Per Acre Grain						**$ 263.37**
Return Per Acre Biomass						**$ 61.65**
			Fixed Costs			
Land Rent/Charge	1	acre	$139.20	per acre	$ 139.20	
Net Return per Acre						**$ 186.02**
Net Return per Acre Grain						**$ 124.17**
Net Return per Acre Biomass						**$ (77.55)**
Net Return on Rotation	With Biomass	Excluding Land Rent/Charge				$ 325.22
		Including Land Rent/Charge				$ 186.02
	Without Biomass	Excluding Land Rent/Charge				$ 263.37
		Including Land Rent/Charge				$ 124.17

D.2 FEPL and FMGAL Scenarios, Enterprise Budgets

Table D. 8 The Switchgrass Enterprise Budget

Grass Budget														
Switchgrass		**Number of Years**	**10**											
					Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Biomass Removal tons/acre									
Yield														
Yield (tons/acre)					2.0	3.7	4.7	4.2	4.1	5.0	5.0	5.0	5.0	5.0
Applications														
Urea N				lbs/acre		40.19	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Phosphorus P				lbs/acre		58.85				58.85				
Potassium K				lbs/acre		249.07				249.07				
Lime				lbs/acre	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00
Chemicals														
Glyphosate				oz/acre	22.38									
2,4-D LV Ester				oz/acre	14.23									
Clarity (dicambia)				oz/acre		10.69								
Crop Oil Concentrate (adjuvant)				oz/acre	12.87	31.50								
Atrazine				oz/acre										
Input Costs														
Seed	$13.00	$/lb	3.572	lbs/acre	$46.44									
Fertalizer (Costs)														
Urea N	$0.63	$/lb.				$25.36	$31.55	$31.55	$31.55	$31.55	$31.55	$31.55	$31.55	$31.55
Phosphorus P	$0.67	$/lb.				$39.30				$39.30				
Potassium K	$0.50	$/lb.				$125.26				$125.26				
Lime	$0.05	$/lb.			$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93
Chemicals														
Glyphosate	$0.11	$/oz			$2.46									
2,4-D LV Ester	$0.23	$/oz			$3.33									
Clarity (dicambia)	$0.69	$/oz				$7.39								
Crop Oil Concentrate (adjuvant)	$0.08	$/oz			$1.01	$2.46								
Atrazin	$0.12	$/oz												
Total ($/acre)					$69.16	$215.71	$47.48	$47.48	$47.48	$212.05	$47.48	$47.48	$47.48	$47.48
Total ($/ton)					$34.68	$58.77	$10.17	$11.39	$11.49	42.7731	$9.58	$9.58	$9.58	$9.58
Summary of Input Costs														
Input Costs/Acre PV Years 1-10	$734.04													
Amortized Input Costs/Acre Years 1-10	$87.81													
Total Tons produced over Years 1-10	43.4													
Input Cost/Ton of PV Years 1-10	$16.90													
Field Operations Costs														
Planting (Drill) without Fert (Year 1 Only)	$12.46	$/acre			$12.46									
Fertilizer (Broadcast)	$5.39	$/acre				$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Chemical (Spray)	$5.53	$/acre			$5.53	$5.53								
Total ($/acre)					$17.99	$10.92	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Total ($/ton)					$9.02	$2.97	$1.15	$1.29	$1.31	$1.09	$1.09	$1.09	$1.09	$1.09
Summary of Field Operations														
Field Operations Cost/Acre PV Years 1-10	$64.54													
Amortized Field Operations Cost/Acre Years 1-10	$7.72													
Total Tons produced over Years 1-10	43.4													
Field Operations Cost/Ton PV Years 1-10	$1.49													
Harvest Costs (Years 2-10, 13-22)														
Swathing	$14.00	$/acre			$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00
Sideraking	$7.00	$/acre			$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00
Baling	$14.00	$/bale			$48.56	$89.37	$113.68	$101.52	$100.58	$120.71	$120.71	$120.71	$120.71	$120.71
Stacking	$4.00	$/bale			$13.87	$25.53	$32.48	$29.01	$28.74	$34.49	$34.49	$34.49	$34.49	$34.49
Harvest Cost														
Total ($/acre)					$90.43	$142.90	$174.17	$158.53	$157.31	$183.19	$183.19	$183.19	$183.19	$183.19
Total ($/ton)					$45.34	$38.93	$37.30	$38.02	$38.08	$36.95	$36.95	$36.95	$36.95	$36.95
Summary of Harvest Operations														
Harvest Cost/Acre PV Years 1-10	$1,398.31													
Amortized Harvest Cost/Acre Years 1-10	$167.27													
Total Tons produced over Years 1-10	43.4													
Harvest Cost/Ton PV Years 1-10	$32.20													
Interest on Operating Costs	6.50%	%/year			$5.77	$12.01	$7.38	$6.87	$6.83	$13.02	$7.67	$7.67	$7.67	$7.67
Total ($/acre)					$5.77	$12.01	$7.38	$6.87	$6.83	$13.02	$7.67	$7.67	$7.67	$7.67
Total ($/ton)					$2.89	$3.27	$1.58	$1.65	$1.65	$2.63	$1.55	$1.55	$1.55	$1.55
Land Charge														
Rental rate ($/acre) (Medium Land)					$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00
Total Costs														
Total ($/acre)					$259.35	$457.53	$310.42	$294.28	$293.02	$489.65	$319.74	$319.74	$319.74	$319.74
Total ($/ton)					$130.05	$124.66	$66.48	$70.57	$70.93	$98.77	$64.50	$64.50	$64.50	$64.50
Summary of Costs				Total ($/acre)	$259.35	$457.53	$310.42	$294.28	$293.02	$489.65	$319.74	$319.74	$319.74	$319.74
Total Cost/Acre PV Years 1-10	$2,925.20													
Amortized Total Cost/Acre Years 1-10	$349.93													
Total Tons produced over Years 1-10	43.4													
Total Cost/Ton PV Years 1-10	$67.37													
Price Received $/Ton FOB				Price ($/ton)	$140.27	$ 140.27	$140.27	$140.27	$140.27	$140.27	$140.27	$140.27	$140.27	$140.27
Revenue				Total ($/acre)	$279.74	$ 514.85	$654.96	$584.91	$579.44	$695.41	$695.41	$695.41	$695.41	$695.41
Summary of Revenue				Total ($/acre)	$279.74	$514.85	$654.96	$584.91	$579.44	$695.41	$695.41	$695.41	$695.41	$695.41
Revenue/Acre PV Years 1-10	$5,181.26													
Amortized Revenue/Acre Years 1-10	$619.80													
Total Tons produced over Years 1-10	43.4													
Revenuet/Ton PV Years 1-10	119.3231													
Summary of Net Return				Total ($/acre)	$20.39	$57.32	$344.54	$290.63	$286.42	$205.75	$375.67	$375.67	$375.67	$375.67
Net Return/Acre PV Years 1-10	$2,256.06			Total ($/ton)	$ 10.22	$ 15.62	$ 73.79	$ 69.70	$ 69.34	$ 41.50	$ 75.78	$ 75.78	$ 75.78	$ 75.78
Amortized Net Return/Acre Years 1-10	$269.88													
Total Tons produced over Years 1-10	43.4													
Net Return/Ton PV Years 1-10	$51.96													
Nominal Discount Rate (annual)	6.50%													
Inflation (annual)	3.00%													
Real Discount Rate (annual)	3.40%													
http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.aspx		2.90%												

Table D. 9 The Big Bluestem Enterprise Budget

						Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Grass Budget															
		Number of Years	**10**												
Bigblue Stem															
						Biomass Removal tons/acre									
Yield															
Yield (tons/acre)						2.0	3.9	2.4	3.2	2.8	3.3	3.3	3.3	3.3	3.3
Applications															
Urea N				lbs/acre			40.19	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Phosphorus P				lbs/acre			58.85				58.85				
Potassium K				lbs/acre			249.07				249.07				
Lime				lbs/acre		333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00
Chemicals															
Glyphosate				oz/acre		22.38									
2,4-D LV Ester				oz/acre		14.23									
Clarity (dicambia)				oz/acre			10.69								
Crop Oil Concentrate (adjuvant)				oz/acre		12.87	31.50								
Atrazine				oz/acre				45.72							
Input Costs															
Seed	$15.00	$/lb	5.6259	lbs/acre		$84.39									
Fertalizer (Costs)															
Urea N	$0.63	$/lb.					$25.36	$31.55	$31.55	$31.55	$31.55	$31.55	$31.55	$31.55	$31.55
Phosphorus P	$0.67	$/lb.					$39.30				$39.30				
Potassium K	$0.50	$/lb.					$125.26				$125.26				
Lime	$0.05	$/lb.				$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93
Chemicals															
Glyphosate	$0.11	$/oz				$2.46									
2,4-D LV Ester	$0.23	$/oz				$3.33									
Clarity (dicambia)	$0.69	$/oz					$7.39								
Crop Oil Concentrate (adjuvant)	$0.08	$/oz				$1.01	$2.46								
Atrazin	$0.12	$/oz						$5.43							
Total ($/acre)						$107.12	$215.71	$47.48	$47.48	$47.48	$212.05	$47.48	$47.48	$47.48	$47.48
Total ($/ton)						$52.78	$54.72	$19.89	$15.00	$17.21	$64.22	$14.38	$14.38	$14.38	$14.38
Summary of Input Costs															
Input Costs/Acre PV Years 1-10	$772.00														
Amortized Input Costs/Acre Years 1-10	$92.35														
Total Tons produced over Years 1-10	30.8														
Input Cost/Ton of PV Years 1-10	$25.07														
Field Operations Costs															
Planting (Drill) without Fert (Year 1 Only)	$12.46	$/acre				$12.46									
Fertilizer (Broadcast)	$5.39	$/acre					$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Chemical (Spray)	$5.53	$/acre				$5.53	$5.53	$5.53							
Total ($/acre)						$17.99	$10.92	$10.92	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Total ($/ton)						$8.86	$2.77	$4.57	$1.70	$1.95	$1.63	$1.63	$1.63	$1.63	$1.63
Summary of Field Operation Costs															
Field Operations Cost/Acre PV Years 1-10	$69.71														
Amortized Field Operations Cost/Acre Years 1-10	$8.34														
Total Tons produced over Years 1-10	30.8														
Field Operations Cost/Ton PV Years 1-10	$2.26														
Harvest Costs (Years 2-10, 13-22)															
Swathing	$14.00	$/acre				$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00
Sideraking	$7.00	$/acre				$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00	$14.00
Baling	$14.00	$/bale				$49.41	$95.98	$58.14	$77.06	$67.16	$80.39	$80.39	$80.39	$80.39	$80.39
Stacking	$4.00	$/bale				$14.12	$27.42	$16.61	$22.02	$19.19	$22.97	$22.97	$22.97	$22.97	$22.97
Harvest Cost															
Total ($/acre)						$91.53	$151.40	$102.75	$127.08	$114.35	$131.36	$131.36	$131.36	$131.36	$131.36
Total ($/ton)						$45.10	$38.41	$43.03	$40.15	$41.45	$39.78	$39.78	$39.78	$39.78	$39.78
Summary of Harvest Costs															
Harvest Cost/Acre PV Years 1-10	$1,069.45														
Amortized Harvest Cost/Acre Years 1-10	$127.93														
Total Tons produced over Years 1-10	30.8														
Harvest Cost/Ton PV Years 1-10	$34.73														
Interest on Operating Costs	6.50%	%/year				$7.04	$12.29	$5.24	$5.85	$5.43	$11.34	$5.99	$5.99	$5.99	$5.99
Total ($/acre)						$7.04	$12.29	$5.24	$5.85	$5.43	$11.34	$5.99	$5.99	$5.99	$5.99
Total ($/ton)						$3.47	$3.12	$2.19	$1.85	$1.97	$3.43	$1.81	$1.81	$1.81	$1.81
Land Charge															
Rental rate ($/acre) (Medium Land)						$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00
Total Costs															
Total ($/acre)						$299.67	$466.31	$242.39	$261.80	$248.66	$436.14	$266.22	$266.22	$266.22	$266.22
Total ($/ton)						$147.67	$118.29	$101.51	$82.72	$90.14	$132.09	$80.63	$80.63	$80.63	$80.63
Summary of Costs				Total ($/acre)		$299.67	$466.31	$242.39	$261.80	$248.66	$436.14	$266.22	$266.22	$266.22	$266.22
Total Cost/Acre PV Years 1-10	$2,630.18														
Amortized Total Cost/Acre Years 1-10	$314.63														
Total Tons produced over Years 1-10	30.8														
Total Cost/Ton PV Years 1-10	$85.42														
Price Received $/Ton FOB				Price ($/ton)	$	140.00	$140.00	$140.00	$140.00	$140.00	$140.00	$140.00	$140.00	$140.00	$140.00
Revenue				Total ($/acre)	$	284.11	$551.88	$334.30	$443.09	$386.18	$462.25	$462.25	$462.25	$462.25	$462.25
Summary of Revenue				Total ($/acre)		$284.11	$551.88	$334.30	$443.09	$386.18	$462.25	$462.25	$462.25	$462.25	$462.25
Revenue/Acre PV Years 1-10	$3,700.46														
Amortized Revenue/Acre Years 1-10	$442.66														
Total Tons produced over Years 1-10	30.8														
Revenuet/Ton PV Years 1-10	120.1783														
Summary of Net Return				Total ($/acre)		-$15.56	$85.57	$91.91	$181.29	$137.52	$26.11	$196.03	$196.03	$196.03	$196.03
Net Return/Acre PV Years 1-10	$1,070.28			Total ($/ton)	$	(7.67)	$ 21.71	$ 38.49	$ 57.28	$ 49.86	$ 7.91	$ 59.37	$ 59.37	$ 59.37	$ 59.37
Amortized Net Return/Acre Years 1-10	$128.03														
Total Tons produced over Years 1-10	30.8														
Net Return/Ton PV Years 1-10	$34.76														
Nominal Discount Rate (annual)	6.50%														
Inflation (annual)	3.00%														
Real Discount Rate (annual)	3.40%														
http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.aspx			2.90%												

Table D. 10 The Alfalfa Enterprise Budget

Grass Budget														
Alfalfa		**Number of Years**	**10**											
					Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
					Biomass Removal tons/acre									
Yield														
Yield (tons/acre)					3.0	4.4	3.7	4.0	3.8	3.5	3.5	3.5	3.5	3.5
Applications														
Urea N				lbs/acre										
Phosphorus P				lbs/acre	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Potassium K				lbs/acre	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Lime				lbs/acre	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00	333.00
Chemicals														
Pursuit				oz/acre	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Warrior 1EC				oz/acre	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
				oz/acre										
				oz/acre										
				oz/acre										
Input Costs														
Seed	$4.43	$/lb	3	lbs/acre	$13.29									
Fertalizer (Costs)														
Urea N	$0.63	$/lb.												
Phosphorus P	$0.67	$/lb.			$26.72	$26.72	$26.72	$26.72	$26.72	$26.72	$26.72	$26.72	$26.72	$26.72
Potassium K	$0.50	$/lb.			$30.18	$30.18	$30.18	$30.18	$30.18	$30.18	$30.18	$30.18	$30.18	$30.18
Lime	$0.05	$/lb.			$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93	$15.93
Chemicals														
Pursuit	$3.81	$/oz			$4.57	$4.57	$4.57	$4.57	$4.57	$4.57	$4.57	$4.57	$4.57	$4.57
Warrior 1EC	$1.77	$/oz			$5.31	$5.31	$5.31	$5.31	$5.31	$5.31	$5.31	$5.31	$5.31	$5.31
		$/oz			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
		$/oz			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
		$/oz			$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total ($/acre)					$96.00	$82.71	$82.71	$82.71	$82.71	$82.71	$82.71	$82.71	$82.71	$82.71
Total ($/ton)					$31.94	$18.85	$22.50	$20.51	$21.52	$23.35	$23.35	$23.35	$23.35	$23.35
Summary of Input Costs														
Input Costs/Acre PV Years 1-10	$728.19													
Amortized Input Costs/Acre Years 1-10	$87.11													
Total Tons produced over Years 1-10	36.7													
Input Cost/Ton of PV Years 1-10	$19.87													
Field Operations Costs														
Planting (Drill) without Fert (Year 1 Only)	$12.46	$/acre			$12.46									
Fertilizer (Broadcast)	$5.39	$/acre			$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Chemical (Spray)	$5.53	$/acre			$5.53									
Total ($/acre)					$23.38	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39	$5.39
Total ($/ton)					$7.78	$1.23	$1.47	$1.34	$1.40	$1.52	$1.52	$1.52	$1.52	$1.52
Summary of Field Operation Costs														
Field Operations Cost/Acre PV Years 1-10	$64.58													
Amortized Field Operations Cost/Acre Years 1-10	$7.73													
Total Tons produced over Years 1-10	36.7													
Field Operations Cost/Ton PV Years 1-10	$1.76													
Harvest Costs (Years 2-10, 13-22)			# of cutting:	4										
Swathing	$14.00	$/acre			$42.00	$56.00	$56.00	$56.00	$56.00	$56.00	$56.00	$56.00	$56.00	$56.00
Sideraking	$7.00	$/acre			$21.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00	$28.00
Baling	$14.00	$/bale			$42.00	$74.46	$62.38	$68.42	$65.23	$60.10	$60.10	$60.10	$60.10	$60.10
Stacking	$4.00	$/bale			$12.00	$21.28	$17.82	$19.55	$18.64	$17.17	$17.17	$17.17	$17.17	$17.17
Harvest Cost														
Total ($/acre)					$117.00	$179.74	$164.20	$171.97	$167.87	$161.27	$161.27	$161.27	$161.27	$161.27
Total ($/ton)					$38.92	$40.96	$44.67	$42.65	$43.67	$45.54	$45.54	$45.54	$45.54	$45.54
Summary of Harvest Costs														
Harvest Cost/Acre PV Years 1-10	$1,385.74													
Amortized Harvest Cost/Acre Years 1-10	$165.77													
Total Tons produced over Years 1-10	36.7													
Harvest Cost/Ton PV Years 1-10	$37.81													
Interest on Operating Costs	6.50%	%/year			$7.68	$8.70	$8.20	$8.45	$8.32	$8.10	$8.10	$8.10	$8.10	$8.10
Total ($/acre)					$7.68	$8.70	$8.20	$8.45	$8.32	$8.10	$8.10	$8.10	$8.10	$8.10
Total ($/ton)					$2.56	$1.98	$2.23	$2.10	$2.16	$2.29	$2.29	$2.29	$2.29	$2.29
Land Charge														
Rental rate ($/acre) (Medium Land)					$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00	$76.00
Total Costs														
Total ($/acre)					$320.06	$352.54	$336.50	$344.52	$340.29	$333.47	$333.47	$333.47	$333.47	$333.47
Total ($/ton)					$106.47	$80.34	$91.54	$85.45	$88.52	$94.16	$94.16	$94.16	$94.16	$94.16
Summary of Costs				Total ($/acre)	$320.06	$352.54	$336.50	$344.52	$340.29	$333.47	$333.47	$333.47	$333.47	$333.47
Total Cost/Acre PV Years 1-10	$2,906.22													
Amortized Total Cost/Acre Years 1-10	$347.65													
Total Tons produced over Years 1-10	36.7													
Total Cost/Ton PV Years 1-10	$79.29													
Price Received $/Ton FOB				Price ($/ton)	$180.27	$180.27	$180.27	$180.27	$180.27	$180.27	$180.27	$180.27	$180.27	$180.27
Revenue				Total ($/acre)	$541.90	$791.04	$662.68	$726.86	$693.00	$638.44	$638.44	$638.44	$638.44	$638.44
Summary of Revenue				Total ($/acre)	$541.90	$791.04	$662.68	$726.86	$693.00	$638.44	$638.44	$638.44	$638.44	$638.44
Revenue/Acre PV Years 1-10	$5,719.81													
Amortized Revenue/Acre Years 1-10	$684.23													
Total Tons produced over Years 1-10	36.7													
Revenuet/Ton PV Years 1-10	156.0503													
Summary of Net Return				Total ($/acre)	$221.84	$438.49	$326.18	$382.34	$352.71	$304.96	$304.96	$304.96	$304.96	$304.96
Net Return/Acre PV Years 1-10	$2,813.60			Total ($/ton)	$ 73.80	$ 99.93	$ 88.73	$ 94.83	$ 91.75	$ 86.11	$ 86.11	$ 86.11	$ 86.11	$ 86.11
Amortized Net Return/Acre Years 1-10	$336.57													
Total Tons produced over Years 1-10	36.7													
Net Return/Ton PV Years 1-10	$76.76													
Nominal Discount Rate (annual)	6.50%													
Inflation (annual)	3.00%													
Real Discount Rate (annual)	3.40%													
http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.aspx		2.90%												