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Evaluation of Breakeven Farm-gate Switchgrass Prices in South Central North Dakota

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A key provision of current U.S. energy policy is to increase domestic ethanol production over the next decade. A renewable fuel standard within current federal policy sets a timeline for the production or introduction into the marketplace for ethanol and other liquid renewable fuels. Policymakers recognized that grain or starch-based ethanol cannot meet the future level of renewable fuel targets in the U.S., so current domestic energy policies have placed substantial emphasis on developing cellulosic biomass as a feedstock for renewable fuel production.

The conversion of cellulosic biomass to ethanol is not yet commercially viable; however, considerable research and development is currently underway to commercialize the technologies (Kotrba 2008). Crop residues (e.g., corn stover, wheat straw), dedicated energy crops (e.g., perennial grasses), and wood products are among the leading feedstocks touted as viable candidates for cellulosic or lignocellulosic ethanol production.

Switchgrass, a warm-season perennial grass, native to the region, has received considerable interest for its potential role as a dedicated feedstock for cellulosic-based bio-fuels. In an effort to aid policymakers and industry leaders in moving forward on the viability of dedicated energy crops in the upper Great Plains, potential supply and cost of acquiring those feedstocks must be evaluated. Although research is beginning to reveal price scenarios under which switchgrass is competitive with traditional crops in some regions of the Upper Midwest, equivalent information is lacking for North Dakota.

METHODS

Two different perspectives to evaluating farm-gate prices for switchgrass were conducted. The first analysis calculates farm-gate prices that would be needed for switchgrass to be competitive with net returns from traditional crops based on different levels of producer profitability. The second analysis calculates farm-gate prices that would be needed for switchgrass to be competitive with net returns from traditional crops based on different levels of soil productivity.

Study Region

Geographic scope of the study was limited to a three-county area in south central North Dakota (Figure 1). The counties of Logan, Kidder, and Stutsman were selected to correspond with the agronomic conditions near the Central Grasslands Research Extension Center (CGREC) in Streeter, North Dakota.

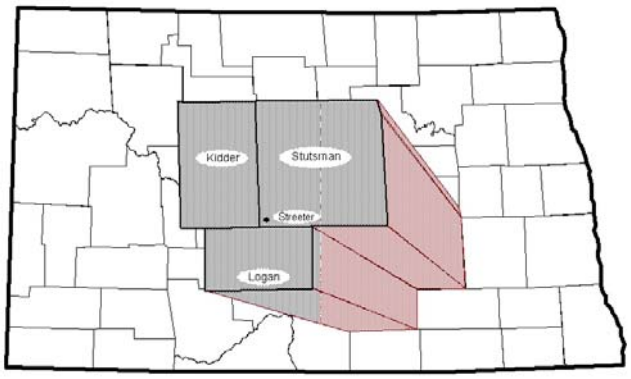

Figure 1. Study Region, South Central North Dakota

Traditional Crops

A composite acre was developed for comparing switchgrass to a mix of traditional crops raised in the region. The composite acre was comprised of soybeans (32 percent), spring wheat (27 percent), alfalfa (17 percent), corn (10 percent), sunflowers and barley (7 percent each).

Breakeven Price Calculation

Both the producer profitability and the soil productivity approaches produced crop budgets and switchgrass budgets from 2008 through 2017. Over that period per-acre costs, yields, and prices changed for most crops. The study used an annualized equivalent approach to handle the time value effects of changes in costs and returns over the 10-year period (Perrin 1972). This procedure required discounting and summing the annual stream of switchgrass costs and net returns from crop production. An average annualized value for switchgrass costs and net returns from crops was then generated. Finally, the average annualized value was divided by switchgrass yield to arrive at a breakeven price.

Producer Profitability Budgets

Essentially, not all producers average the same level of net returns per acre over their crop enterprises. Differences in debt, size, managerial ability, soils, and other factors cause the profitability of crop production to vary considerably from producer to producer within the study region. Budgets were generated to account for those differences based on information obtained from the FINBIN database of farm production records (Center for Farm Financial Management 2008).

Trends in past production expenses, trends in crop yields, and future crop price projections were used to develop a typical or average profitability budget for each crop. Those budgets were then adjusted to reflect the historical revenue and cost patterns associated with producers who are typically more or less profitable (i.e., based on an average net return per acre) than regional averages.

Establishment-year and production-year switchgrass budgets were based on the type and amount of inputs and type and frequency of field operations performed during the plot trials at the CGREC. Machinery costs, net of operator labor charges, were based on data from Aakre (2007) and Lazarus (2007).

The establishment budget for switchgrass also included the foregone net return (i.e., opportunity costs) from raising a crop during the year of establishment. The costs of establishing switchgrass were amortized over 10 annual years at 5 percent interest and included as an expense in the production budgets.

Soil Productivity Budgets

The premise for this approach is that switchgrass might have a competitive advantage over traditional crops when raised on low productivity soils. Since trial data for switchgrass yields and farm financial records for traditional crops were not available for different soil productivity levels, budget generators and soil data were used to estimate crop revenues, production expenses, and net returns on three classes of soil productivity, holding all other parameters constant (e.g., managerial skill, producer profitability).

The NDSU Extension Crop Budget Generator was used to generate crop and switchgrass enterprise budgets for 2008 based on production assumptions for farm debt, machinery complement, production practices, field operations, and input prices (Swenson and Haugen 2007). Budgets were generated using an anticipated average yield for each soil productivity class. The annual nominal change in per-acre production expenses for the NDSU projected crop budgets for the South Central region was averaged from 1993 through 2008. The average annual change in expenses, expressed in dollars per acre, was used to increase production expenses for the crop budgets from 2009 through 2017.

An establishment budget for switchgrass was based on 2007 input prices and reflected the general assumptions used to produce the 2007 NDSU projected budgets (Swenson and Haugen 2006). The opportunity cost of foregone net revenues from traditional crops during the establishment year was estimated using data from Swenson and Haugen (2006). The overall net cost of establishing switchgrass was amortized for a 10-year period and included as an annual expense in the 2008 through 2017 annual production budgets.

Trends in crop yields reported by NDASS from 1992 to 2006 in the study counties were examined. Only corn and soybean yields exhibited statistically significant time trends in yields over the 15-year period. Corn and soybean yields (i.e., yields in 2008) were adjusted annually from 2009 through 2017 using the yield trend from 1992 to 2006. Future yields for the remaining crops were held at the 2008 level for the 2009 through 2017 period.

Crop Prices

Crop prices for production year 2008 were based on average new crop farm prices in April of 2008 (South Central Grain 2008). Projected future national crop prices from 2009 through 2017 were obtained from the Food and Agriculture Policy Research Institute (2008) and Taylor and Koo (2008) and adjusted to reflect anticipated prices received by producers within the study region.

Defining Soil Productivity Groups

Soil data for the study region were obtained from the National Cooperative Soil Survey (Natural Resources Conservation Service 1995, 2004; Soil Conservation Service 1986). Soil map units, which can represent a soil series, a soil phase, or a soil complex, generally fall into eight different land capability classifications. Those classifications, along with land capability subclasses (when available), were used to determine soils that represented cropland in the study region.

Soil data for cropland includes information on acreage and yield potential. Yield potential represented an expected yield under normal growing conditions with a 'high level of management.' Yield potentials therefore directly reflect the inherent site-specific factors affecting soil productivity and thus represent a relative measure of productivity given a fixed level of technology. Yield potentials were used to sort soils based on a common productivity criterion.

Objective measures, in an economic context, of what constitutes a marginal or low productivity soil or an expected yield from a 'marginal' soil were not found in soil or economic literature. Therefore, average crop yields were used as a reference for defining marginal and productive soils. However, delineating how much less/more than average any particular soil would need to be for it to be considered marginal or highly productive remains subjective.

Soils producing spring wheat yields within five bushels (roughly +/- 15 percent) of the regional average were considered to be of average productivity. Once the range of yields for average productivity soils was determined, all soils with expected yields that were below the lower range of average productivity soils would constitute marginal soils. The same would hold for high productivity soils having expected yields that exceed the upper bound of yields for average soils.

The ratio between expected yields from the soil data and actual average yields in the study counties was used to generate yield estimates reflecting different soil productivity for use in the crop budgets. The end result created typical yields for wheat, corn, soybeans, barley, sunflowers, and alfalfa on marginal, average, and productive soils (Table 1). A similar approach was used to differentiate switchgrass yields based on soil data for alfalfa.

RESULTS

Soil Productivity Analysis

Yields for switchgrass were estimated to range from an average of 2.67 tons per acre in marginal soils to 3.5 tons per acre in the high productivity soils (Table 2). Switchgrass production costs ranged from just over $40 per ton in marginal soils to $34.80 per ton in productive soils, but did not include land charges or transportation expenses beyond the field. Breakeven switchgrass prices were estimated as the price required to cover switchgrass production expenses and provide for the same level of net return from traditional crops. Breakeven switchgrass prices across the three soil productivity classes ranged from $47 per ton in the low productivity soils to $76 per ton in the most productive soils (Table 2). Switchgrass generated the same level of net returns per acre on average soil productivity with a farm-gate price of $67 per ton (Table 2).

Table 1. Estimated Yields on Marginal, Average, and High Productivity Soils, Kidder, Logan, and Stutsman Counties, North Dakota, 2004 Through 2006

		Marginal			Average			High		
Crop	Category	Lower	Avg[a]	Upper	Lower	Avg[a,b]	Upper	Lower	Avg[a]	Upper
Wheat	Yield Potential (Soil Data)	8.0	15.8	21.4	21.4	25.2	28.2	28.2	32.8	40.0
	Estimated Actual Yields[c]	na	20.8	28.1	28.1	33.1	38.1	38.1	43.8	na
Barley	Yield Potential (Soil Data)	13.0	25.7	34.0	34.0	40.7	47.0	47.0	54.0	65.0
	Estimated Actual Yields[c]	na	35.5	na	na	56.2	na	na	74.5	na
Sunflowers	Yield Potential (Soil Data)	400.0	790.8	1,050.0	1,050.0	1,262.0	1,500.0	1,500.0	1,659.0	2,000.0
	Estimated Actual Yields[c]	n	778.0	na	na	1,241.6	na	na	1,632.2	na
Alfalfa	Yield Potential (Soil Data)	na	1.86	na	na	2.09	na	na	2.44	na
	Estimated Actual Yields[c]	na	1.57	na	na	1.76	na	na	2.06	na
Soybeans	Estimated Actual Yields[c,d]	na	19.0	na	na	30.3	na	na	39.8	na
Corn	Estimated Actual Yields[c,d]	na	55.5	na	na	89.6	na	na	116.5	na
Switchgrass	Estimated Actual Yields[c,e]	na	2.67	na	na	3.01	na	na	3.51	na

na = not available or not applicable.

[a] Weighted by acreage of each soil type.

[b] Yield potential for each crop represents weighted average for study region.

[c] Actual yields for average productivity soils represent average yields for the entire region from 2004 through 2006 (NDASS 2005-2007). Estimated actual yields for marginal and high productivity soils were estimated from ratio of expected yields (soil data) on marginal soils to expected yields on average soils multiplied by county average yield.

[d] Corn and soybean yields on marginal and high productivity soils estimated by adjusted county average yield by ratios for sunflower yields.

[e] Central Grasslands Research Extension Center trial research data adjusted based on soil productivity factors for alfalfa.

Table 2. Switchgrass Yields, Production Costs, and Breakeven Farm-gate Prices, by Soil Productivity Class, Baseline Conditions, South Central North Dakota, 2008 through 2017

Soil Productivity Class	Switchgrass		Net Return on Composite Acre[a]	Breakeven Switchgrass Price
	Yield	Production Cost[a]		
	tons/acre	--- $/ton ---	--- $/acre ---	--- $/ton ---
Low	2.67	40.26	18.40	47.14
Average	3.01	38.27	86.40	67.02
High	3.51	34.80	145.27	76.16

[a] Production cost does not include land charges. Net returns are defined as returns to operator labor, management, equity, and land. Values represent an average annualized equivalent from 2008-2017. Discount rate was 5 percent.

Producer Profitability Analysis

Switchgrass yields for the farm profitability groups were estimated to range from 2.5 tons per acre for the lowest profitability producers to about 3.9 tons per acre for the most profitable producers. A difference of about 1.4 tons per acre separated the five producer profitability groups (Table 3).

Average switchgrass production expenses were adjusted among the five producer profitability groups based on the historic difference in variable and fixed production expenses among the profitability groups. The results suggest that low-profit producers would have per unit costs that substantially exceed the average cost for the region–$47 per ton compared to the regional average of $37.50 per ton. Switchgrass production costs for the remaining groups ranged from about $33.50 per ton to about $36.75 per ton (Table 3).

Projections of net returns from traditional crops varied considerably among the profitability groups (Table 3). The average annualized net return for the region was estimated to be about $123 per acre from 2008 to 2017, with net returns varying from around $22 per acre for the low-profit producers to over $230 for the most profitable producers. The breakeven switchgrass price ranged from $56 per ton for the two lowest profitability groups to over $94 per ton for the most profitable producers. Generally, as producer profitability increased, switchgrass yields increased, per unit production costs decreased, net returns from traditional crops increased, and breakeven switchgrass prices increased. It appeared that reductions in production cost associated with the higher profitability groups was overshadowed by much higher net returns from traditional crops which equated to considerable differences in breakeven switchgrass prices among the producer groups (Table 3).

Table 3. Switchgrass Yields, Production Costs, and Breakeven Farm-gate Prices, based on Producer Profitability Classes, Baseline Conditions, South Central North Dakota, 2008 through 2017

Profitability Class	Switchgrass		Net Return on Composite Acre[a]	Breakeven Switchgrass Price
	Yield	Production Cost[a]		
	--- tons/acre ---	--- $/ton ---	--- $/acre ---	--- $/ton ---
Average	3.01	37.58	122.81	75.75
Low 20%	2.53	47.25	21.59	55.79
20-40%	2.66	33.47	87.76	66.44
40-60%	2.77	36.26	92.82	69.71
60-80%	3.23	36.73	179.26	92.29
Top 20%	3.86	34.20	232.63	94.50

[a] Production cost does not include land charges. Net returns are defined as returns to operator labor, management, equity, and land. Values represent an average annualized equivalent from 2008-2017. Discount rate was 5 percent.

Alternative Scenarios

Several components of the analysis were varied to determine the sensitivity of breakeven switchgrass prices to changes in default values. Changes in commodity prices, switchgrass yields, and expected costs were examined.

Switchgrass Yields

Data on switchgrass yields in the region remain sparse. Very little is known about yields across different soil types or alternative management regimes. Switchgrass yields were adjusted in both the soil productivity and producer profitability analyses (Tables 4 and 5).

Production costs, on a per-acre basis, did not appear to be overly impacted with the yield changes modeled, at least not over the range of alternative yields used in each soil class. However, relatively minor yield changes had noticeable effects on breakeven prices
(Table 4). For example, a 0.17 ton per-acre yield reduction on marginal soils raised the breakeven price by $2.70 per ton. A 0.24 ton per-acre yield difference on the average productivity soils resulted in over a $5 per ton change in breakeven price. A similar decline in yield on the high productivity soils resulted in similar changes in the switchgrass breakeven price.

Table 4. Switchgrass Yields, Production Costs, and Breakeven Farm-gate Prices, by Soil Productivity Class, with Alternative Switchgrass Yields, South Central North Dakota, 2008 through 2017

Soil Productivity Class	Switchgrass		Net Return on Composite Acre[b]	Breakeven Switchgrass Price
	Yield	Production Cost[a]		
	--- tons/acre ---	--- $/ton ---	--- $/acre ---	--- $/ton ---
Low	2.50	42.47	18.40	49.83
Low (baseline)	2.67	40.26	18.40	47.14
Low	2.75	39.30	18.40	45.99
Average	2.75	41.14	86.40	72.56
Average (baseline)	3.01	38.27	86.40	67.02
Average	3.25	35.99	86.40	62.57
High	3.25	37.00	145.27	81.70
High (baseline)	3.51	34.80	145.27	76.16
High	3.75	33.08	145.27	71.82

[a] Production costs among different soil productivity groups will differ even with the same switchgrass yield due to unequal foregone net returns during establishment year. Foregone net returns increased with improvements in soil productivity. Thus, unequal establishment costs produce different per-unit production costs across soil classes that have the same yield.

[b] Net returns are defined as returns to operator labor, management, and land. Values represent an annualized equivalent from 2008-2017. Discount rate was 5 percent. Composite acre represents the average crop rotation in the study region expressed on a per-acre basis.

A decrease in the regional switchgrass yield from 3 tons per acre to 2.75 tons per acre increased breakeven switchgrass prices about $4.50 per ton for the lowest profitability group and over $8 per ton for the highest profitability group (Table 5). An increase in regional switchgrass yield from 3 tons per acre to 3.25 tons per acre decreased breakeven switchgrass price about $3.50 per ton for the lowest profitability group and about $6.50 per ton for the highest profitability group.

Table 5. Switchgrass Yields, Production Costs, and Breakeven Farm-gate Prices, based on Producer Profitability Classes, Alternative Switchgrass Yields, South Central North Dakota, 2008 through 2017

Profitability Class	Switchgrass		Net Return on Composite Acre[a]	Breakeven Switchgrass Price
	Yield	Production Cost		
	--- tons/acre ---	--- $/ton ---	--- $/acre ---	--- $/ton ---
Average (default)	3.01	37.58	122.81	75.75
Low 20%	2.53	47.25	21.59	55.79
40-60%	2.77	36.26	92.82	69.71
Top 20%	3.86	34.20	232.63	94.50
	---------- decrease in expected switchgrass yields ----------			
Average	2.75	40.56	122.81	82.33
Low 20%	2.31	51.03	21.59	60.37
40-60%	2.54	39.11	92.82	75.73
Top 20%	3.52	36.88	232.63	102.87
	---------- increase in expected switchgrass yields ----------			
Average	3.25	35.26	122.81	70.60
Low 20%	2.73	44.30	21.59	52.21
40-60%	3.00	34.03	92.82	65.01
Top 20%	4.17	32.11	232.63	87.95

[a] Net returns are defined as returns to operator labor, management, equity, and land. Values represent an annualized equivalent from 2008-2017. Discount rate was 5 percent.

Alternative Prices

Forecasting prices is problematic, especially given recent structural changes in domestic demand for corn, which has in turn affected prices for crops that must compete with corn for acreage. Forecasted prices were uniformly increased and decreased to examine how the breakeven price of switchgrass is affected by changes in future commodity prices.

Commodity prices for 2008 were left unchanged from the baseline analysis since forward contracts and other pricing options would allow farmers to lock in prices for the 2008 production year. Annual commodity

prices from 2009 through 2017 were increased and decreased by 10 percent.

The effects of reducing future commodity prices by 10 percent produced lower breakeven prices for switchgrass as net returns from competing crops decreased. The decrease in net returns for traditional crops reduced breakeven prices by $4.80 per ton for low productivity soils to about $7.40 per ton for high productivity soils. With commodity price increases of 10 percent, breakeven switchgrass prices increased by the same magnitude, on a per-ton basis, as the effects associated with a 10 percent decrease in commodity prices.

Changes in the Default Rate of Cost Increases

An increase in the default rate of change for variable and fixed expenses, without adjusting commodity prices or yields, raised production costs for switchgrass and decreased net returns for traditional crops relative to the baseline. The combined changes lowered the breakeven prices for switchgrass across all soil productivity groups by less than $0.50 per ton. Breakeven prices also changed little (less than $1 per ton) when variable and fixed expenses were modeled to increase 10 percent less than default rates.

The effects of increasing and decreasing the rate of change in future variable and fixed expenses in the producer profitability analysis also resulted in relatively small changes in breakeven switchgrass prices. The magnitude of change in breakeven switchgrass prices were generally less than $1 per ton across all profitability groups.

DISCUSSION and CONCLUSION

The study results clearly showed that the economic competitiveness of switchgrass will be influenced by several factors. The difference between this study and much of the economic work on switchgrass to date was the requirement that switchgrass generate the same level of net returns that could be obtained from traditional crops.

This study calculated the breakeven price for switchgrass that covered production costs and matched the net returns from traditional crop production. However, farmers may decide to produce switchgrass for a price that does not generate a net return equal to traditional crops. Or, conversely, some producers may require that switchgrass provide a net return above what they could obtain from traditional crops. While economists like to focus on net returns or other measures of profitability when evaluating producers' decisions for which farm enterprises to adopt, decisions on what crops to raise are based on more than just net returns. Factors such as yield and income risk, crop rotations, soil characteristics, personal preference, production knowledge, financial and labor constraints, and other factors (e.g., whether the producer has livestock) often are important determinants in choosing farm enterprises. Currently, much is unknown about how these other factors may influence producers' willingness to raise dedicated energy crops.

Assuming producers will require a return from switchgrass that is at a minimum, close to net returns from traditional crop production, changes in future commodity prices will also influence prices farmers are willing to accept to produce switchgrass. Therefore, increases in commodity prices due to starch-based ethanol demand and/or bio-

diesel demand have the potential to increase the farm-gate breakeven price for switchgrass.

A better understanding of fertilization management would greatly improve the budgeting process for switchgrass. Fertilizer has increased in cost considerably in recent years, and represented the largest single variable input cost in the switchgrass budgets. Fertilization influences costs, but also has the ability to influence yields. Hopefully, future research will provide insights on the trade-offs associated with fertilization cost and yield response.

The breakeven prices presented in this study should be considered preliminary given the paucity of switchgrass yield data, the unknowns with fertilization and yield response, recent and potential future changes in input prices, and the extent of future commodity price shocks linked to bio-fuels demand. The time frame for when commercial cellulosic ethanol production from herbaceous energy crops might become mainstream or widespread is unknown, but given current knowledge and activity levels in the bio-fuels industry, the time frame is certain to be sufficiently long to require re-examining the economics of herbaceous energy crops. While the breakeven switchgrass prices presented in this study are likely to change in the future, the value of this research lies less with the specific prices presented as it does with fostering an understanding of the factors that will influence the economic competitiveness of herbaceous energy crops with traditional crops. Further, energy industry leaders, policy makers, and researchers now have additional information with which to continue evaluations of the economic viability of cellulosic ethanol.

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