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Profitability of Converting to Biofuel Crops

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A comparison of profitability of cellulosic feedstock crops — switchgrass, mixed-species grass, restored prairie, miscanthus and poplar — with corn.

Recent changes in energy markets and policy have created expectations of rising demand for biofuel crops. The 2007-08 run-up of oil prices pulled up demand for ethanol (and with it corn grain) to record levels. The 2007 Energy Independence and Security Act mandates progressive increases in the blending of ethanol and advanced biofuels into the national transportation fuel supply up to a level of 36 billion gallons annually by the year 2022. In Michigan, the 2008 Renewable Portfolio Standard requires that 10 percent of the state's electrical energy supply come from renewable sources by 2015. Eligible renewable energy sources include biomass co-fired with coal. The Obama administration's commitment late in 2009 to limit future U.S. greenhouse gas emissions can be expected to add further to demand for renewable fuels.

Although prospects for future biofuel demand look bright, farmers considering conversion of land to biofuel crop production face many uncertainties. Markets for biofuel crops are absent or just getting started. Price volatility patterns are unclear, but they are likely to differ from those in current crop commodity markets because of links to fossil fuel markets. Most of the cellulosic bioenergy crops are not commonly grown, so it will take time for growers to learn best agronomic practices and for plant breeders to develop good varieties for bioenergy yield. Also, most of these crops are perennials that take 2 or more years to reach mature yield. So crop growers face investment and cash flow risks different from those for annual crops. Many analysts expect to see new contracts designed to help producers and buyers of biofuel feedstocks manage these risks.

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The purpose of this bulletin is to explore the price and yield conditions under which alternative cellulosic bioenergy crops could become profitable enough to replace existing crops. It provides a framework for evaluating alternative crops that are potential biomass feedstocks for either co-firing or cellulosic ethanol production. Residues from the production of corn grain – cobs and stalks – make corn a promising candidate. Tallgrass crops such as switchgrass and miscanthus also show potential as high-volume production systems. Mixed stands of native grasses and restored prairies can provide significant quantities of biomass while offering improved wildlife habitat and increased biodiversity. Finally, hybrid poplar may produce comparable yields to native grasses and could be suitable for areas that will not support profitable grass production.

There are many factors for a farmer to consider before dedicating land to bioenergy crop production. Questions worth asking before planting a biofuel crop include: Do I have access to a reliable market? Do I need to invest in additional equipment or labor to plant, harvest or handle biomass? What is my cost of production? Which energy crop species fit my situation? What are the potential yield and price I need for a biofuel crop to be at least as profitable as my current crop?

This bulletin focuses on the last question and examines three measures of profitability. The first is a direct comparison of current crop profitability, based on partial enterprise budgets of annualized expenses. This provides a performance baseline for cash flow and potential net revenue. The second method is a comparative break-even price analysis that incorporates the opportunity cost of giving up earnings from continuous corn into the profitability calculation on switching to other biomass crops. This analysis calculates the price needed for a dedicated biomass crop to be as profitable as growing continuous corn and harvesting both grain and 38 percent of stover. Finally, a comparative break-even yield analysis shows the biomass yield level necessary to make a biofuel crop equally profitable to continuous corn.

Assumptions about Crop Yields, Prices and Costs of Production

These budgets are based on a series of assumptions about production cost, yield and corn grain prices, and potential biomass prices. Production cost includes the cost for planting material, pest control, fertilizer, and the necessary mechanical treatments for those applications as well as for harvest, including baling of biomass, corn drydown to 15 percent moisture content and trucking. Storage costs are not included. Average prices for 2006-08 represent the Great Lakes region (sources include the USDA National Agricultural Statistical Service, Michigan Department of Agriculture data, and consultations with Extension agents and farmers).

Corn production costs and yields are taken from the most recent MSU Extension enterprise budgets. Because of soil conditions, corn yields vary widely in Michigan. We assume an average yield of 135 bushels per acre (bu/acre). Corn prices have been volatile, especially over the past 3 years, so we use a range of corn prices from $2.50 to $4.50. The midpoint of $3.50 per bushel is close to current outlook projections by the USDA Economic Research Service.

There is little commercial production data available for switchgrass, miscanthus, poplar, mixed-grass or prairie systems in the Great Lakes region. The production assumptions and yield data are informed estimates based on recent scientific literature. Although recent scientific studies have not shown miscanthus yields to respond to nitrogen[1], we have included fertilizer applications to replace nutrients removed by

[1] See E. Heaton, T. Voight and S. Long, "A quantitative review comparing the yields of two candidate C4 perennial biomass crops in relation to nitrogen, temperature and water," Biomass and Bioenergy 27 (2004) 21-30.

harvested biomass. There is no observable market price for biomass, so we use a range of prices here as well: $30, $60 and $90 per dry ton. The low end of this range is an estimate of the price that refineries are likely able to afford; the high end reflects the 2006-08 average price for non-alfalfa hay, an alternative crop. Typical mature biomass contains 20 percent moisture, but eventual contract prices will likely be based on energy content rather than raw tonnage. (For full details on the production assumptions used in this bulletin, visit **www.bioenergy.msu.edu/economics**.)

Table 1. Summary of input and output assumptions.

Crop	Fertilizer applied?	Avg. annual yield over 10 years	Cost per acre (annualized)
Corn	yes	135 bu grain 1.4 tons stover	$ 433
Switchgrass	yes	4 tons	$ 167
Grass mix	no	3.5 tons	$ 123
Prairie	no	2.1 tons	$ 131
Miscanthus *(a)*	yes	10 tons	$ 1,302
Miscanthus *(b)*	yes	10 tons	$ 325
Poplar	no	5 tons	$ 267

(a) Costly rhizomes @ $1.80. (b) Cheap rhizomes @ 5 cents.

Comparative Profitability

These perennial biofuel crops are evaluated on a 10-year replanting cycle. The grass crops take 2 to 3 years to reach mature biomass yields, and poplar grows for the full 10 years with only one harvest. During this establishment period, input costs (especially for weed control) are relatively high. We convert all costs over a 10-year period to an annual amortized basis so that profitability can be compared with that of continuous corn. Table 2 presents the per-acre annualized net return to land, labor and management, assuming biomass prices at $30/ton, $60/ton and $90/ton. Shaded cells indicate where annualized expenses exceed annual revenues.

Table 2. Annualized net return to land, labor and management[2] ($/acre).

Crop System	$30/ton	$60/ton	$90/ton
Corn + Stover	$ 83	$ 126	$ 169
Switchgrass	$ -63	$ 34	$ 131
Grass Mix	$ -32	$ 53	$ 138
Native Prairie	$ -76	$ -25	$ 25
Misc – costly rhiz	$ -1048	$ -811	$ -574
Misc – cheap rhiz	$ -71	$ 166	$ 403
Poplar	$ -147	$ -36	$ 75

Miscanthus Rhizomes: A Special Case

The cost of miscanthus rhizomes deserves special mention. Miscanthus is propagated by rhizome and typically planted at a density of 4,050 rhizomes per acre. Current Michigan prices are about $2 per rhizome, leading to a cost of $8,100 per acre for planting material alone. Scientific literature in Europe shows the cost there to be near 5 cents per rhizome, and 2008 Michigan field research showed rapid rhizome proliferation. If U.S. rhizome prices fall to European levels, the rhizome cost drops to $202.50 per acre. Therefore, we evaluate miscanthus under two scenarios — one with costly rhizomes and one with cheap rhizomes.

When the price of biomass is low, corn is the only crop that covers its variable production costs. However, revenues for crops with higher biomass yields increase more rapidly than revenues for crops with low input costs. Stover is not a major contributor to overall revenue from a complete corn system (grain + stover) if grain sells for $3.50 per bushel, so corn revenue also increases slowly as biomass prices rise. When biomass prices reach $60 per ton, miscanthus with cheap rhizomes becomes the stand-out crop, with net

[2] Land and management costs are assumed equal across all crops and are not included in the analysis.

revenues surpassing those of all other crops, including corn. At $90 per ton, the net revenue of miscanthus with cheap rhizomes hits an impressive $403 per acre. At such a high price for biomass, switchgrass net revenues almost match those of the corn system, but each crop nets only about one-third the income from miscanthus with cheap rhizomes. Rhizome costs are such a major factor that miscanthus with costly rhizomes is the worst performer at each biomass price examined.

Comparative Break-even Price

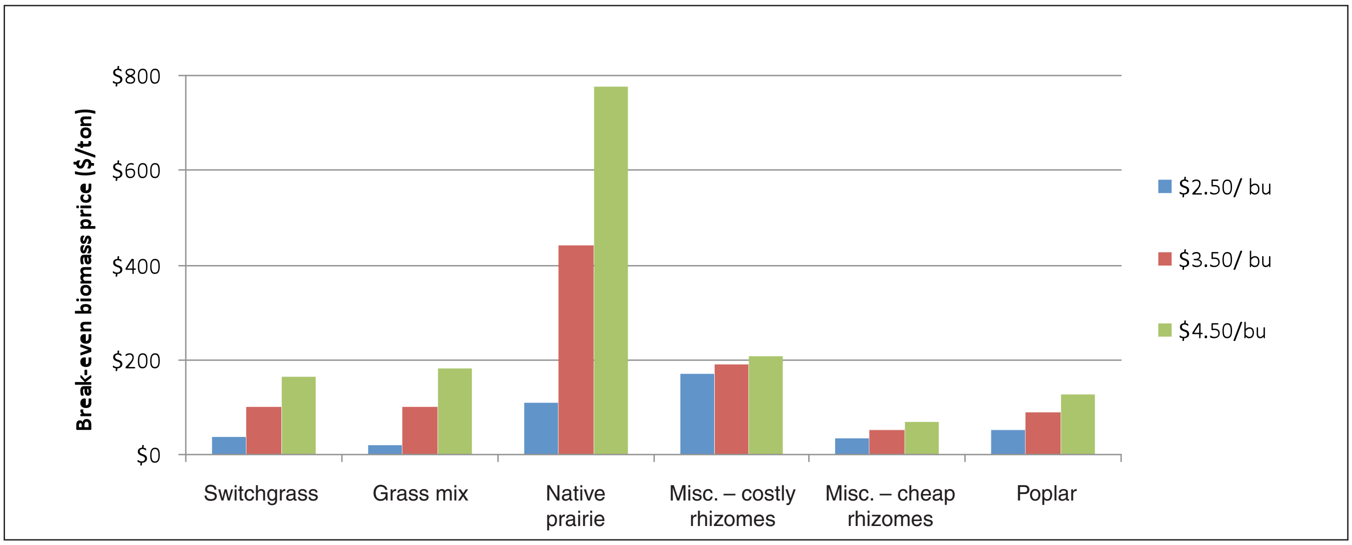
Break-even price is the price at which revenues equal costs. A **comparative** break-even price is a similar concept, but it counts as an extra cost the profit earned from the crop being replaced. A break-even price tells a farmer at what point he is covering his costs for a particular crop. A comparative break-even price tells a farmer at what point he is earning more from the new ("challenger") crop than from the old ("defender") crop. To find the comparative break-even price, the net revenue from the traditional or most likely to be planted crop is added as an expense to the new crop budget. For the grower to break even, the price must be high enough that the new crop generates revenues to cover all its expenses plus the profit the farmer would have earned planting the traditional crop.

To calculate the comparative break-even price for a biomass crop relative to corn, one needs to know the expected net revenue per acre for corn grain, the expected cost per acre for the biomass crop and the expected yield per acre for the biomass crop. We must also account for the stover that is produced by the corn system. To do this, we simply subtract the stover yield from the expected biomass yield. In this case, the comparative break-even price analysis incorporates the opportunity cost of both the corn grain and the corn stover when determining at what price a biomass crop will break even with a corn system in net revenue.

We compare the biomass-only crops to corn at corn grain prices of $3.50 per bushel, bracketed by a low price of $2.50 and a high price of $4.50/bu.

$$\text{biomass price (\$/ton)} = \frac{\text{corn grain net revenue (\$/acre)} + \text{biomass crop cost (\$/acre)}}{\text{biomass yield} - \text{stover yield (tons/acre)}}$$

Figure 1. Comparative break-even biomass prices at three corn grain prices.



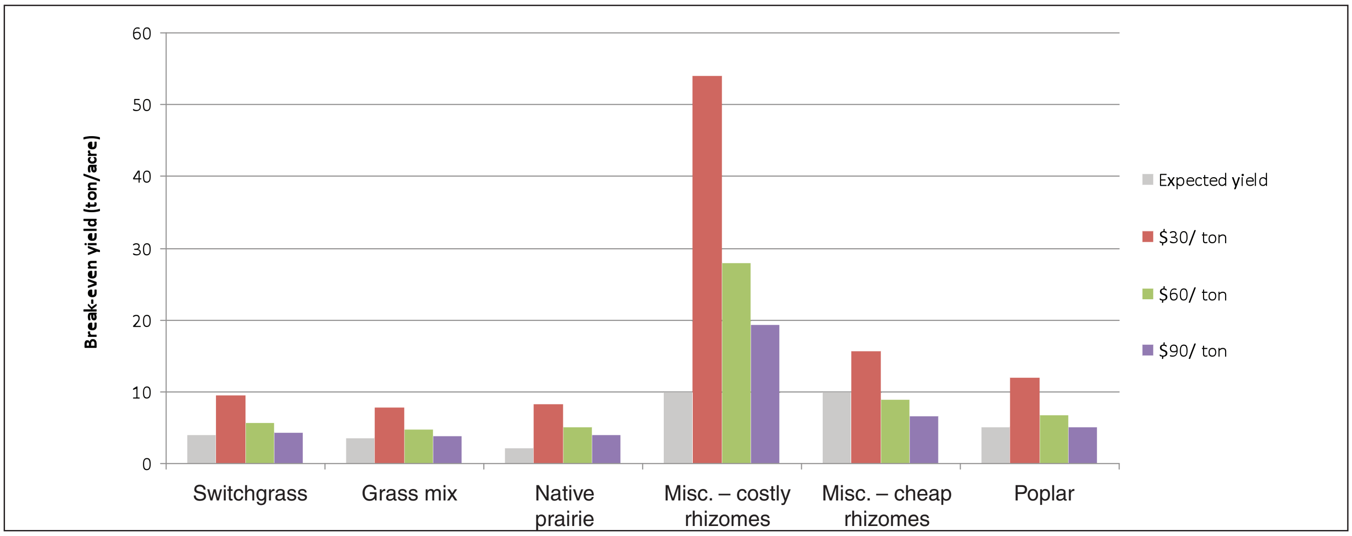
Miscanthus with cheap rhizomes again stands out as being able to break even with corn at the lowest price of biomass regardless of the corn grain price. The only other crop coming close is grass mix when corn grain is $2.50/bu. The break-even price for miscanthus with cheap rhizomes is $52 per ton at $3.50/bu corn grain, with a range from $33 to $70/ton at corn prices of $2.50 and $4.50/bu. Miscanthus with costly rhizomes, on the other hand, has a very high break-even price regardless of the price of corn. At $3.50 and $4.50 corn, native prairie requires the highest price for biomass to be a justifiable investment because it has the lowest yield of the dedicated biomass crops.

Comparative Break-even Yield

The comparative break-even yield identifies the biomass yield needed from a biofuel crop for it to be as profitable as continuous corn. Most biomass crops are still relatively unimproved by genetic engineering or traditional breeding methods, so there is potential for significant yield improvements in the near term. In addition, best production practices have yet to be precisely determined. It is reasonable to expect that yields for all biomass crops will increase as research into these crops continues, though obviously it is not certain to what extent. The important question for farmers is at what point the expected yield of a biomass crop would make it equally profitable to a corn system. The comparative break-even yield formula is similar to that used for comparative break-even price[3].

Break-even yields for selected biomass crops are presented in Figure 2. The first column for each crop shows the current expected yield. Note that, for this analysis, the corn price is held at $3.50 per bushel. At $60/ton for biomass, the break-even yield for miscanthus with cheap rhizomes is 8.8 tons/acre, well below the 10 tons/acre that

Figure 2. Comparative break-even yields at $3.50 corn grain and three biomass prices ($/ton).



[3] To calculate comparative break-even yield:

$$\text{break-even yield (tons/acre)} = \frac{\text{corn grain net revenue (\$/acre)} + \text{biomass crop cost (\$/acre)}}{\text{biomass price (\$/ton)}} + \text{stover yield (tons/acre)}$$

the crop could likely achieve in Michigan. The break-even yields for switchgrass, grass mix and poplar at that price — 5.6 tons, 4.8 tons and 6.8 tons, respectively — are possible to achieve with existing cultivars in Michigan, though only on the best soils.

Impact of Federal Subsidies for Farmers

The 2008 Farm Bill includes a provision that authorizes the USDA to create an incentive program for perennial or managed-forest cellulosic biofuel feedstocks. This program, known as the Biomass Crop Assistance Program (BCAP), was designed

Figure 3. Changes to break-even price given BCAP subsidies.

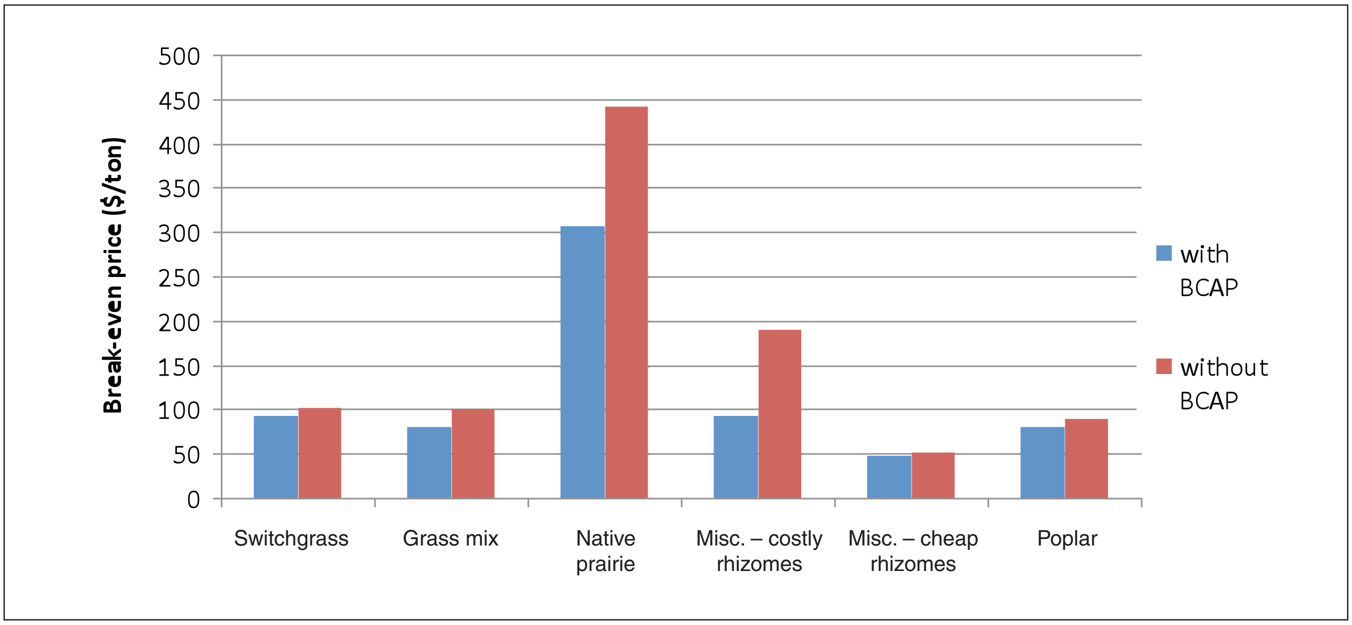
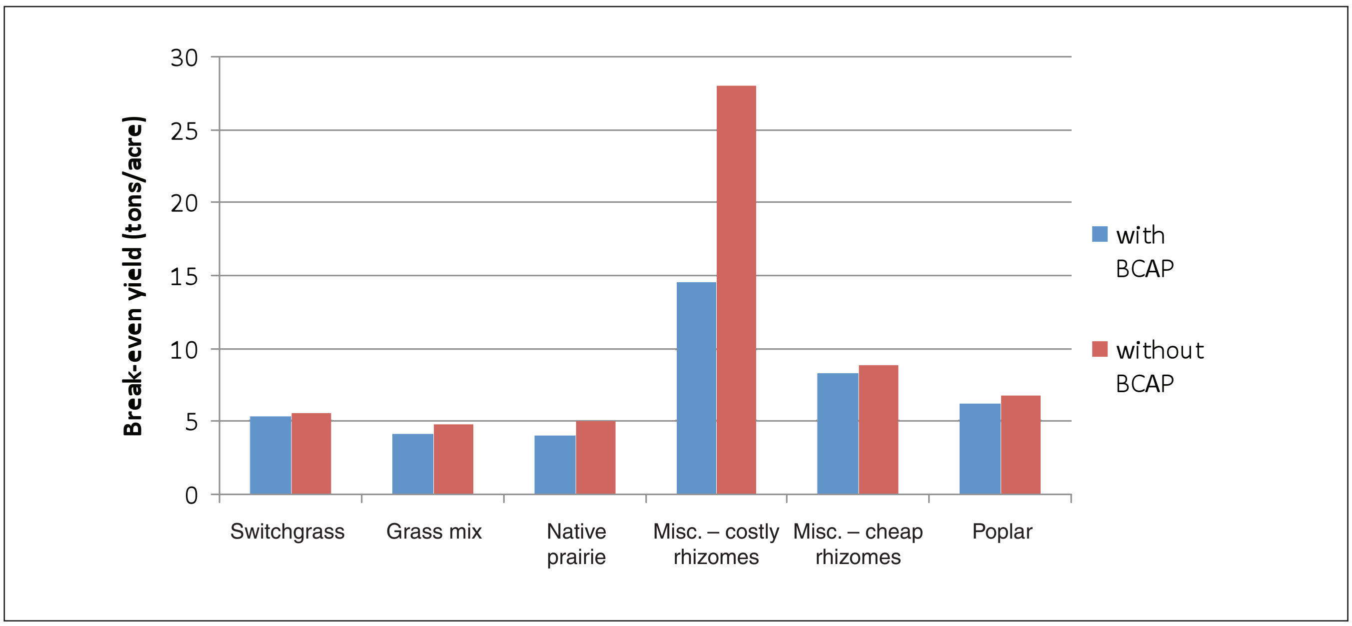


Figure 4. Changes to break-even yield given BCAP subsidies.



to have three components: a 75 percent reimbursement for certain establishment costs, an annual incentive payment, and a matching payment for biomass harvested, stored and transported to a cellulosic biofuel refinery — up to $45 per dry ton for a maximum of 2 years. Funding for some areas of this program is pending. Check with a local Farm Service Agency office or the BCAP Web site for up-to-date information. As shown in Figures 4 and 5, BCAP offers the greatest benefits for crops that have high establishment costs — namely, miscanthus with costly rhizomes and native prairie. The net present value of the matching payment does not produce a significant decrease in either break-even price or break-even yield for the remaining systems.

Bottom Line

When adapted to individual grower conditions, the break-even biomass prices and yields offered here provide benchmarks for evaluating the profitability potential of converting current cropland to bioenergy crops. Until a market develops for biomass, corn remains a better option for Michigan farmers than biofuel crops. Once a market does develop, break-even budgeting is just a first step in evaluating whether to grow these crops. Other important direct costs will include storage and new equipment needs. Contract designs and the risks that they present to growers will also deserve careful scrutiny before a grower engages in production of perennial bioenergy crops.

For more information, please consult the following references:

- James, L.K., S.M. Swinton and K.D. Thelen. "Profitability Analysis of Cellulosic Energy Crops Compared to Corn." Agronomy Journal (forthcoming in 2010).

- **www.bioenergy.msu.edu/economics/**
  This Web site has the electronic version of this bulletin as well as supplemental materials including downloadable Excel spreadsheets that you can use to customize budgets for your farm operation.
- **www.bioenergy.msu.edu/**
  This Web site provides information about recent and ongoing research in the bioenergy sector that is occurring within Michigan or is relevant to Michigan farmers and businesses.
- **www.sustainecon.msu.edu/**
  This Web site offers tools and information on budgeting for economic analysis of agricultural enterprises.
- **www.greatlakesbioenergy.org/**
  This Web site contains information on the Great Lakes Bioenergy Research Center, whose ongoing biomass crop experiments provided the framework for the research presented in this bulletin.
- **www.fsa.usda.gov/bcap**
  This Web site contains details about the Biomass Crop Assistance Program.

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