Effects of Corn Ethanol vs Switchgrass Based Biofuels in the Midwest

Silvia Secchi¹, Phillip Gassman², Manoj Jha², Lyubov Kurkalova³, and Catherine L. Kling²

¹ Department of Agribusiness Economics, Southern Illinois University Carbondale
² Center for Agricultural and Rural Development, Iowa State University
³ Department of Economics, North Carolina Agricultural and Technical State University

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Recent increases in biofuels production

- 7 billion gal vs. < 2 billion gal in 2002
- 154 biorefineries operating + 49 under construction (as of June 2008)
- EISA 2007 (latest energy bill) mandates 36 billion gal of ethanol by 2022
  - 15 from corn
  - 21 from second generation technologies
Concerns for water quality

- Increasing ethanol production
- Increasing demand for corn
- Increasing corn acreage
- Concerns related to water quality in the Upper Mississippi River Basin (UMRB)
  - Nitrogen from corn contributes to Gulf of Mexico hypoxia and local water quality concerns throughout the Midwest
Research questions

- How much additional nutrients (N and P) are likely to end up in the rivers and streams of the UMRB as a result of the increase in the relative profitability of corn?

- How would those nutrient levels differ if switchgrass production in UMRB became widespread in lieu of total reliance on corn-based ethanol?
Scenarios considered

- Baseline
- Commodity prices as forecast by
  - FAPRI long term projections
    - $3.9/bu for corn, ~ $9.8/bu for soybeans
    - Year 2018
  - Futures markets (CBOT)
    - $6.58/bu for corn, $14.7/bu for soybeans
    - Futures contracts for 2010
- Switchgrass
  - 10% of UMRB’s cropland converted away from row crops
  - Production restricted to the most erodible land.
Integrated economic and water quality modeling system

- National Resources Inventory (NRI) data
  - 110,000 NRI points in UMRB
  - Weather, soil characteristics, crop choices, rotations
- Economic model
- Soil and Water Assessment Tool (SWAT)
Economic model

- Assumes farmers choose the crop and associated rotation to maximize net returns
  - Profitability depends on soil type, climate, other physical characteristics of land
  - Commodity prices
- Cost of production are based on Iowa costs of production for 2008 (ISU Extension)
- Rates of fertilizer application are based on historical, state-specific averages (USDA-ERS)
Location of corn area – no switchgrass scenarios

Baseline

UMRB states

Hundred hectares

0 - 400
400 - 1000
1000 - 1750
1780 - 2830
2830 - 5340

FAPRI prices

CBOT prices
Acreage Response of Corn, Soybean, and Switchgrass to Switchgrass Prices

Land use changes due to SG price changes, assuming CBOT prices and CRP constant

<table>
<thead>
<tr>
<th>Switchgrass price, $/metric ton</th>
<th>Km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>200,000</td>
</tr>
<tr>
<td>75</td>
<td>150,000</td>
</tr>
<tr>
<td>80</td>
<td>100,000</td>
</tr>
<tr>
<td>90</td>
<td>50,000</td>
</tr>
<tr>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

- C area with CBOT prices
- SB area with CBOT prices
- SG area with CBOT prices
Location of switchgrass area

SG with FAPRI prices  SG with CBOT prices  SG with targeting

Legend:
- UMRB states
- Hundred hectares
  - 0 - 90
  - 90 - 490
  - 490 - 970
  - 970 - 1830
  - 1830 - 3070
## SWAT results

<table>
<thead>
<tr>
<th></th>
<th>Avg Sediment Out,000 Metric tons</th>
<th>Avg NO3 Out,000 Kgs</th>
<th>Avg P Out Kgs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>23,975</td>
<td>329,377</td>
<td>25,045</td>
</tr>
<tr>
<td><strong>FAPRI prices – W/ CRP</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No switchgrass</td>
<td>25,412</td>
<td>357,808</td>
<td>24,912</td>
</tr>
<tr>
<td>With switchgrass</td>
<td>22,321</td>
<td>363,888</td>
<td>22,321</td>
</tr>
<tr>
<td>With targeted switchgrass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBOT prices – W/ CRP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No switchgrass</td>
<td>24,541</td>
<td>346,083</td>
<td>27,238</td>
</tr>
<tr>
<td>With switchgrass</td>
<td>20,482</td>
<td>353,125</td>
<td>24,503</td>
</tr>
<tr>
<td>With targeted switchgrass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20,264</td>
<td>401,183</td>
<td>25,009</td>
</tr>
</tbody>
</table>
Implications for EISA 2007

- The unrestricted switchgrass production levels are around 37-41 million tons.
- The targeted scenarios have a much lower switchgrass production scenarios production level – 18 million tons.
- With an ethanol conversion efficiency of 0.3 liters/kg (realistic), this would mean that our scenarios show that the UMRB could supply between 7 to over 15% of the 21 billion gallon cellulosic ethanol EISA numbers.
Policy implications

- The 25 by 25 study estimated biomass prices of $44-88/metric ton. The RAND report re-released this year has prices of $81-181 metric ton – delivered at the plant.
- Our prices are $78 and $125/metric ton at the farm gate.
- To produce switchgrass levels in the UMRB, substantial subsidies may be needed.
  - The Farm bill subsidies are in the range.