Land Use Conversion for Perennial Energy Crops
Production: Dynamics and Uncertainty

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Introduction

- Switchgrass provides environmental benefits compared to corn-soybeans, but it is currently undersupplied in the U.S.
- Switchgrass production supply may be hindered by the volatility and uncertainty in its yields and returns to farmers.
- Incentive policy tools like Payments for Ecosystem Services (PES) may mitigate the uncertainty and promote land use conversion towards switchgrass

Objectives

- Investigate the uncertainties in the yields and costs of switchgrass production
- How much do we have to pay farmers to convert corn-soybean fields to switchgrass when no PES is offered vs. PES is available to switchgrass farmers?
- In the long run, how does the land use ratio of switchgrass change over time?
- Compared with the case of no PES, how much more agricultural land would be used for switchgrass production with PES being offered?

Methods

Model Highlights

- Dynamic optimization: extended simulations by Song et al. (2011)
- In each period (per annum) compare net present value (NPV) of the net returns from two land use types - switchgrass and corn-soybean, which follow a stochastic process
- Farmers determine whether to keep the current land use type or convert to the other type in order to receive maximum payoff net of all costs
- Switching boundaries are obtained from necessary net returns for conversions
- Conversion between land use types is assumed costly to farmers
- Ecosystem services and environmental performance are evaluated and used to determine the offers of PES provision
- Monte Carlo simulations predict the proportion of land use in switchgrass in the long run (30 years)

Data

- Corn-soybean yields in the U.S. Northern Crescent region in 1996-2012
- Simulated switchgrass yields
- Calibration using the parameters for switchgrass demand from other studies
- OSSOLVER toolbox in MATLAB
- Simulation using parameters from the optimization results

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Presenter: Xiaogu Li, Penn State University
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References

- Willardson, R. B., K. Kempton, J. Jacobson, and M. Longholtz. Improving water quality in the Chesapeake Bay using payments for ecosystem services for perennial biomass production. (Under Review)

Results and Discussion

auses for Alternative Scenarios:
- a. $100/acre - PES to grow switchgrass
- b. No PES offered

PES for Switchgrass

| Minimum Return from Switchgrass Needed to Convert from Corn-Soybean to Switchgrass |
|---------------------------------|---------------------------------|
| $0/acre                         | $380/acre ($93/Mg, $5.22/GJ, $0.69/gallon) |
| $100/acre                      | $263/acre ($64/Mg, $3.62/GJ, $0.48/gallon) |

Predicted Proportion of Land Used for Switchgrass Production

<table>
<thead>
<tr>
<th>Supply of switchgrass</th>
<th>30% of the landscape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality benefits (18 kg N reduction/ha per year)</td>
<td>2.09 million kg of N reduction (~8% of required reduction)</td>
</tr>
<tr>
<td>Payments for ecosystem services</td>
<td>None</td>
</tr>
<tr>
<td>Uniform payments</td>
<td>$100/acre</td>
</tr>
</tbody>
</table>

- Farmers must receive higher returns than the breakeven returns to convert to switchgrass.
- A $100/acre PES to grow switchgrass lowers the returns needed to incentivize conversion to switchgrass by $117/acre.
- Monte Carlo simulation results predict about 10% more agricultural land used for switchgrass in the long run (20-30 years) when PES is offered.