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

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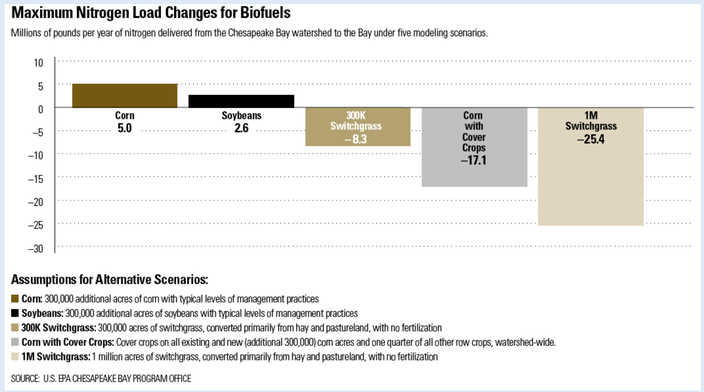
Introduction

- 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

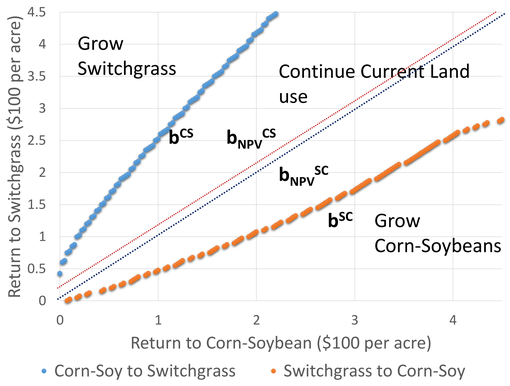
- Dynamic optimization: extended simulations by Song et al. (2011)
- In each period (per annum) compare net present value (NPV) of the net returns from two land use types- switchgrass and corn-soybean, which follow a stochastic process
- Farmers determine whether to keep the current land use type or 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

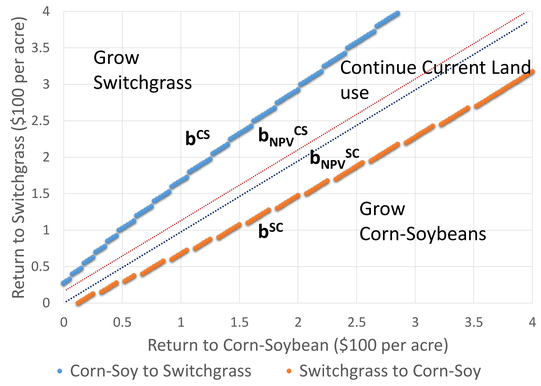
- Corn-soybean yields in the U.S. Northern Crescent region in 1996-2012
- Simulated switchgrass yields
- Calibration using the parameters for switchgrass demand from other studies
- OSSOLVER toolbox in MATLAB
- Simulation using parameters from the optimization results

Results and Discussion

Net Present Value vs. dynamically optimal conversion boundaries



a. No PES offered



b. $100 per acre† PES to grow switchgrass

† Based on the amount of PESs for cover crops in the Chesapeake Bay area states

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

	Baseline	Uniform payments
Supply of switchgrass	30% of the landscape	40% of the landscape
Water quality benefits (18 kg N reduction/ha per year)	2.09 million kg of N reduction (~8% of required reduction)	2.79 million kg of N reduction (~10% of required reduction)
Payments for ecosystem services	None	$100/acre

- 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.

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