# Are Bioenergy Crops Riskier than Corn? Implications for Biomass Price

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PROGRAM

## Introduction

The adoption of commercial production for cellulosic biofuel feedstock depends not only on their expected returns relative to that of conventional crops but also on their relative riskiness.

In this study we examine the riskiness of bioenergy crop production and compare it to the riskiness of corn production based on a unique dataset of simulated yields of two bioenergy crops (miscanthus and switchgrass) over rain-fed area in the United States. Specifically, the primary aims are to:

- Identify the best fitted county-level yield distributions for miscanthus and switchgrass.
- Compare relative yield risk of energy crops and corn.
- Quantify the breakeven biomass price needed to induce energy crop production.

## Approach:

- Based on county-level yield data over 1979-2010 for energy crops and corn, the maximum likelihood method is applied to fit eight parametric yield distributions. Then Kolmogorov-Smirnov test is applied to select the best fitting distributions.
- We employ coefficient of variation (CV) and insurance loss index (ILI) to measure and then compare relative yield risk of energy crops and corn. Following Hennessy (2009), ILI is defined as

$$ILI(\phi) = \frac{\mathrm{E}[\max(\phi\mu - y, 0)]}{\mu},$$

where $\phi$ is insurance coverage level, $\mu$ is mean yield, $y$ is the random yield, and $\mathrm{E}[\cdot]$ is expectation operator. CV measures yield risks on both left and right tails while ILI measures yield risks only on the left tail.

- Mean-variance utility function is used to determine the breakeven price of biomass for bioenergy crop production. Let $p$ denote crop price and $c$ denote production costs. Then the utility from growing the crop is

$$U = \mathrm{E}[py - c] - \frac{\lambda}{2}\mathrm{Var}[py - c],$$

where $\lambda$ is risk aversion parameter, and $\mathrm{Var}[\cdot]$ is variance operator. Given a reservation utility (i.e., utility from enrolling land into CRP or from growing corn), we can identify the breakeven biomass price needed to induce adoption of the bioenergy crop.

## Data:

- BIOCRO, a semi-mechanistic dynamic crop growth and production model, was used to simulate miscanthus and switchgrass yields over a 32 year period using climate and soil data for 1979-2010, on a 32 by 32 km grid for the continental US.
- Yields of corn and soybeans over 1979-2010 for the rain-fed area of U.S. were obtained from NASS/USDA.
- Production costs of miscanthus and switchgrass in 30 states of the rain-fed U.S. were obtained from Khanna et al. 2008. Corn and soybean price data was obtained from NASS/USDA.

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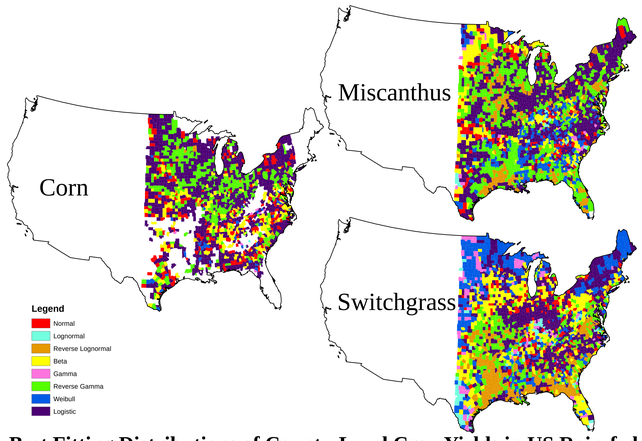
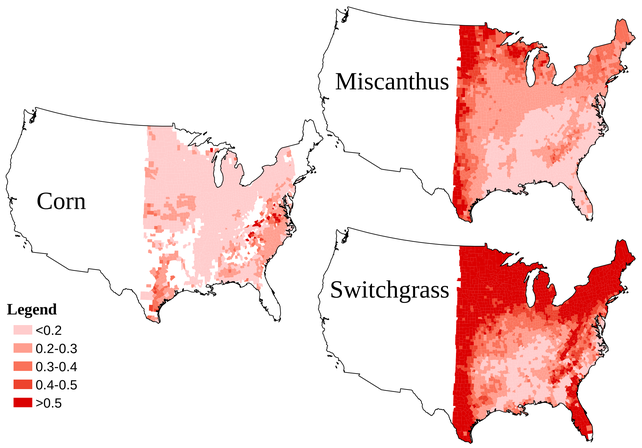
## Results:

### Best fitting yield distributions

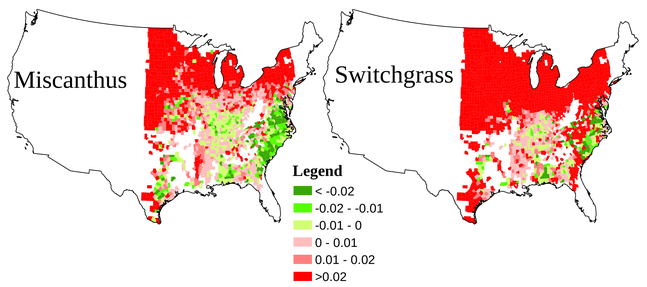



**Best Fitting Distributions of County-Level Crop Yields in US Rain-fed Area**

### Yield risk comparison

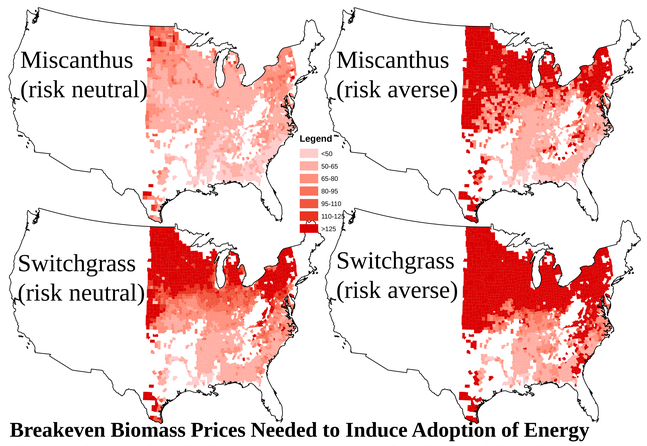



**Coefficient of Variation of Crop Yields in US Rain-fed Area**

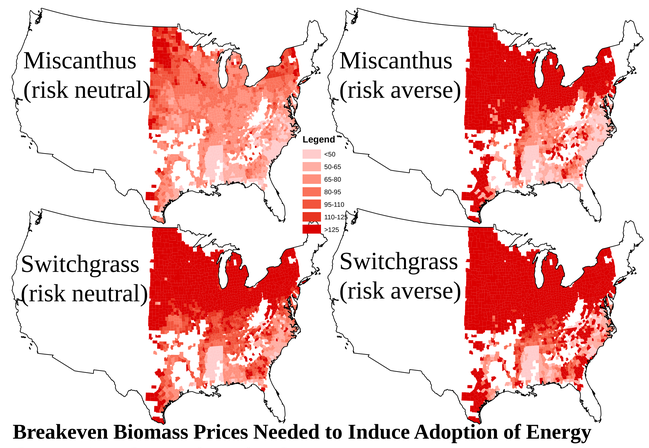



**The Difference between Insurance Loss Index of Energy Crops and That of Corn (**red colors indicate that the difference is positive and that energy crops are riskier than corn; green colors indicate the opposite**)**

### Breakeven biomass prices




**Breakeven Biomass Prices Needed to Induce Adoption of Energy Crops when Using CRP Rent as Opportunity Costs of Land** (unit: $/metric tonne)




**Breakeven Biomass Prices Needed to Induce Adoption of Energy Crops when Competing with Corn** (unit: $/metric tonne)

## Conclusions:

- The best fitting yield distributions of miscanthus and switchgrass vary across regions and differ considerably from those of corn. Miscanthus and switchgrass yields are more variable in the northern region and the Great Plains region while corn is relatively more risky in the Atlantic states.
- Under the assumption of risk neutrality, the breakeven biomass price ranges between $40-162 per metric tonne and is lowest in the Atlantic states and highest in the northern midwest region. The breakeven price is about 42% higher for switchgrass than for miscanthus.
- On average, breakeven price for miscanthus and switchgrass with risk aversion increases by 5-17% when compared with that under risk neutrality assumption. The risk premium required is higher for converting marginal land to an energy crop since the alternative land use is likely to be CRP with a risk free return. The risk premium is smaller for converting land currently under corn because of the riskiness of corn production.

## References

Hennessy, D.A. 2009. “Land Retirement Program Design in the Presence of Crop Insurance Subsidies.” Center for Agricultural and Rural Development *Working Paper 09-WP 495*, Iowa State University.

Khanna, M., B. Dhungana, and J. Clifton-Brown. 2008. “Costs of Producing Miscanthus and Switchgrass for Bioenergy in Illinois.” Biomass and Bioenergy. 32:482-93.