Integrated Simulation Modeling of Supply Chain Impacts from Genetic Improvements in Switchgrass

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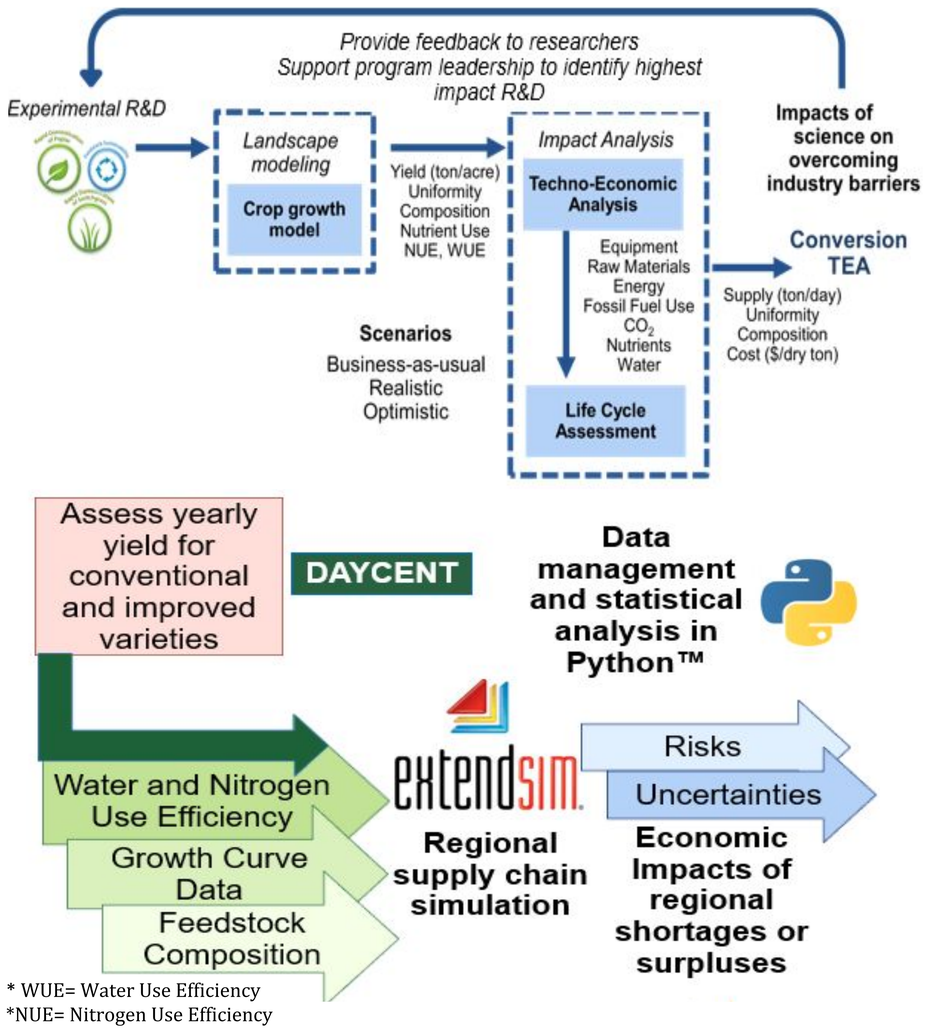
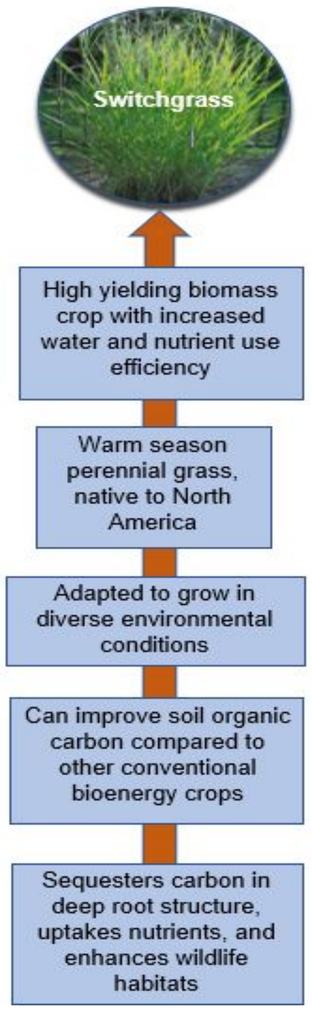
Abstract

The implementation of advanced lignocellulosic biofuel production in the U.S. is largely dependent on identifying and addressing uncertainty and risk along the feedstock supply chain. Switchgrass is a warm season herbaceous perennial grass native to North America that is well suited for biofuel production, according to the Department of Energy (DOE). This proposed research will evaluate the impacts on the supply chain from improved switchgrass phenotypes, accounting for increased yield and better yield stability. Data will be taken from the daily time-step biogeochemical model, DayCent, and incorporated into a supply chain model, ExtendSim Pro, via Python, quantifying risks along different regional supply chains. The results generated from these integrated models will enable better informed current and future decision making regarding the U.S. switchgrass bioenergy supply chain for growers, processors, and policy makers alike.

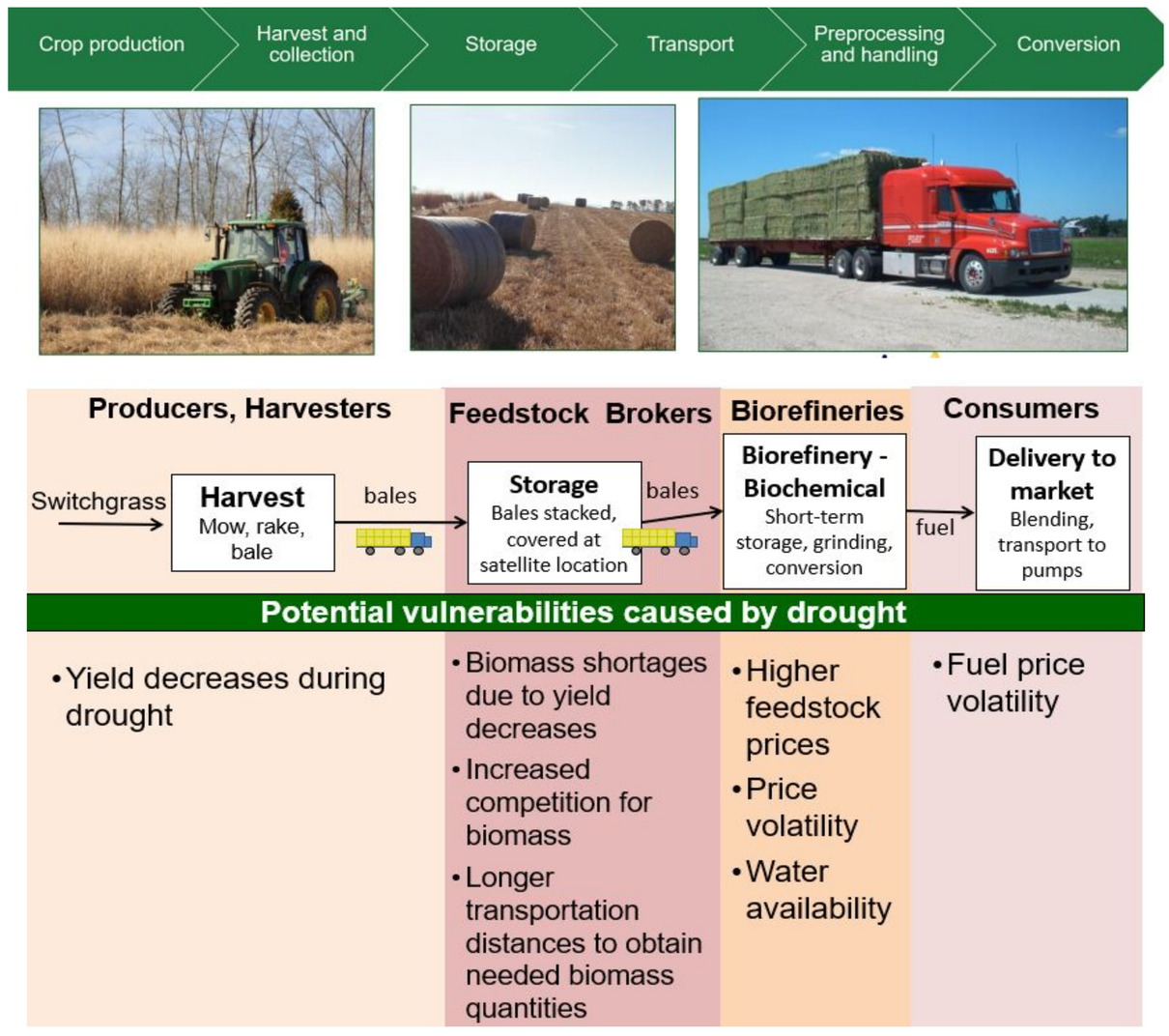
Analysis Tools to evaluate the Potential Impacts of Yield



Why Switchgrass as a Biomass Feedstock?



Switchgrass Bioenergy Supply Chain



Research Questions & Objectives

Research Question 1

- What are the economic trade-offs of increased yield and yield stability in regional switchgrass bioenergy supply chains with conventional vs. improved phenotypes?

Research Question 2

- What are the risks and uncertainties within the biomass supply chain and how will they interact with yield fluctuations to impact farmers and biorefineries?

Objective 1

- Identify trade-offs (risks and uncertainties) associated with biomass supply chains for conventional and improved switchgrass phenotypes in different geographic regions within the U.S.

Objective 2

- Determine the yield response (mean and statistical ranges) of improved switchgrass phenotypes compared to conventional varieties across a wide range of anticipated water and nutrient stresses

Methodology

Phase 1:
- Build the supply chain model based on literature values, including yield variability and supply chain risks

Phase 2:
- Research case studies on different U.S. regions of interests (Upper Midwest, Lower Midwest, Northeast, Southeast) evaluating and accounting for crop yield risks during a given year and yield stability risks from year to year

Phase 3:
- Incorporating baseline, medium, and future scenarios for estimations of supply shortage, excess supply, or projected average mean supply into software quantifying annual risk

Phase 4:
- Transfer scenario results into the regional simulation model ExtendSim for further evaluation of key trade-offs and future pathway decision making

Expected Results

Yield	Quantify the potential benefits of improved Water and Nitrogen Use Efficiency (WUE, NUE) with respect to average yield and/or yield stability
Risk	Evaluating regional response scenarios for biorefineries and farmers alike across the bioenergy supply chain will provide insight into designing supply chain risk management tools
Uncertainty	Model uncertainty will be characterized through a stochastic modeling and Monte Carlo approach with various iterations.
Decision Making	A comprehensive portfolio of decision making scenarios for stakeholders will help developers (and operators) make better decisions

Acknowledgments

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References

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