DOE Bioenergy Technologies Office (BETO)

2021 Project Peer Review

1.2.1.5 Resource Mobilization

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Feedstock Technologies

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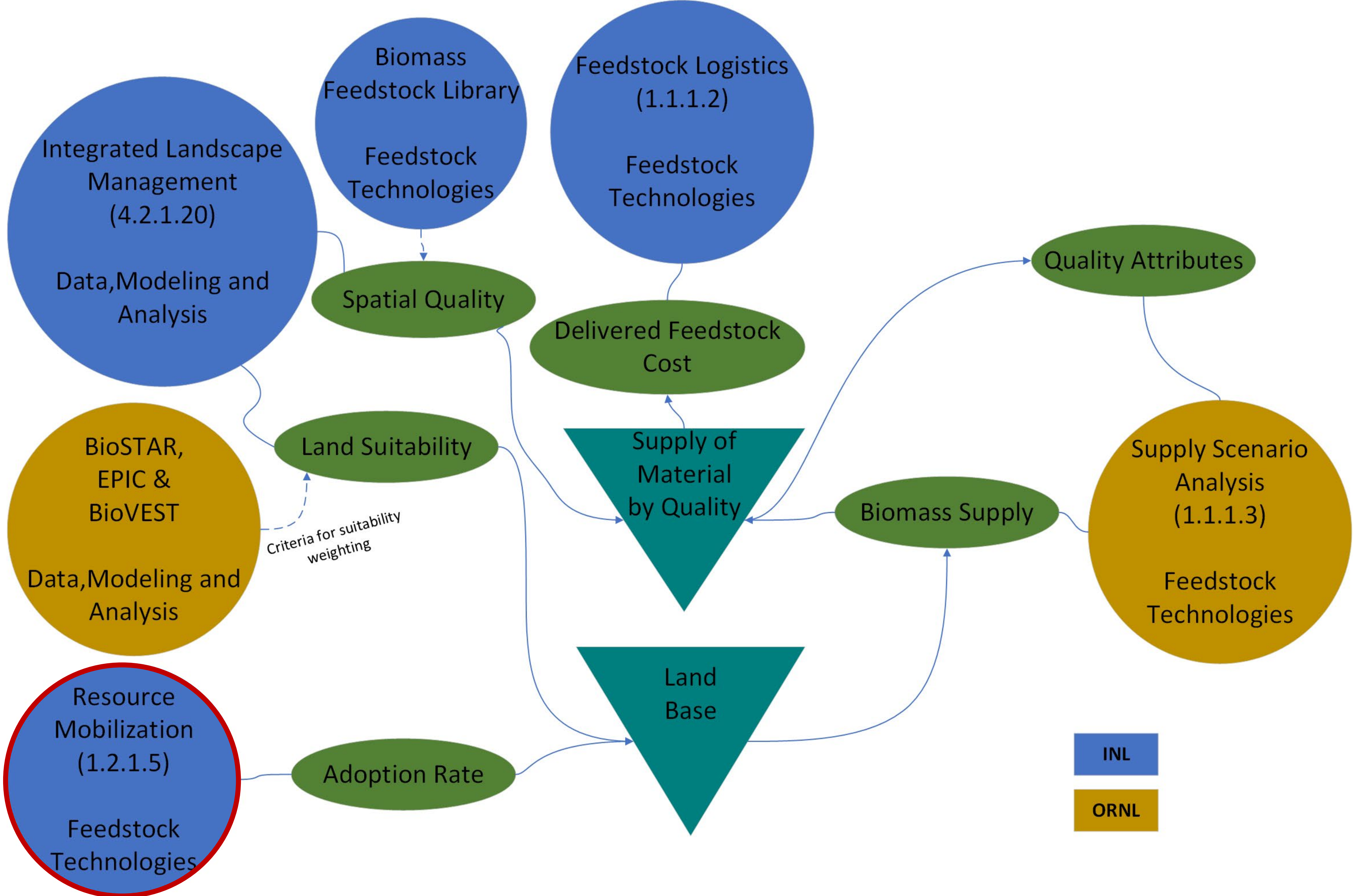
Project Overview

- **Objectives:**
  - Identify risks and opportunities for increasing feedstock mobilization through increased grower adoption.
  - Identify non-biofuel feedstock industries (e.g., animal feed, composite materials) that can be leveraged grow the resource base.
- **Why:** Consistent and economical access to biomass feedstocks represents a barrier to the establishment and growth of a biofuel industry
- **Project Goals:**
  - Identify strategies to reduce the near-term biorefinery supply chain establishment and operating cost.
  - Analyze adoption of bioenergy feedstock production by examining producer and consumer behavior, leading to increasing grower participation by 25% or more.
- **Relevance to industry:** Increasing grower participation directly supports reducing supply chain costs. Additionally, increased participation supports the mobilization of the U.S. billion ton biomass resource base, which current mobilization and participation rates may not achieve.



Biomass Feedstock Library
Feedstock Technologies
Feedstock Logistics (1.1.1.2)
Feedstock Technologies
Integrated Landscape Management (4.2.1.20)
Data,Modeling and Analysis
Spatial Quality
Quality Attributes
Delivered Feedstock Cost
BioSTAR, EPIC & BioVEST
Data,Modeling and Analysis
Land Suitability
Supply of Material by Quality
Biomass Supply
Supply Scenario Analysis (1.1.1.3)
Feedstock Technologies
Criteria for suitability weighting
Land Base
Resource Mobilization (1.2.1.5)
Feedstock Technologies
Adoption Rate
INL
ORNL

1 – Management

- **Team:**
  - Damon Hartley – PI/Model Development
  - Ruby Nguyen – System Dynamics
  - Pralhad Burli – Resource Economist
- **Communication/Collaboration**
  - Monthly Check-in with BETO
  - Biweekly Coordination Meetings
  - 4 milestones per year (3 Quarterly Progress/1 Annual)
- **Risks/Risk Mitigation**
  - Data availability and understanding industrially relevant practices
    - Mitigated through interproject collaboration, industry outreach, and engagement in working groups.

2 – Approach

TECHNICAL APPROACH

- Develop behavioral models that approximate the decisions made by individual producers
- Identify factors that influence producer participation in the establishment and production of bioenergy feedstocks
- Quantify the impact of grower participation on the cost of establishing biofuel supply chains.
- Identify potential enabling biomass feedstock markets
  - Identify critical material attributes
  - Estimate potential market demand

TECHNICAL CHALLENGES

- "*All models are wrong, but some are useful*" – G. Box
- Adequately summarizing behaviors for heterogeneous populations.
- Defining the social structures across age, sex and education levels.

2 – Approach

Go/No-Go Decision Point

The Go/No-Go decision will assess the capability to model the dynamics and related costs associated with setting up herbaceous biorefinery supply chains as they relate to different levels of grower participation.

Go Criteria: Demonstrate modeled pathways that lead to a minimum increase of grower adoption to 10% of the amenable and suitable acreage.

Go Criteria met in Q2 of FY19: Demonstrated a modeled grower participation of >29% for both switchgrass and corn stover

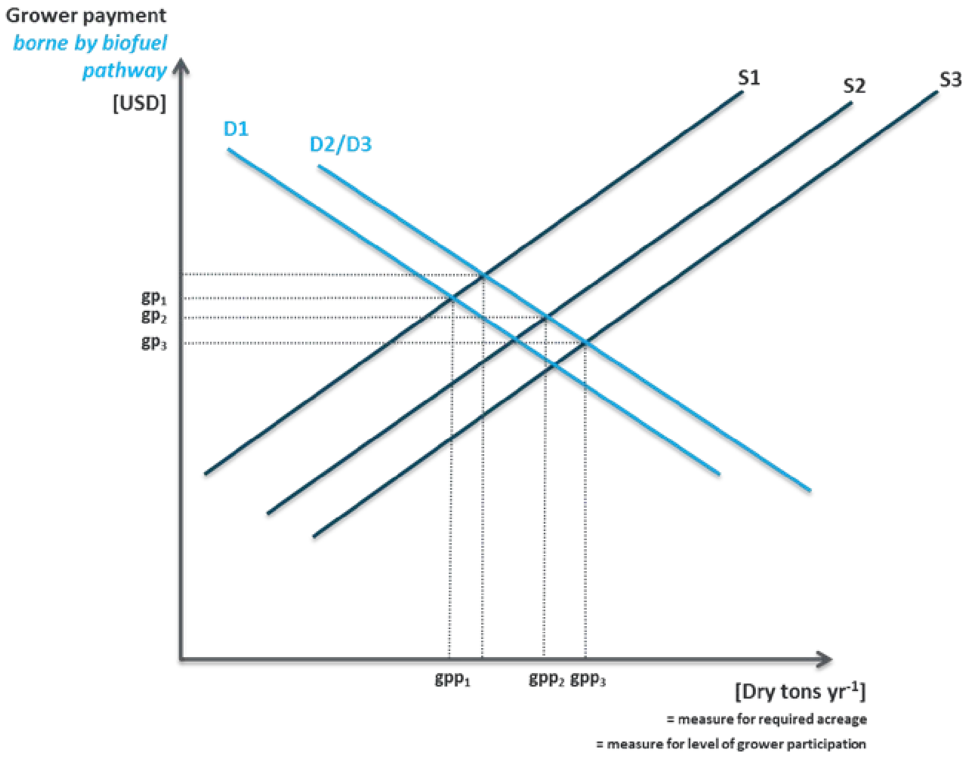
Performance Metrics

- Producer participation: proportion of suitable and available acres that are used for production
- Supply Chain establishment costs: Costs associated with the contracting of producers
- Defined scenarios that lead to successful and sustained development of a bioeconomy.

3 – Impact

Project Impact

- This project aims to understand the motivations and drivers of the actors within a bioenergy supply chain, and how to access those materials for the development of a bioeconomy.
- Non-biofuel markets to mobilize biomass resources (which makes them accessible to biorefineries).
- Availability of resources that have advantageous attributes may be able to drive the development of a market given sufficient quantities and market conditions.

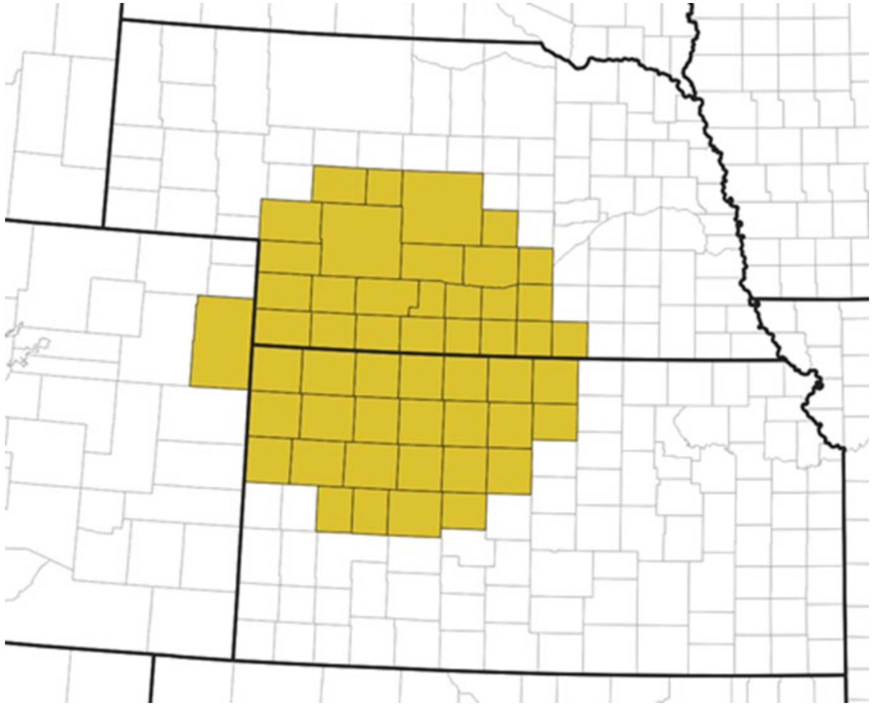


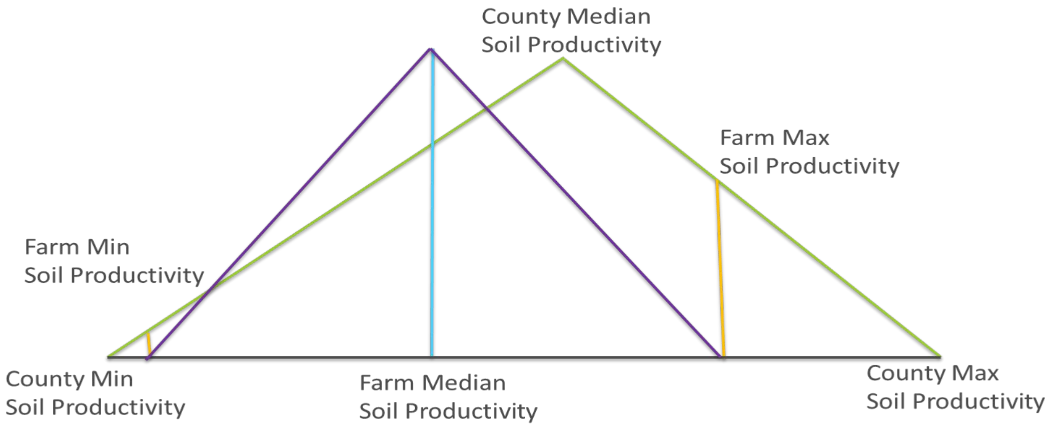
Products and Outputs

- Manuscript in submission to Energy (Impact Factor 6.082)
- Presentations to:
  - ASABE
  - Harvard CRSC Workshop on AI for Social Impact
  - IEA Task 40

4 – Progress and Outcomes

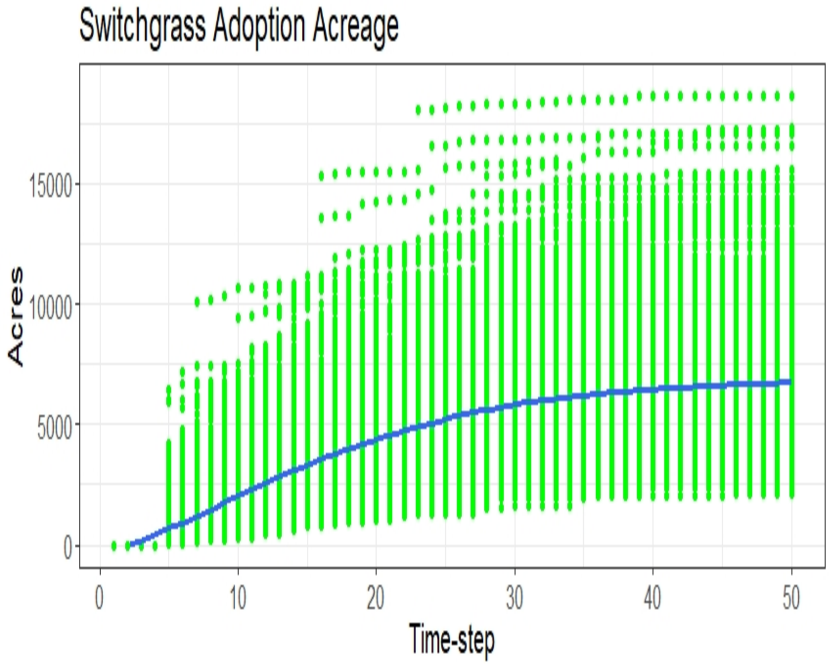
- **Area of Interest and Synthetic Population**
  - **Establish base model conditions of crop production**
    - 50 county region
    - 6 agricultural land-uses
    - Only considering cropland
  - **Development of Production Agents**
    - Age (Ag Census)
    - Farm Size (Ag Census)
    - Distribution of Land Quality (SSURGO)
    - Social Connections
    - Knowledge/Awareness
    - Innovation

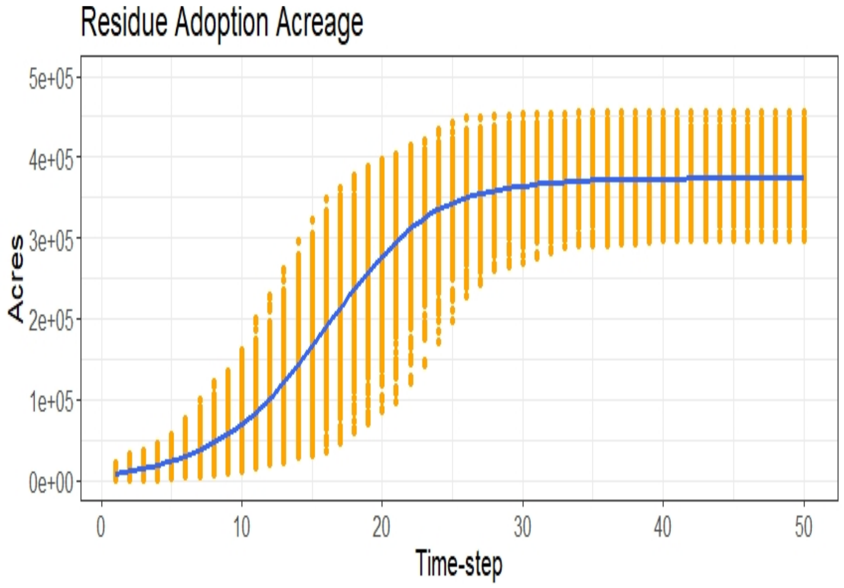




4 – Progress and Outcomes

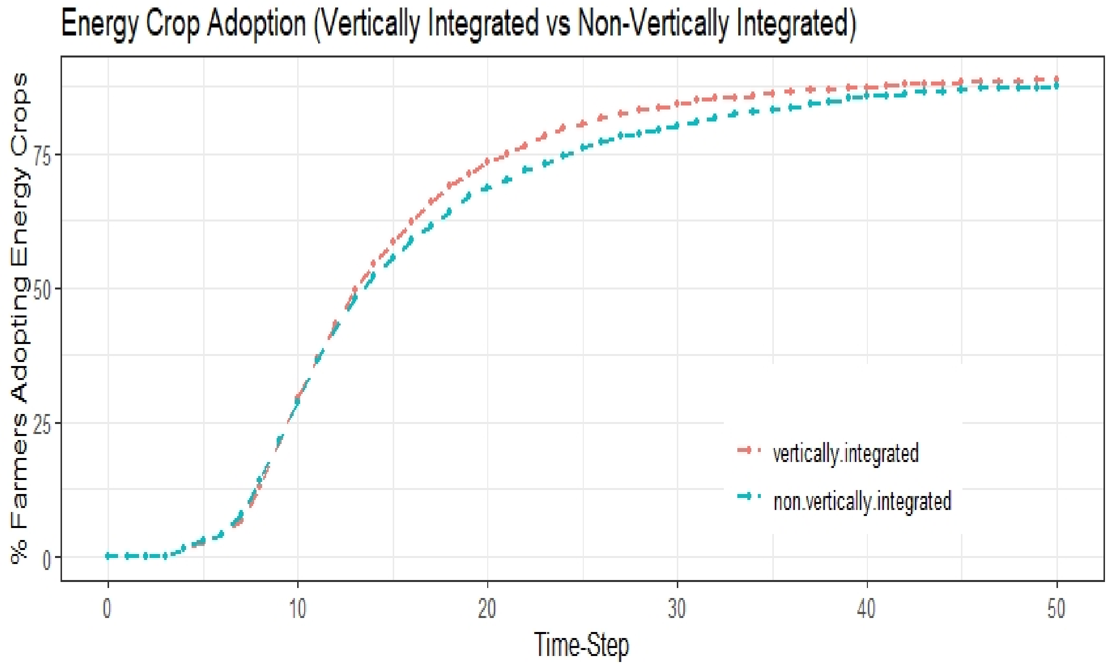
- **Establishing Base Estimates of Participation**
  - Assume low yielding ground not accepted into CRP available to be contracted to energy crops
  - Highest yielding areas (>150 bu/ac) of corn production potentially available for residue collection
  - Assumed no cap on demand
  - Adoption simulated for 50 years
- **Base Results**
  - Switchgrass
    - 35% of available acres adopted after 15 yrs.
    - 77% of available acres adopted after 50 yrs.
  - Corn Stover
    - 29% of available acres adopted after 15 yrs.
    - 44% of available acres adopted after 50 yrs

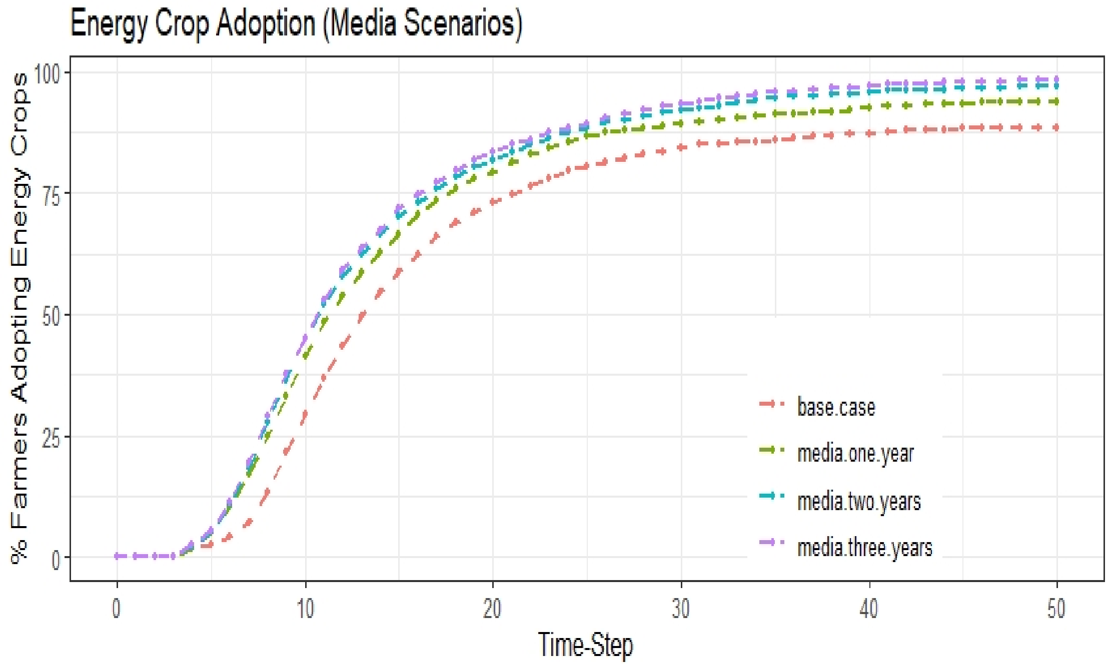




4 – Progress and Outcomes

- **Effect of Business Structure**
  - Examined vertically integrated vs non-vertically integrated
  - Adoption rate averaged 2.35% higher for vertically integrated firms
- **Impact of Media**
  - Media campaigns spanning 1, 2, or 3 years
  - 5.9%, 8.4% and 9.5% increase in energy crop adoption seen respectively
- **Large Farmer Influence**
  - Increased overall adoption
  - Shortened the time of adoption





4 – Progress and Outcomes

- **End of Project Target:** Demonstrate a modeled increase of participation at least 25%
  - Residue Adoption:
    - 32.74% - Base Case
    - 57.66% - Advanced

    76% increase
  - Switchgrass Adoption:
    - 12.20% - Base Case
    - 39.21% - Advanced

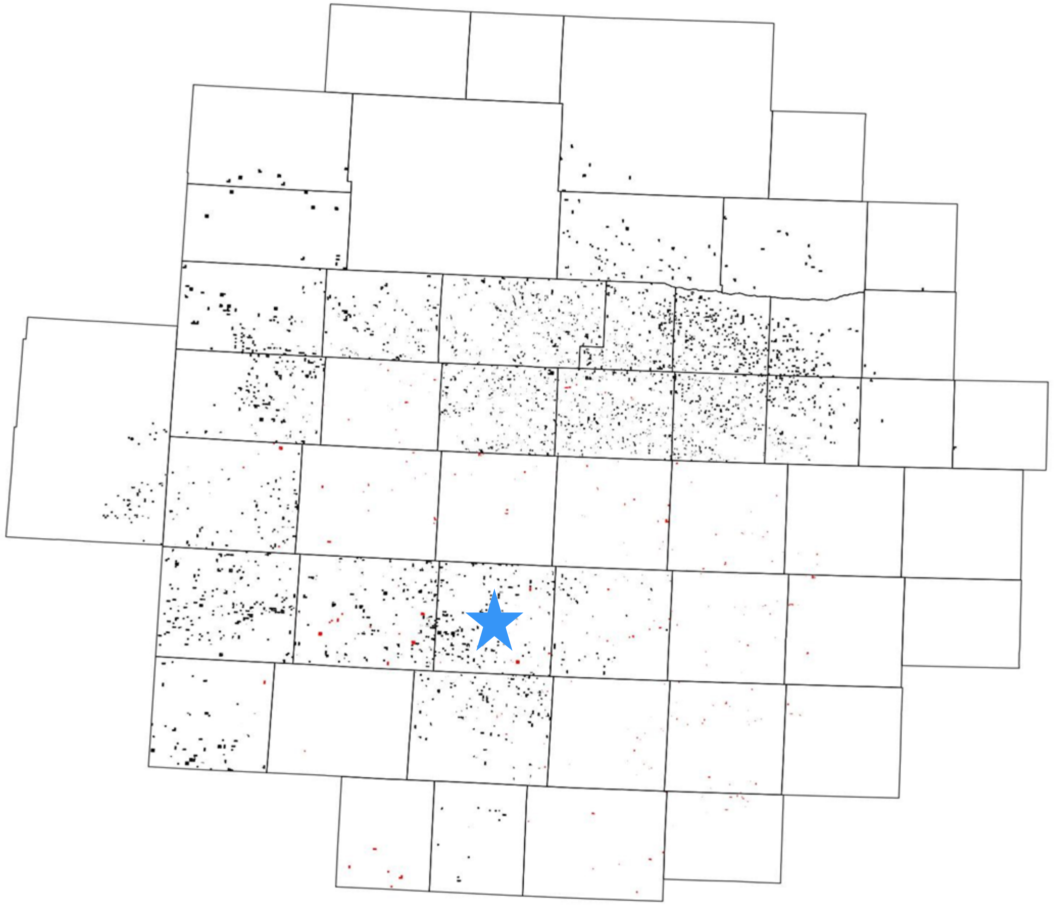
    221% increase

4 – Progress and Outcomes

- **Feedstock supply chain establishment cost**
  - Spatially distributed the production of residue and energy crops based on modeled adoption rates.
  - There is a marked difference in the per ton cost for establishing supply for corn stover and switchgrass

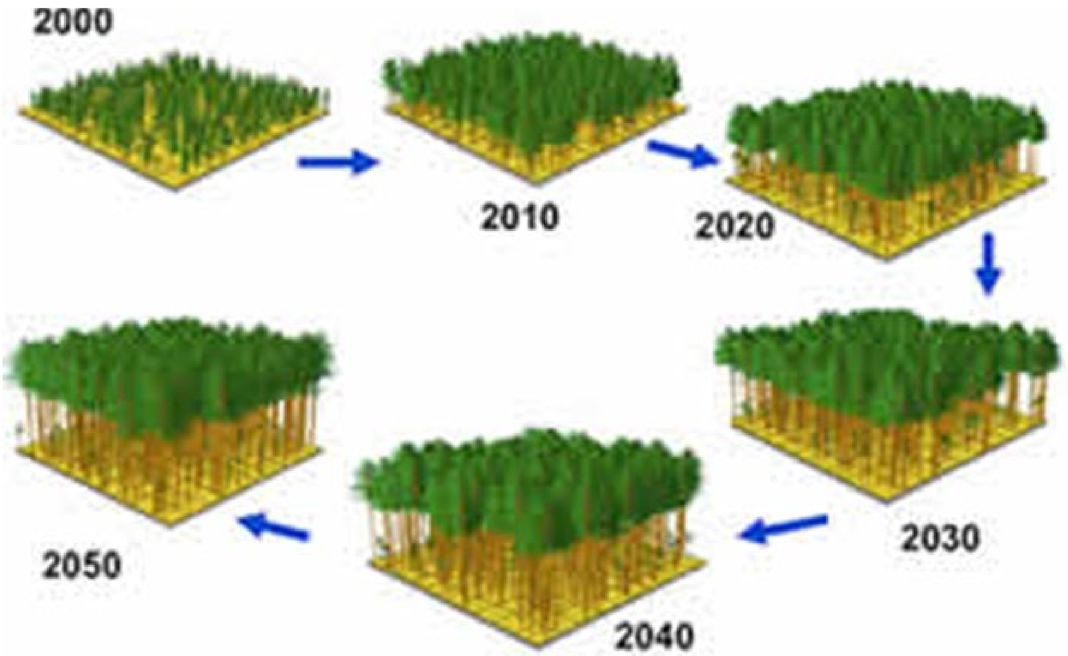
Feedstock	Base	Advanced	% change
Corn stover	$1.68/ton	$0.85/ton	-50%
Switchgrass	$20.73/ton	$5.11/ton	-75%

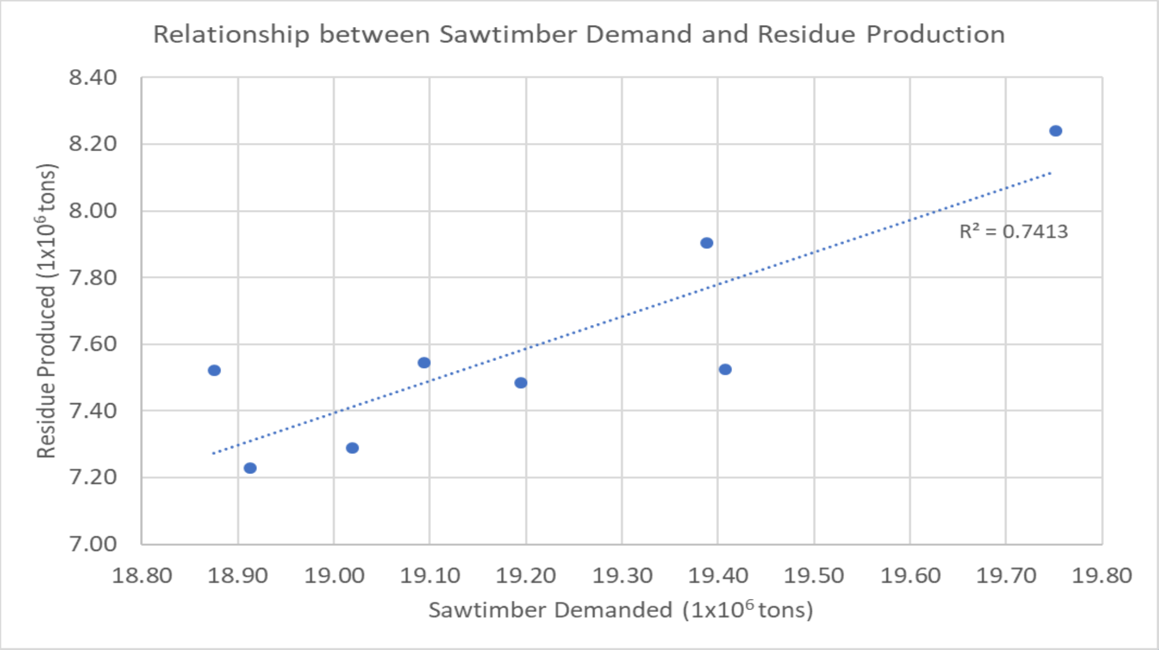
  - Perceived risk contributes to cascading effects on the overall cost of supply chain establishment by increasing the distance travelled and effort required for enlisting potential biomass suppliers.



4 – Progress and Outcomes

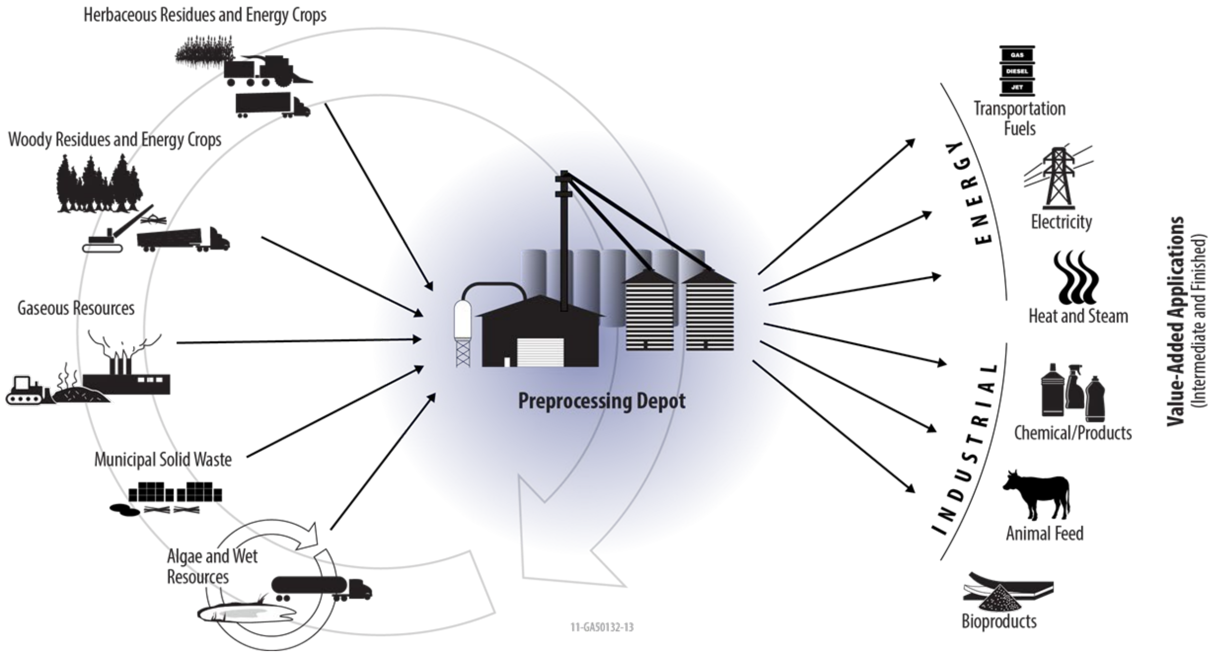
- **Extend adoption model to forest derived biomass**
  - Modeled the harvest of forest residues from non-industrial private forest lands in the southeast U.S.
    - Agents generated from FIA and NWOS
    - Stand level simulation
  - Initial market demand from USDA Forest Service reports, with demand adjusted annually
  - Residue generated from sawtimber, pulpwood and pre-commercial harvest
  - Residue availability tied directly to demand for solid wood products
  - Increased early forest management may lead to increased quantity of feedstocks





4 – Progress and Outcomes

- **Existing midstream markets**
  - Products made from biomass have applications in markets from personal care to construction
  - Examined potential markets for corn stover and woody material fractions
    - Detailed analysis of 10 markets across the two feedstock types
  - Identified Critical Material Attributes for use in a specific market
  - Estimated potential material demand
  - Utilizing biomass fractions for their most valuable use can reduce risk to producers and lead to an overall increase in supply



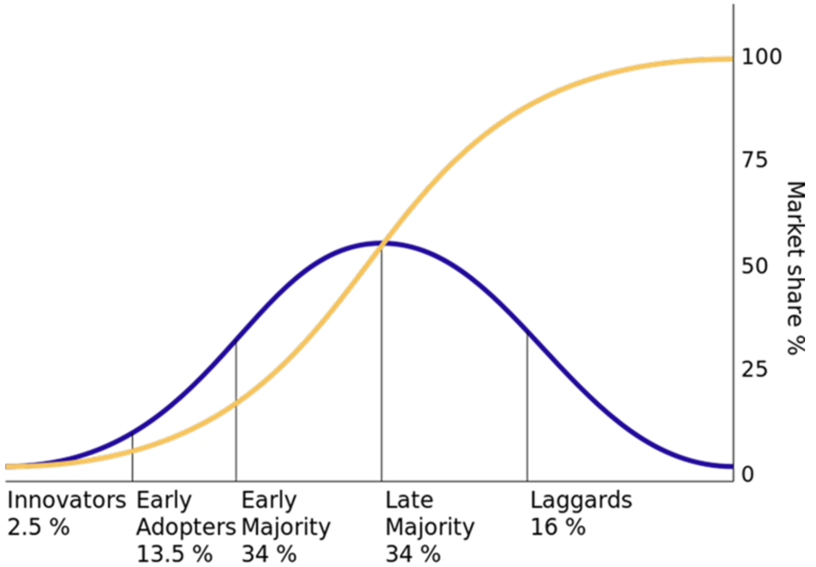
Summary

Challenge: Identify value propositions that increased the value of biomaterials and reduce the risks to producers, leading to an increase the production of biomass feedstocks for a developing biofuels industry and reducing the cost of establishing supply chains

Approach: Utilize an agent based approach to simulate and evaluate the effectiveness of potential strategies for speeding the acceptance of the production of biomass feedstocks

Accomplishments: Demonstrated through modeling that identified potential actions and business strategies can be utilized to increase participation levels and reduce the overall cost of establishing supply chains.

Relevance: Reducing risk through business structure and innovative contracting along with educational programs to increase knowledge can significantly increase the supply of biomass, improving the overall economics of the biomass facility



Diffusion of innovation through society (Bass,1969)

Questions

Quad Chart Overview

Timeline

- 10/01/2020
- 09/30/2023

	FY20	Active Project
DOE Funding		

Project Partners*

- WBS 1.1.1.2 – Feedstock Supply Chain Analysis
- WBS 4.2.1.20 – Integrated Landscape Management

Barriers addressed

Ft-A: Feedstock Availability and Cost. This project contributes to understanding drivers of grower adoption, establishment costs, potential markets for biomass feedstock fractions. Supply chain uncertainties and steady product demand have been a key factor inhibiting the establishment of a national biorefinery industry.

Project Goal

The goal of this project is to understand the socio-economic factors that control the adoption of practices that produce biomass feedstocks and identify strategies that can be utilized to increase participation and steepen the adoption curve.

End of Project Milestone

Demonstrate a modeled increase of participation of at least 25% and/or a minimum reduction in supply chain cost of at least 5% over the business as usual case

Funding Mechanism

*Only fill out if applicable.

Additional Slides

Previous Reviewer Comments

- **Weakness:** Project accomplishments after the first year are not clearly presented. This project needs more details on HOW the work will be accomplished. From the presentation: "Data collection and alignment through collaboration, industry outreach, and engagement in platform working groups--and--Leveraging of existing collaborations to create synergies across the platform and reduce costs" does not provide enough detail to understand what the researchers will do to address the project's goal and are too vague to make a determination on the project's merit.

- **Response:** We are approaching the modeling in a step-wise approach in which behaviors and decision making processes are being added to the model in a manner that allows for verification and validation. Throughout the project we have been in contact with extension agents that work with the producers of bioenergy crops as well as business that are currently growing crops that could be used as bioenergy feedstocks, as the project continues we are planning on continuing this dialog and hope to benefit on the knowledge gained through research projects such as the Sustainable Landscape Design (WBS 4.2.2.62) which is being led by the Anteres group and is collecting information about decision making in term of energy crops, directly from farmers. "

Previous Reviewer Comments

- **Weakness:** I am not sure how interactions between consumers and producers affect the supply chain for biomass materials in ways that we don't already understand. For example, if consumers demand more miscanthus pellets for home heating then additional supply strains will be developed. A simplistic but true interaction. If the consumer decides that they will not consume a biomass created using certain pesticides then the supply chain will react. There should be more attention paid to the future work of not only identifying strategies to increase producer participation but also how to implement such strategies.

- **Response:** The question that we are looking at is more complex than simple supply and demand. Your example is correct, if there is a raise in the demand of the product first the price increases if there is not currently sufficient quantity and if the demand is sustained production capacity will increase. The examples that you are describing are long term behaviors of established markets. The more pertinent question and the question that we are trying to answer is how do we entice producers to supply when the market is not proven.

Publications and Presentations

Burli, P.H., Nguyen, R.T., Hartley, D.S., Griffel, L.M., Vazhnik, V. and Lin, Y. 2021 "Grower characteristics and farming decisions: A model for bioenergy crop adoption", *Energy*. In Submission.

Hartley, D.S., Burli, P.H., Griffel, L.M. 2020. Effect of Grower Characteristics and Farming Decisions on Supply Chain Establishment for Biofuels. ICOSSE 2020, August 3-5, 2020. Virtual (Invited)

Burli, P.H., Nguyen, R.T., Vazhnik,V., Lin, Y., Griffel, L.M., Hartley, D.S. 2020. Bioenrgy Crop Adoption: The role of farmer behavior, market structure and information. CRCS Workshop on AI for Social Impact, March 5-6, 2020, Harvard University, Boston, MA

Hartley, D.S., Nguyen, R.T., Griffel, L.M., Burli, P.H. and Lin, Y. 2019. Using Agent-based Modeling to Examine the Adoption of Bioenergy Crops in Agricultural Production Areas, ASABE Annual International Meeting, July 7-10, 2019. Boston, MA.