DOE Bioenergy Technologies Office (BETO) 2023 Project Peer Review

1.2.1.5 Resource Mobilization

April 3, 2023

Feedstock Technologies

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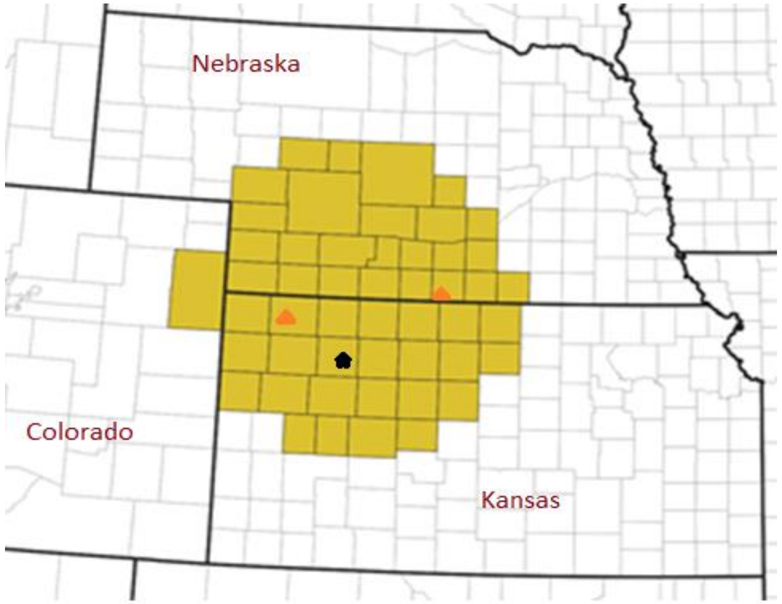
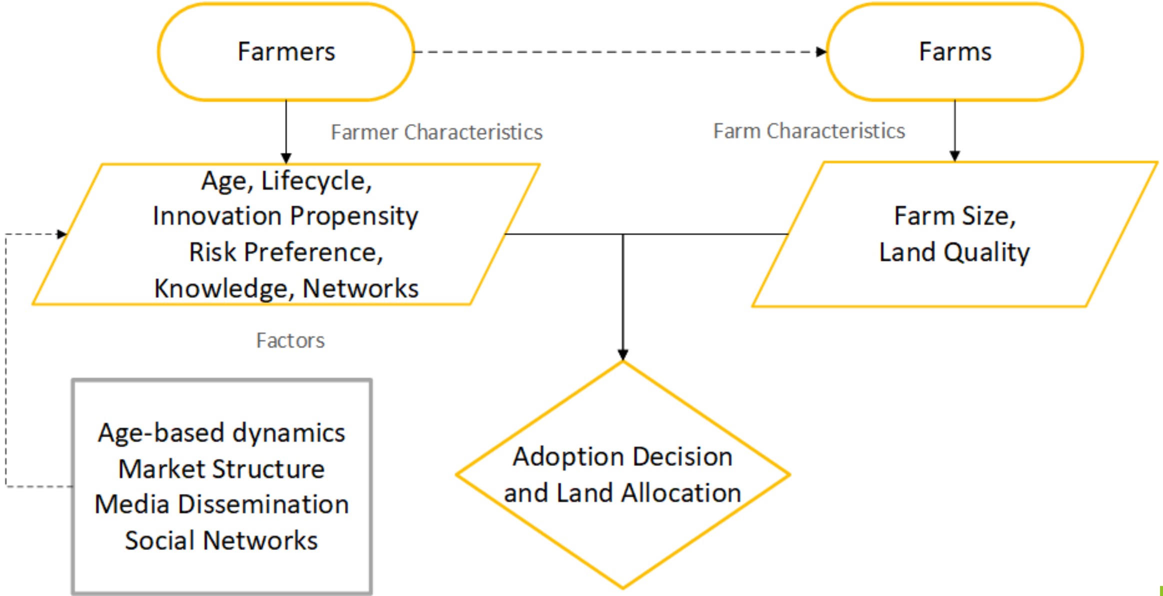
Project Overview

- Context and History:
  - Costs and uncertainties of setting-up supply chains inhibit the biorefining industry
  - Evaluate opportunities and risks focusing on farmer adoption of bioenergy feedstocks
  - Evaluate non-biofuel feedstock industries to mobilize the resource base
- Project Goals and Relevance:
  - Analyze the impact of interactions between growers and biorefineries at supply shed level
  - Assess potential for alternate bio-based markets that enable a steady demand for biomass feedstocks
  - Understand scenarios that support overall biorefinery economics and support BETO's objectives of decarbonizing the transportation and agriculture strategy pillars
- Driving Question:
  - What are the factors that influence the establishment of biomass supply chains, increase farmer participation, mobilize the biomass resource base, and support a viable bioeconomy?

1 – Approach (Technical)

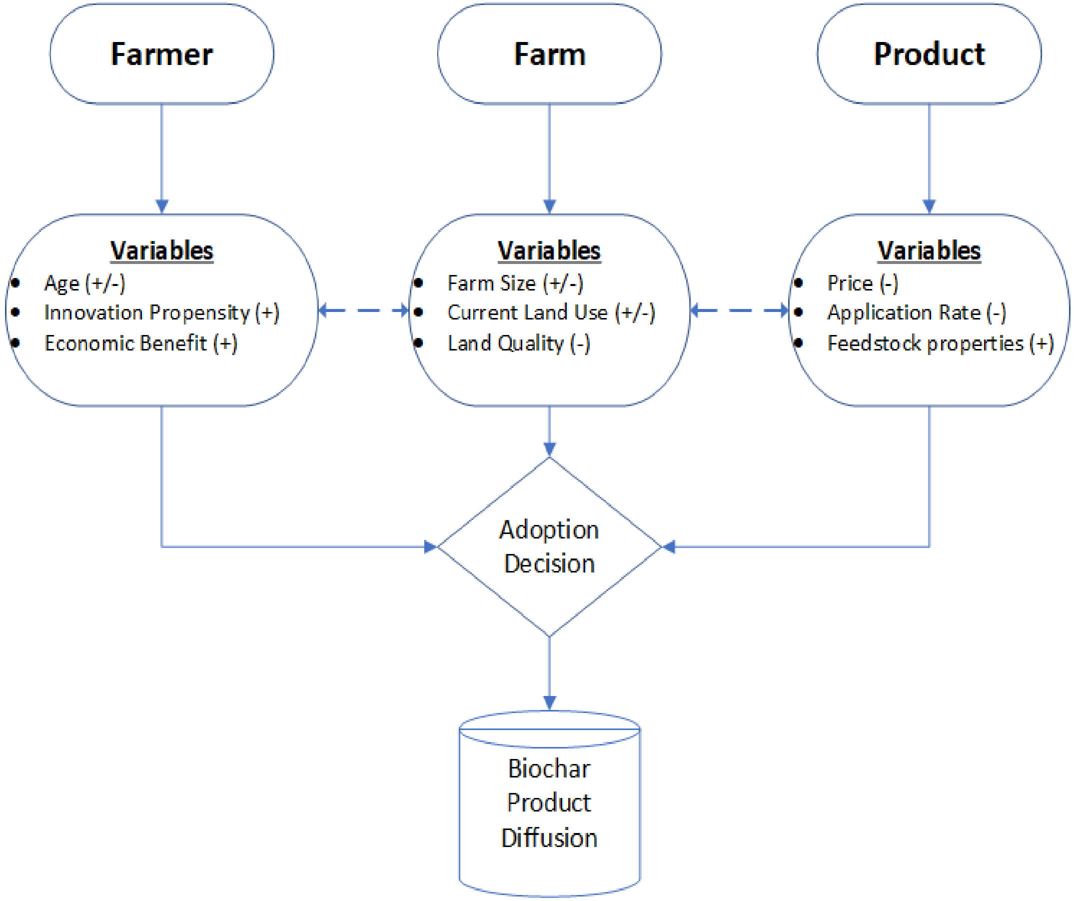
- Spatially explicit Agent Based Model (ABM)
  - Approximate the impacts of micro-level behaviors on macro-level outcomes
  - Evaluate factors influencing farmer adoption decisions and evolution of biomass supply chain
    - Social networks (large farmer influence) increased overall adoption
    - Media dissemination increased energy crop adoption
  - Incorporate feedstock quality attributes and develop integrated models for alternate markets utilizing off-spec materials
- Technical challenges
  - Technology readiness of innovative products and uncertainties around market diffusion
  - Limited opportunities for ground-truthing insights from model outcomes





1- Approach (Technical) cont'd

- Go/No-Go Decision Point:
  - The Go/No-Go decision assessed the ability to demonstrate a product diffusion model for at least one of the identified midstream market
  - Go Criteria: The sources of data required for the model as specified in the data needs document have been identified or assumptions have been validated through literature.
  - Go Criteria met in Q2 of FY22: Identified greater than 80% of the data needs for the selected diffusion modeling approach
- Performance Metrics
  - Evaluation of model output against analogous practices/products
  - Demonstrate scenarios where material that is off-spec for downstream conversion is channeled to alternate markets

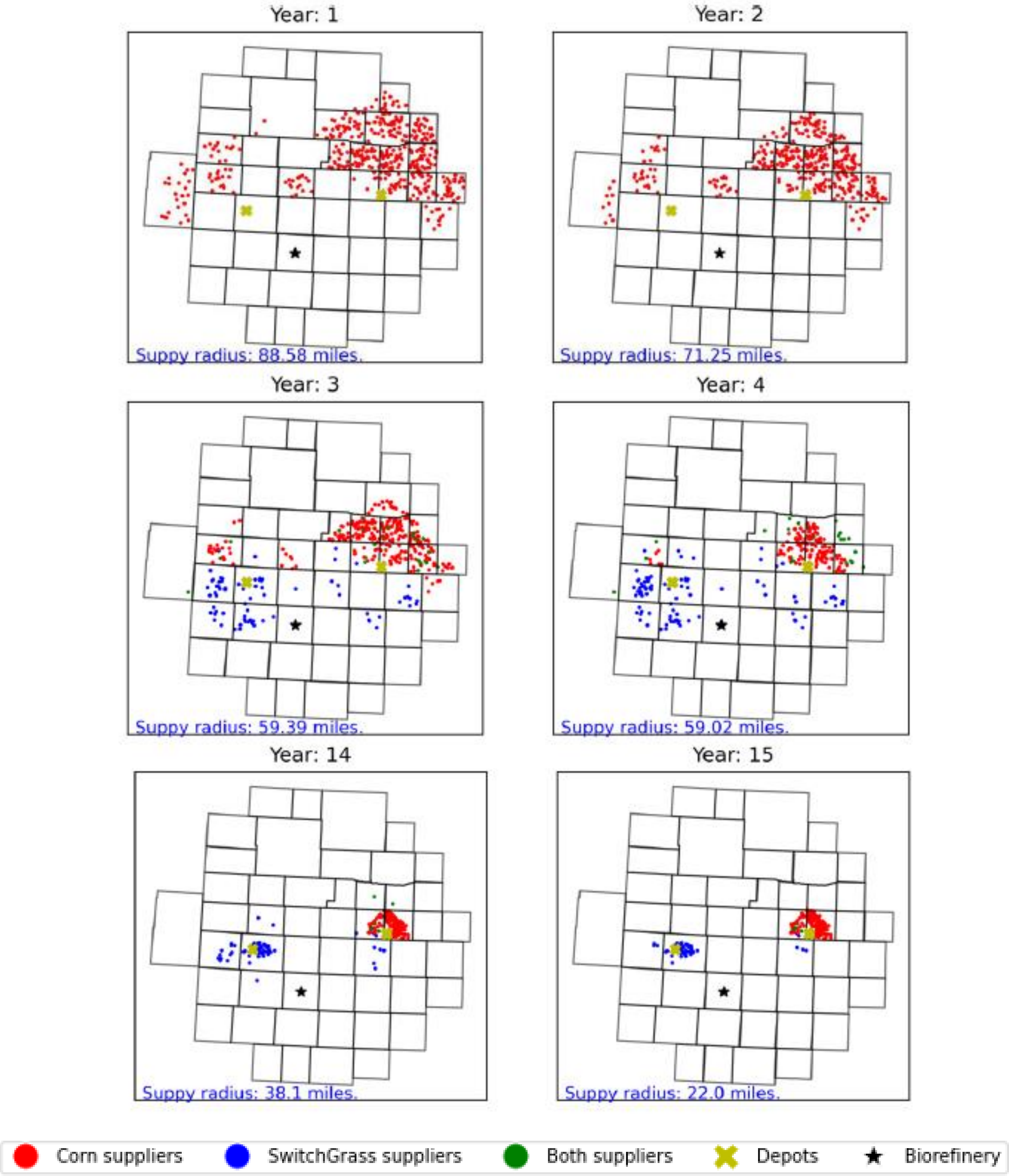


1 – Approach (Management)

- Team:
  - Pralhad Burli – PI / Economist
  - Rajiv Paudel – Systems Modeling Scientist
  - Damon Hartley – Strategic Advisor
- Communication/Collaboration:
  - Quarterly presentations to BETO
  - Biweekly coordination meetings
  - 3 Quarterly Progress and 1 Annual Report
- Risks/Risk Mitigation:
  - Data gaps and validation of model assumptions
    - Mitigated through discussions with industry participants, collaboration with other researchers.
- Diversity, Equity, and Inclusion were not formally stated goals of this project, however, understanding DEI impacts of this research will be included during merit review in FY23.

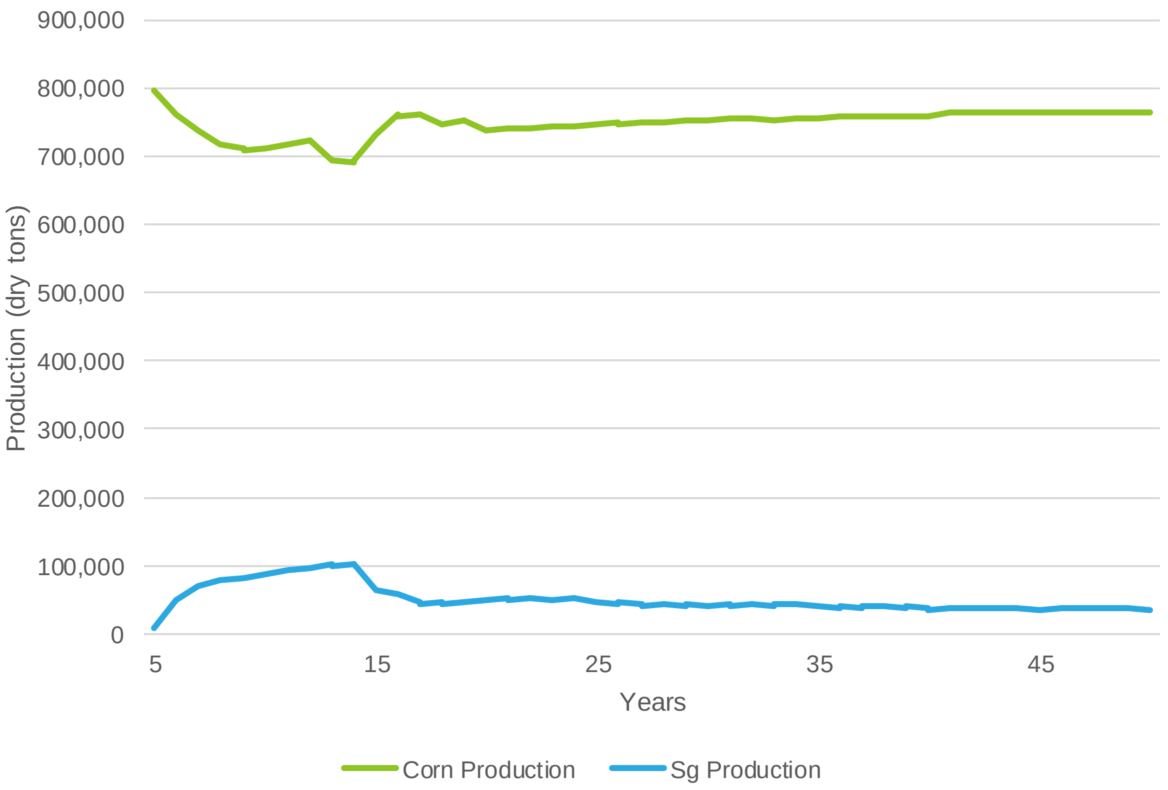
2 – Progress and Outcomes

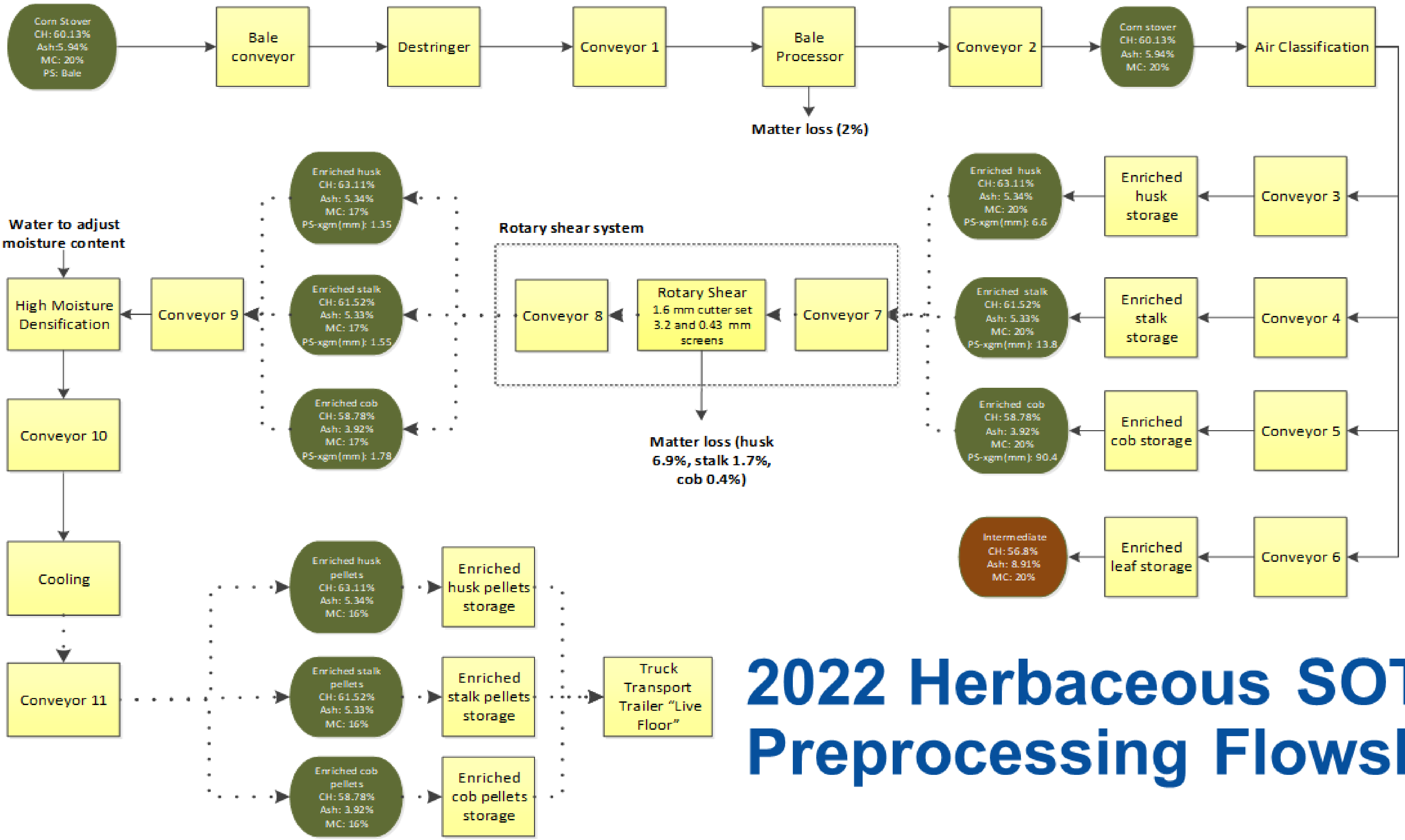
- Supply chain evolution in the 50-county region supporting 1 biorefinery (800,000 dry tons)
  - Highest yielding acres (>150 bu/acre) of corn production are considered for residue harvest
  - Low yielding acres, not selected in Conservation Reserve Program (CRP), can be converted to energy crop
  - Biorefinery agents visit farmers to establish contracts
  - Switchgrass suppliers only participate under long-term (10-year contracts)
  - Corn stover contracts can be annual
  - Supply radius decreased over time from approximately 90 miles to 22 miles



2 – Progress and Outcomes

- Biomass supply and procurement costs
  - Supply in initial years is met using only corn stover
  - It takes a few years for farmers to learn about switchgrass and establish energy crops
  - Around year 15, biomass supply achieves its steady state
    - 95.6% corn stover
    - 4.4% switchgrass
  - Procurement operations cost an additional $1.11/ dry ton

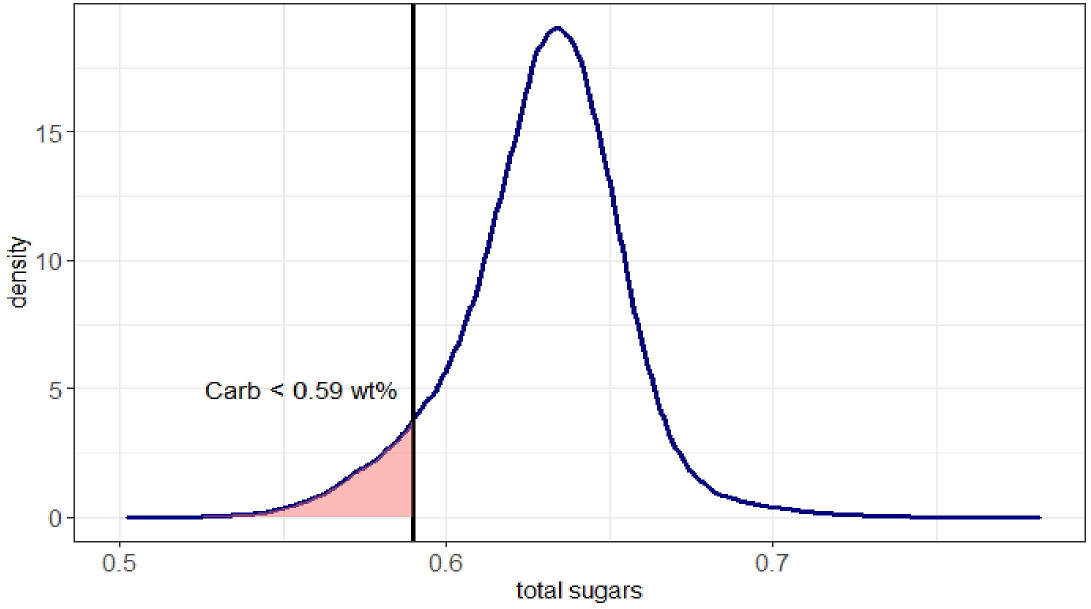


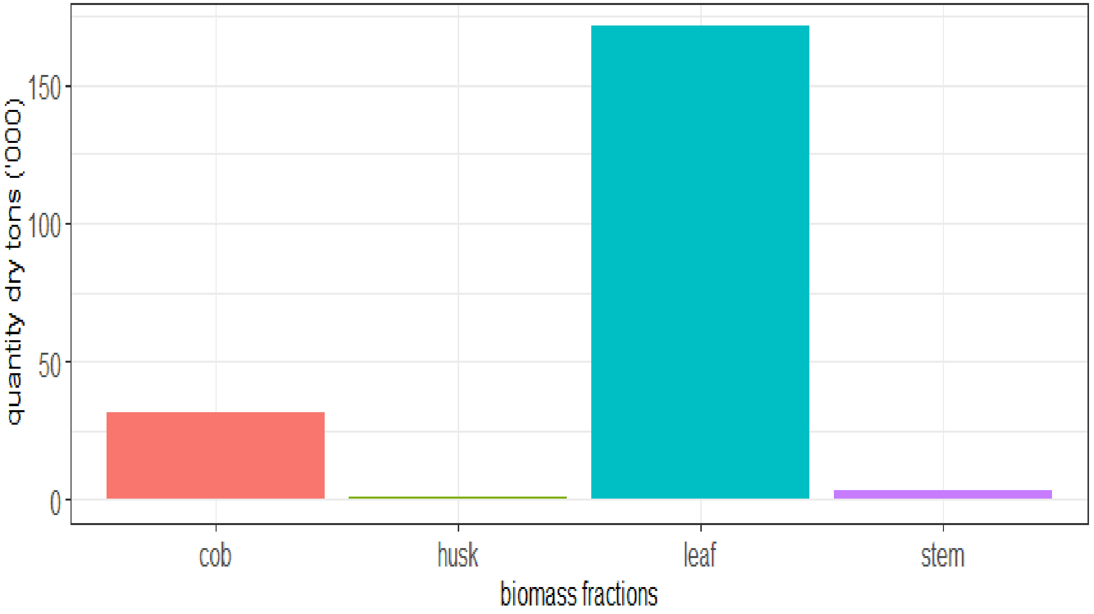


2022 Herbaceous SOT – Preprocessing Flowsheet

2 – Progress and Outcomes

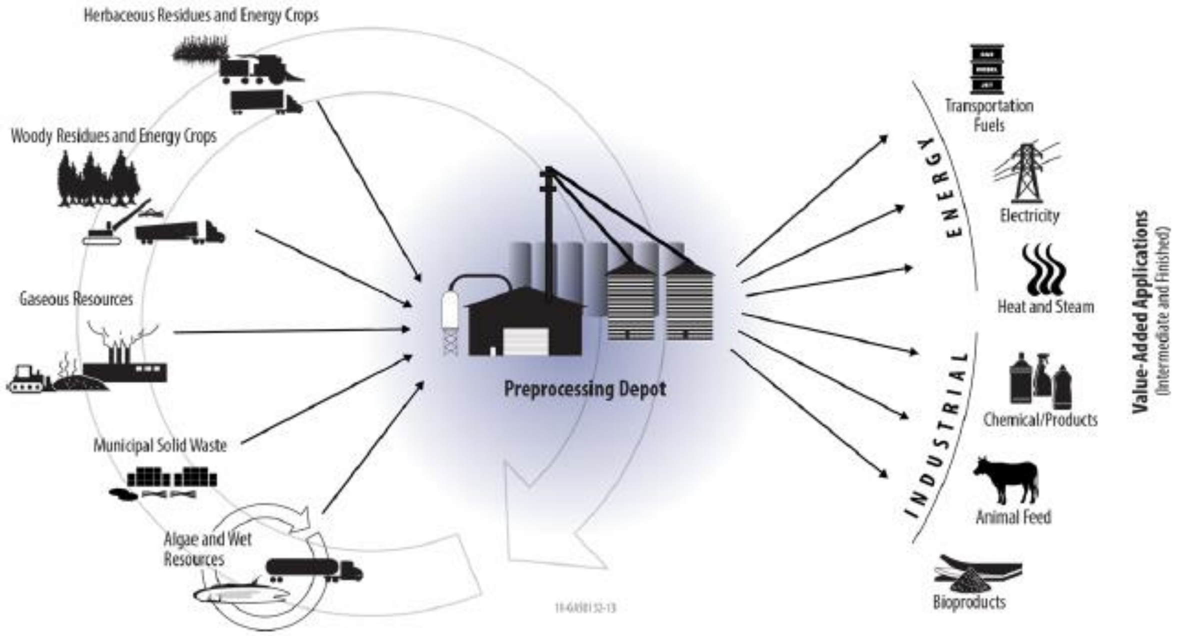
- Feedstock Quality and off-spec materials
  - Variability in biomass quality renders materials unusable for conversion processes
  - Drawing from research undertaken in the Feedstock Logistics Project (1.1.1.2), it is possible to quantify off-spec material
    - Approximately 7% of biomass does not meet required carbohydrate quality requirement (Carb ≥ 59 wt%)
    - Leaf (high ash) and cob (low carbohydrate) can be used in alternate markets
  - A preprocessing system design delivering 725,000 dry tons of biomass annually generates off-spec biomass:
    - 171,084 dry tons of leaf fraction ($56.15/dt)
    - 31,617 dry tons of cob fraction ($76.71/dt)
    - small quantities of husk and stem





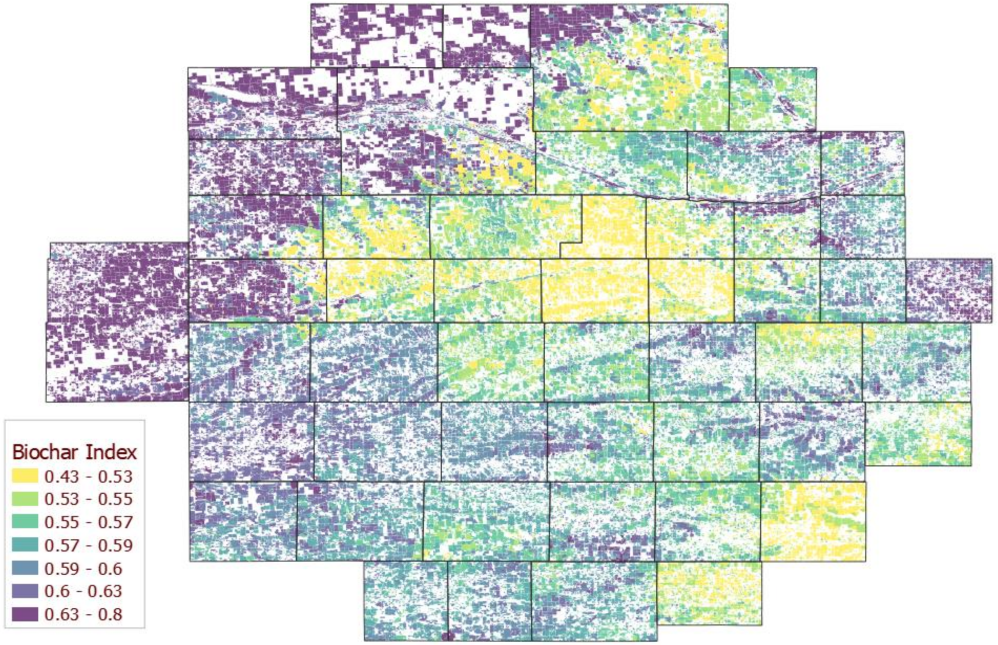
2 – Progress and Outcomes

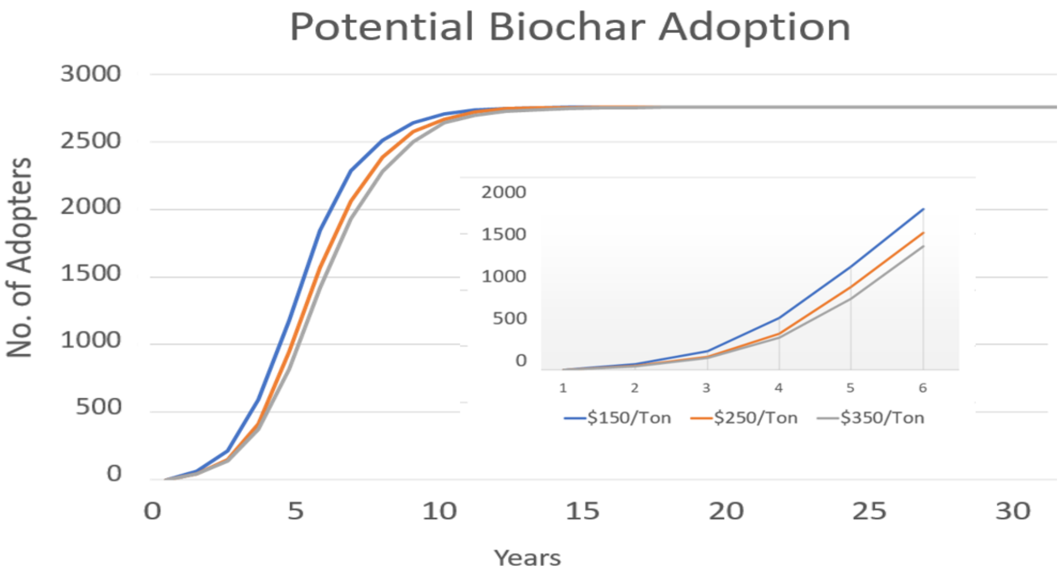
- Midstream markets:
  - Identify alternate uses of fractions to reduce feedstock costs at the biorefinery
  - Biomass can be used to produce a wide range of products including animal feed, building materials, chemicals, biochar, and nanomaterials
  - Down-select 1-2 markets
    - Biochar (diffusion model developed in Q4 FY2022)
    - Animal Feed (model development in progress)



2 – Progress and Outcomes

- Estimating a biochar requirement index (darker shades indicate higher biochar requirement):
  - Available soil water storage
  - pH
  - Cation exchange capacity
  - Moisture Difference z-score
- Application of biochar can increase crop yields and reduce irrigation requirements
- Assumed one-time application of biochar and evaluated price sensitivity of adoption for biochar costs at $150, $250, and $350/dry ton
  - At year 5, biochar adoption rates range between 4% and 7% of potential adopters under the different scenarios



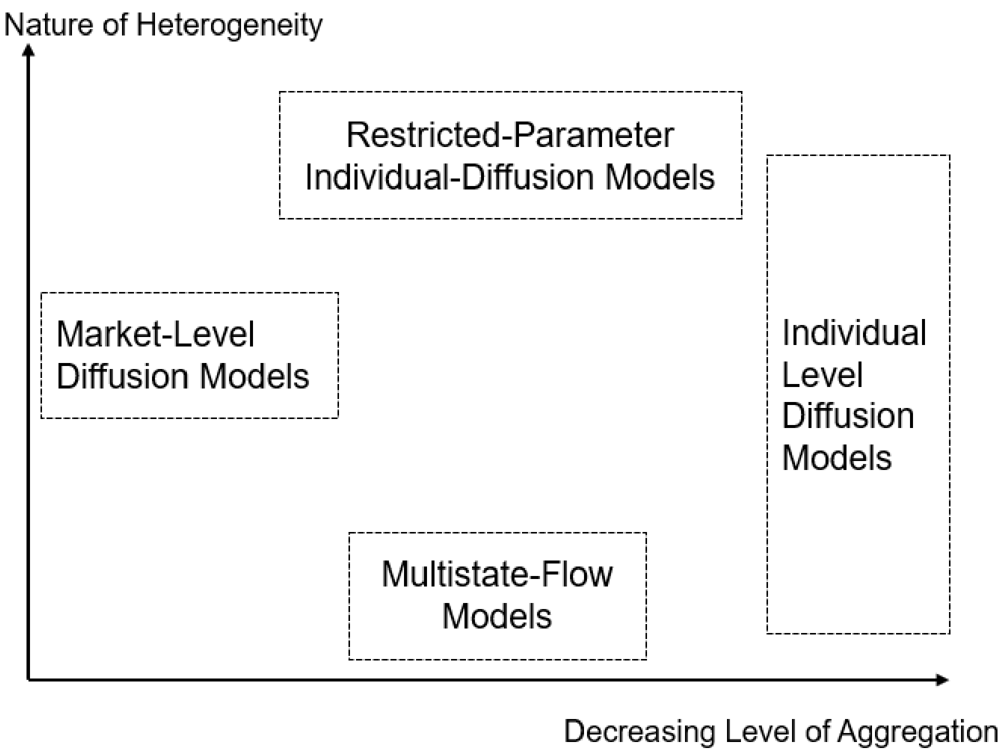


3 - Impact

- Project Impact
  - Identify pathways that can influence the transition of the bio-based resource base into viable industries for biofuels and bioproducts
  - Analytical insights and development of modeling approaches to enable stakeholder interactions and demonstration of research capabilities
- Products and Outputs
  - Manuscript on farmer characteristics and influence on decision making published in Energy journal in 2021 (Impact Factor 8.857)
  - Manuscript on farm delineation from field boundaries in submission to Computers and Electronics in Agriculture (Impact Factor 6.757)
  - Presentations to:
    - ExxonMobil
    - ARPA-E TERRA-ROOTS SMARTFARM
    - IEA Task 40

Summary

- **Challenge:** Understand determinants of participation in a relatively nascent market of biofuels and bioproducts and identify factors that can facilitate development of robust biomass supply chains to support a viable bioeconomy.
- **Approach:** Use integrated modeling approaches to simulate farmer participation in the biomass supply chain, evaluate interactions between market participants, and assess diffusion of materials in alternate value-added products.
- **Accomplishments:** Demonstrated supply chain evolution, incremental costs, and avenues for utilizing off-spec materials for development of bio-based industries.
- **Relevance:** Forward-looking insights can help our understanding of potential transition pathways for utilizing renewable carbon feedstocks, identify alternatives for risk mitigation, and support development of biomass supply chains.



Source: Roberts and Lattin, 2000

Quad Chart Overview

Timeline
- *Project start date: 10/01/2020*
- *Project end date: 09/30/2023*

	FY22 Costed	Total Award
DOE Funding	*$255,538*	*$705,000*
Project Cost Share*		

TRL at Project Start: N/A
TRL at Project End: N/A

Project Goal
Identify strategies to enable greater biomass mobilization by examining factors that influence participation in bio-based supply chains and diffusion of biomaterials to their most valuable end use.

End of Project Milestone
Demonstrate that a biorefinery can meet fuel production demand by accessing a minimum of 725,000 dry tons of biomass, while also channeling at least 20% of the material, that is off-spec for downstream conversion, to value-added midstream markets.

Funding Mechanism*

Project Partners
- WBS 1.1.1.2 – Feedstock Supply Chain Analysis (INL)
- WBS 4.2.1.20 – Integrated Landscape Management (INL)
- WBS 1.1.1.3 – Supply Scenario (ORNL)

*Only fill out if applicable.

Publications

- Burli, P. H., Nguyen, R. T., Hartley, D. S., Griffel, L. M., Vazhnik, V., & Lin, Y. (2021). Farmer characteristics and decision-making: A model for bioenergy crop adoption. *Energy*, *234*, 121235.
- Paudel, R., et al. (2023). Fast and less-spurious: A pragmatic approach for field to farm aggregation for agricultural systems, in submission Computers and Electronics in Agriculture.

Presentations

- Burli, P., Paudel, R. & Hartley, D. From far and near: An agent-based model for biomass supply chain evolution. Association of Environmental and Resource Economists (Forthcoming May 2023)

Questions?

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