

DOE Bioenergy Technologies Office (BETO) 2023 Project Peer Review

1.1.2.3 – National availability and delivered costs of cover crops managed as biofuel feedstocks

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Feedstock Technologies Program

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ORNL is managed by UT-Battelle, LLC for the US Department of Energy

Project Overview

Project goals:

- Evaluate competitiveness of oilseed and biomass cover crops contributing to BETO goals for decarbonization and sustainable aviation fuel (SAF) production
- Generate foundational cover crop supply curve data sets for BETO conversion and sustainability modeling

From cover cropping to double cropping

- To be feasible as a secondary crop, cover crops must
 - Reach harvestable maturity
 - Provide additional farm revenue—*Can this incentivize more cover crop plantings?*
 - Revenue must not be outweighed by additional management costs or potential changes to the primary cash crop if harvest and planting dates are adjusted to accommodate the cover crop
 - Improve soil health and/or water quality
 - Maximum environmental benefit from cover crops comes when the biomass is not harvested, missed opportunities for ecosystem services must be considered



Photo Credit: Sustainable Agriculture Research and Education

1 – Approach

Coordination with Billion Ton Update

Need for cover crop supply curves accelerated

Original 1.1.2.3 proposal

FY22: Model time to maturity of select cover crops to assess feasibility as biofuel feedstock

FY23: Supply chain analysis to estimate harvest and logistics costs

FY24: National-scale county-level availability maps and supply curves, offered price vs quantity, for select cover crops available on the Bioenergy KDF

During FY22.....

Efforts began on a new Billion-ton report (BT23)

Will include oilseed cover crops

To be published late 2023

Adjusting Year 2 and 3 goals

FY22: Model time to maturity of select cover crops, focus on biomass cover crops

FY23: Coordinate with Billion Ton study to fill data gaps for supply curve development and support validation; supply chain analyses; **focus on biomass cover crops**

FY24: Evaluate cover crop deployment strategies, accounting for **adoption barriers**, income from **ecosystem service benefits** (e.g. water quality)

1 – Approach

Consider additional benefits of Cover Crops, such as:

- Improved soil health
 - decreases in erosion and nutrient leaching
 - increases in organic material
- Increased resilience to erratic weather conditions
 - soil moisture conservation through reduced evaporation
 - increased infiltration through reduced soil compaction
- Natural weed and pest control
- Pollinator attraction and support
- Increased yields of corn and soy
- Forage for cattle



Photo Credit: [Sustainable Agriculture Research and Education](#)

Consider how these potential benefits may be impacted by the crop rotation, choice of cover crop, geographic location, timing of planting and harvesting, equipment, etc.

1 – Approach

Oilseeds are easily converted to sustainable aviation fuel (SAF)

Oilseed cover crops evaluated (*to be included in Billion Ton 2023*)



(Photo: AgMRC)

Pennycress

- Early source of food for pollinators
- Protects soil against erosion, nutrient leaching and weeds
- Average oilseed yield of 1,600 lb/acre*

*Yield estimates from Jim Larson of UTIA



(Photo: University of Florida)

Carinata (*Ethiopian mustard*)

- Unfit for human consumption, but good feed for livestock
- Releases fumigants that can control soil borne diseases, insects and weeds; deep roots help prevent erosion
- Average oilseed yield of 1,933 lb/acre*



(Photo: Millborn Seeds)

Camelina

- High oil content that is suitable for food uses as well as biodiesel
- Good for dryland cropping systems & marginal soils
- Matures quickly with an average oilseed yield of 1,050 lb/acre*

1 – Approach

Herbaceous cover crops evaluated (*not included in Billion Ton 2023*)



(Photo: [University of Wisconsin-Madison](#))

Rye

- Small grain crop with significant biomass potential (can yield up to 4 tons/acre)
- Can be grazed or harvested as forage
- Harvested just before seed emergence



(Photo: [North Dakota State University](#))

Winter wheat

- Small grain crop
- Can be grazed or harvested as forage
- Harvested just before seed emergence



(Photo: [Cornell University](#))

Hairy Vetch

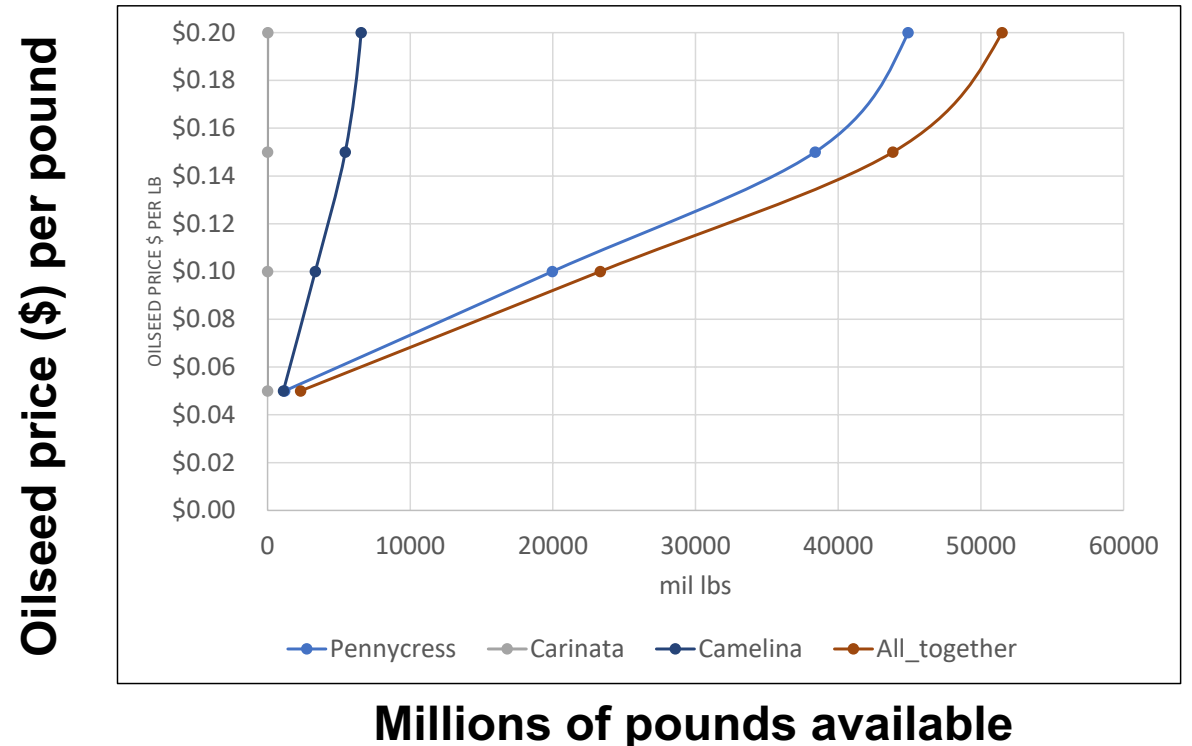
- A legume, fixes nitrogen (N)
- Can be grazed or harvested as forage
- Should not be terminated too early for max N fixation

2 – Progress and Outcomes

Oilseed Cover Crops added to Billion Ton 2023

- Integrated work from UT ASCENT project into ORNL's economic model (POLYSYS)
 - ASCENT = Alternative Jet Supply Fuel Chain Analysis for the Federal Aviation Administration (FAA)
 - County level yields and budgets for Pennycress, Carinata, Camelina in corn/soy and cotton/soy rotations

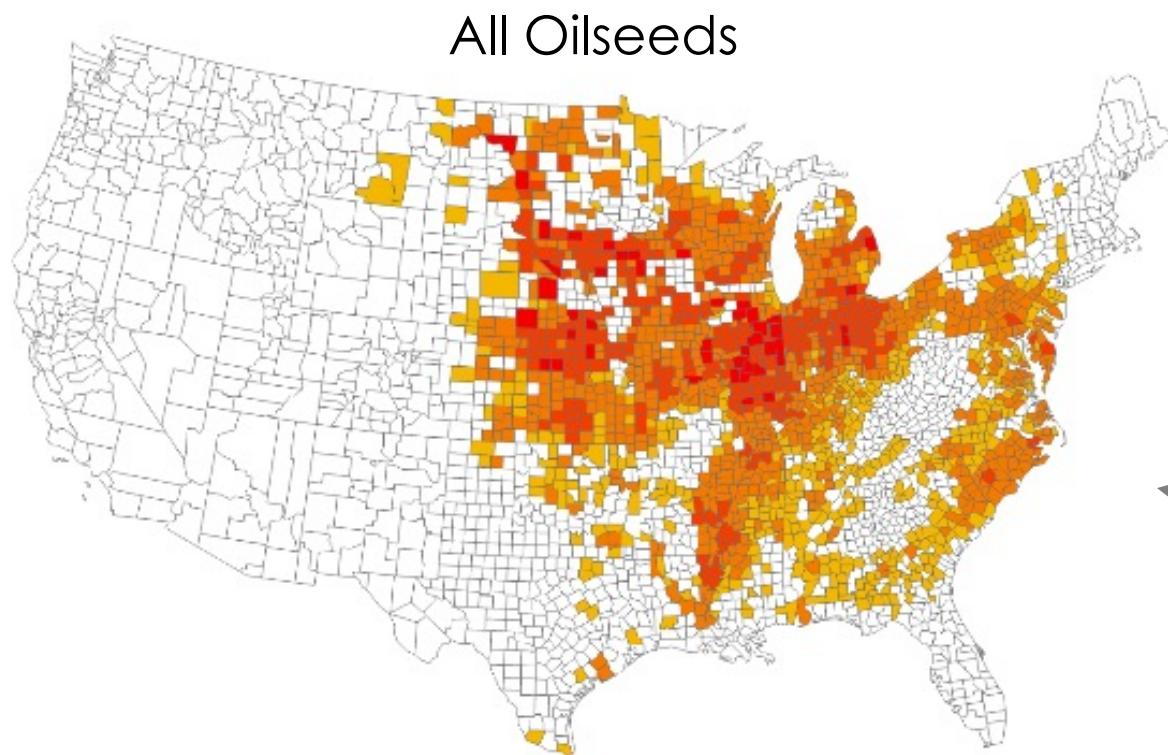
Supply curves developed for BT23



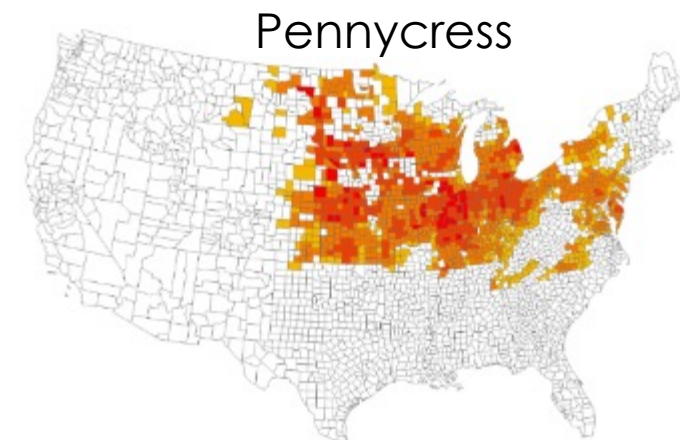
2 – Progress and Outcomes

Oilseed Cover Crops added to Billion Ton 2023

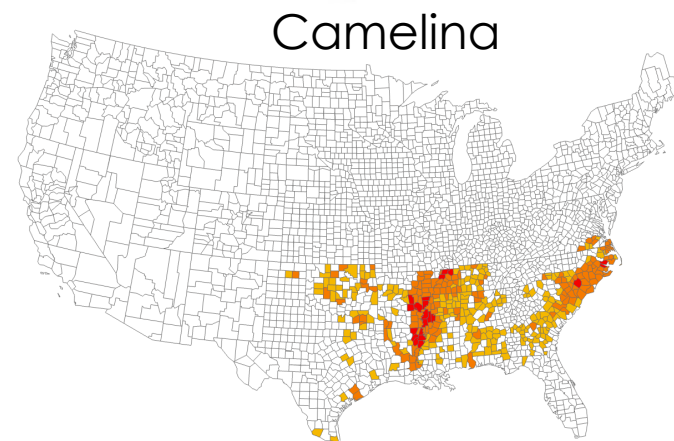
New analysis suggests ~22 million tons of oilseeds at price of \$0.15/lb (yielding ~3 billion gallons SAF)



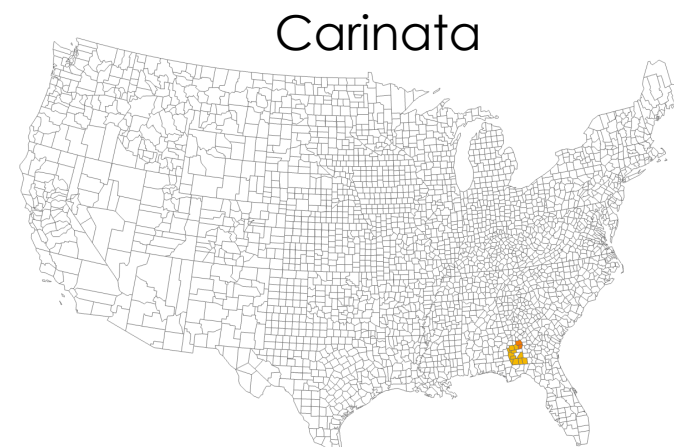
All Oilseeds



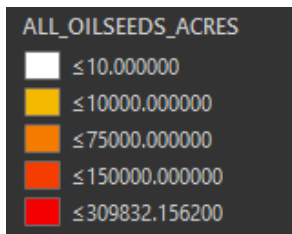
Pennycress



Camelina



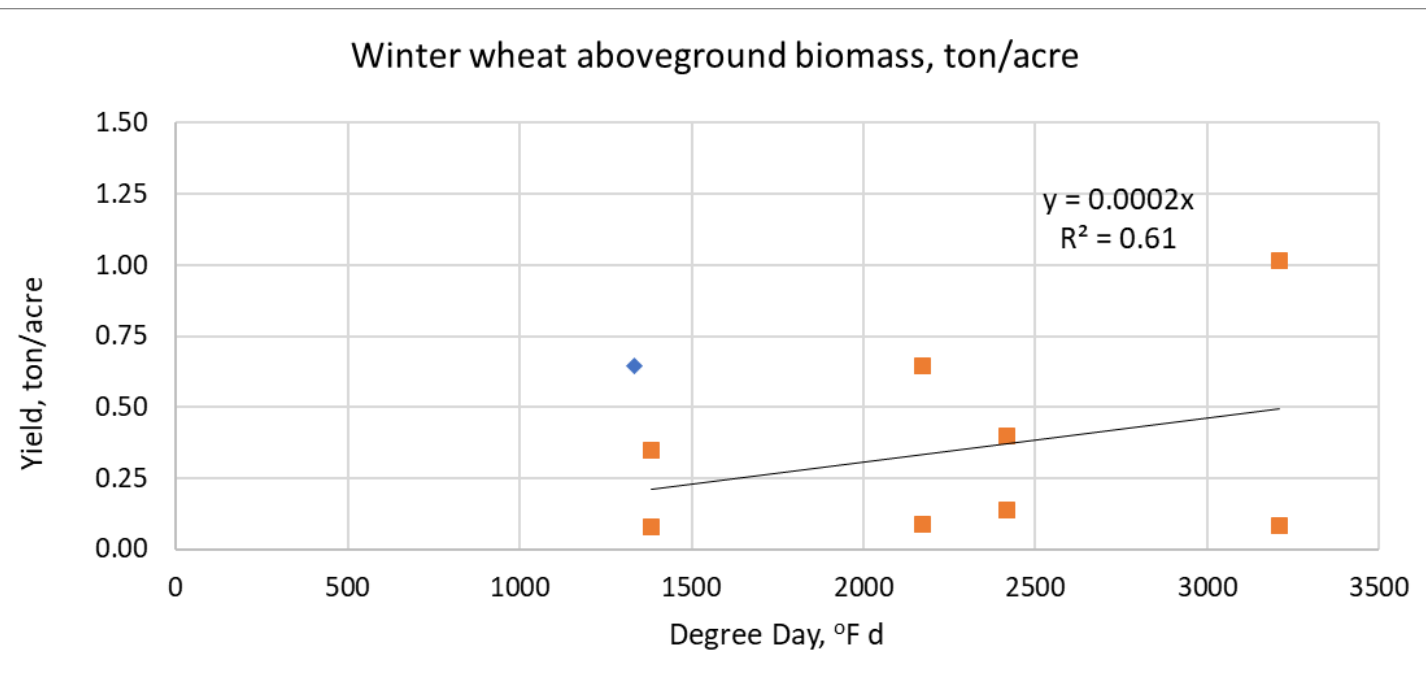
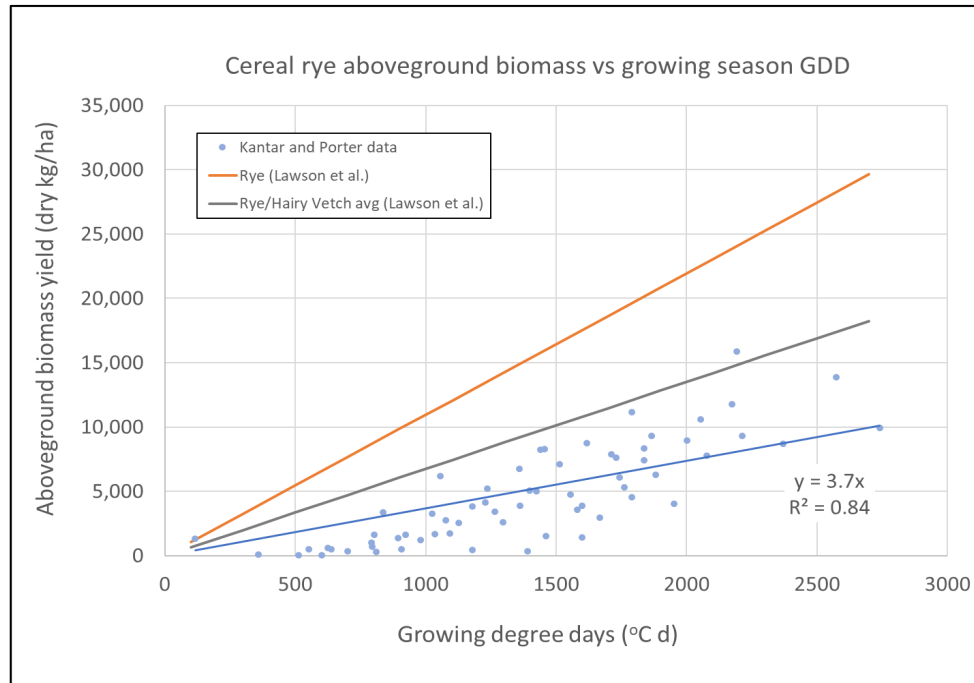
Carinata



2 – Progress and Outcomes

Herbaceous cover crop yield models under development

- Reviewing literature
- Developing growing degree day (GDD) models
- Will use GDD models to develop national yield maps

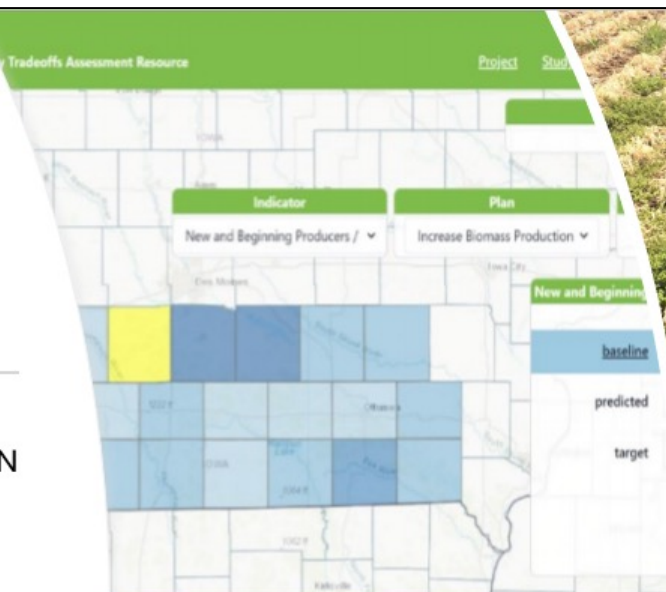


1 – Approach

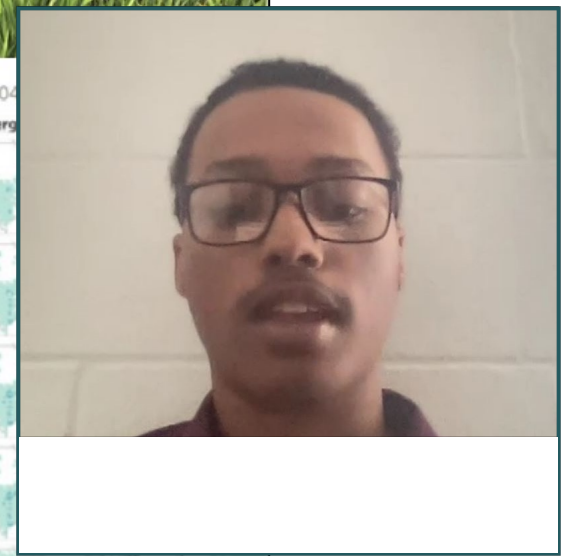
DelMarVa Peninsula of the Chesapeake Bay region

Student research opportunity

- Paid internship, including summer opportunity to conduct research at Oak Ridge National Laboratory in Oak Ridge, TN
- Study environmental benefits of cover crop production for sustainable aviation biofuels
 - Survey farmers to identify barriers to cover crop adoption
 - Review literature and other information sources to assemble datasets to support modeling environmental benefits and costs of cover crop adoption
 - Communicate findings with contributions to team reports, papers, and presentations
- Learn data analysis, data visualization, and scientific communication skills



Map Credit: VA Eastern Shore



For more information contact Dr. Jonathan Cumming: jrcumming@umes.edu

2 – Progress and Outcomes

Exploration of ecosystem service tradeoffs with a rye cover crop

- Repurposed Antares Iowa Landscape Design project datasets
- Used subfield data for 48 management scenarios
- Ran optimizations for 16-county biofuel supply shed area centered on Nevada, IA

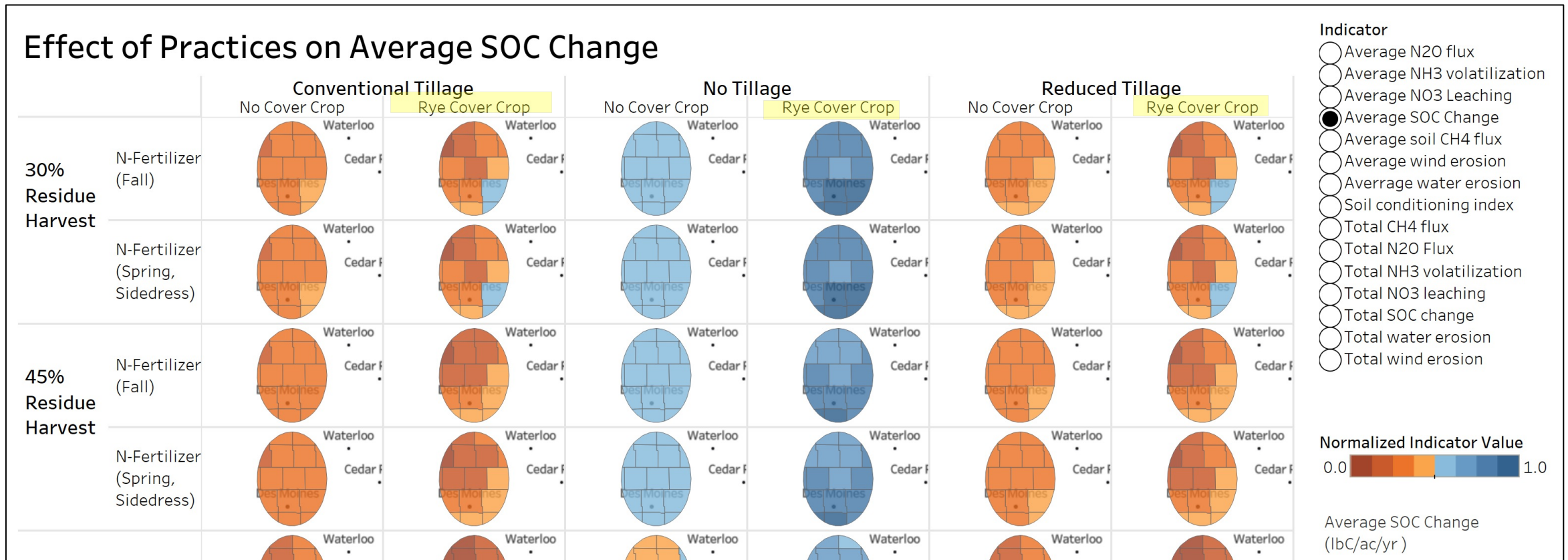


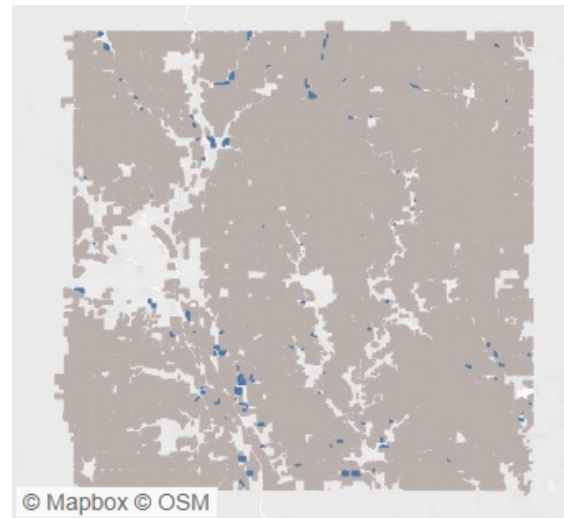
Tableau data dashboard from former BETO DMA Project 4.2.2.40, Quantifying & Visualizing Progress Toward Sustainability

2 – Progress and Outcomes

Example of optimized land management practices for Story County, Iowa

- Determining the profit level at which rye cover crops are most widely adopted for specific ecosystem service benefits can help define incentives that may be needed.
- With expanded markets for SAF, harvesting the rye cover crop for biofuels production could generate additional income that should also be considered.

Baseline scenario (profit at 100%)



- No Cover Crop
- Rye
- Switchgrass
-

Environmental scenarios (profit at 40%)

Soil Organic
Carbon
Change



Nitrate
Leaching

Source: Parish, Hilliard and Xie. Optimization of Land Management Practices for Cellulosic Biomass Production with Environmental Benefits. Manuscript in preparation.

2 – Progress and Outcomes

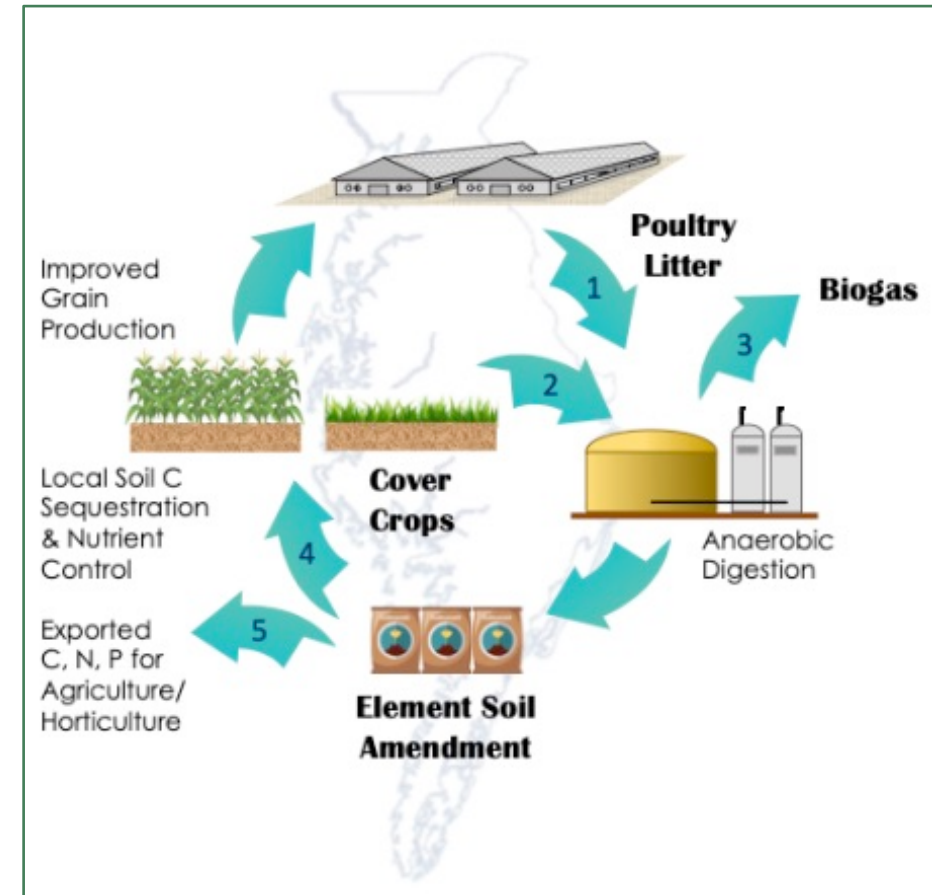
Future Work: Explore barriers & incentives for cover crop adoption

Refine hypotheses related to barriers

- Low availability of seeds?
- Higher operational costs?

Explore recent uptick in oilseed and cover crop adoption

- USDA Environmental Quality Incentives Program (EQIP)
- Recent investments by the airline industry



We will learn more about cover crop adoption barriers through our collaboration with University of Maryland Eastern Shore (UMES). They will be conducting farmer surveys as part of their newly funded USDA SMART project in the DelMarVa peninsula.

2 – Progress and Outcomes

Future Work: Building new collaboration with Virginia Sykes at UT Institute of Agriculture

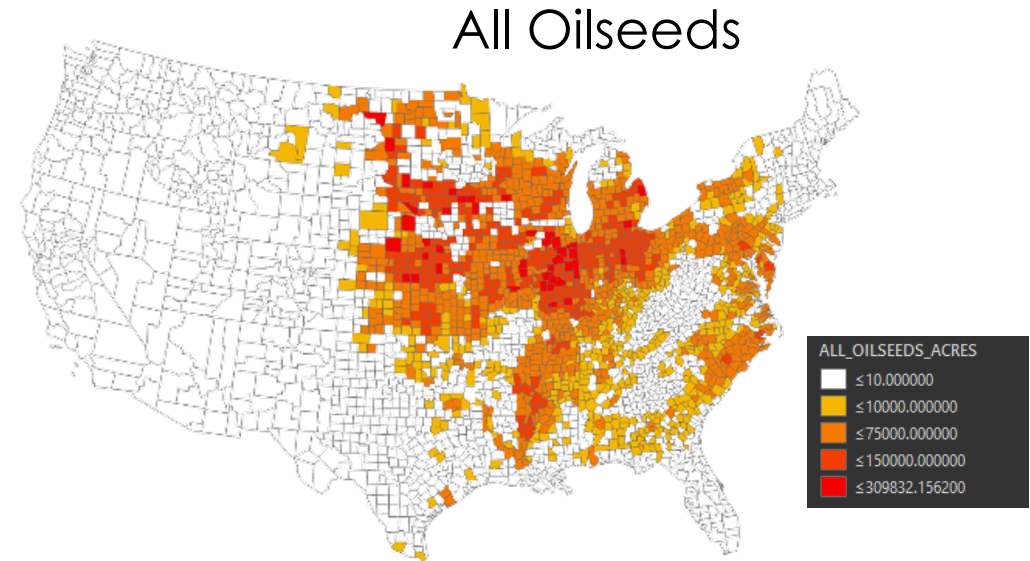
- Sykes' research is multi-disciplinary, bringing together experts on diseases, insects, weeds, soils, economics and crops in an effort to build more sustainable agricultural systems.
- Her current focus is on cover crops, plants grown off-season from corn and soybean cash crops. Sykes examines how cover crops might add economic value to producers.
- Sykes coordinates the statewide variety testing program, working with corn, soybean and alternative crops.
- She will share datasets from new cover crop variety trial
 - 10 Southern states
 - 20 locations, 12 species
- She will share data from ongoing trials of winter oilseed crops
 - 18 varieties
 - Assessments which are best for biofuel, forage, etc.



3 – Impact

Project will generate foundational data sets for **BETO conversion and sustainability modeling, including:**

- National yield maps
- Oilseed and Herbaceous cover crop budgets
 - Production costs
 - Harvest costs
- Supply curves
 - Likelihood of adoption given ecosystem services AND market potential for sustainable aviation fuel (SAF) and other products
- Ecosystem tradeoffs
 - Soil carbon, water quality, biodiversity
- Adoption barriers



Preliminary national analyses show that as much as 3 billion gallons of SAF can be developed from oilseed crops

Summary

This new BETO project was established to:

- Evaluate competitiveness of oilseed and herbaceous biomass cover crops contributing to BETO biofuel and decarbonization goals
- Generate foundational cover crop supply curve data sets for BETO conversion and sustainability modeling
- Evaluate cover crop deployment strategies, accounting for adoption barriers, income from ecosystem service benefits (e.g., water quality, carbon sequestration)



Photo credit: [SARE](#) image of clover cover crop in wheat



Photo credit: [Conservation Media Library](#) image of cereal rye cover crop

Quad Chart Overview

Timeline

- *Project start date: October 1, 2021*
- *Project end date: September 30, 2024*

	FY22 Costed	Total Award
DOE Funding	(10/01/2021 – 9/30/2022)	\$580,000
Project Cost Share *	N/A	

TRL at Project Start: TRL-2
TRL at Project End: TRL-2
(*Early-stage R&D*)

Project Goal

Evaluate competitiveness of oilseed and biomass cover crops contributing to BETO goals for decarbonization and sustainable aviation fuel (SAF) production

End of Project Milestone

National-scale assessment of cover crop deployment strategies to assess sensitivity of oilseed and herbaceous biomass cover crop availability and cost as impacted by ecosystem service valuation and adoption barriers with datasets made available on the Bioenergy KDF.

Funding Mechanism

Lab Call for the Feedstock Technologies Platform

Project Partners

- University of Maryland Eastern Shore (UMES)
- University of Tennessee Institute of Agriculture (UTIA)

Additional Slides

Publications, Patents, Presentations, Awards, and Commercialization

- Upcoming Billion Ton 2023 Report
- Parish, Hilliard and Xie. Optimization of Land Management Practices for Cellulosic Biomass Production with Environmental Benefits. Manuscript in preparation.