DOE Bioenergy Technologies Office (BETO) 2019 Project Peer Review

Integrated Landscape Management WBS# 4.2.1.20

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Analysis and Sustainability

L. Michael Griffel
Idaho National Laboratory

Goal Statement

- The goal of this project is to demonstrate through modelling that Integrated Landscape Management (ILM) can reduce biomass feedstock production costs at a field level.
- The intended outcome of this project is to contribute to the Bioenergy Technology Office (BETO)'s renewable fuel cost target (2030) of $2.50/gge by reducing biomass production costs.
- This project is relevant to the bioenergy industry in that it demonstrates potential pathways to achieve reduced feedstock costs while maintaining or improving economic and sustainability outcomes of agricultural production systems.

Quad Chart Overview

Timeline

- Project start date: 10/01/2017
- Project end date: 9/30/2020
- Percent complete: 41.67%

	FY 17 Costs	FY 18 Costs	Total Planned Funding (FY 19-Project End Date)
DOE Funded	$582,032	$333,874	$600,000

Barriers addressed

At-E. Quantification of Economic, Environmental, and Other Benefits and Costs

Ft-A. Feedstock Availability and Cost

Objective

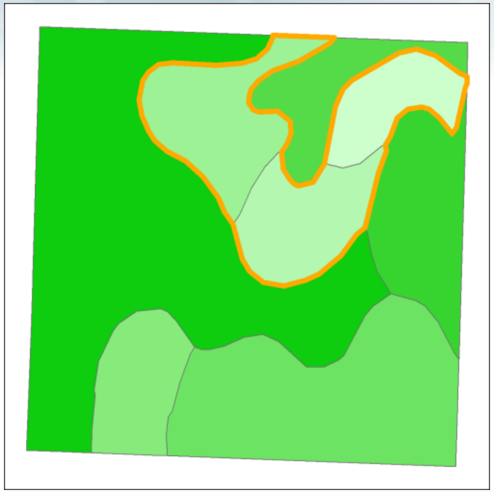
- Demonstrate ILM designs where stakeholder economic and sustainability outcomes are maintained or improved with reduced biomass production costs.
- Maintain or improve biomass harvest and collection field operation efficiencies.

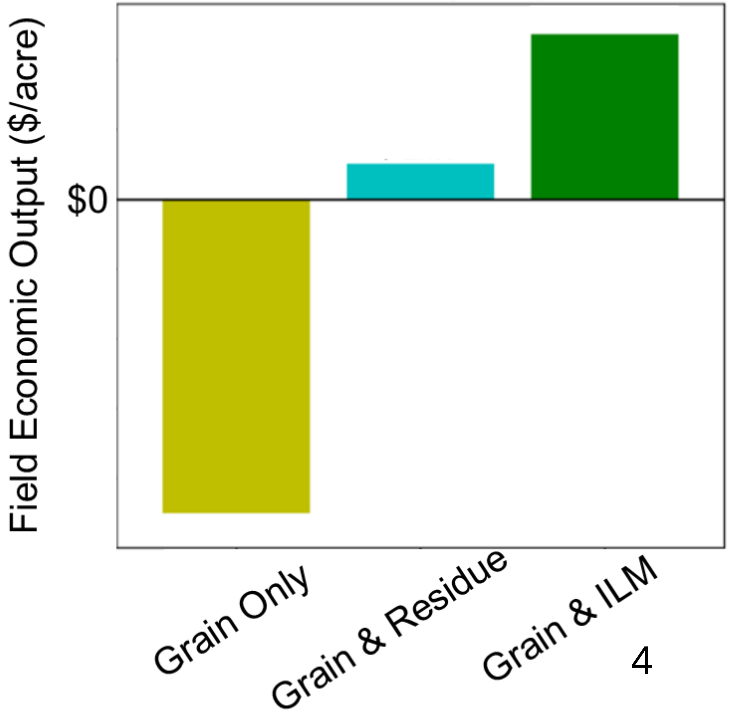
End of Project Goal

The goal of this project is to demonstrate through modelling that Integrated Landscape Management (ILM) can reduce biomass feedstock production costs at a field level supporting BETO renewable fuel cost targets.

1 - Project Overview

- **History**
  - Project was conceived in 2014 from WBS 1.1.1.2 (Sustainable Feedstock Production – Logistics Interface)
  - Leverages Landscape Environmental Assessment Framework (LEAF).
- **Context**
  - Agricultural producers and land managers are potential major suppliers of biomass materials for energy conversion.
  - The **diverse** agricultural landscape represents a significant opportunity to source biomass feedstocks from excess crop residues and cultivated perennial energy crops such as *Panicum virgatum* (switchgrass) and *Miscanthus x giganteus* (miscanthus).





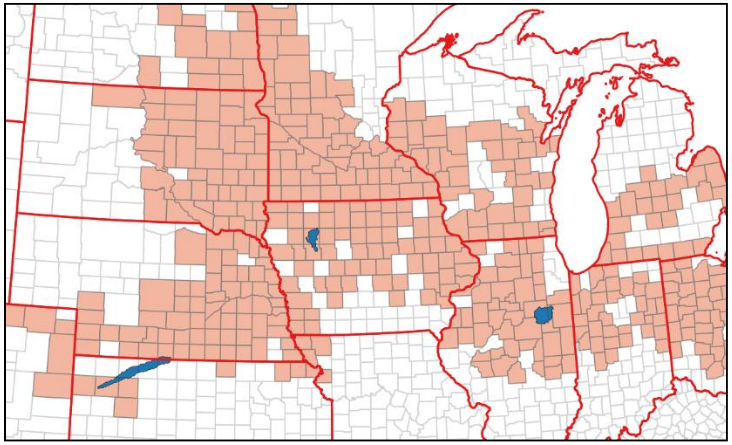
1 - Project Overview (Cont'd)

- **Project Objectives**
  - Demonstrate ILM designs where stakeholder economic and sustainability outcomes are maintained or improved with reduced biomass production costs.
  - Maintain or improve biomass harvest and collection field operation efficiencies.
- **Project Impact**
  - ILM designs provide opportunities to improve economic and sustainability outcomes at a subfield level for agricultural producers while providing biomass to bioenergy producers at reduced costs.

2 – Approach (Management)

- Alignment with BETO analysis and feedstock projects including Argonne National Laboratory (ANL) (WBS 4.2.2.10 Biomass Production and Nitrogen Recovery), Oak Ridge National Laboratory (ORNL) (WBS 1.1.1.3 Supply Scenario Analysis) and INL (WBS 4.2.2.62 Enabling Sustainable Landscape Design for Continual Improvement of Operating Bioenergy Supply Systems)
- Incorporated research assumptions relative to crop budgets, land management practices, and biomass and crop yields with the Billion Ton 2016 (BT16) analysis (ORNL) and USDA.
- Integrated biomass production costs as baselines from the Herbaceous Feedstock 2018 State of Technology Report for stover and switchgrass.
  - Based on the estimated grower payment derived from BT16 farmgate price (<$50/dry ton)

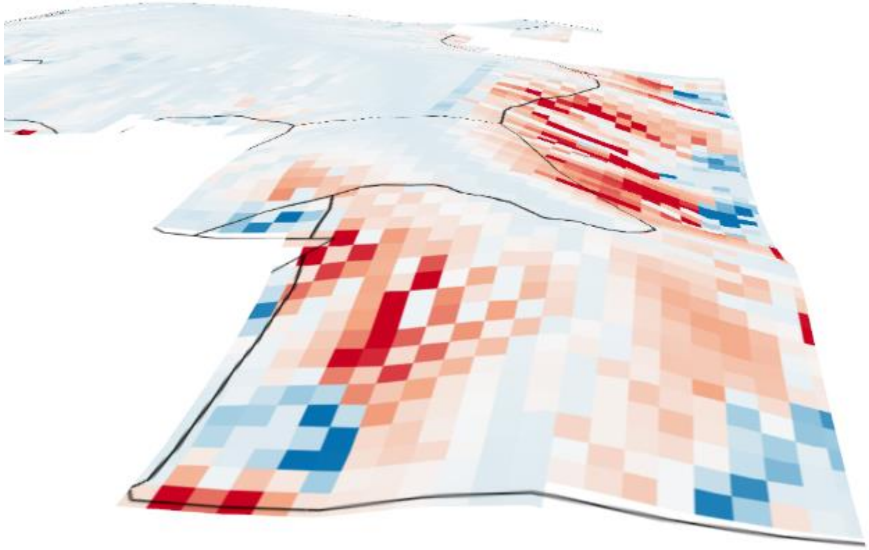
Watershed	Predominant Agricultural Production Practices
Upper Vermillion River	Rain-fed corn and soybeans
North Raccoon	Rain-fed corn and soybeans
Prairie Dog Creek	Rain-fed corn, soybeans, winter wheat, and fallow



INL/ANL joint watershed AOIs.

2 – Approach (Management Cont'd)

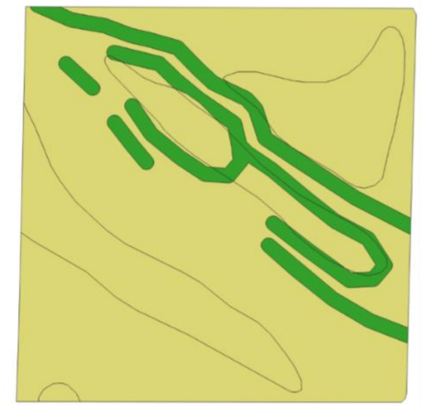
- Engaged US Department of Agriculture – Agricultural Research Services (USDA-ARS) researchers to update soil erosion modelling.
- Provided estimates of ILM-derived biomass for the Herbaceous Feedstock 2018 State of Technology Report (2022 Herbaceous Feedstock Cost Projection).
- Ongoing contributions to WBS 1.1.1.2 Feedstock Supply Chain Analysis and WBS 1.2.1.5 Resource Mobilization.
- Quarterly conference calls with BETO.
- Hosted ANL researchers at INL for on-site meeting (FY2018 Q1).
- Bi-weekly conference calls with ORNL.
- Four quarterly milestones per year (SMART).
- Team Members
  - Damon Hartley, Shyam Nair, Mohammad Roni, Ross Kunz, David Thompson

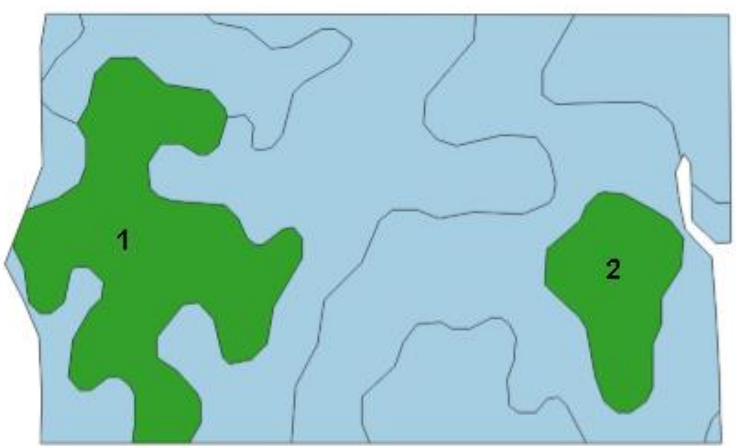


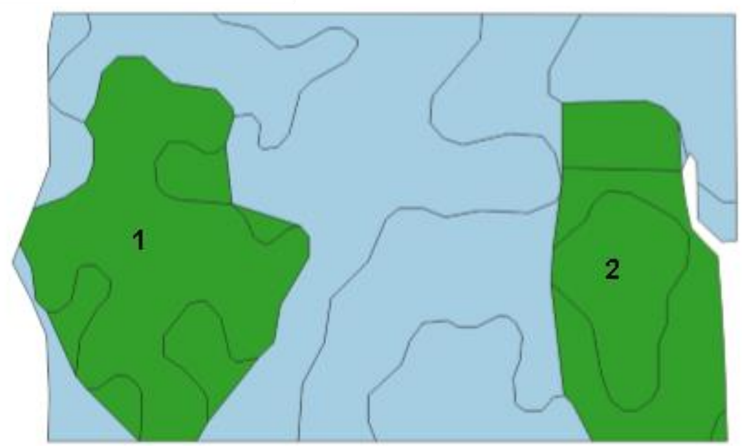
Modeled soil loss due to erosion under traditional cropping practices.

2 – Approach (Technical)

- Perform large-scale analyses of ILM scenarios (LEAF) to demonstrate potential biomass availability and cost impacts.
- Perform watershed-scale analysis to demonstrate the potential of ILM to reduce nutrient loading of water bodies from agricultural fields.
- Complete a techno-economic analysis (TEA) showing the potential of ILM designs to reduce biomass production costs by 20 percent over baseline assumptions.







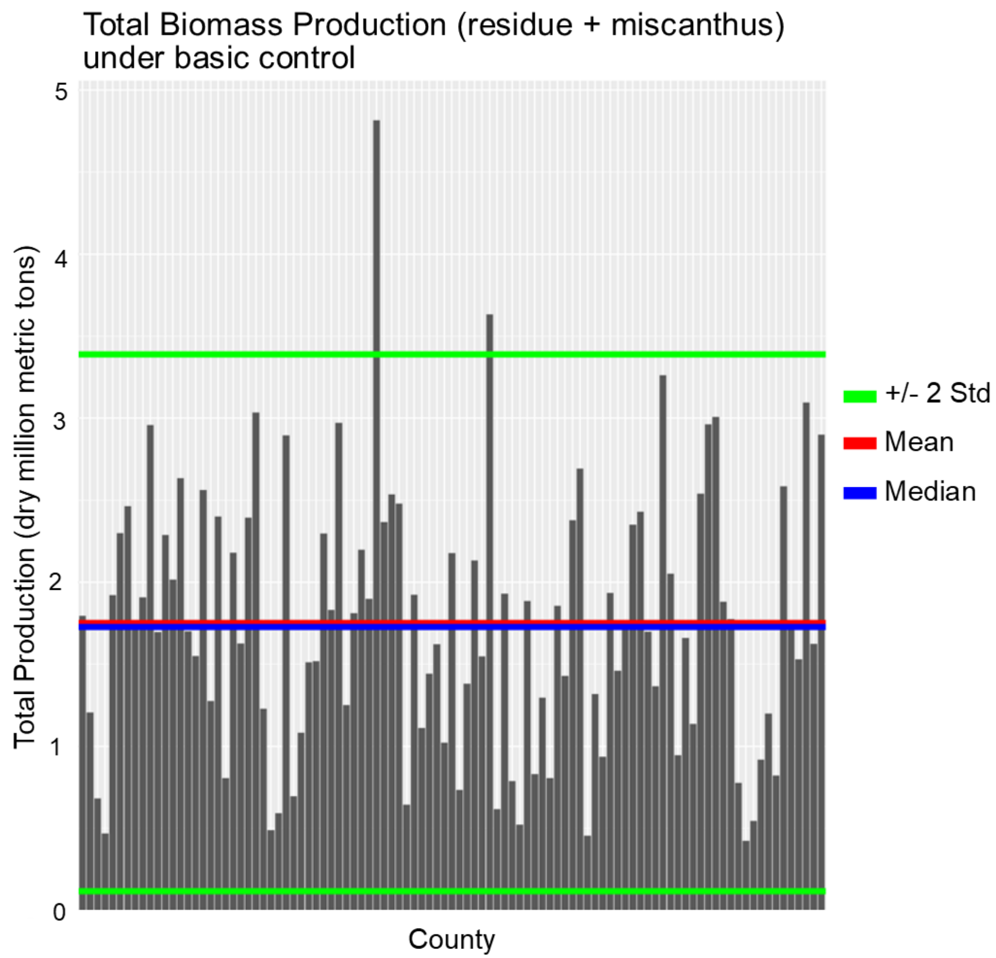
2 – Approach (Technical Cont'd)

- **Challenges**
  - Extensive coding and scripting were required to facilitate data preprocessing prior to modelling and analysis.
  - Updating soil erosion capabilities required extensive collaboration and communication with USDA-ARS researchers.
    - Revised Universal Soil Loss Equation 2 – Raster (RUSLER)
  - The updated soil erosion modelling is computationally intensive which limited the number of fields for analysis.
- **Success Factors**
  - Successfully integrated RUSLER and automated data preprocessing methods into ILM analysis.
  - Showed, through modelling, economic and sustainability outcomes at a field level by leveraging ILM designs to produce lower-cost biomass supplies

3 – Technical Accomplishments/ Progress/Results (FY17)

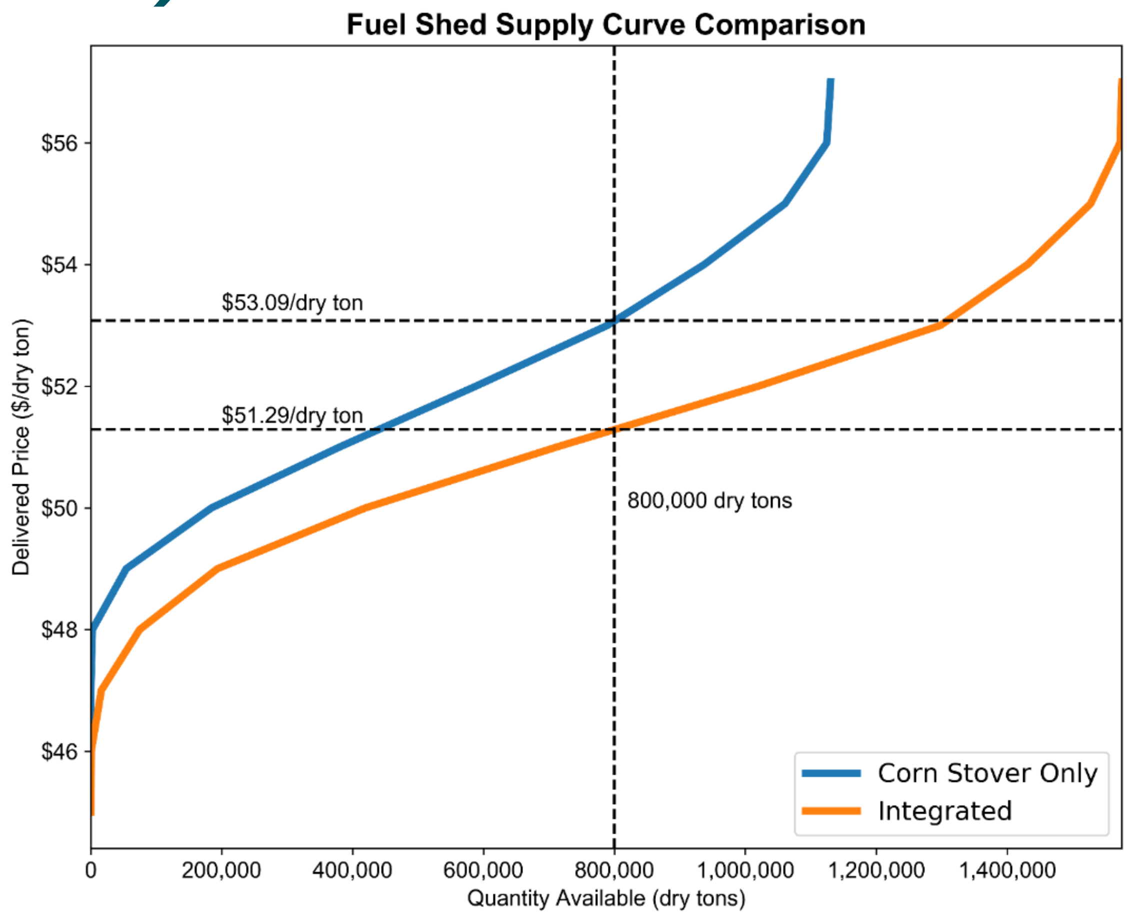
- Completed statewide analysis for Iowa and Kansas using LEAF.
- Completed analysis of effectiveness of bioenergy crops in reducing nutrient loading from agricultural fields within the Headwaters Beaver Creek Watershed in Iowa.

Miscanthus Integration	Sediment Loading	Nitrogen Loading	Phosphorus Loading
	(tons)	(tons)	(tons)
No	18,354	625.03	65.34
Yes	13,794	360.70	51.49



3 – Technical Accomplishments/ Progress/Results (FY18)

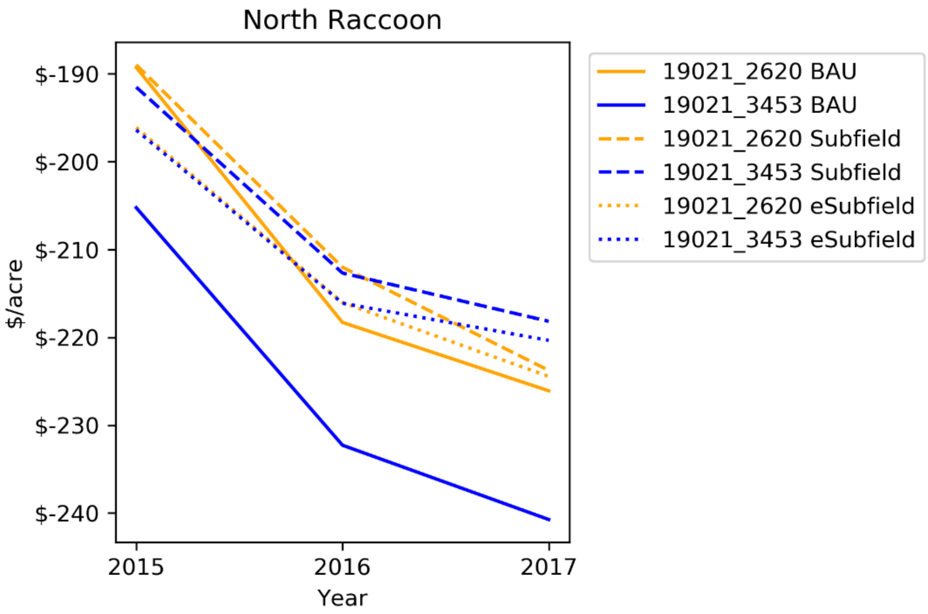
- Completed a techno-economic analysis (TEA) showing ILM field designs can reduce biomass production costs by 20% while maintaining or improving field economic and sustainability outcomes.
- Four specific ILM design scenarios were analyzed in comparison to business as usual (BAU) practices.
  - Traditional subfield, efficient subfield, prairie strips, biomass sorghum

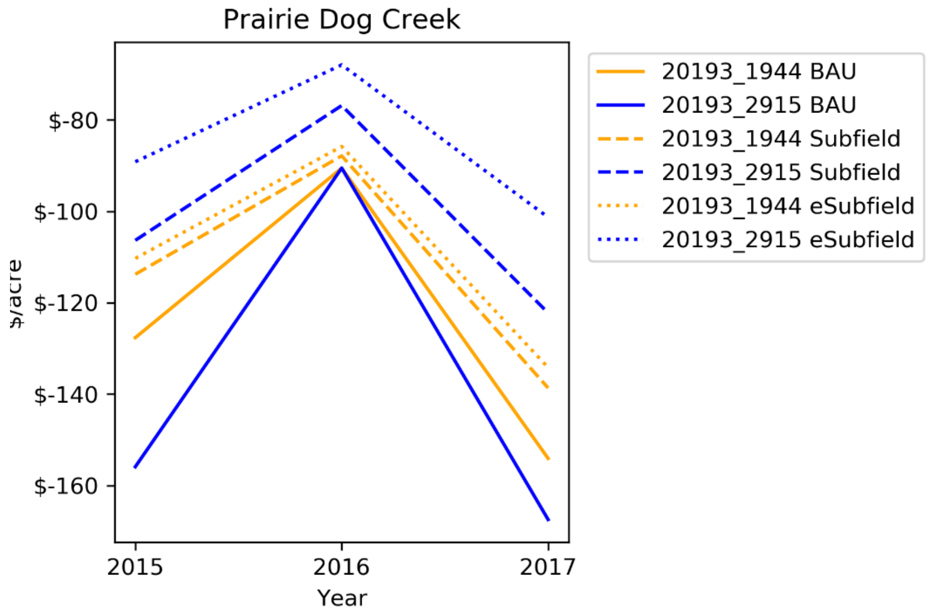


Cost	Residue	Switchgrass	Biomass Sorghum
Baseline	$26.66	$38.87	N/A
Reduced	$21.31	$31.07	$21.69

3 – Technical Accomplishments/ Progress/Results (FY18 Cont'd)

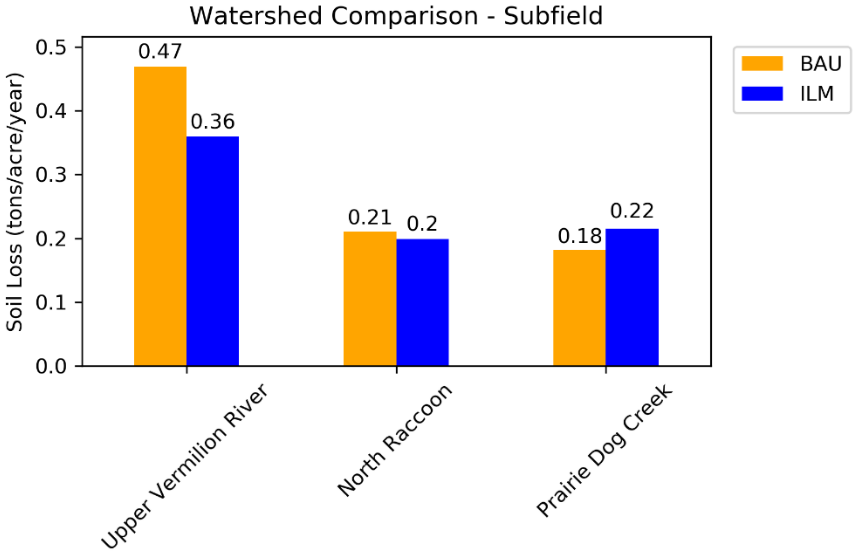
- In all watersheds, field net revenue was increased through the implementation of ILM designs.

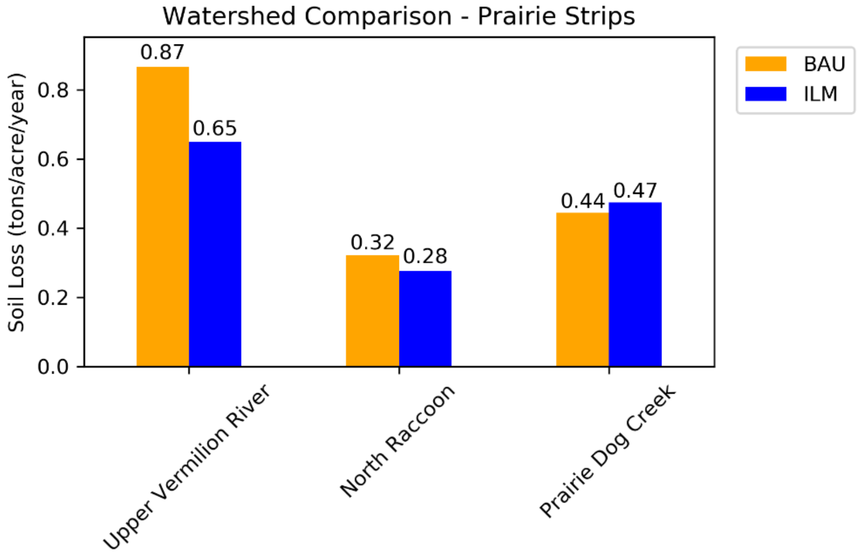




3 – Technical Accomplishments/ Progress/Results (FY18 Cont'd)

- In two of the three watersheds, soil erosion was reduced at the field level after ILM implementation.





4 – Relevance

- ILM analysis supports the quantification of economic and environmental benefits (At-E) related to biomass production at a field level.
- This project directly supports BETO's renewable fuel cost target (2030) of $2.50/gge by reducing feedstock production costs.
- The goal of this project is to demonstrate through modelling how ILM can reduce feedstock production costs.
- The FY17 – FY20 study areas of interest (AOIs) were chosen to capture Midwest agricultural production system heterogeneity where maize, soybean, and wheat dominate the landscape.
- Fields supporting the TEA were selected from within AOIs that best represented common agricultural production practices and where economic analysis indicated aggregate field performance was chronically low.
- ILM analysis and insights are now supporting feedstock logistics and resource mobilization projects.

5 – Future Work

- **Go/No-Go Decision Point**
  - Develop subfield yield variability prediction model based upon remotely sensed data of standing crop parameters. Compare against baseline subfield yield estimates derived from SSURGO data.
  - **(Go)** If the newly-developed subfield yield prediction model using publicly available remote sensing data demonstrates improved accuracy over the SSURGO-derived baseline values, it will be incorporated into the Landscape Environmental Assessment Framework (LEAF).
  - **(No-Go)** If the newly-developed model fails to outperform SSURGO-derived baseline accuracy, LEAF will continue to rely upon SSURGO data for subfield yield values.

5 – Future Work (Cont'd)

- **Field Operations Efficiency**
  - Compile empirical machinery movement data representative of agricultural field operations.
  - Develop modelling capabilities to measure field operation efficiencies to account for ILM impacts on grower field operations efficiencies.
- Using updated ILM analysis capabilities, show ILM design improvements can be enhanced to maintain agricultural field operations efficiencies while contributing to BETO cost targets.

Summary

- ILM analysis supports the quantification of economic and environmental benefits (At-E) related to biomass production at a field level.
- This project directly supports BETO's renewable fuel cost target (2030) of $2.50/gge by reducing feedstock production costs.
- The goal of this project is to demonstrate through modelling how ILM can reduce feedstock production costs.
- Completed state-wide analysis demonstrating availability of significant amounts ILM-derived biomass supplies at a subfield resolution.
- Completed a TEA showing ILM field designs can reduce biomass production costs by 20% while maintaining or improving field economic and sustainability outcomes.
- Future work will shed more light on ILM impacts on field operations efficiency and improved subfield yield modelling.

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Questions

Additional Slides

Responses to Previous Reviewers' Comments

Reviewer: However, at present, the development of tools designed to support the farmer do not have a subfield level resolution. This type of scale will be required to make the work applicable at the individual grower level.

Response: In response to the reviewer's statement, "However, at present, the development of tools designed to support the farmer do not have a subfield level resolution," the framework is developed with subfield as the smallest unit and therefore results can be obtained at subfield resolution.

Reviewer: It would be important identifying what are the reasons that such economic opportunities are being overlooked or not pursued and doing some focus groups or field tests of the hypotheses.

Response: We agree with the reviewer that "It would be important identifying what are the reasons that such economic opportunities are being overlooked or not pursued and doing some focus groups or field tests of the hypotheses." Our project is designed to provide technical, sustainable, and economically feasible solutions to make subfields profitable, which can be used in focus groups and field tests.

Publications, Patents, Presentations, Awards, and Commercialization

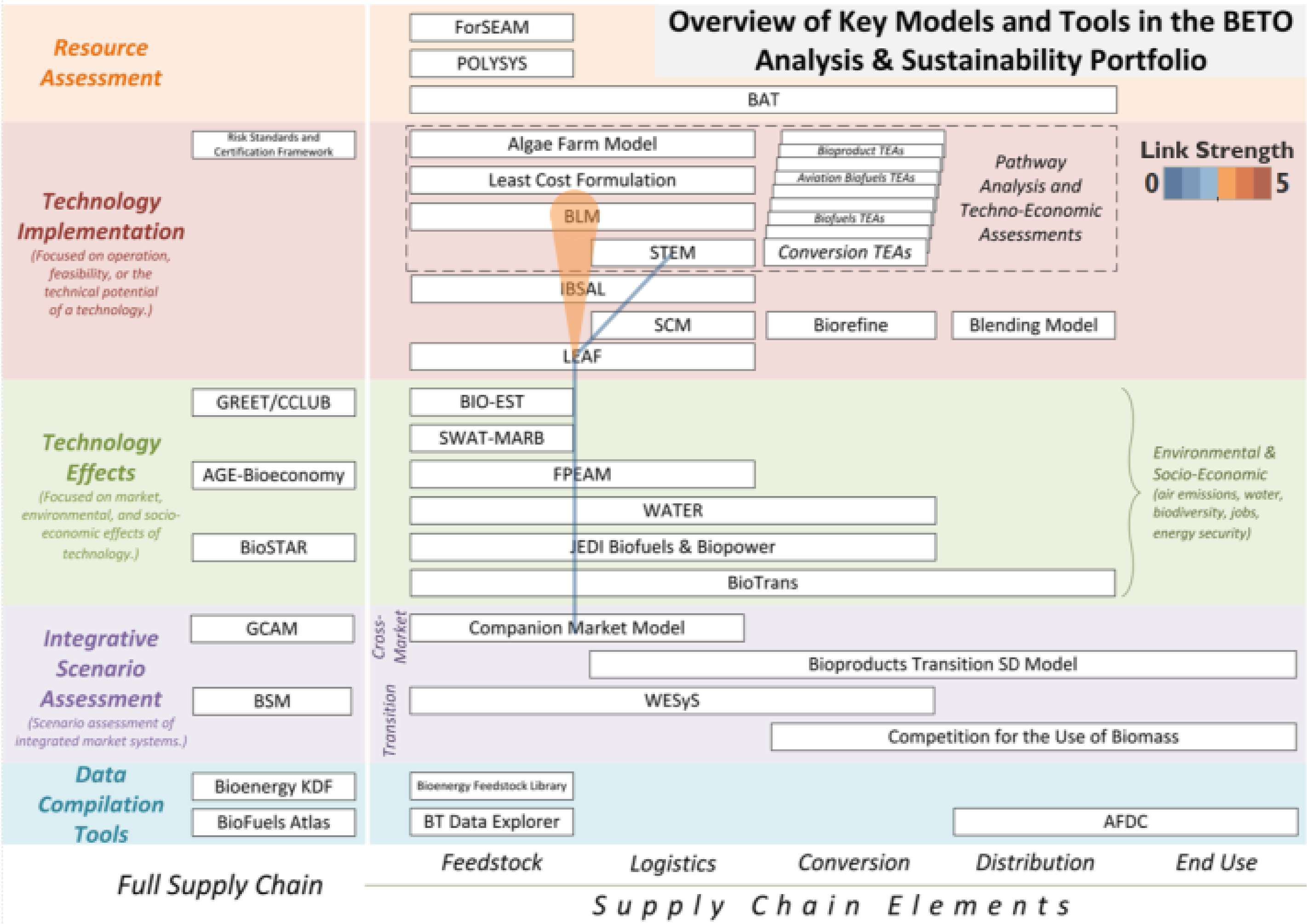
Nair, S. K., Griffel, L. M., Hartley, D. S., McNunn, G. S., & Kunz, M. R. (2018). Improvements in Nutrient and Carbon Retention in Soils through Energy Crop Integration into Agricultural Croplands. Research presented at Governing Sustainability of Bioenergy Biomaterial and Bioproduct Supply Chains from Forest and Agricultural Landscapes, Copenhagen, Denmark.

Nair, S. K., Griffel, L. M., Hartley, D. S., McNunn, G. S., & Kunz, M. R. (2018). Investigating the Efficacy of Integrating Energy Crops into Non-Profitable Subfields in Iowa. BioEnergy Research, 1-15.

Nair, S. K., Griffel, L. M., Hartley, D. S., McNunn, G., and Kunz, R. (2018). Integration of energy crops into corn and soybean subfields in Kansas to increase sustainable biomass production. Manuscript submitted to Energy, Sustainability, and Society, September 2018.

Hartley, D. S., Griffel, L. M., and Nair, S. K. (2018). Sustainability gains in energy-crop integrated agricultural landscapes to produce herbaceous biomass. Manuscript in submission to Energy, Sustainability, and Society, October 2018.

LEAF - Inputs



Overview of Key Models and Tools in the BETO Analysis & Sustainability Portfolio
Resource Assessment
ForSEAM
POLYSYS
BAT
Technology Implementation
(Focused on operation, feasibility, or the technical potential of a technology.)
Risk Standards and Certification Framework
Algae Farm Model
Least Cost Formulation
BLM
STEM
IBSAL
SCM
LEAF
Bioproduct TEAs
Aviation Biofuels TEAs
Biofuels TEAs
Conversion TEAs
Pathway Analysis and Techno-Economic Assessments
Biorefine
Blending Model
Link Strength
0
5
Technology Effects
(Focused on market, environmental, and socio-economic effects of technology.)
GREET/CCLUB
AGE-Bioeconomy
BioSTAR
BIO-EST
SWAT-MARB
FPEAM
WATER
JEDI Biofuels & Biopower
BioTrans
Environmental & Socio-Economic
(air emissions, water, biodiversity, jobs, energy security)
Integrative Scenario Assessment
(Scenario assessment of integrated market systems.)
GCAM
BSM
Cross-Market
Transition
Companion Market Model
Bioproducts Transition SD Model
WESyS
Competition for the Use of Biomass
Data Compilation Tools
Bioenergy KDF
BioFuels Atlas
Bioenergy Feedstock Library
BT Data Explorer
AFDC
Full Supply Chain
Feedstock
Logistics
Conversion
Distribution
End Use
Supply Chain Elements

LEAF - Outputs