OAK RIDGE National Laboratory

DOE Bioenergy Technologies Office (BETO) 2019 Project Peer Review

1.1.1.3 Supply Scenario Analysis

March 4th-8th, 2019

Feedstocks Supply and Logistics

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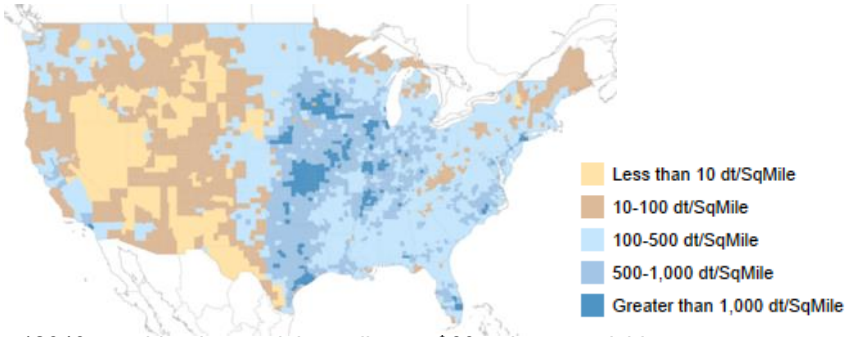
for the US Department of Energy

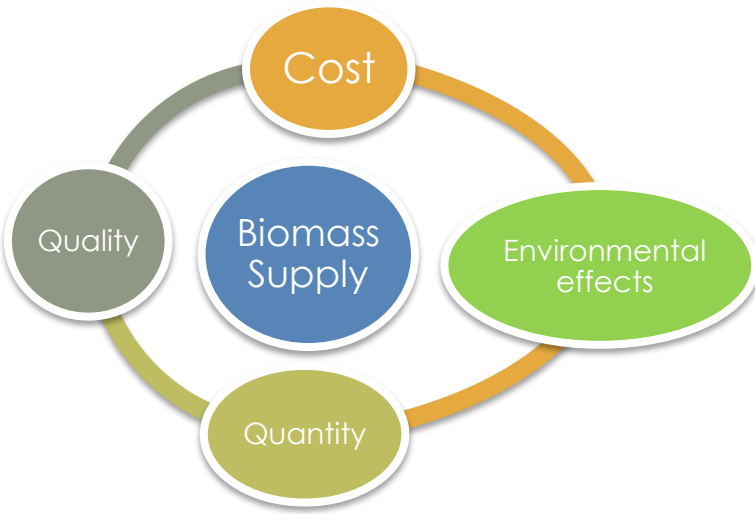
U.S. DEPARTMENT OF ENERGY

Goal Statement

All Feedstocks, 2040*



*2040, combined potential supplies, at $60 or less, roadside, base-case scenario, including wastes. Source: https://www.bioenergykdf.net/billionton2016/1/2/tableau



- *Goal: Provide BETO and bioeconomy stakeholders with scenario-specific biomass feedstock quantity and cost information.*
  - *Previous: Resource Assessment - 2016 Billion-Ton Report*
  - *Current: Supply Analysis – Scenario-specific analyses*
- *Outcome: Derisk the biomass feedstock supply chain.*
- *Relevance: Feedstock costs typically comprise $^1/_3$ to $^1/_2$ of a biofuel target price. Identification of the cost and location of biomass resources is needed to lower supply chain risk.*

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Quad Chart Overview

Timeline

- October 1st, 2013
- Sept 30th, 2020
- 50% complete. This project is foundational to the BETO FSL portfolio and is an ongoing project

	Total Costs Pre FY17**	FY 17 Costs	FY 18 Costs	Total Planned Funding (FY 19-Project End Date)
DOE Funded	$5,613k	$1,644k	$1,108K	$1,550K

Partners:

- INL, PNNL, NREL, ANL
- Agricultural Policy Analysis Center (APAC) University of Tennessee

Barriers addressed

Ft-A. Feedstock Availability and Cost

At-C. Data Availability across the Supply Chain:

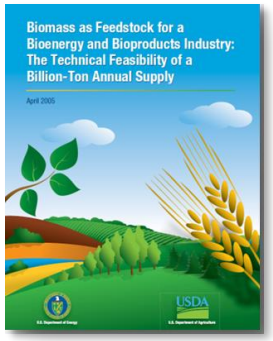
Objective

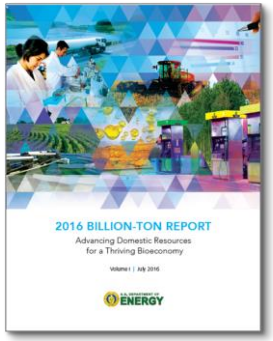
Provide BETO and bioeconomy stakeholders with scenario-specific biomass feedstock quantity and cost information.

End of Project Goal

Provide objective feedstock supply & cost data to other projects and platforms.

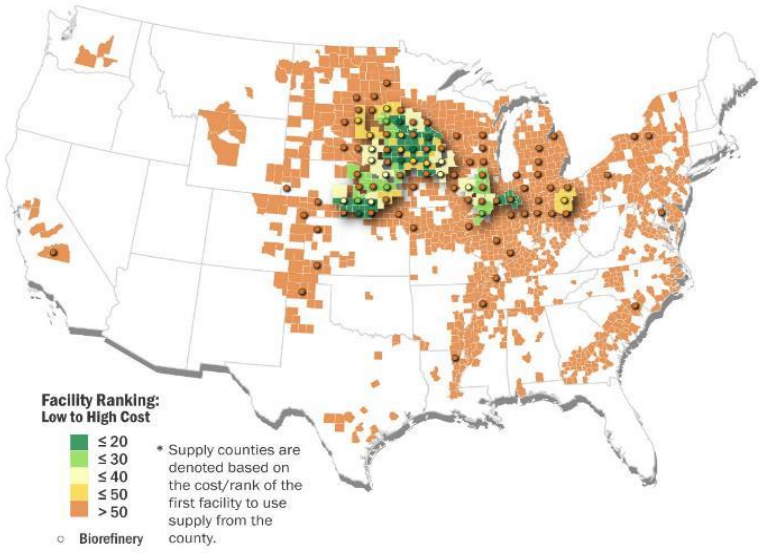
1 - Project Overview





- Previous work: Resource Assessment
  - Identified adequate biomass supply to displace 30% of petroleum consumption (2016 Billion-ton Report Volume 1), and estimated environmental effects of biomass (2016 Billion-ton Report Volume 2).
  - Disseminated county-level data (feedstock quantities) through Bioenergy Knowledge Discovery Framework (Billion-Ton Update, 2011, 2016).
- FY18 Work: Supply Scenario Analysis
  - Shift from national potential to strategic scenario analyses
  - Biomass cost and environmental opportunities (environmental supply curves)
  - Spatially-explicit delivered supplies
  - Stochastic supply simulations
  - Incorporation of quality valuation

Economic accessibility of stover



2 – Approach (Management)

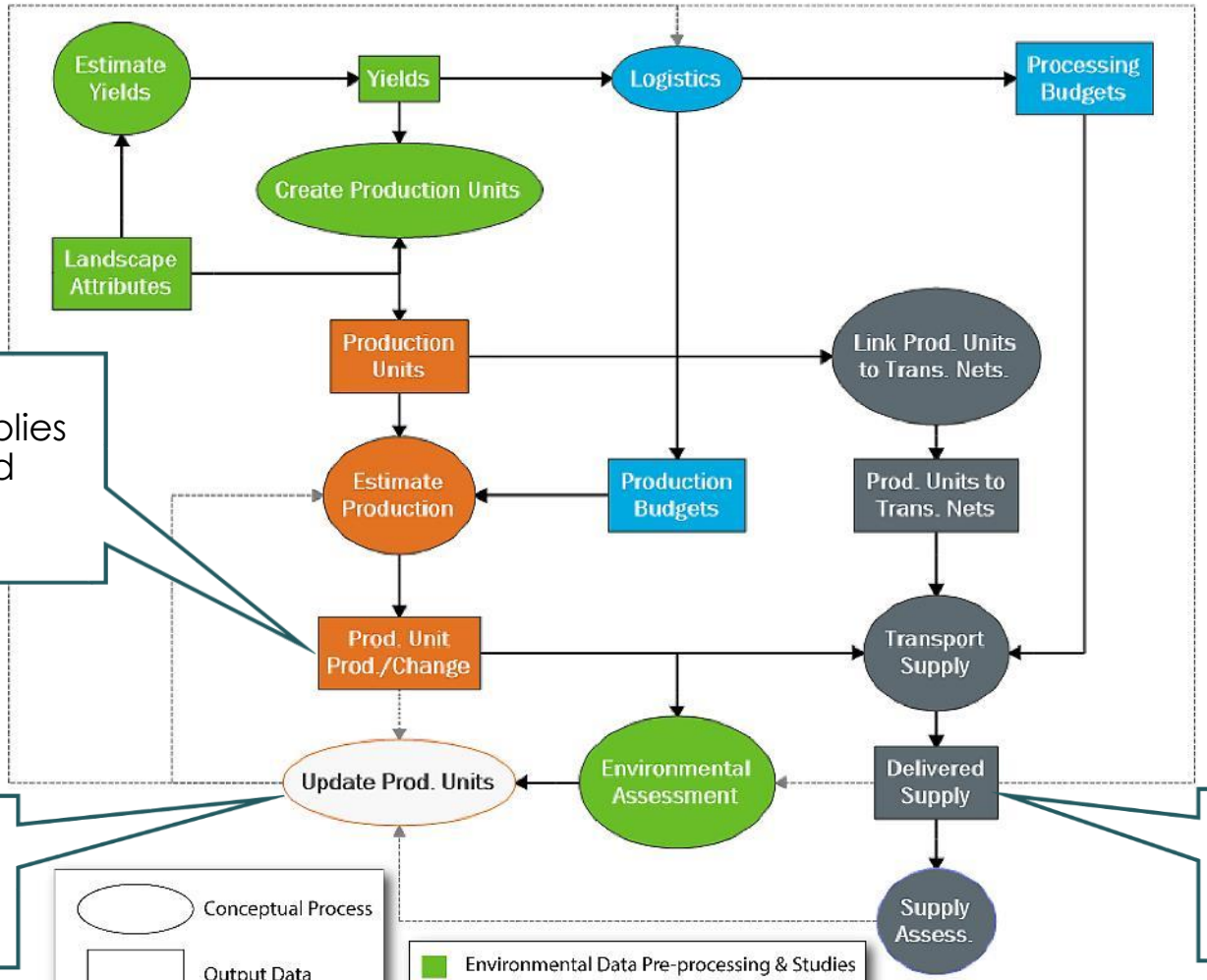
- *Weekly team meetings.*
- *Bi-weekly calls with BETO technology manager.*
- *Coordination with 1.1.1.2 Feedstock Supply Chain Analysis and 4.2.1.20 Integrated Landscape Management at Idaho National Laboratory for State of Technology Reports.*
- *Coordination with project 4.2.1.40 Visualizing Ecosystem Service Portfolios for environmental supply curves.*
- *Using a shared workflow environment (KNIME with Anaconda).*
- *Goal: Quick response with robust supply and price analytics.*
- *Tasks:*
  - *Work flow and data processing (Craig Brandt)*
  - *Economic simulations (Maggie Davis)*
  - *Spatial downscaling (Chris Derolph)*
  - *Environmental Effects (Rebecca Efroymson)*
  - *Interactive visualization (Michael Hilliard and Nicole Samu)*

2 – Approach (Technical)

- **Technical approach:** Macroeconomic partial-equilibrium models for agriculture and forestry sectors. Adding stochastic simulations, delivered to biorefinery throat, quantifying biorefinery-specific (i.e., "n^{th} plant" supply risk).
- **Challenge is to accurately simulate:**
  - Interactions between conventional products and biomass resources.
  - Representation of outyear economic conditions.
  - Spatial/economic logistics of supply allocation.
- **Output: Support Conversion platform and other projects**
  - Cost implication of quality specifications.
  - Robust feedstock cost and supply information.
  - To de-risk, we must understand risk.

2 – Approach (Technical)

Supply Analysis workflow diagram



County-level feedstock supplies and price, land management change

Go/no-go: Subcounty allocation of energy crops

Delivered feedstock supplies and prices.

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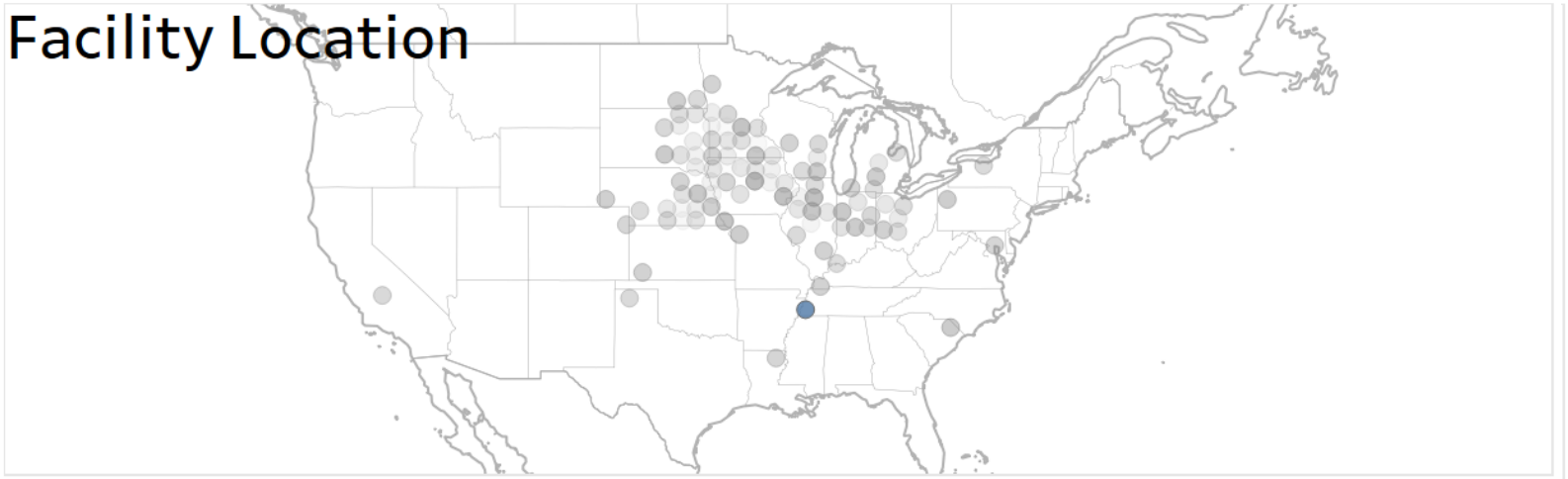
2 – Approach (Technical)

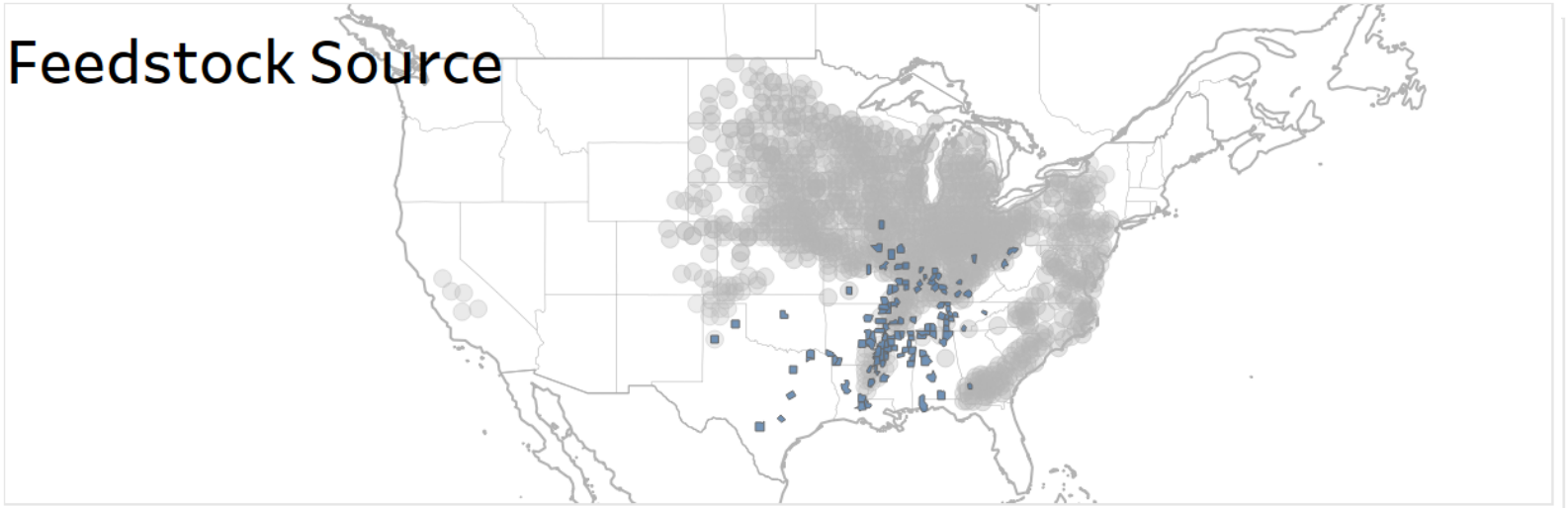
Go/no-go (March 24th 2018):

- Proof of principle of Integrated Landscape Management (ILM):
  - Quantification of switchgrass from agricultural lands.
  - Based on 50-m raster analysis.
  - Outcome: quantify national biomass supplies that can be realized with ILM and associated economics.
- Criteria: Go/no-go criteria:
  - Successful execution of Python script to quantify yields (tons per acre) and cost of production (dollar per dry ton equivalent) of energy crops on a 50-meter resolution on agricultural lands of the conterminous US.

3 – Technical Accomplishments

Biorefinery #125



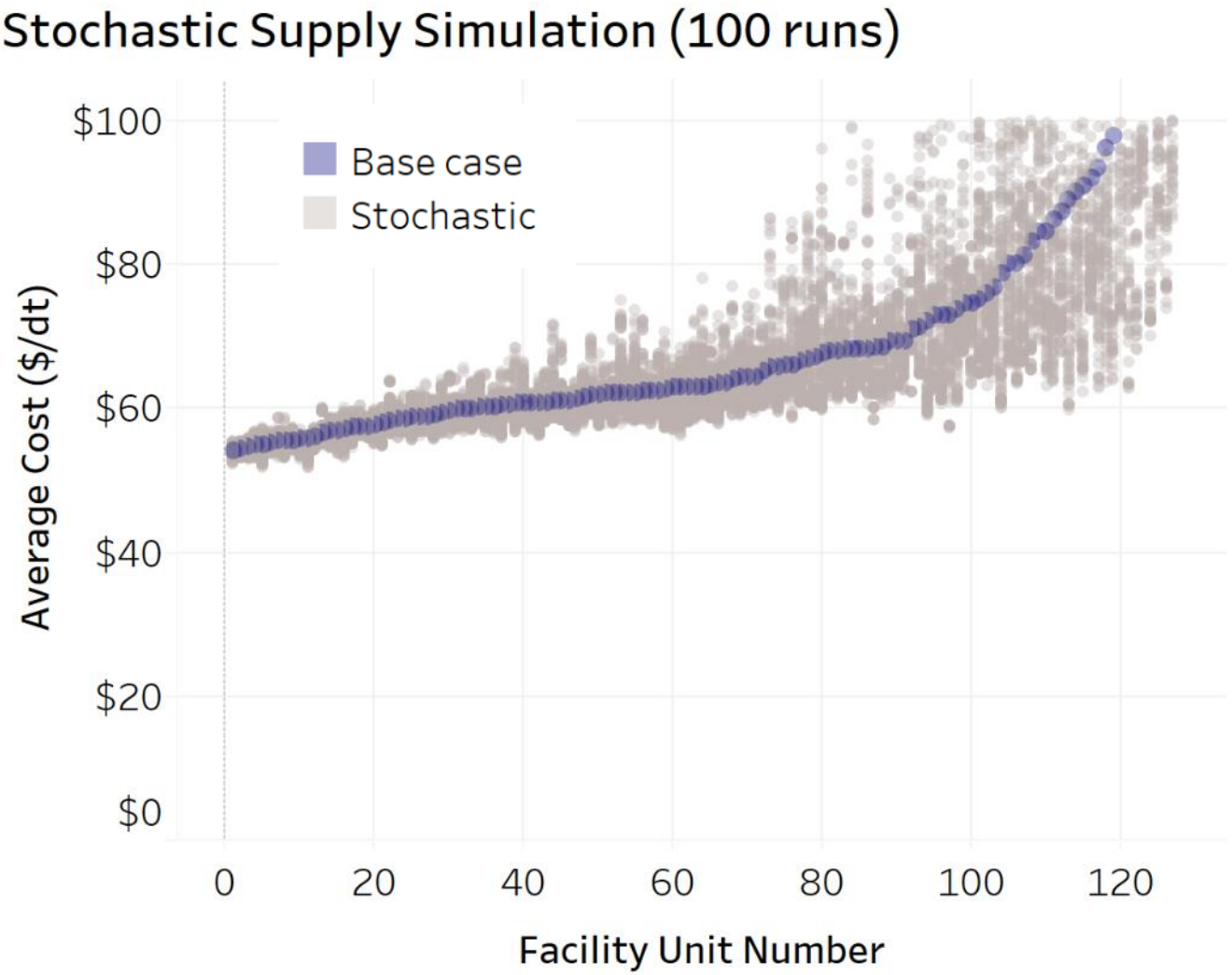


Langholtz, M., Maggie Davis, Laurence Eaton, Michael Hilliard, Craig Brandt, Erin Webb, Chad Hellwinckel, Nicole Samu.(in review) Biorefinery-specific feedstock price and uncertainty, Part 1: Corn stover. Biofuels, Bioprod. Bioref

3 – Technical Accomplishments

Supply risk quantified

Corn stover delivered price, base case deterministic and stochastic (corn yield)



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3 – Technical Accomplishments

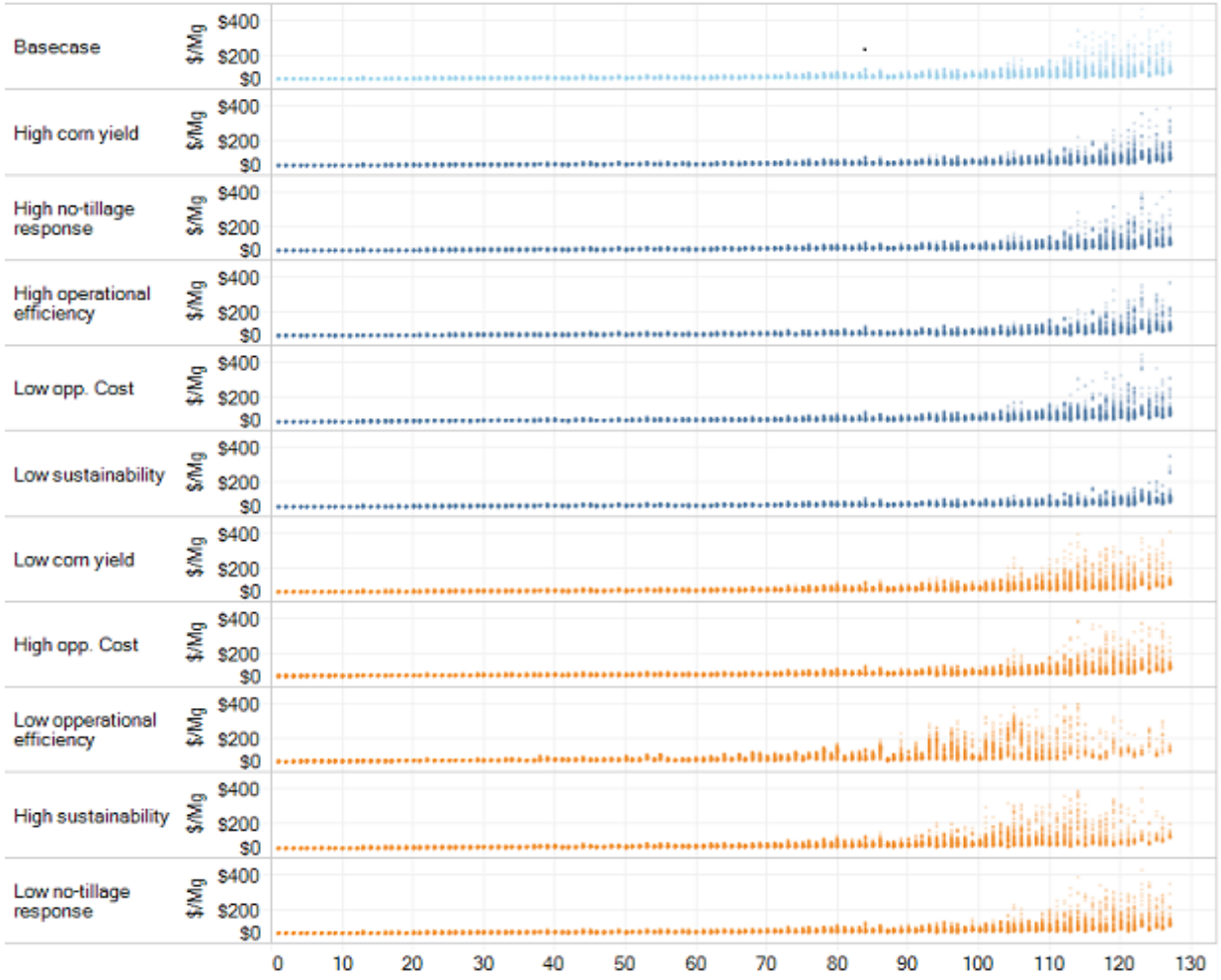
Corn stover, delivered supplies

<u>Supply risk characterization</u>

Deterministic variables:

- Corn grain yield (bu/acre, national)
- No-till response
- Harvest efficiency (% harvestable)
- Residue constraints
- Opportunity cost ($/dry ton)

Stochastic variable: corn yield



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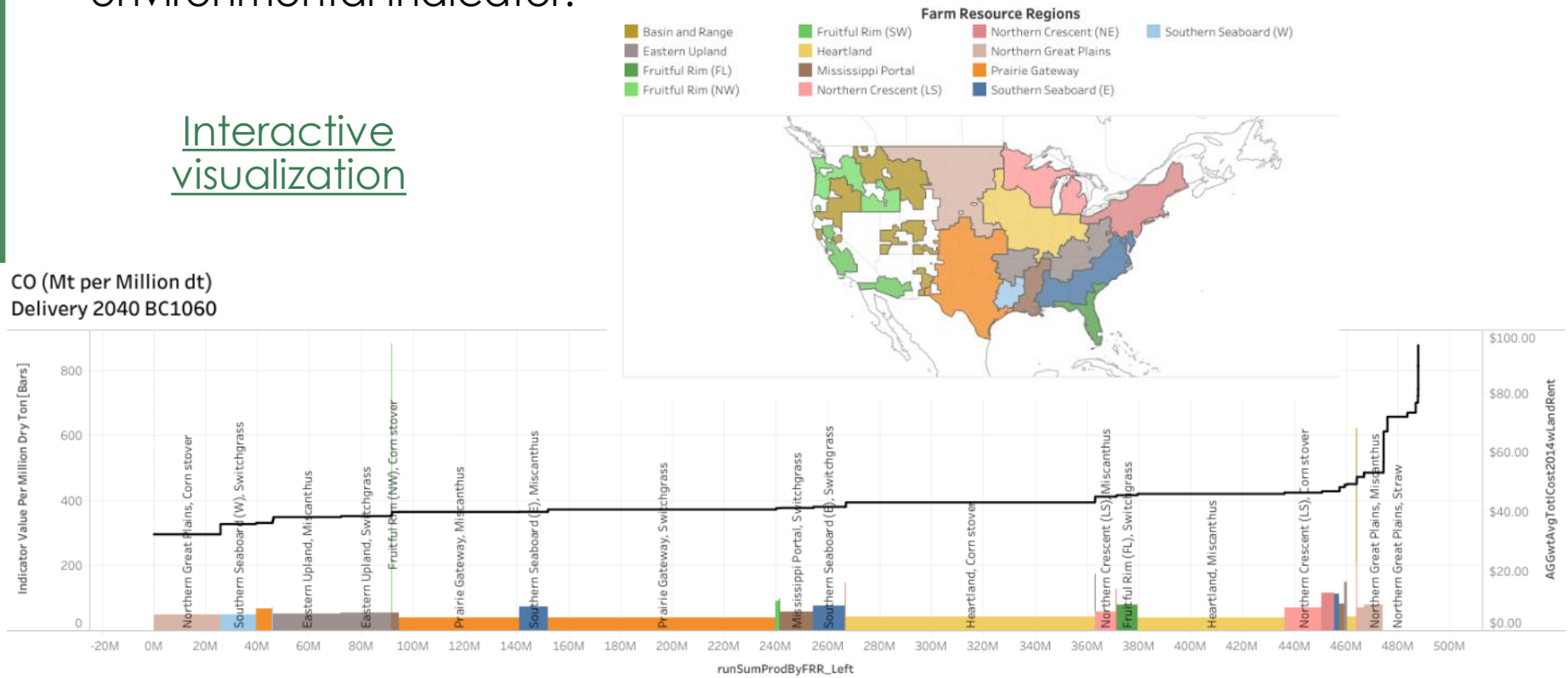
3 – Technical Accomplishments

Environmental supply curves:

- Thirteen environmental indicators in categories of soil quality, water quality and quantity, greenhouse gases, biodiversity, and air quality.
- Data developed in collaboration with other Labs and USFS.
- Visualization of data to elucidate relationship between cost and environmental indicator.

Interactive visualization



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Efroymson, R., Hilliard, M., Langholtz, M., Jager, Y., Brandt, C. (in preparation) Environmental effects of biomass feedstock production in the US.

4 – Relevance

- *Goal: Provide stakeholders with scenario-specific biomass feedstock quantity and cost information.*
  - *10,300 visits to BT16 on KDF, 11,300 downloads of BT16 data (since FY18)*
  - *>90 and >800 citations of 2016 and 2011 Billion-Ton Reports, respectively*
- *New focus on feedstock risk, cost targets, and feedstock strategies, consistent with new goals.*
- *Project success will support other efforts to advance SOT and contribute to commercial viability.*
  - *Analysis of supplies and grower payments for herbaceous SOT*
  - *Data for project 2.1.0.502 Bioenergy with Carbon Capture and Sequestration*
  - *BETO Biopower Projects*
  - *Biomass Research and Development Interagency Working Group (forestry supplies; FY19 IWG goals)*
  - *Binding constraints and land management for Integrated Landscape Management*
  - *Sun Grant Initiative Yield data for Biomass Library*
  - *Commercial Aviation Alternative Fuels Initiative*

5 – Future Work

- *Apply Environmental Supply Curves to identify feedstock types and regions that are both economically and environmentally advantaged.*
- *Assess national potential of Integrated Landscape Management in collaboration and 4.2.1.20 Integrated Landscape Management at Idaho National Laboratory (subcounty downscaling, national scale).*
- *Detail n^{th} plant modeling assumptions with 1.1.1.2 Feedstock Supply Chain Analysis.*
- *Incorporate valuation of quality. "By 2022, characterize, identify, and understand sources of variability in feedstock quality and energy content of renewable carbon feedstocks …to deliver conversion-ready feedstock in support of the $86/dry ton goal." (2019 MYP)*

Summary

- Previous work: National resource potential.
- Current work: Scenario- and end-use-specific supply analysis.
- Enable higher resolution on cost, cost uncertainty & variability, and spatial availability with enhanced analytical tools.
- Support BETO with scenario-specific analyses (e.g., SOTs, MYP targets, data requests for other projects).
- Future work:
  - Coordinate with 4.2.1.20 on Integrated Landscape Management.
  - Advance Nth-plant (and "nth" plant) modeling assumptions with 1.1.1.2.
  - Apply Feedstock Analytics to needs of the Conversion platform.

Additional Slides

Publications

- Eaton, L. , Langholtz, M. and Davis, M. (2019), The impact of alternative land and yield assumptions in herbaceous biomass supply modeling: one-size-fits-all resource assessment?. Biofuels, Bioprod. Bioref., 13: 120-128. doi:10.1002/bbb.1946
- Langholtz, M. , Eaton, L. , Davis, M. , Shedden, M. , Brandt, C. , Volk, T. and Richard, T. (2019), Economic comparative advantage of willow biomass in the Northeast USA. Biofuels, Bioprod. Bioref., 13: 74-85. doi:10.1002/bbb.1939
- Efroymson, R., Hilliard, M., Langholtz, M., Jager, Y., Brandt, C. (in review) Environmental effects of biomass feedstock production in the US.
- Langholtz, M., Maggie Davis, Laurence Eaton, Michael Hilliard, Craig Brandt, Erin Webb, Chad Hellwinckel, Nicole Samu.(in review) Biorefinery-specific feedstock price and uncertainty, Part 1: Corn stover. Biofuels, Bioprod. Bioref.
- Langholtz, M., Maggie Davis, Craig Brandt, Michael Hilliard, Erin Webb, Chad Hellwinckel, Nicole Samu, Chris Daly, Mike Halbleib. (in review) Biorefinery-specific feedstock price and uncertainty, Part 2: Mixed herbaceous feedstock under conventional and advanced logistics. Biofuels, Bioprod. Bioref.
- Eaton, L., Langholtz M., Davis, M., Brandt C. Hilliard H., Hartley, D. (in review) Cost and profit impacts of modifying stover harvest operations to improve feedstock quality. Biofuels, Bioprod. Bioref.

Responses to Previous Reviewers' Comments

- Incorporate more nuanced and validated crop productivity and environmental impact data.
  - Since the last peer review we have emphasized crop yield uncertainty with stochastic analyses and elucidating environmental effects of different crop types in different regions.
- Express results as a function of the status quo for fossil and commodity crops so the public and decision makers can realistically compare systems performance.
  - More work needs to be done in the area of comparing environmental effects of bioenergy with conventional crops and conventional energy sources.
- Continued refinement of the biomass availability estimates will be of less importance than technical advancements that support industry growth.
  - We agree and hope to contribute to technical advancements with technology-specific feedstock information.