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DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

Supply Forecast and Analysis (SFA)

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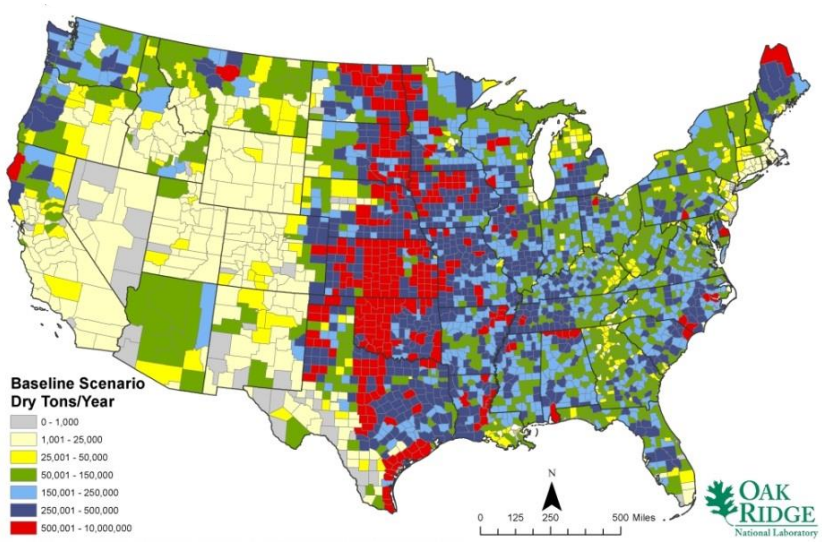
Goal Statement

- Provide timely and credible estimates of feedstock supplies and prices to support
  - the development of a bioeconomy; feedstock demand analysis of EISA, RFS2, and RPS mandates
  - the data and analysis of other projects in Analysis and Sustainability, Feedstock Supply and Logistics, Conversion, etc.



- "Future growth of the U.S. bioenergy industry will depend on the cost, quality, and quantity of biomass available to biorefineries." –BETO MYPP (2014)

Quad Chart Overview

Timeline

- Project start date: FY07
- Project end date: FY18
- Percent complete: 70%

Barriers

- Ft-A. Feedstock Availability and Cost
- Ft-B. Sustainable Production
- Ft-L. Biomass Material Handling and Transportation
- At-C. Inaccessibility and Unavailability of Data

Budget

	Total Costs FY 10 –FY 12	FY 13 Costs	FY 14 Costs	Total Planned Funding (FY 15-Project End Date
	(millions)			
DOE Funded	$3.15	1.9	1.0	4.87

Partners

- INL, PNNL, NREL, ANL
- Agricultural Policy Analysis Center (APAC) University of Tennessee, Oregon State PRISM Climate Group
- Sun Grant Regional Feedstock Partnership
- Other agencies: USDA Forest Service, EPA, USDA-ARS
- Southern Forest Analysis Consortium
- NEWBio Consortium

1 - Project Overview

- History and accomplishments
  - Identified adequate supply to displace 30% of petroleum consumption; i.e., physical availability (Billion-Ton Study, 2005).
  - Quantified potential economic availability of feedstocks (Billion-Ton Update, 2011).
  - Disseminated county-level data (feedstock quantities, by scenario, price, year) through Bioenergy Knowledge Discovery Framework.
- Ongoing objectives: 2016 Billion-Ton Report (BT16)
  - Full farm-to-reactor analysis.
  - Adding algae, Miscanthus, and energy cane to feedstocks
  - Addressing environmental sustainability, climate variability/change, uncertainty, and feedstock quality.
  - Report releases: BT16 Vol. 1 release in June 2016, Vol. 2 in Sept. 2016.

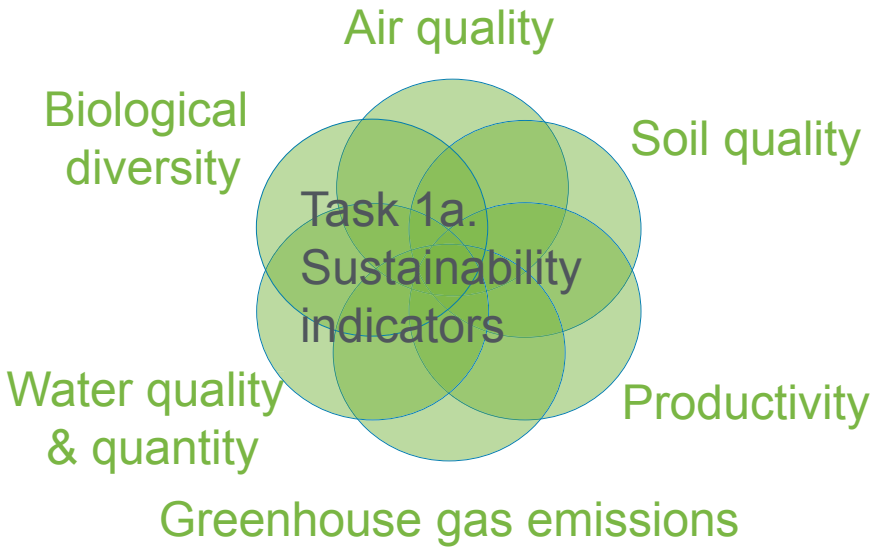
2 – Approach (Technical)

- POLYSYS: BETO version operating at a county-level, for agricultural and forest resources.
- Data from NASS Census of Agriculture, USDA Baseline Projections, Forest Inventory and Analysis, Sun Grant Initiative, and other data from USFS Forest Products Lab.
- Key technical assumptions from contributing authors and collaborators.
  - Crop residue retention, tillage, rotations
  - Energy crop productivity
  - Scenarios from high-yield workshops, advanced logistics workshop
  - Land-cover and land-use change assumptions to 2040
- Output: Feedstock Supply and Price projections
  - Grower payments (crop residues & energy crops) and stumpage (forest residues)
  - Collection and harvest costs (INL and ORNL models for cropland resources; USFS model for forestland resources)

2 – Approach (Management)

- Critical success factors: resource projections with credible economics and latest available information (e.g., agronomics, logistics, sustainability).
- Challenges: account for uncertainty (e.g. economic climate, climate events, innovation, etc.).
- Scrum management: iterative and incremental agile development framework for facilitating product development and risk analysis.
- Collaboration: ongoing engagement with other labs and agencies on forestry, algae, and sustainability chapters of the BT16; UT on POLYSYS modeling.
- Review process: for modeling assumptions and results.

2 - Approach: Sustainability in Billion Ton 2016

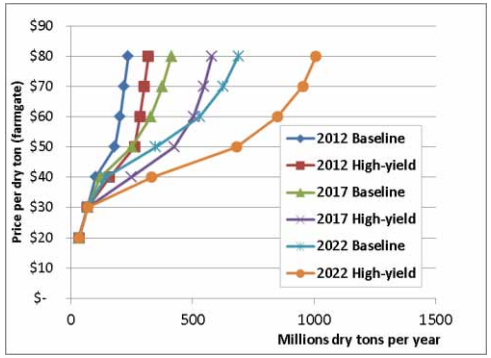


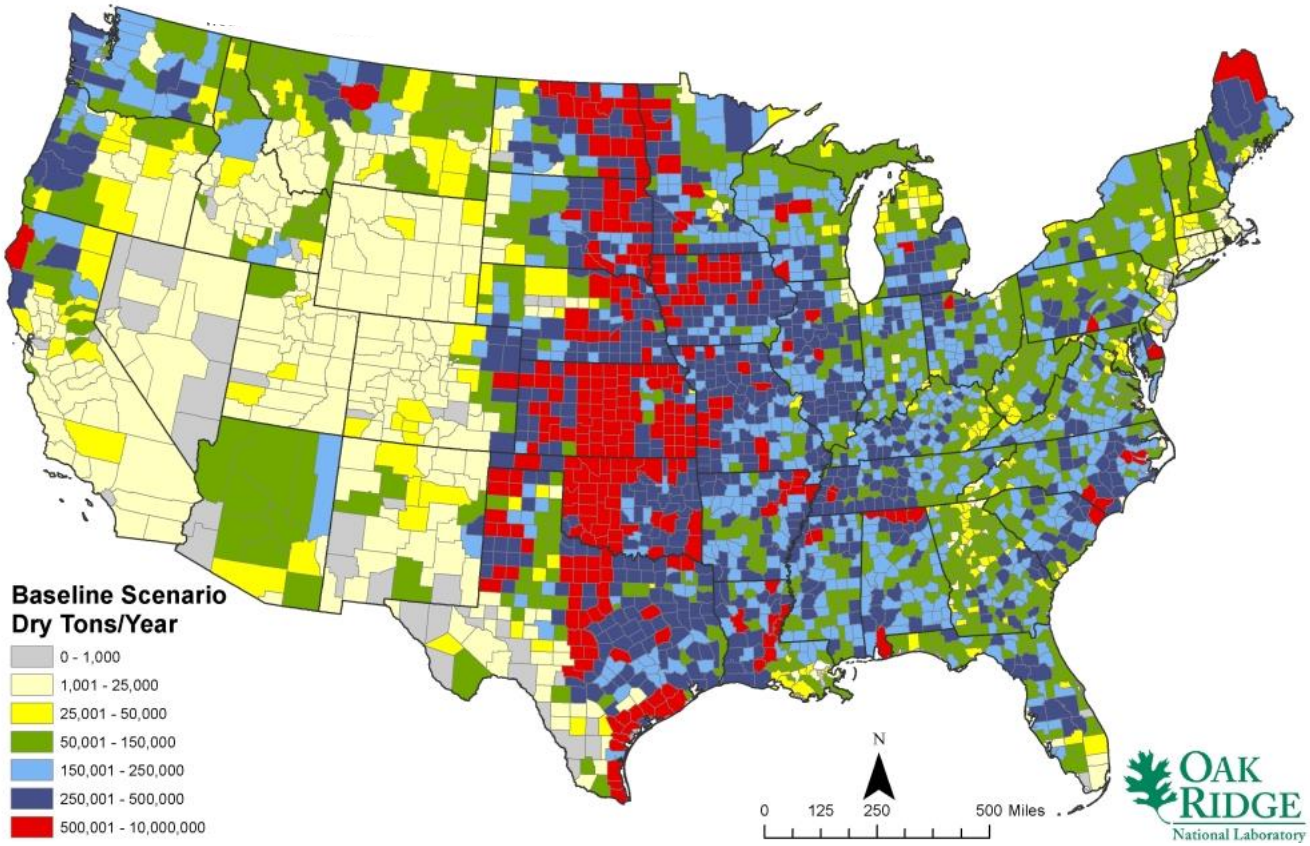
- Address multiple indicators in 6 indicator categories
- Use appropriate models (SWAT, Century, GREET, F-PEAM, species distribution model)
- Involve several national labs and agencies
- Focus on 2040, with potential outputs for 2030 and 2020
- Output: environmental effects
- Maximize environmental benefit by allocating biomass production
- Output: tradeoffs among effects

3 – Technical accomplishments

- **2022**
- **Baseline scenario**
- **$60 dry ton^{-1}**

529 x 10^6 dt





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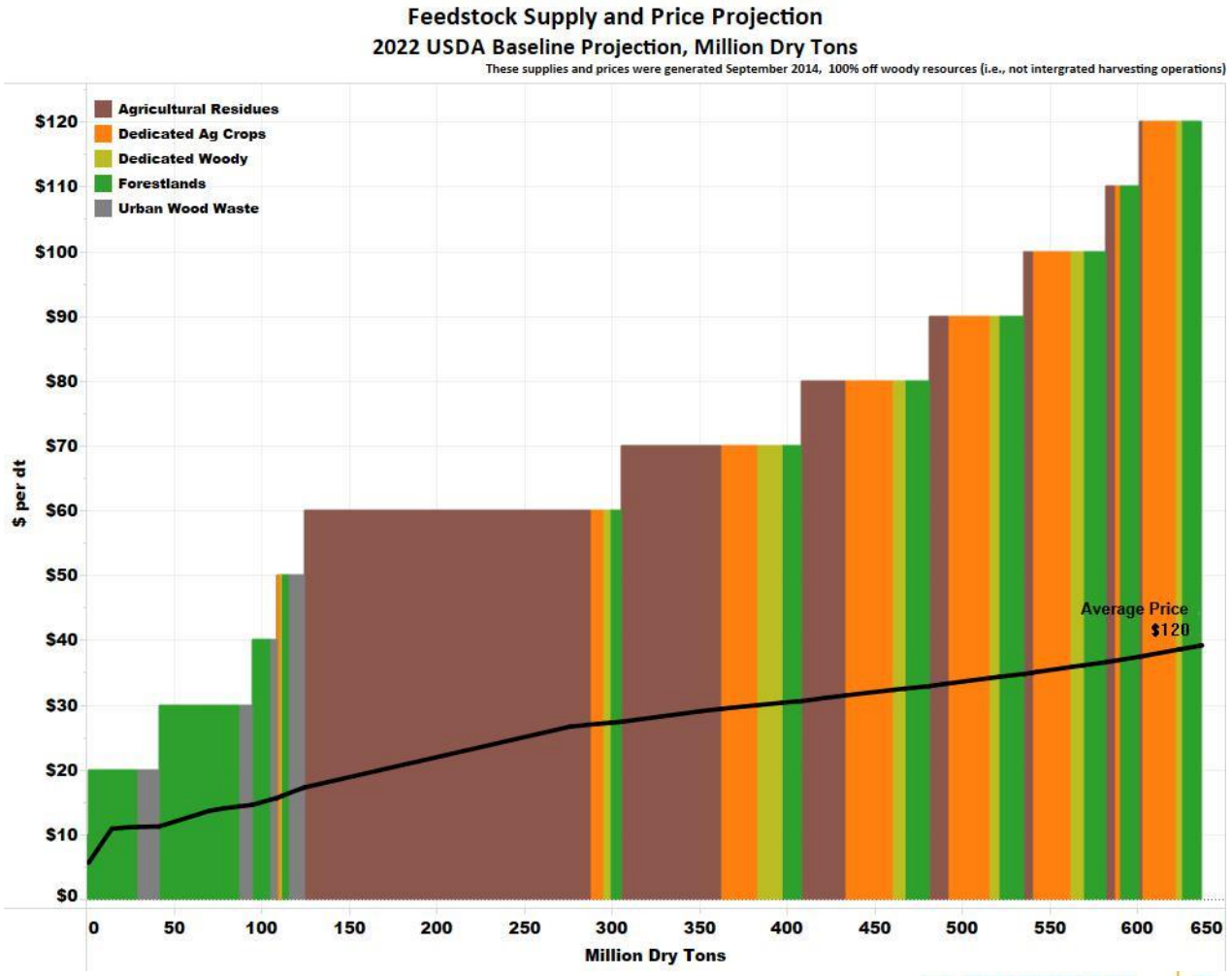
3 – Technical Accomplishments/Progress/Results

- 2013 Feedstock Supply and Price Projections and Sensitivity Analysis:
  Langholtz MH, Eaton LM, Turhollow A, Hilliard MR. 2013 Feedstock Supply and Price Projections and Sensitivity Analysis. BioFPR [Internet]. 2014;8(4).
  http://onlinelibrary.wiley.com/doi/10.1002/bbb.1489/abstract



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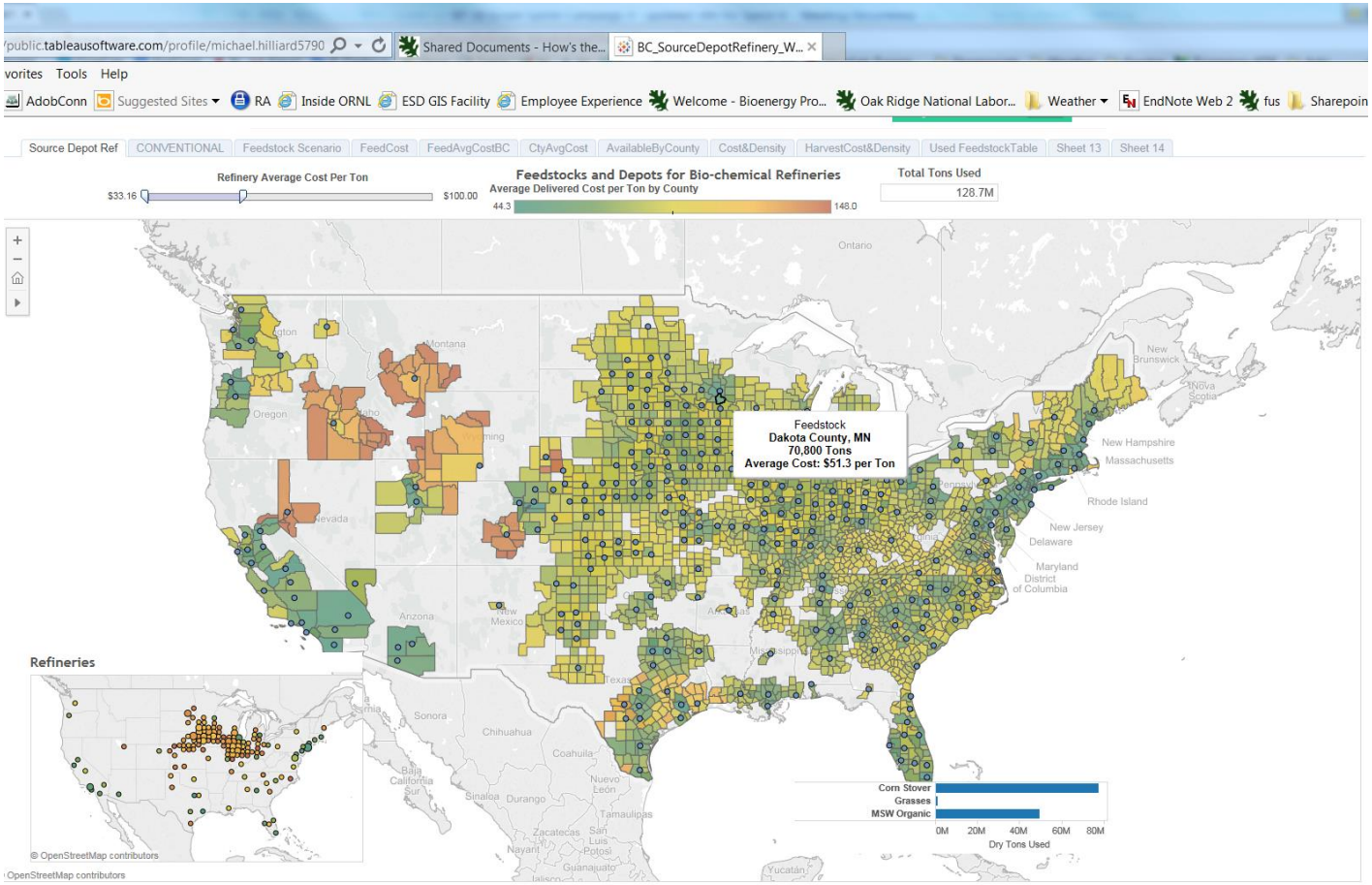
3 – Technical Accomplishments/Progress/Results

Interactive visualization



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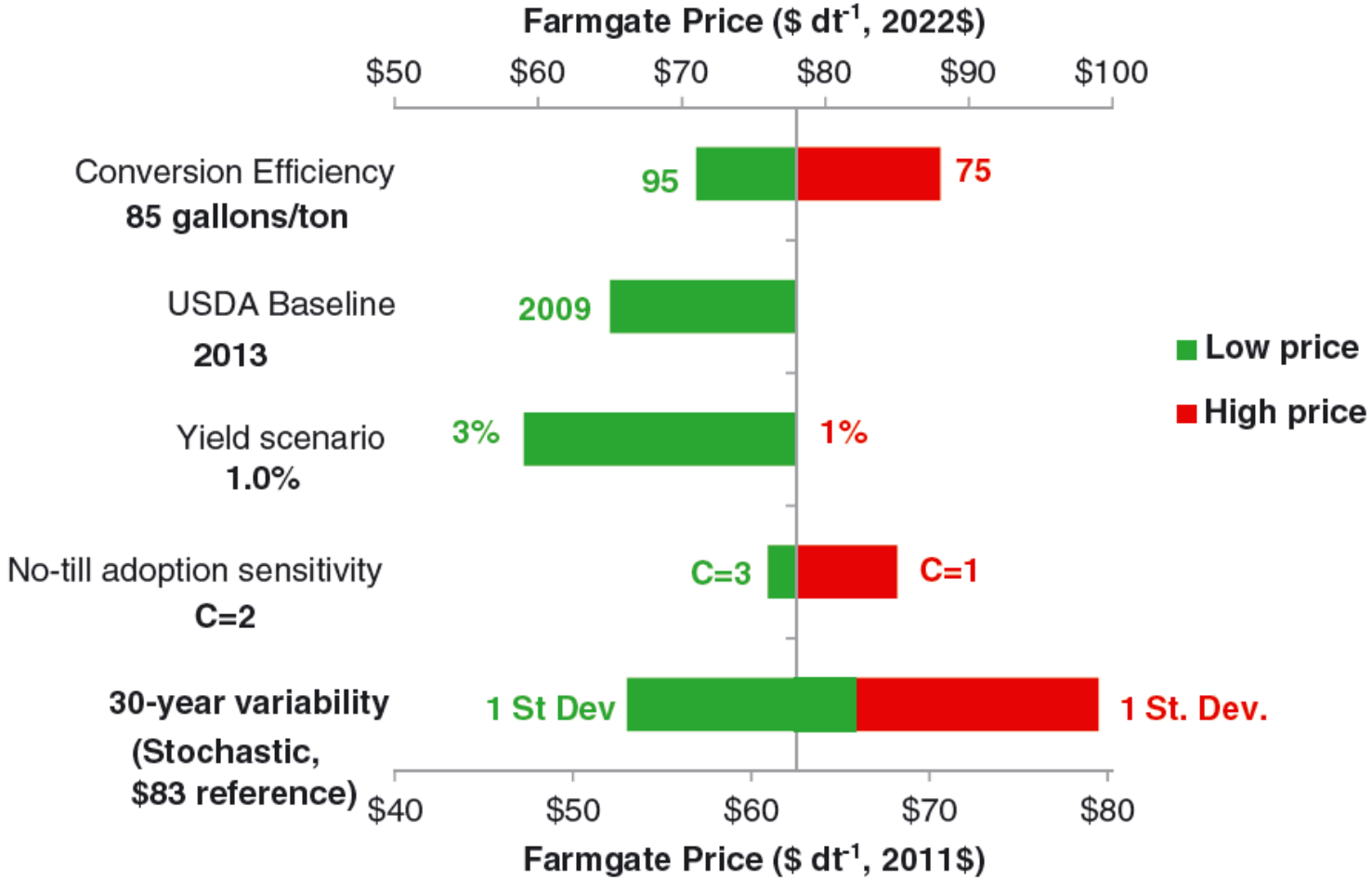
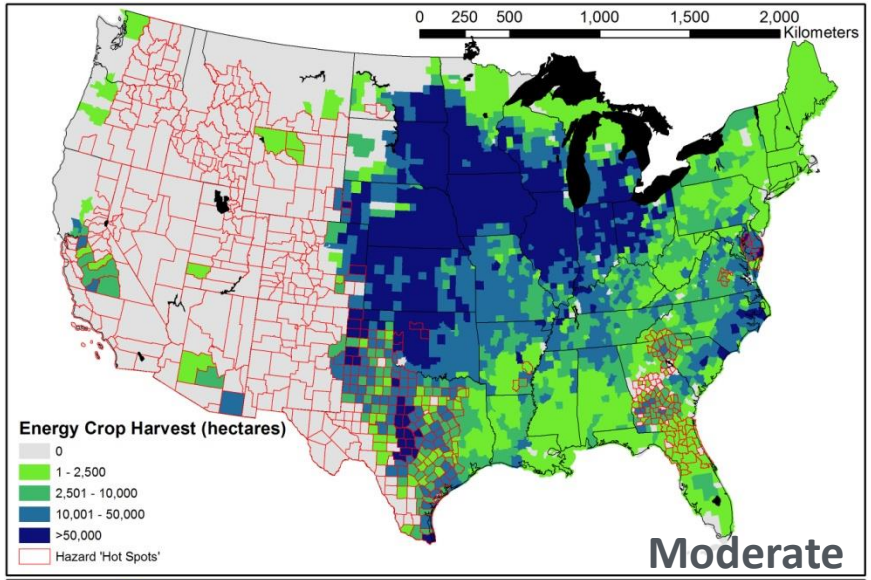
3 – Technical Accomplishments/Progress/Results

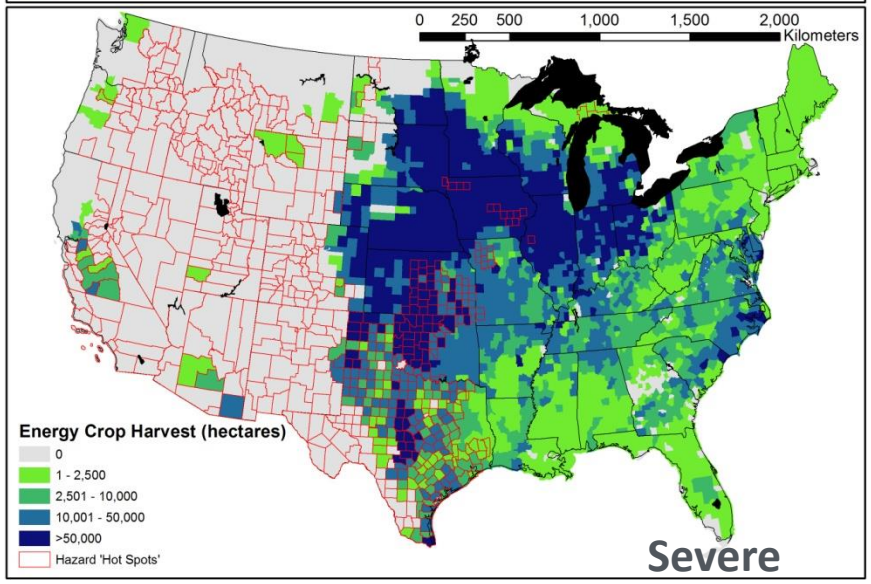
Sensitivity analysis to key variables



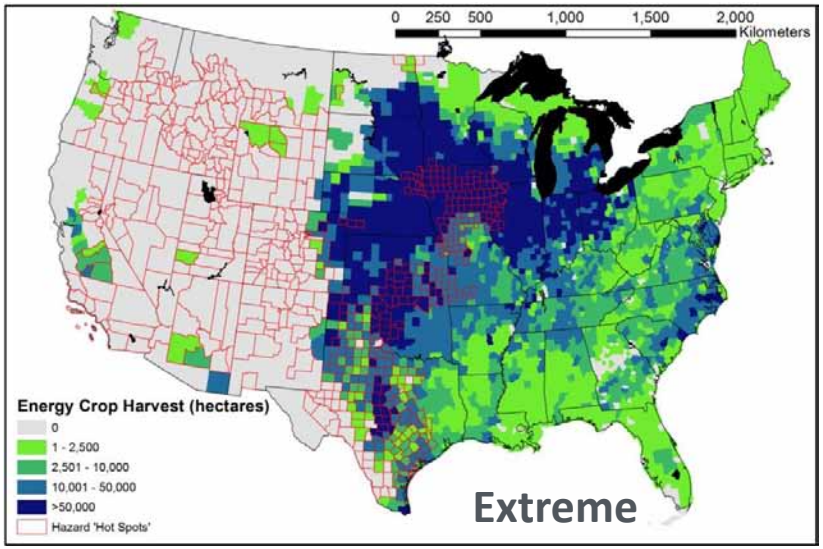
Source: 2013 FSPP: 1. Langholtz MH, Eaton LM, Turhollow A, Hilliard MR. 2013 Feedstock Supply and Price Projections and Sensitivity Analysis. Biofuels Bioprod Biorefining-Biofpr [Internet]. 2014;8(4). Available from: http://onlinelibrary.wiley.com/doi/10.1002/bbb.1489/abstract

Drought (moderate, severe, extreme)



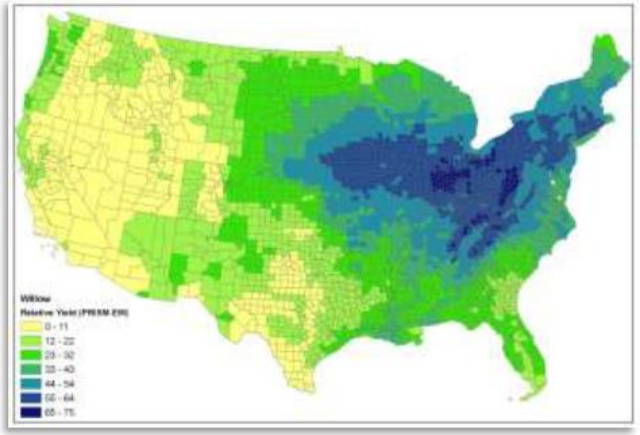


- Crop harvest areas based upon baseline projections of energy crops (perennial grasses, woody biomass, annual energy crops, corn stover) assuming baseline growth (price=$55)
- Drought based upon frequency of counties experiencing different severities of drought



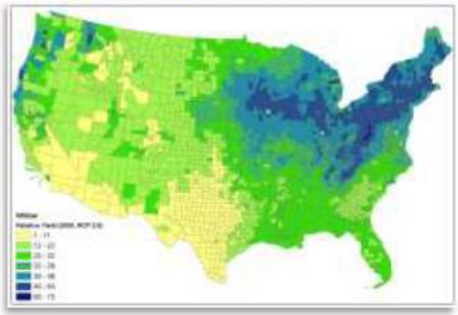
County yields: Willow

PRISM-EM (Current Baseline)

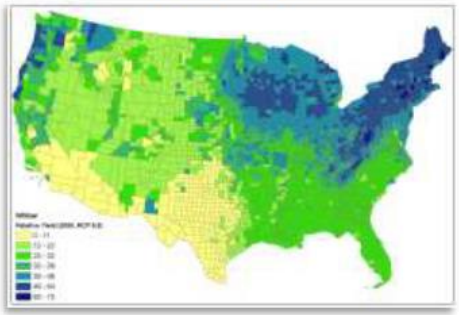


WorldClim Ensemble Mean (2050)

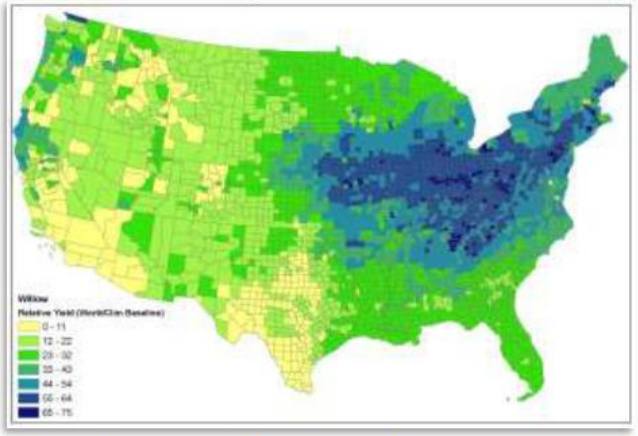
RCP 2.6



RCP 8.5

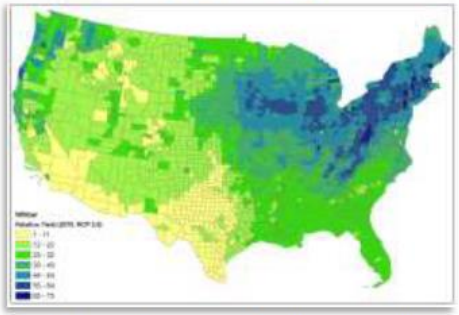


WorldClim (Current Baseline)

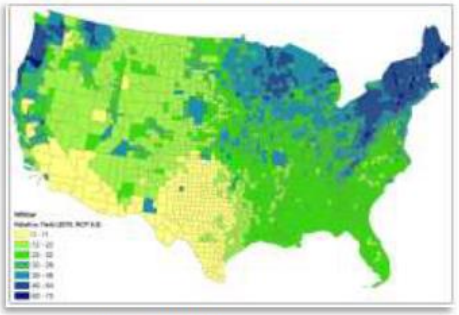


WorldClim Ensemble Mean (2070)

RCP 2.6

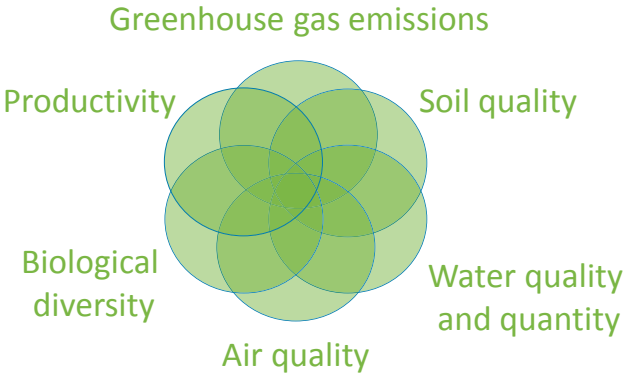


RCP 8.5



Results based on application of 11 global climate model simulations to the Willow PRISM-EM Bayesian emulator

3 - Technical accomplishments—Review of BT2 sustainability constraints



Review of sustainability in national/international biomass resource analysis

- Restrict or incentivize area or crops
- Assume sustainable management practices (e.g., no till, yield, removal)
- Connect supply estimates to sustainability targets (e.g., water quality criteria)
- Incorporate environmental impact constraints in farmer/forester choices

Review of sustainability in BT2:

- **Soil quality** and **water quality** addressed via residue removal and tillage assumptions
- **Water quantity** addressed via excluded land areas west of 100th meridian and broad irrigation assumptions, but regional water scarcity/conflicts not addressed
- **Biodiversity** addressed by excluding wilderness areas, national parks, roadless areas
- **Greenhouse gas emissions** not considered
- **Air quality** not considered

BT16:

Establishing methodologies to assess key indicators (next slide)

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Methodology for environmental sustainability indicators

	Indicator
Soil quality	1. Total organic carbon (TOC)
	2. Total nitrogen (N)
	3. Extractable phosphorus (P)
	4. Bulk density
Water quality and quantity	5. Nitrate loadings to streams (and export)
	6. Total phosphorus (P) loadings to streams
	7. Suspended sediment loadings to streams
	8. Herbicide concentration in streams (and export)
	9. Storm flow
	10. Minimum base flow
	11. Consumptive water use (incorporates base flow)
	Addition: Water yield

	Indicator
Greenhouse gases	12. CO_2 equivalent emissions (CO_2 and N_2O)
Biodiversity	13. Presence of taxa of special concern
	14. Habitat area of taxa of special concern
Air quality	15. Tropospheric ozone
	16. Carbon monoxide
	17. Total particulate matter less than 2.5 μm diameter ($PM_{2.5}$)
	18. Total particulate matter less than 10 μm diameter (PM_{10})
	Possible additions: VOCs, SO_x, NO_x, NH_3
Productivity	19. Aboveground net primary productivity or Yield

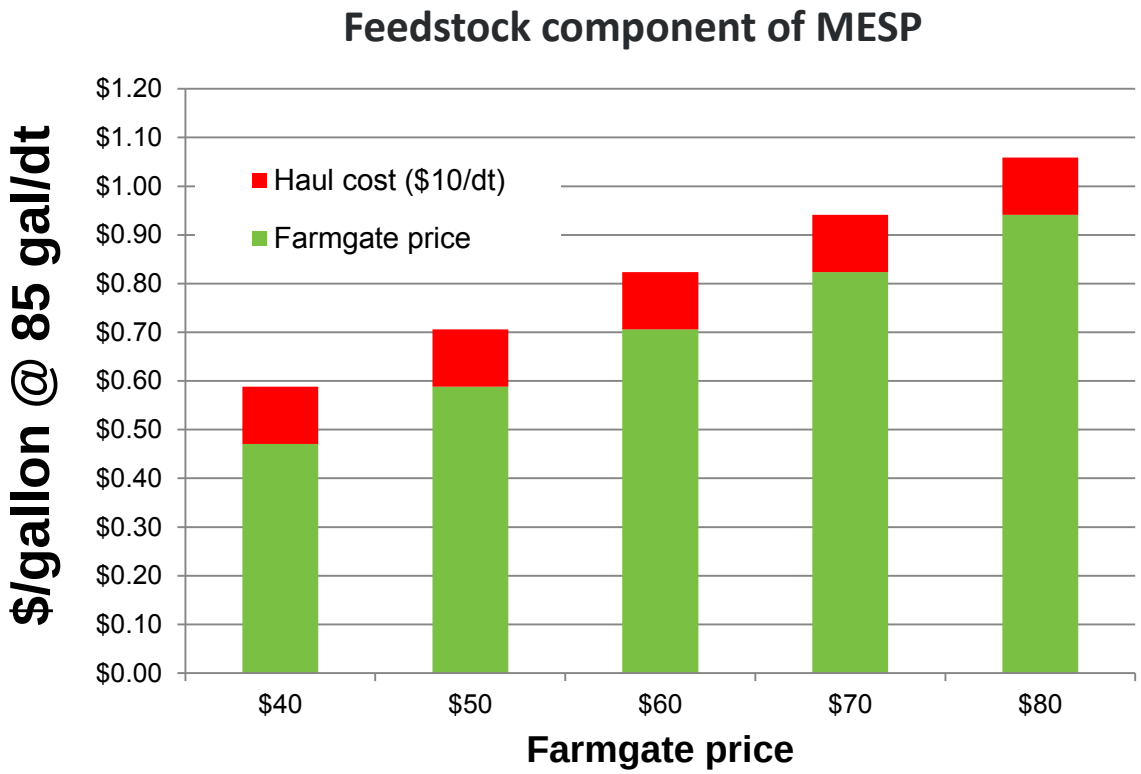
McBride et al. (2011) *Ecological Indicators* 11:1277-1289

Yellow—12 indicators anticipated in Billion Ton 2016

White—other BETO- and ORNL-recommended indicators

4 - Relevance: Feedstock price ~1/4 of Minimum Ethanol Selling Price

Delivered prices of $50-$90/dt @85 gal/dt ~=$0.60-$1.06/gal, or 30%-35% of $3.00/g MESP



Variables:

- Economic climate
- Climatic events
- Production budgets
- Yields (tons/acre)
- Sustainability constraints

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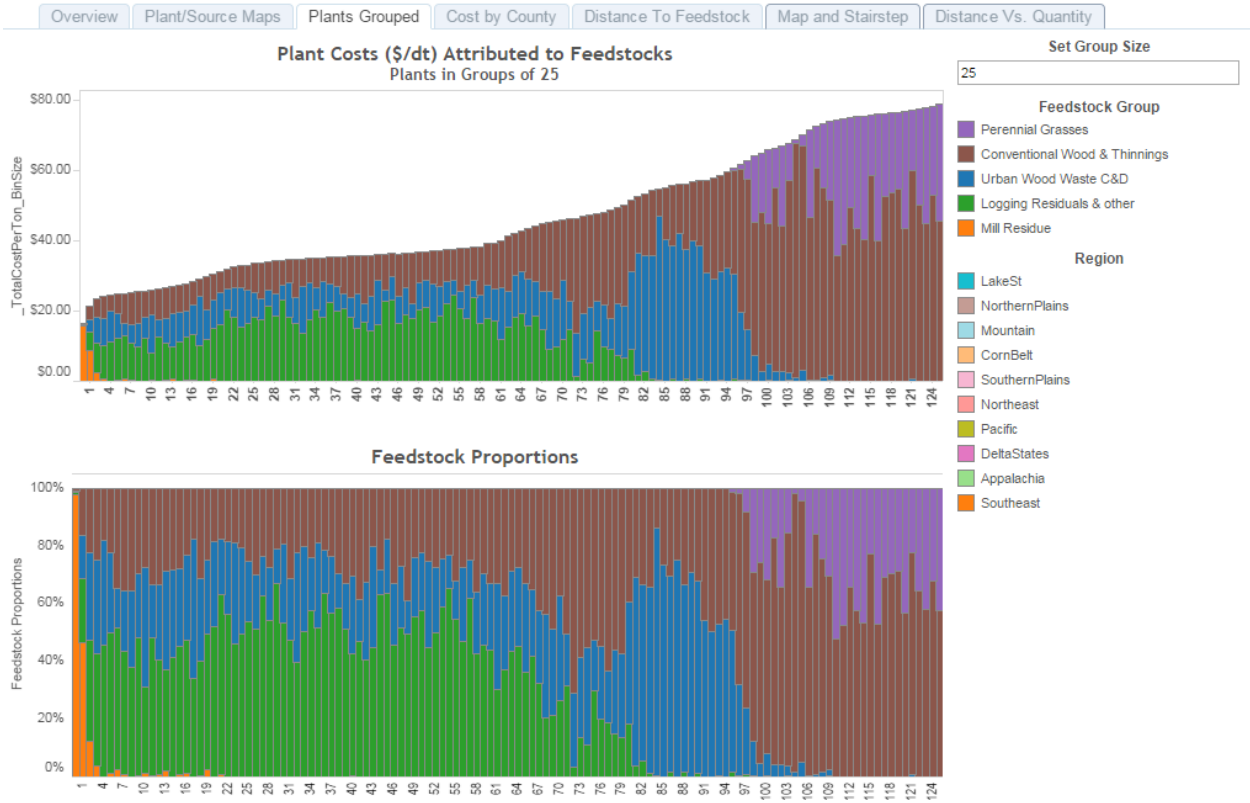
4 – Relevance

- Objective: inform biofuels commercialization strategies with feedstock supply and price projections: feedstock quantities, types, and spatial distribution.
- Dissemination achieved through distribution via KDF
- Extending beyond the farmgate to delivered scenarios to better reflect potential industry.
- Providing dynamic interactive visualization is expected to better serve user community.



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5 – Future Work

- FY15: Incorporate new feedstocks; generate projections to farm gate and reactor throat.
- 2016 Billion-Ton Report, Volume 1: final draft in September 2015, reviewed by April 2016, released by June 2016.
- 2016 Billion-Ton Report, Volume 2, tentative schedule: final draft in March 2016, reviewed by July 2016, published by September 2016.
- Future - assess ongoing resource analysis needs.

Summary

1. Overview: Critical need for up-to-date feedstock supply and price information.
2. Approach: Improving established modeling approach, and extending the analysis.
3. Technical Accomplishments/Progress/Results: Peer reviewed supply and price projections, revised projections with latest information.
4. Relevance: Feedstock is about 1/3 of biofuels price. Supply information is needed.
5. Future work: 2016 Billion-Ton Report.

Goals from 2013

- Current and relevant feedstock price and supply projections: Achieved
- Incorporation of additional feedstocks (e.g., algae, miscanthus, MSW): In preparation, BT16
- Move toward Integrated Land Management: In preparation, BT16
- Spatially-explicit realizations: Moved to CDL/CLU
  - Economically stranded resources: In preparation, BT16
  - Farmgate to Rx throat: In preparation, BT16
  - Integrated modeling of externalities: Under consideration
  - Testing of policy scenarios: In preparation, BT16

Additional Slides

Acronyms, initialisms, and abbreviations

- BTS: 2005 Billion-Ton Study, (Perlack et al., 2005)
- BT2: 2011 Billion-Ton Update
- BT16: 2016 Billion-Ton Report
- ForSEAM: Forest Sustainable and Economic Analysis Model
- FSPP: Feedstock supply and price projection
- NASS: National Agricultural Statistics Service
- MESP: minimum ethanol selling price
- MSW: municipal solid waste
- MYPP: Multi Year Program Plan
- POLYSYS: Policy Analysis System model
- RPS: Renewable Portfolio Standard
- SGI: Sun Grant Initiative
- SRTS: Subregional Timber Supply Model

Responses to Previous Reviewers' Comments

- Consider appropriateness of scale- Agreed. We are finding that different scales are appropriate to different aspects of analysis, and aim to not imply unrealistic spatial precision. POLYSYS will not run below county level.
- Consider project growth plan- Agreed. Currently we are finding that projections benefit from revision based on latest economic data.
- Do not over-extend modeling, rather integrate with additive models. – Agreed. Focus has been on keeping core analysis current, while applying farmgate results to analysis of delivered supplies.

Sustainability constraints in Billion-Ton Update: Agriculture

Sustainability assumption or constraint	Sustain. category	Implementation
Scenarios assume trend toward reduced till and no till for corn, wheat	Soil quality, water quality	Management assumptions in scenario definition
Much higher (than Billion-Ton Study) fraction of crop acres no-till	Soil quality, water quality	Management assumptions in scenario definition
Residue removal prohibited on conventionally tilled acres	Soil quality, water quality	Management assumptions in scenario definition
Acceptable residue removal based on wind and water erosion estimates and soil carbon loss for most crops	Soil quality, water quality	Residue removal tool used to estimate retention coefficients
Residue removal not acceptable for soy	Soil quality, water quality	Management assumption in scenario definition
Acceptable residue removal different for reduced and no till	Soil quality, water quality	Residue removal tool used to estimate retention coefficients
Use of multi-county NRCS crop management zones with management assumptions (e.g., tillage)	Soil quality, water quality	Spatially explicit rotation and management assumptions
Land in counties west of 100th meridian excluded	Water quantity	Excluded land area
Irrigated cropland or pasture excluded	Water quantity	Excluded land area
No supplemental irrigation of energy crops	Water quantity	Management assumptions in scenario definition
Annual energy crops restricted to cropland with low erosion potential and assumed part of multicrop rotation	Soil quality, water quality	Excluded land area
No conversion of non-agricultural lands (except pasture) to energy crops	Greenhouse gas emissions	Excluded land area
No conversion of pasture in counties west of 100th meridian except for northwestern US	Water quantity	Excluded land area

Sustainability constraints in Billion-Ton Update: Forestry

Sustainability assumption or constraint	Sustainability category	Implementation
Acceptable residue removal for fuel treatment thinning different for different slopes (0%, 60%, or 70%)	Soil quality, water quality	Management assumptions in scenario definition
Acceptable residue removal for logging residues (70%)	Soil quality, water quality	Management assumptions in scenario definition
No biomass removal in wet areas to avoid soil compaction	Soil quality	Excluded land area
No production in administratively reserved forestlands, such as wilderness areas and National Parks	Biodiversity	Excluded land area
No production in roadless areas, as inventoried by USDA Forest Service, which may qualify for wilderness or conservation protection	Biodiversity	Excluded land area