Feedstocks for the Bioeconomy

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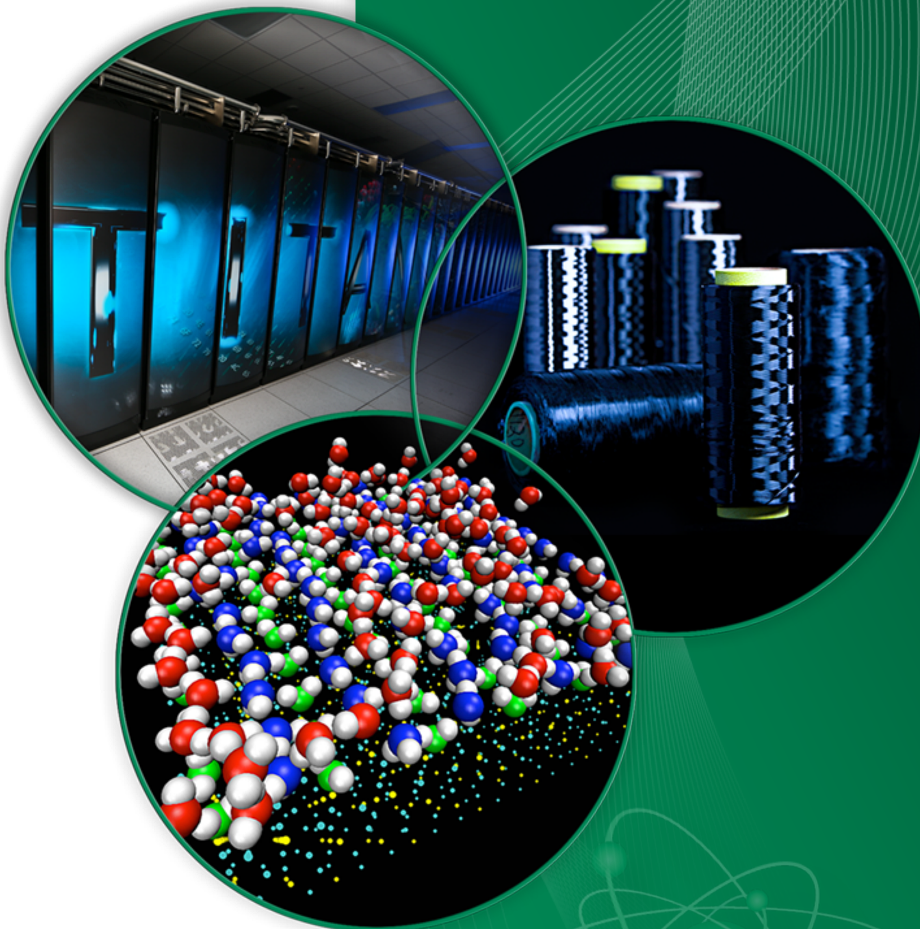
Oak Ridge National Lab

Environmental Sciences Division



Wednesday, June 8th, 2016

ABFC

Miami, FL

U.S. DEPARTMENT OF ENERGY

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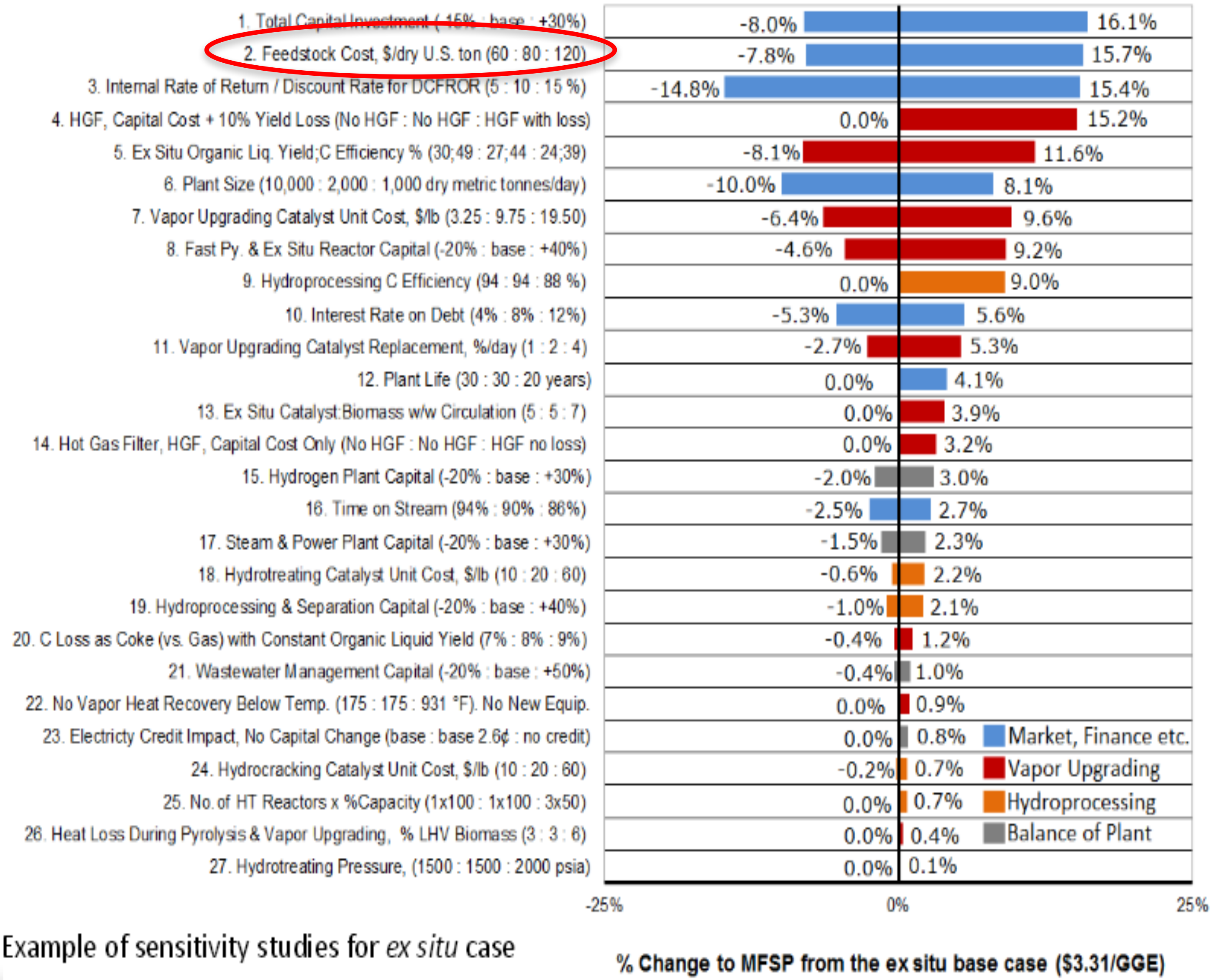
Relevance of Resource Assessment

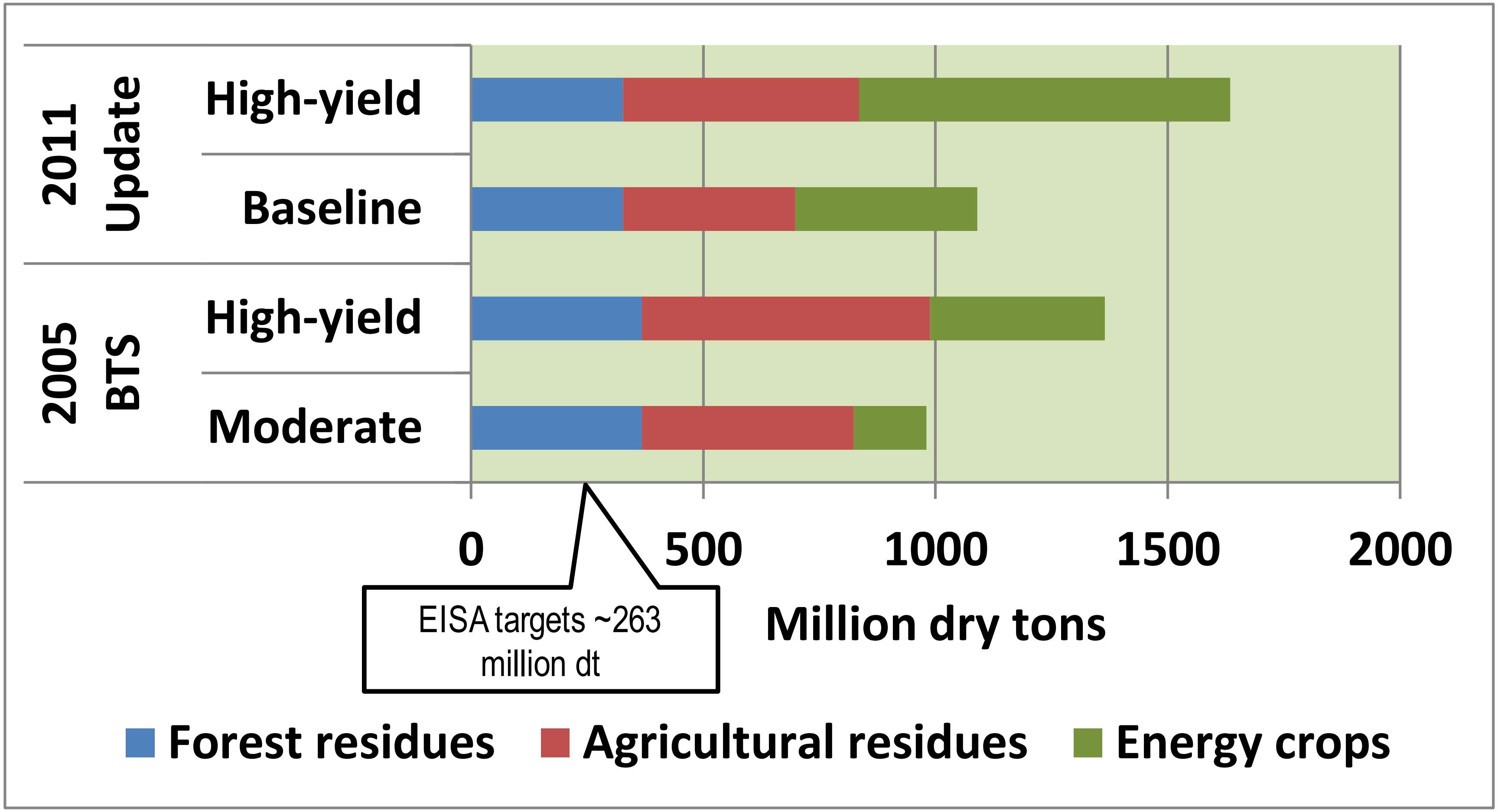


Example of sensitivity studies for *ex situ* case

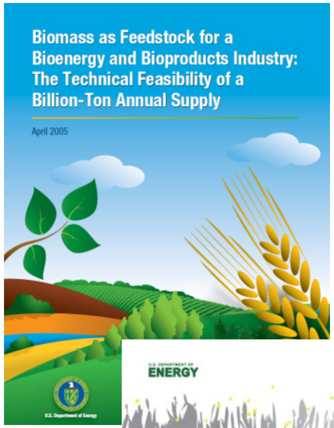
http://www.energy.gov/sites/prod/files/2015/04/f21/thermochemical_conversion_dutta_210302.pdf

Comparison of 2005 BTS with 2011 BT2

Comparison of 2030 at $60/dry ton with the 2005 BTS



Resource Assessments



Billion-Ton Study (BTS), 2005

- Technical potential of agricultural and forestry systems to supply biomass
- Identified supply to displace 30% of petroleum consumption; i.e. physical availability

Billion-Ton Update (BT2), 2011

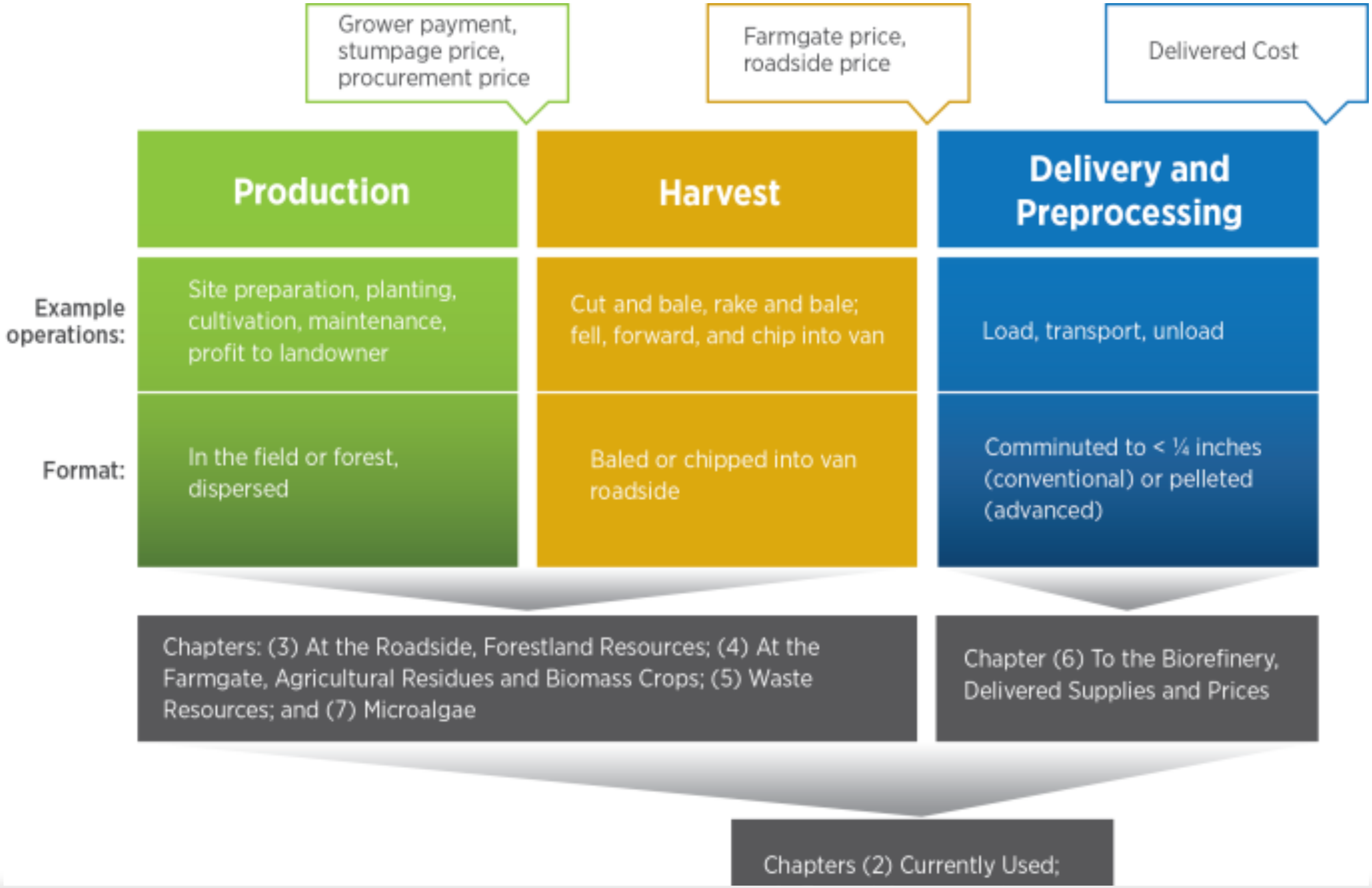
- Economic potential of feedstocks
- Data via Bioenergy Knowledge Discovery Framework

BT16

2016 Billion-Ton Update (BT16), 2016

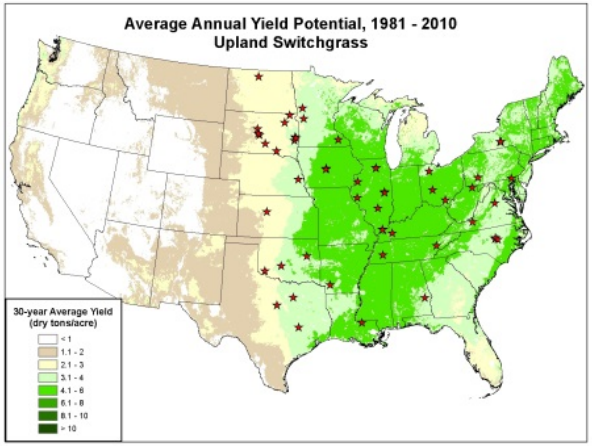
- Economic potential
- Two volume approach
  1. Economic Availability of Biomass Feedstocks
  2. Environmental Effects of Select Scenarios

2016 Billion-Ton Report

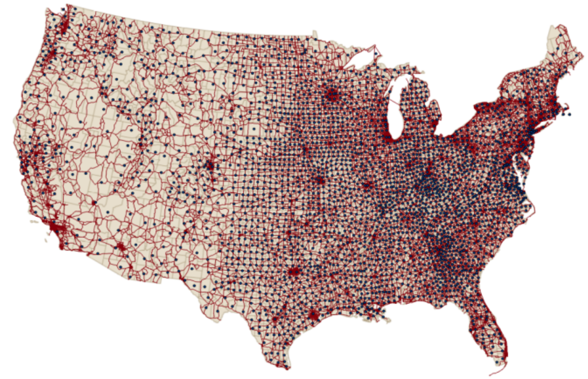


Enhancements of the BT16

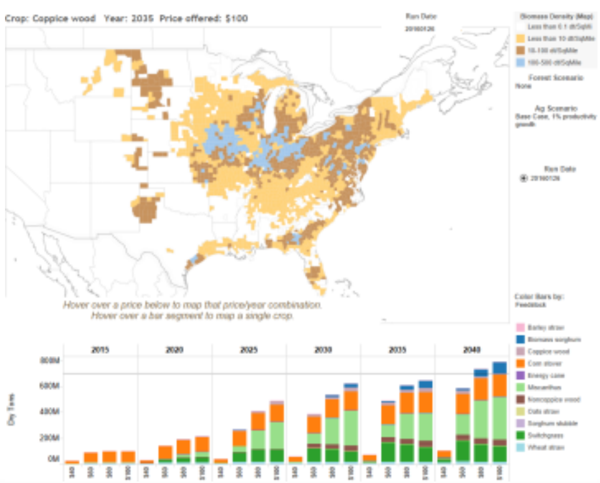
Modeled crop yields



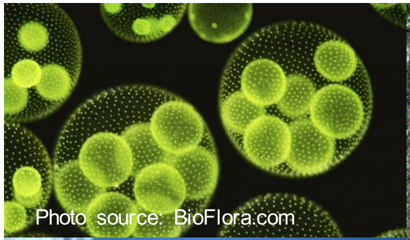
Scenario study of delivered supplies

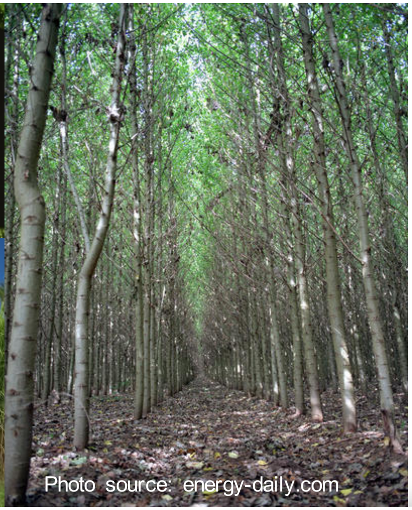


Interactive visualization



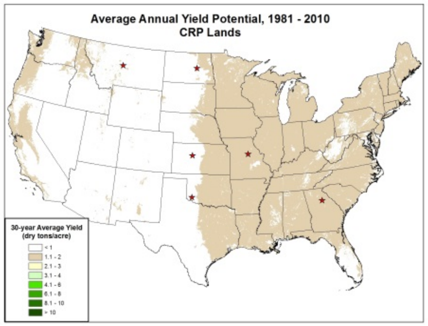
Adding algae and other energy crops

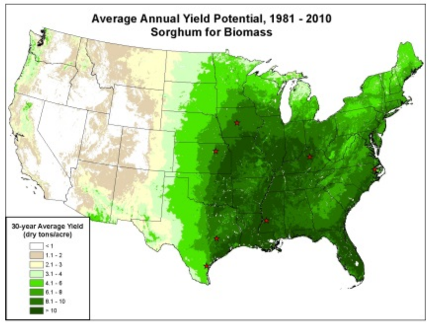


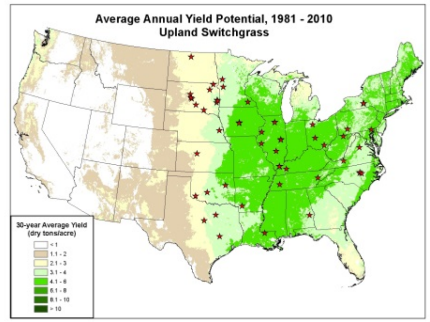


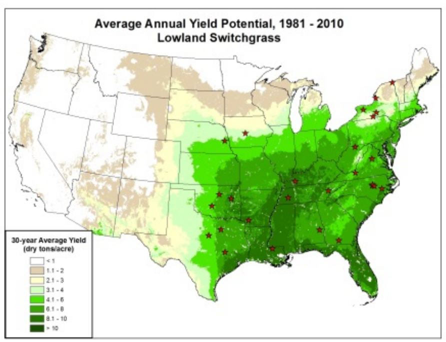
Enhanced Energy Crop Potential Yield

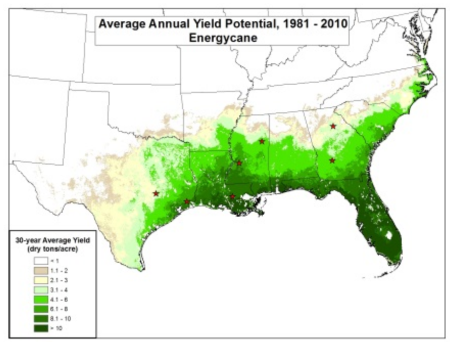
Herbaceous Energy Crops



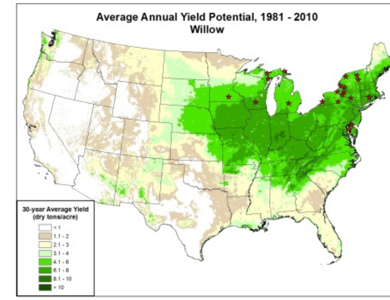


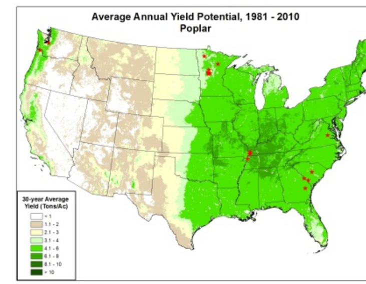


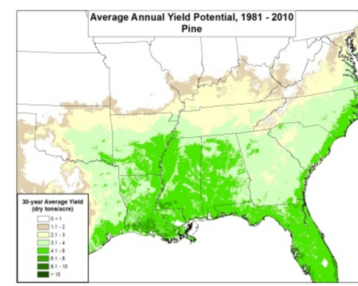




Woody Crops







Manuscript in preparation by SGI Field Trial and Resource Assessment Teams

Credit: Oregon State University PRISM Climate Group

BT2-Table ES1: Current and Potentially Available Feedstocks, $60/dt

Feedstock	2012	2017	2022	2030
	Million dry tons			
Baseline scenario				
Forest resources currently used	129	182	210	226
Forest biomass & waste resource potential	97	98	100	102
Agricultural resources currently used	85	103	103	103
Agricultural biomass & waste resource potential	162	192	221	265
Energy crops[a]	0	101	282	400
Total currently used	**214**	**284**	**312**	**328**
Total potential resources	**258**	**392**	**602**	**767**
Total – baseline	**473**	**676**	**914**	**1094**
High-yield scenario (2%–4%)				
Forest resources currently used	129	182	210	226
Forest biomass & waste resource potential	97	98	100	102
Agricultural resources currently used	85	103	103	103
Agricultural biomass & waste resource potential[b]	244	310	346	404
Energy crops	0	139–180	410–564	540–799
Total currently used	**214**	**284**	**312**	**328**
Total potential	**340**	**547–588**	**855–1009**	**1046–1305**
Total high-yield (2-4%)	**555**	**831–872**	**1168–1322**	**1374–1633**

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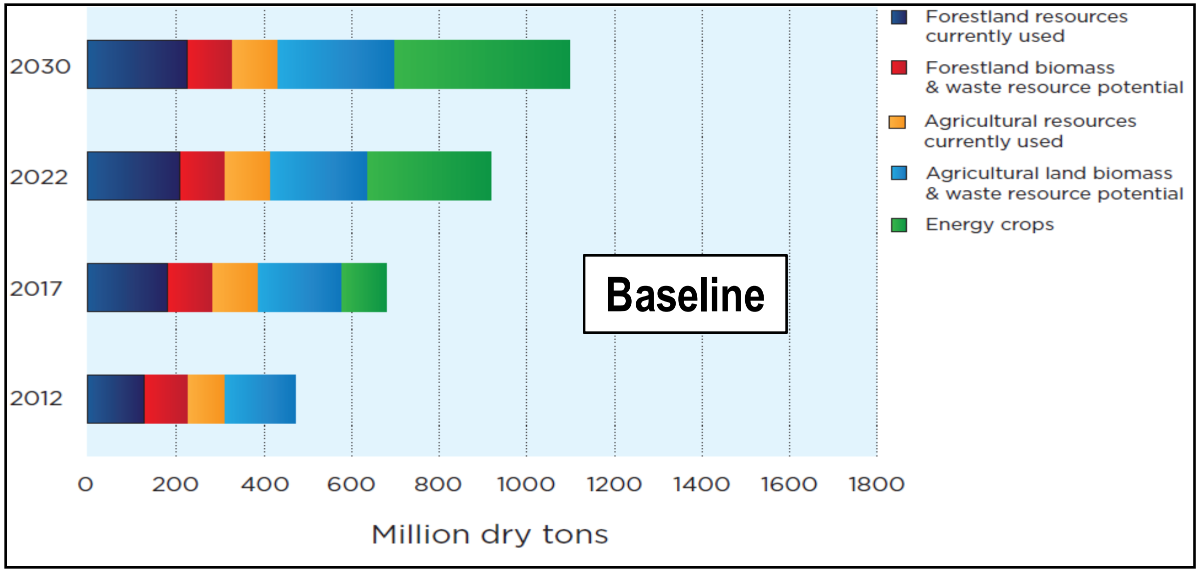
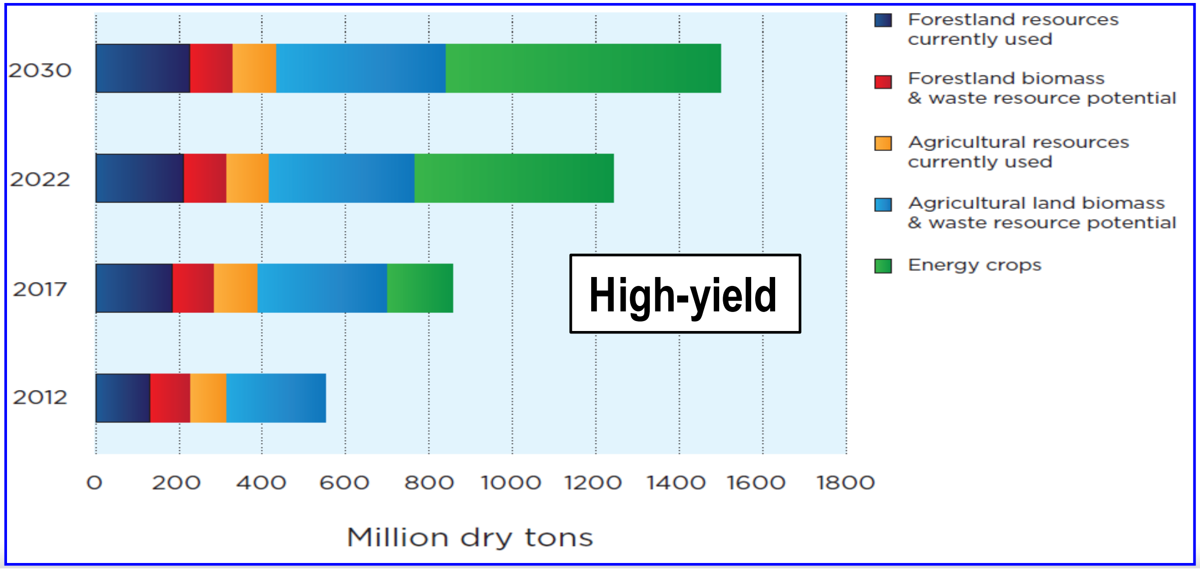
2011 U.S. Billion-Ton Update: <$60/dt





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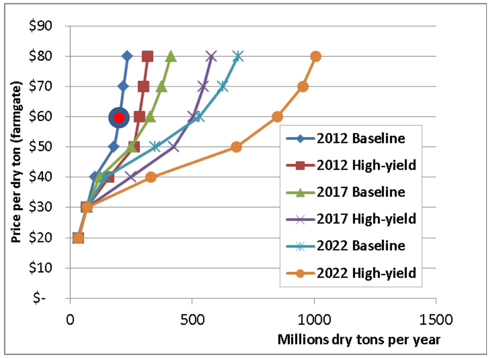
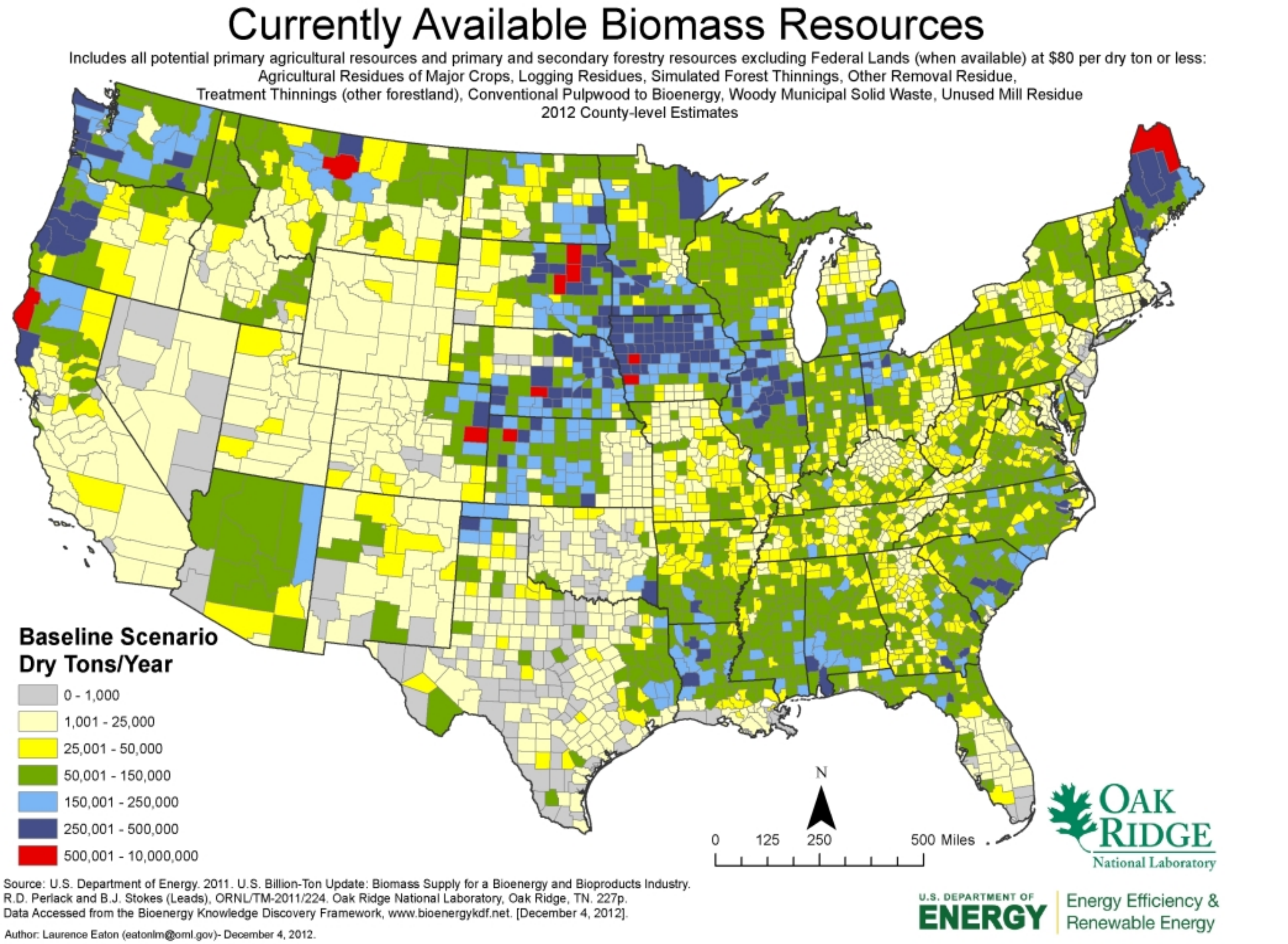
Near-term Potential

www.bioenergykdf.net

- **2012**
- **Baseline scenario**
- **$60 dry ton^{-1}**

201 x 10^6 dt



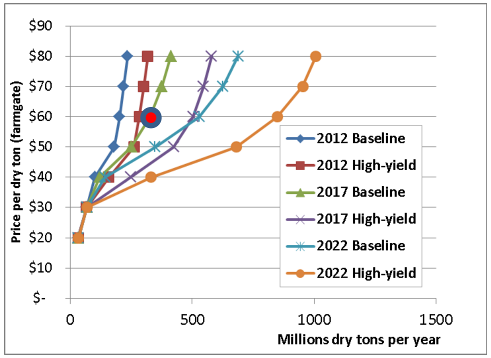


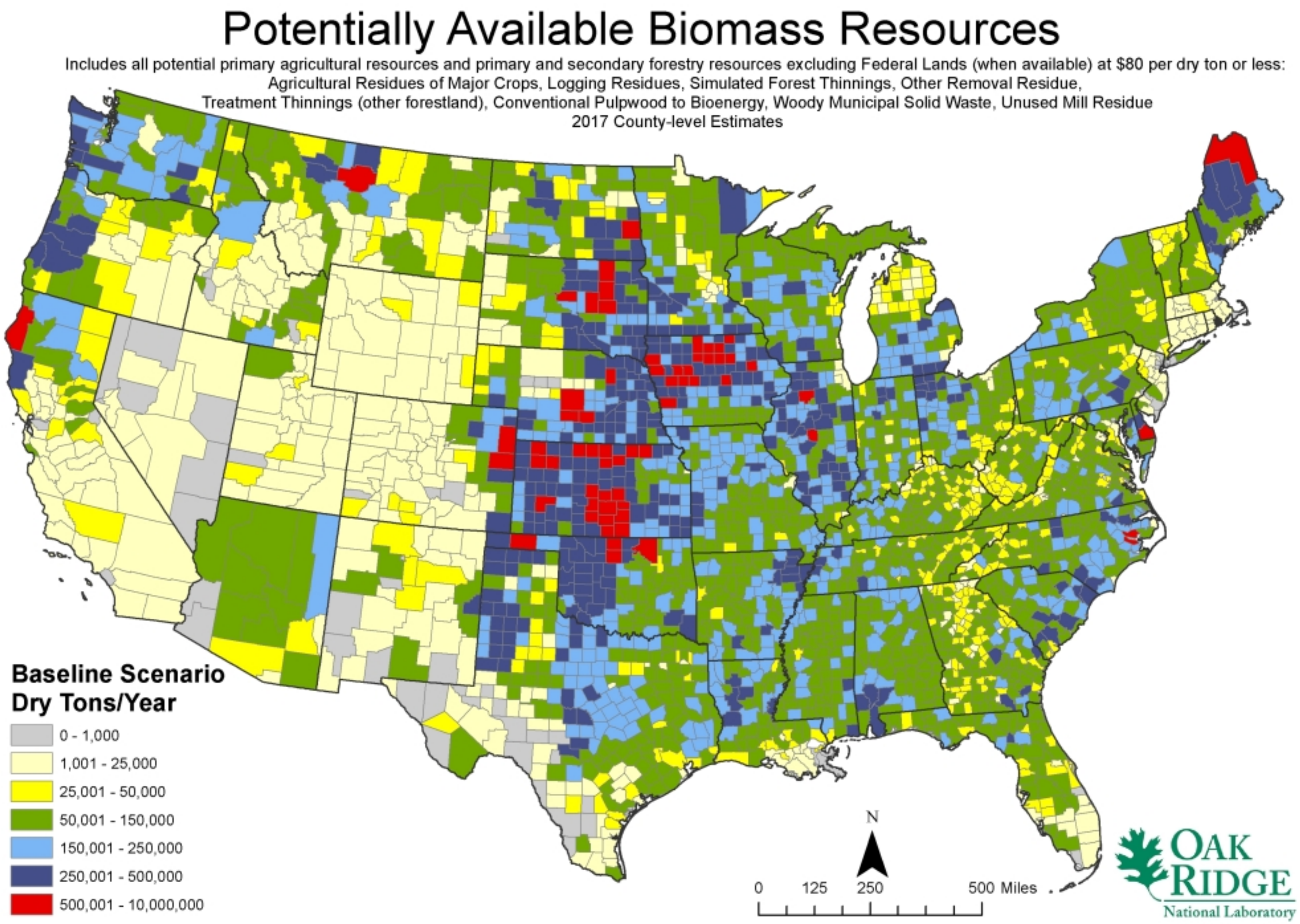
2011 Billion-ton Results

www.bioenergykdf.net

- **2017**
- **Baseline scenario**
- **$60 dry ton^{-1}**

327 x 10^6 dt





Source: U.S. Department of Energy. 2011. U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p. Data Accessed from the Bioenergy Knowledge Discovery Framework, www.bioenergykdf.net. [December 4, 2012].

Author: Laurence Eaton (eatonlm@ornl.gov)- December 4, 2012.

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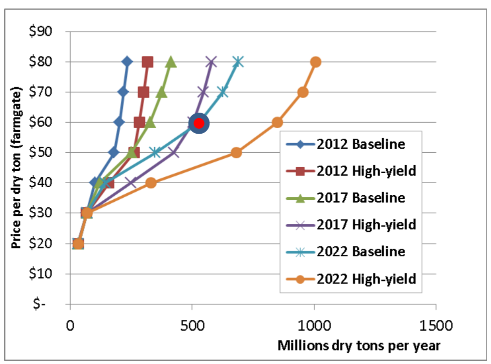
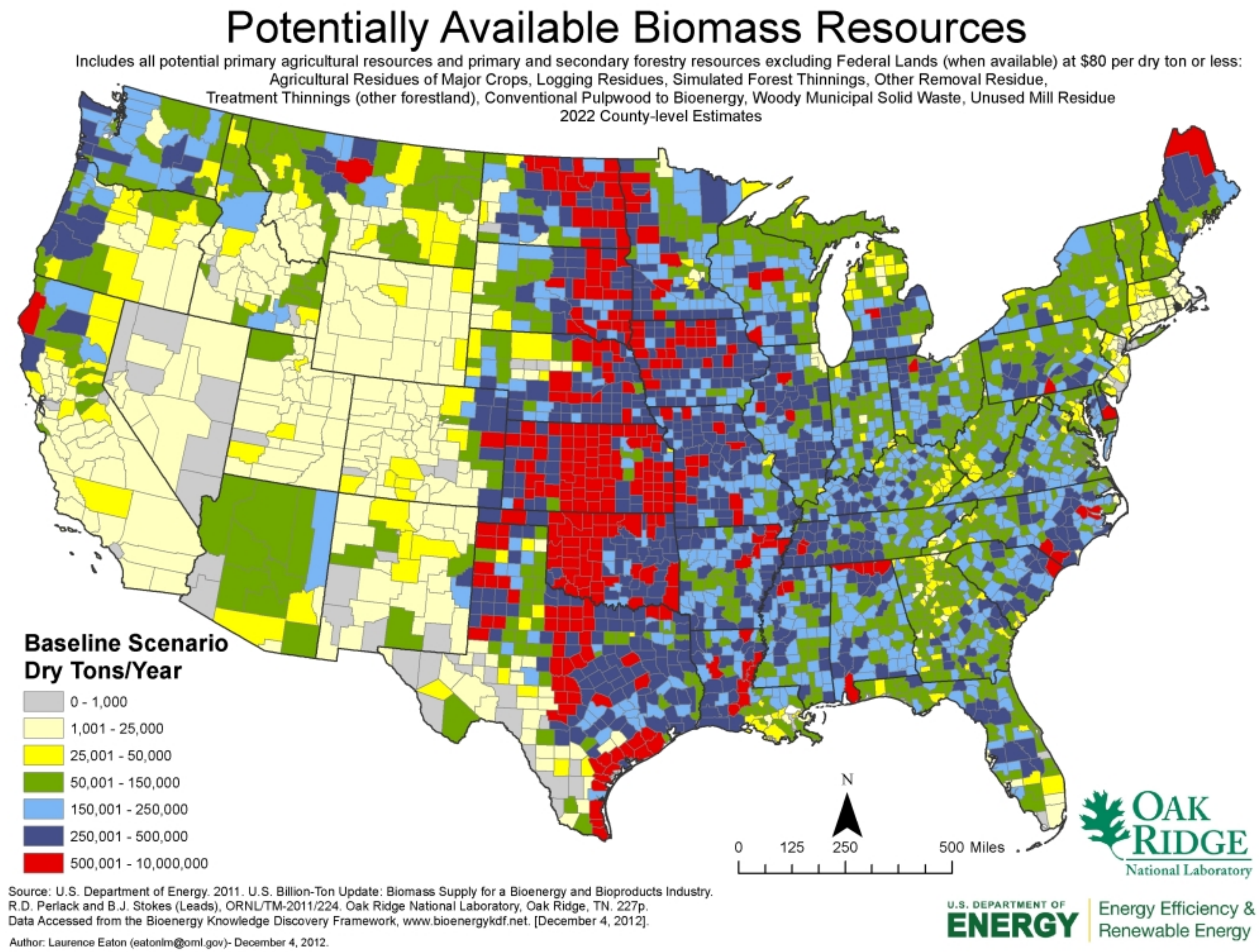
2011 Billion-ton Results

www.bioenergykdf.net

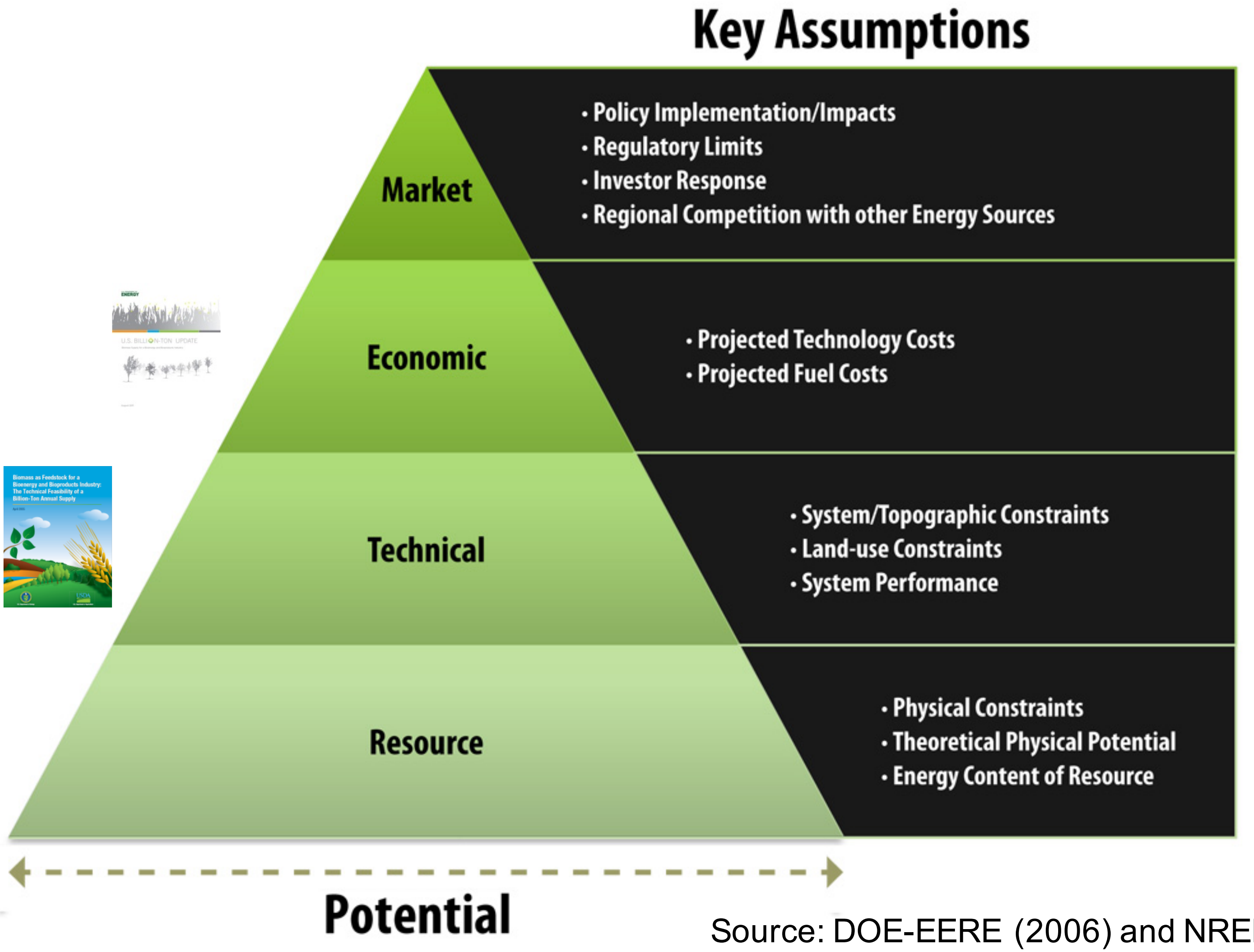
- 2022
- Baseline scenario
- $60 dry ton^{-1}

529 x 10^6 dt





Advancing Resources



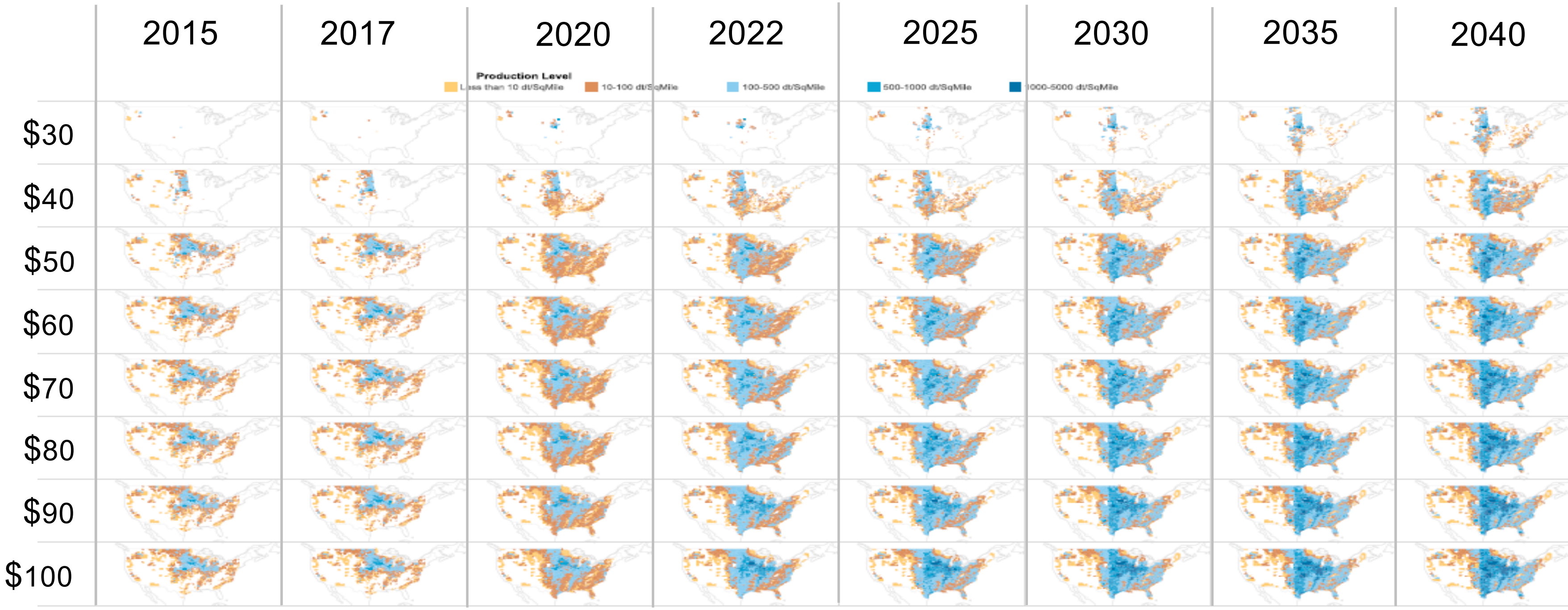
Source: DOE-EERE (2006) and NREL (2011)

Advancing Resources

- Crop improvement
- Advanced logistics
- Precision agriculture

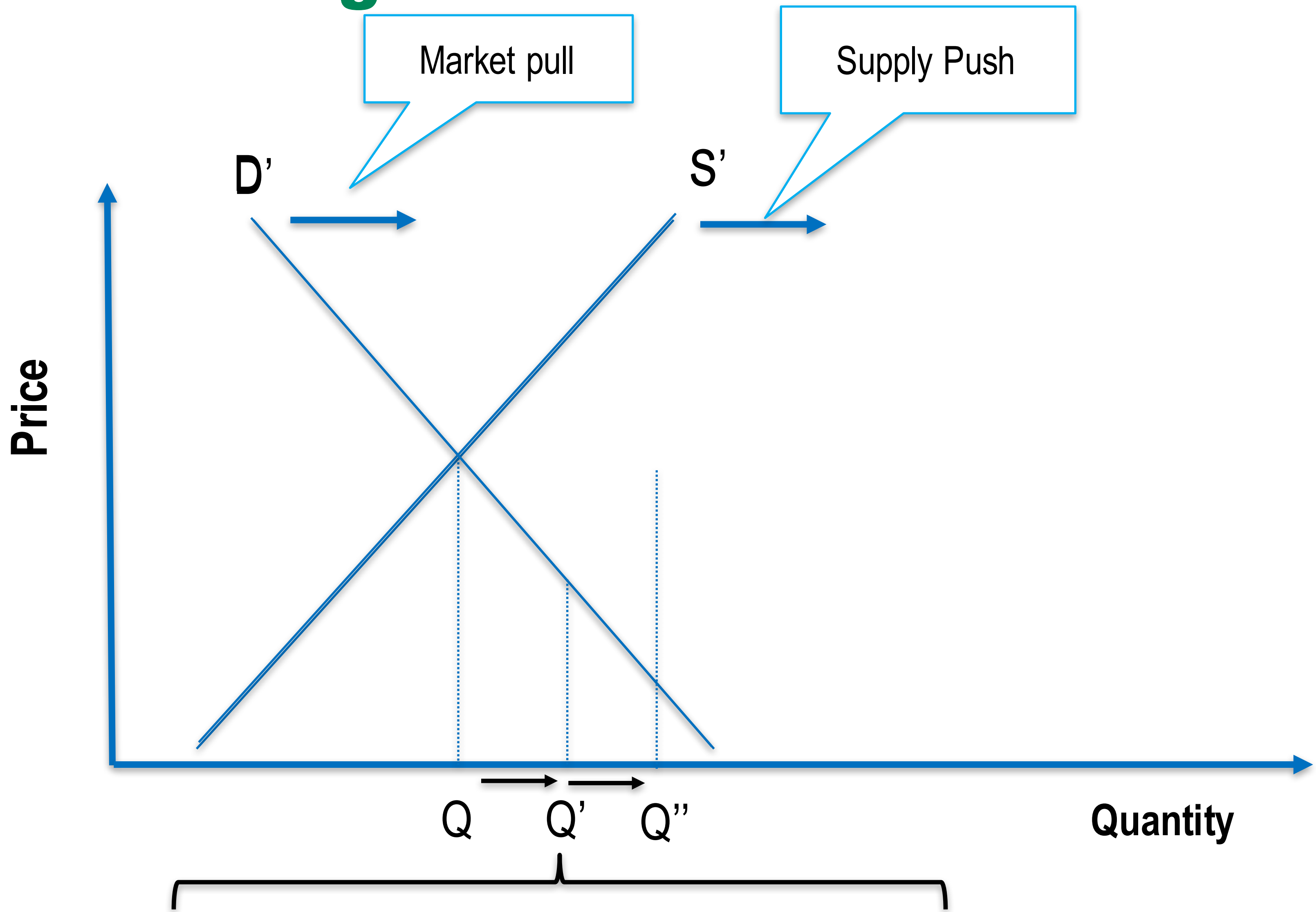
Supply push

Market pull



- Conversion
- Bioproducts
- International markets

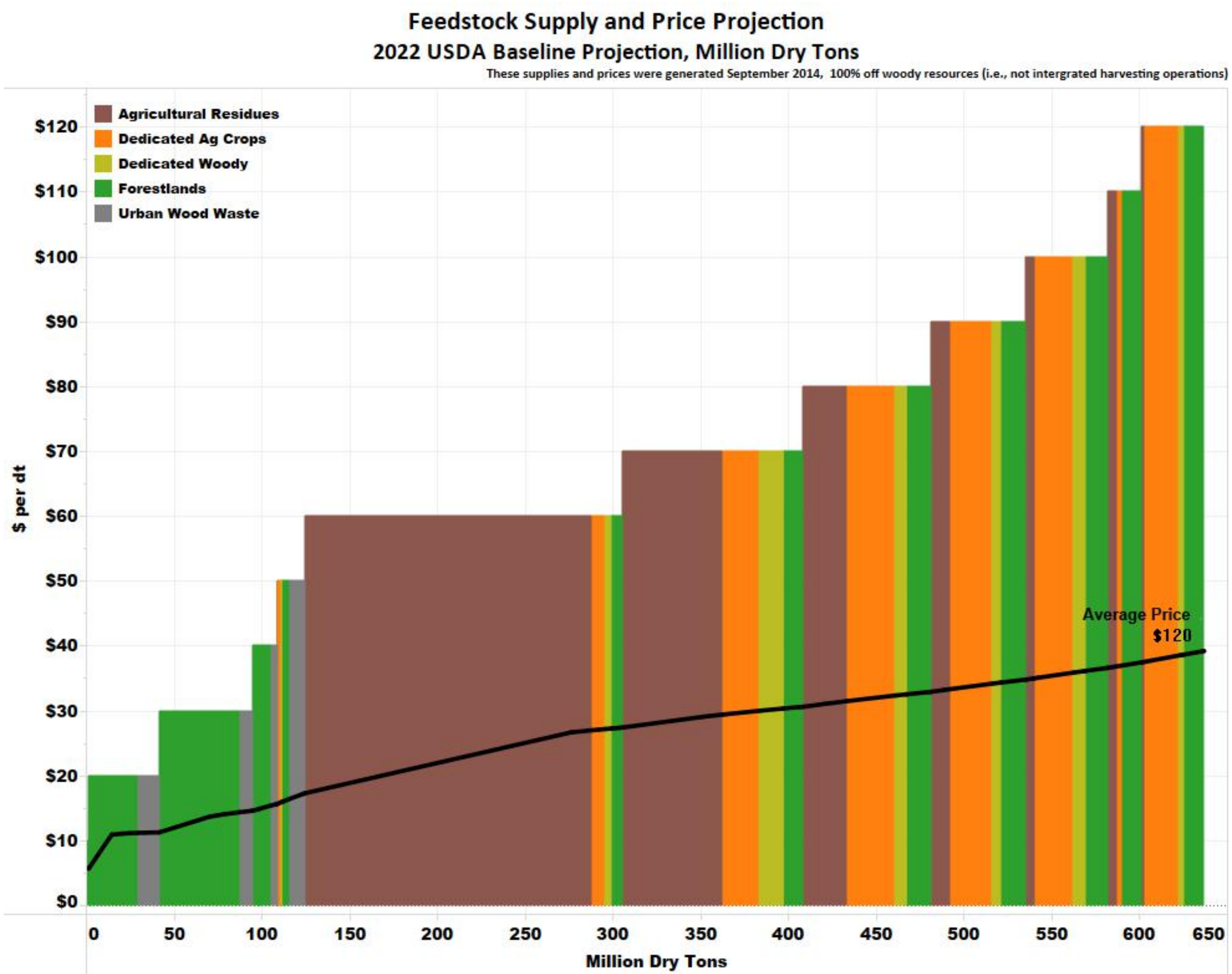
Advancing Resources



Supply push (e.g., high yield, improved logistics, improved quality, added value) and/or market pull (commoditization, co-products, increased conversion yield, policy)= mobilization

Farmgate: National Supply Curves

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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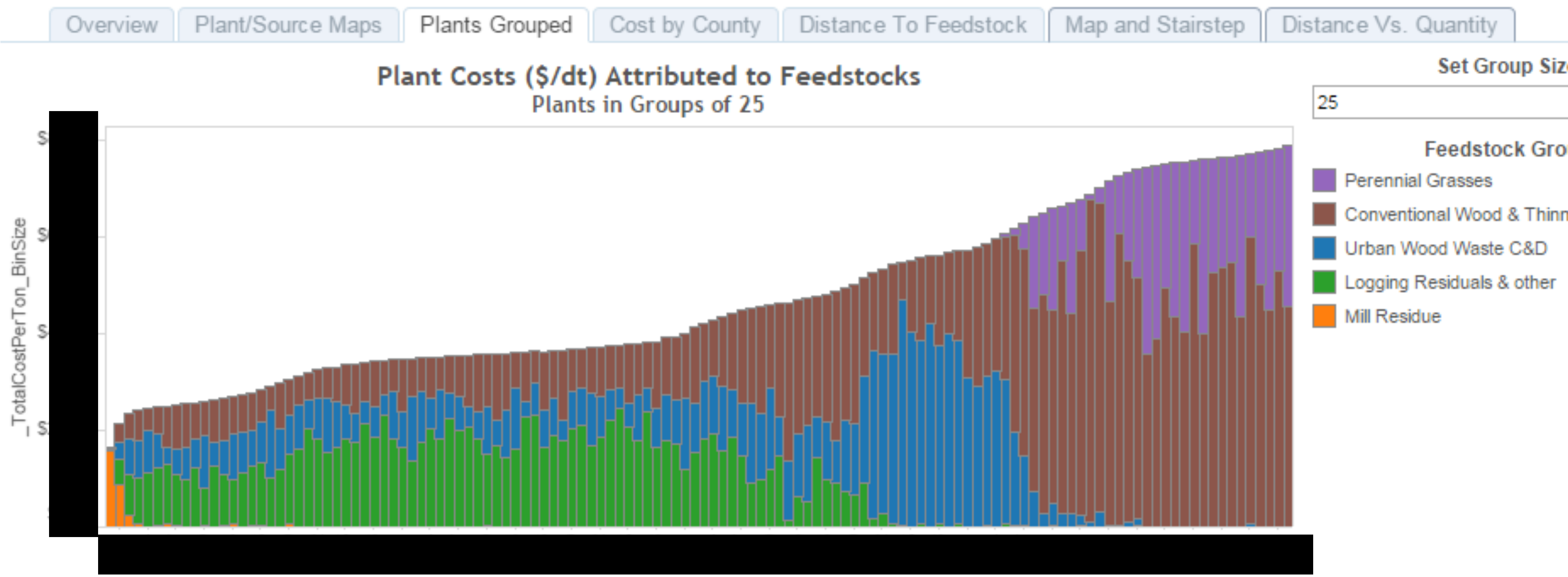
BT16 Delivered Supplies: (preliminary, do not cite, values redacted)



BT16 Volume 2: Environmental sustainability indicators

	Indicator
Soil quality (ANL, USFS)	1. Total organic carbon (TOC)
	2. Total nitrogen (N)
	3. Extractable phosphorus (P)
	4. Bulk density
Water quality and quantity (ANL, ORNL, USFS)	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 (ANL)	12. CO_2 equivalent emissions (CO_2 and N_2O)
Biodiversity (ORNL)	13. Presence of taxa of special concern
	14. Habitat area of taxa of special concern
Air quality (NREL)	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 (ORNL)	19. Aboveground net primary productivity or Yield

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

Summary

- Resource assessments indicate vast national biomass resource potential, ~1.0-1.5 billion tons/yr.
- Future biomass utilization is a function of supply and demand interactions.
- Resource assessments can help evaluate impacts of supply push and market pull and inform strategies to increase biomass utilization.
- Future research should advance from “how much is there” to “how can it happen”.


Photo source: Knox News Sentinel

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Upcoming Event

- Bioenergy 2016, July 12-13

Washington, DC

- 2016 Billion-ton Report
  - Interactive data visualizations
  - Expanded feedstock cost and supply data

- Sun Grant Regional Feedstock Partnership Synthesis Report
  - Seven field trial teams and national laboratory analysis of field trial data validate input data in supply projections

Thank you!

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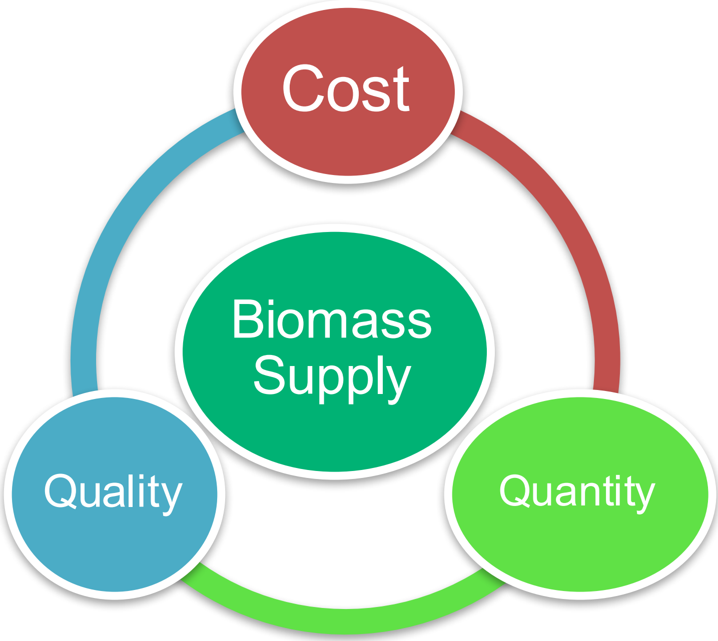
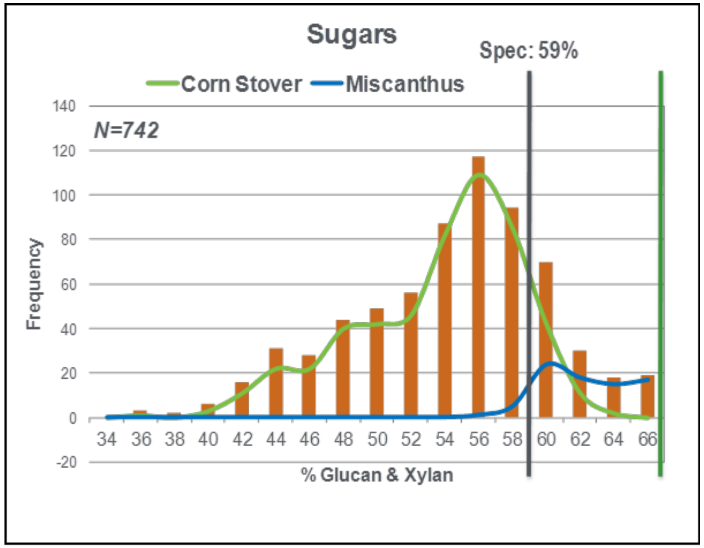
Key Points

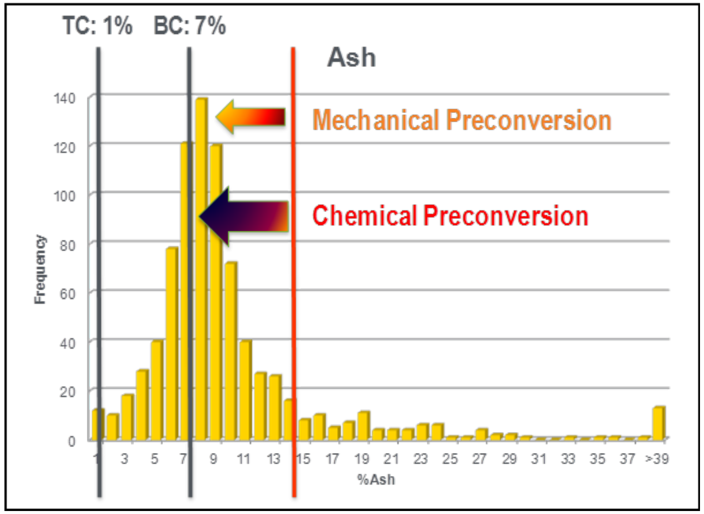
- U.S. bioeconomy potential is enormous, yet difficult to quantify
- Many assumptions on crop/residue yield, grower contracts, traditional crop demand, among many others
- Resource assessments serve multiple industries, stakeholders
- Growth of bioeconomy is limited by availability of feedstocks



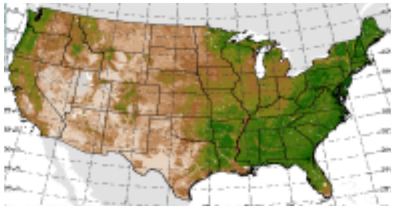
Quality: Biomass vs. Feedstock

- There is a lot of biomass, but not all biomass is the same
  - Between feedstocks and within a feedstock
- The quality of field-run biomass is impacted by:
  - inherent species variability
  - production conditions
  - differing harvest, collection, and storage practices
- Conversion processes desire consistency
- Variability can be with respect to ash, sugars, particle morphology, and moisture, for example

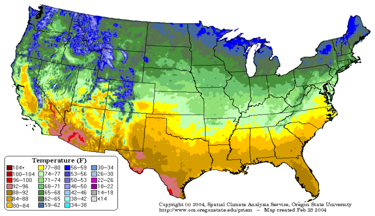




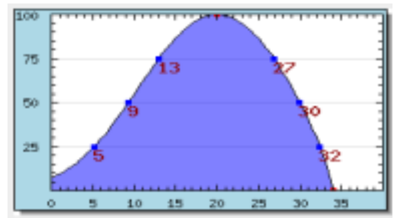
National Crop Yield and Variability Modeling



SSURGO Soil Maps

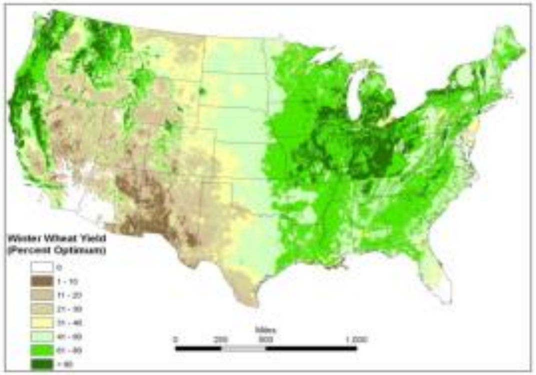


PRISM Climate Maps

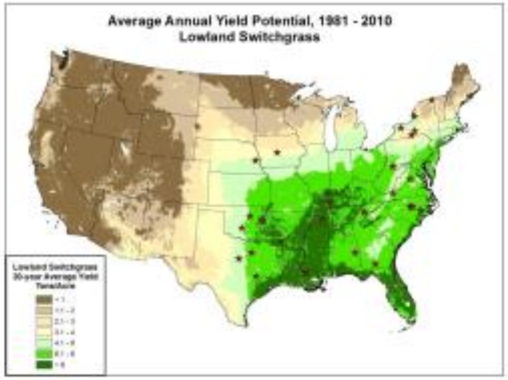


PRISM-EM Crop Suitability Model

Percent of Maximum Yield
(Relative Yield Map)



Biomass Yield
(Absolute Yield Map)



Interface with Crop Experts

KDF Field Trial Database

SunGrant INITIATIVE

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Adaptability Woody and Herbaceous of Bioenergy Crop

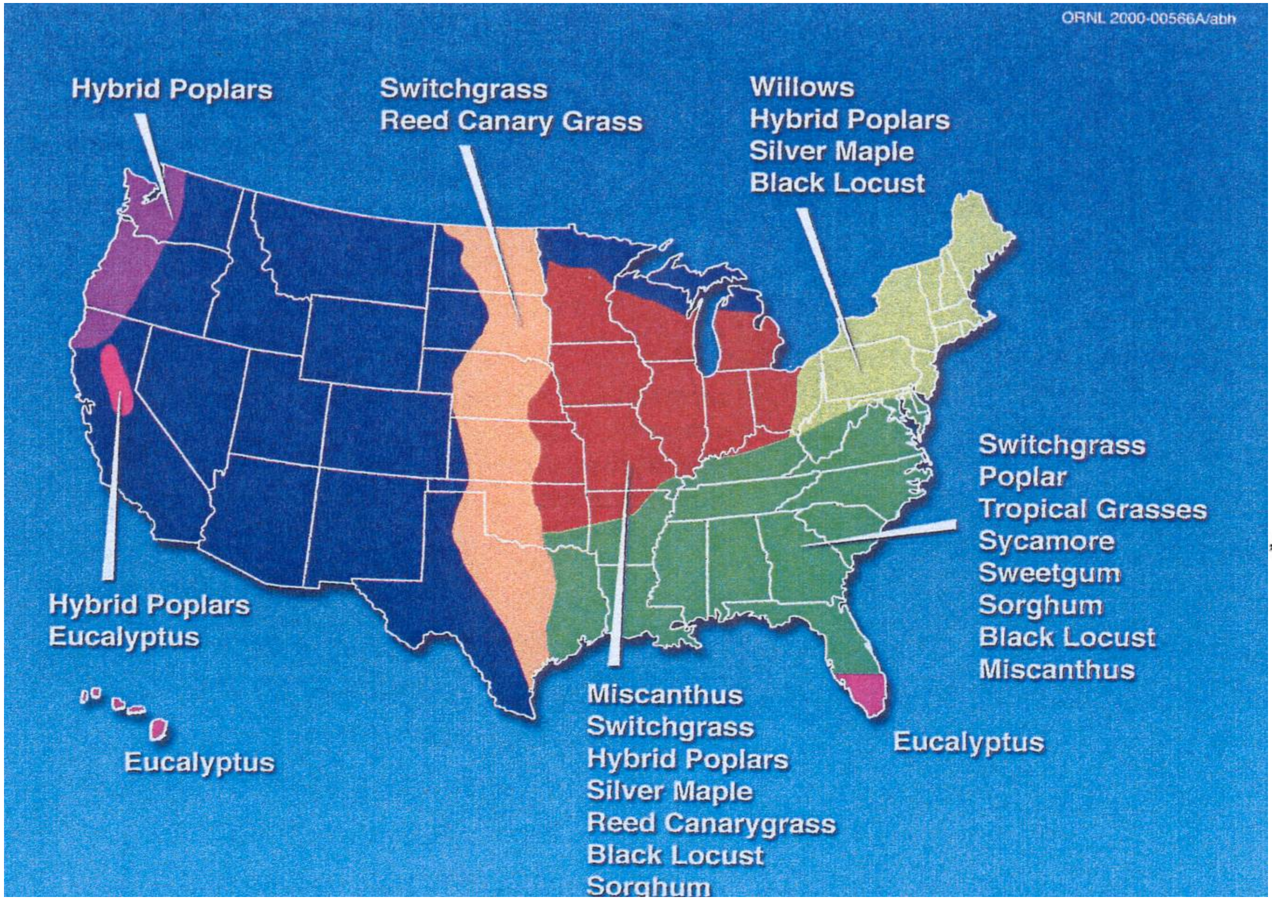
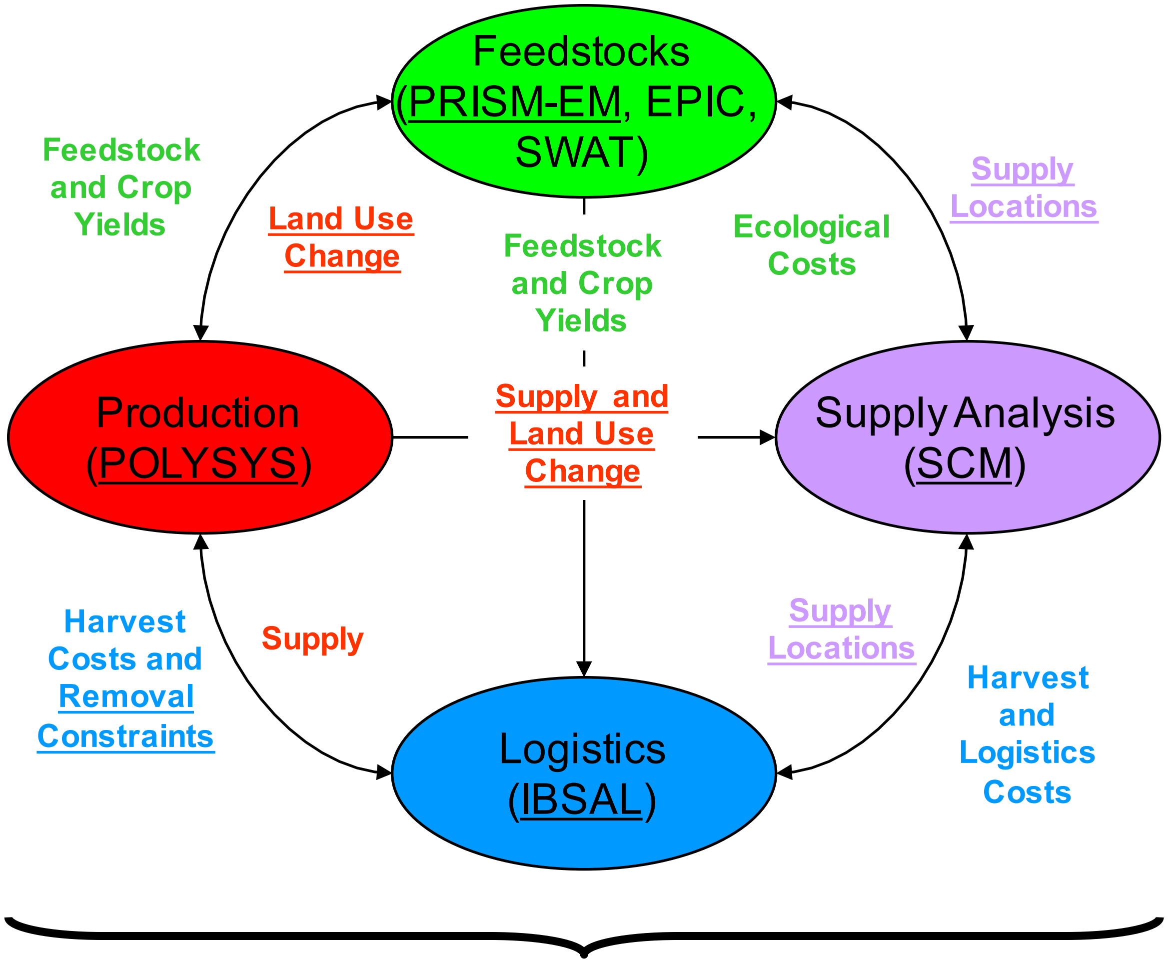


FIG. 4. Map of recommended biofuel feedstock plantings in the United States (updated from Wright [1994]).

- >110 Trials in Sun Grant Regional Feedstock Partnership

Integrated Resource Assessment and Analysis



Source: Brandt, ORNL (2015)

Underlined items identify implemented tools and interfaces

Current and Future Estimates (± Uncertainty) of Sustainable Supply