

U.S. Biomass Potential

An Update to the 2005 and 2011 Assessments

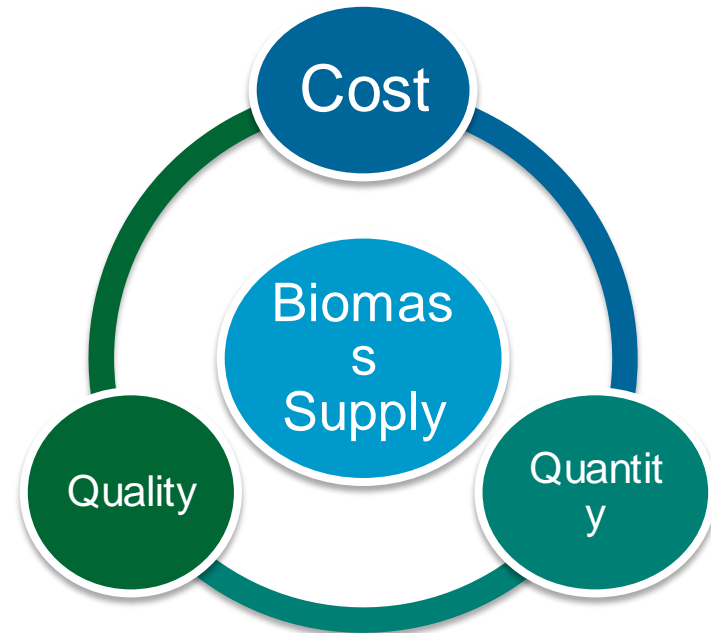
March 26, 2015

Alison Goss Eng

Acting Feedstocks Supply and Logistics Team Lead

Motivation

- In order to realize a commercial advanced biofuels industry, we need a **significant sustainable supply of biomass**
- DOE is focused on analyzing the resource potential of biomass to understand feedstocks supply for the **bioeconomy** of the future
- Supply analysis is housed in the BETO Feedstock Supply and Logistics R&D Platform



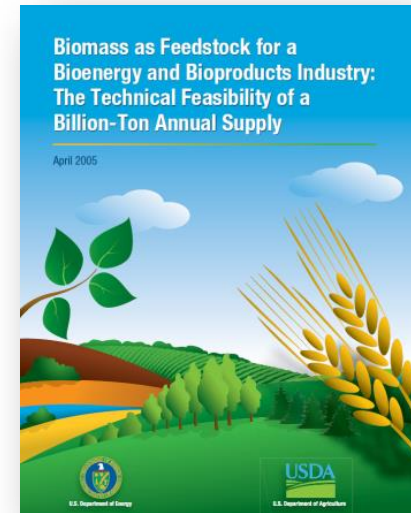
History and Accomplishments

Billion-Ton Study (BTS), 2005

- **Technical assessment of agricultural and forestry systems to supply low-valued biomass for new markets**
- **Identified adequate supply to displace 30% of petroleum consumption; i.e. physical availability**

Billion-Ton Update (BT2), 2011

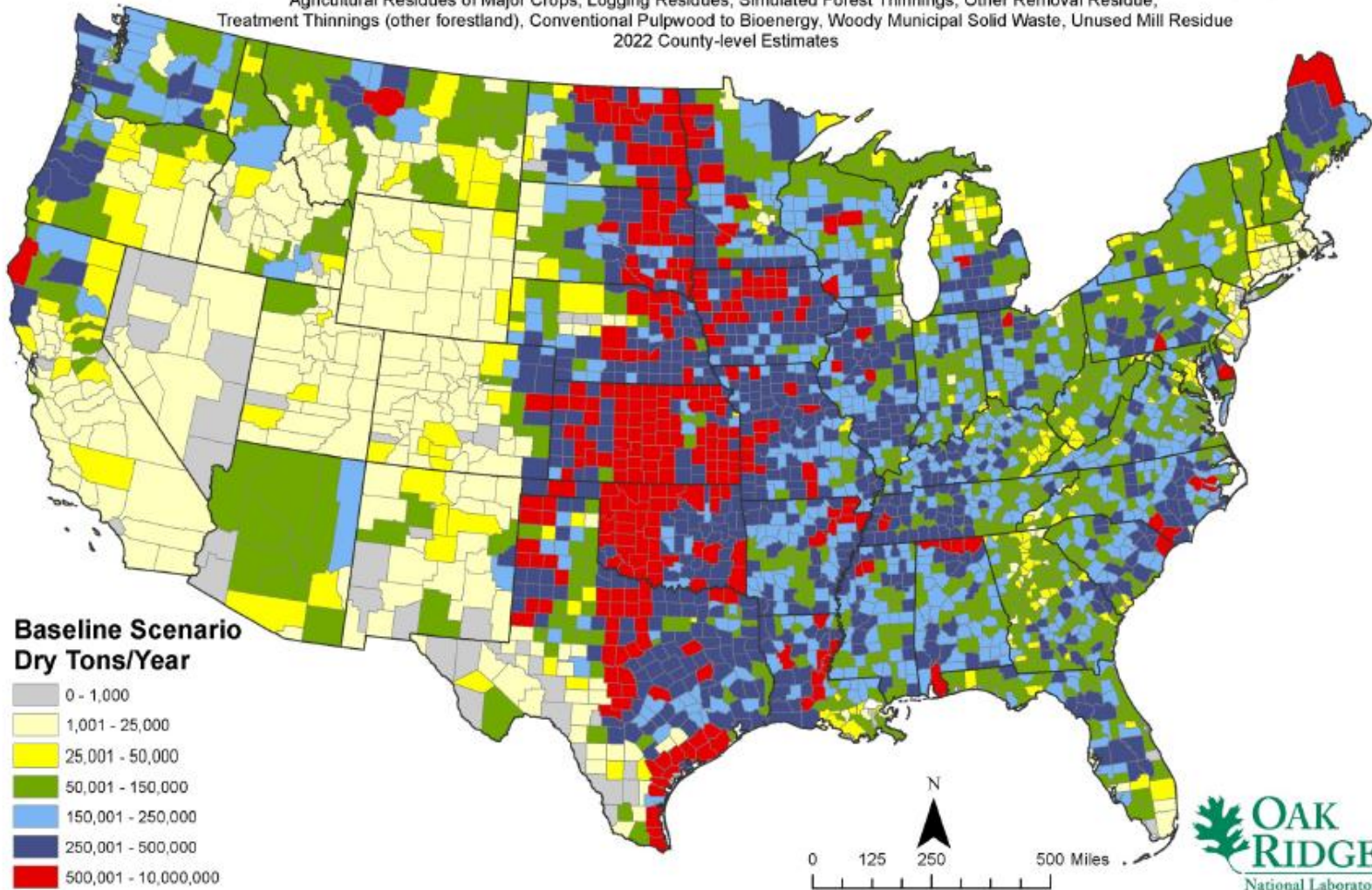
- **Quantified potential economic availability of feedstocks for 20-year projection**
- **Publicly released county-level supply curves for 23 candidate feedstocks through Bioenergy Knowledge Discovery Framework.**



Map Results from BT2: 2022 Baseline, \$60/dry ton

Potentially Available Biomass Resources

Includes all potential primary agricultural resources and primary and secondary forestry resources excluding Federal Lands (when available) at \$80 per dry ton or less:
Agricultural Residues of Major Crops, Logging Residues, Simulated Forest Thinnings, Other Removal Residue,
Treatment Thinnings (other forestland), Conventional Pulpwood to Bioenergy, Woody Municipal Solid Waste, Unused Mill Residue
2022 County-level Estimates

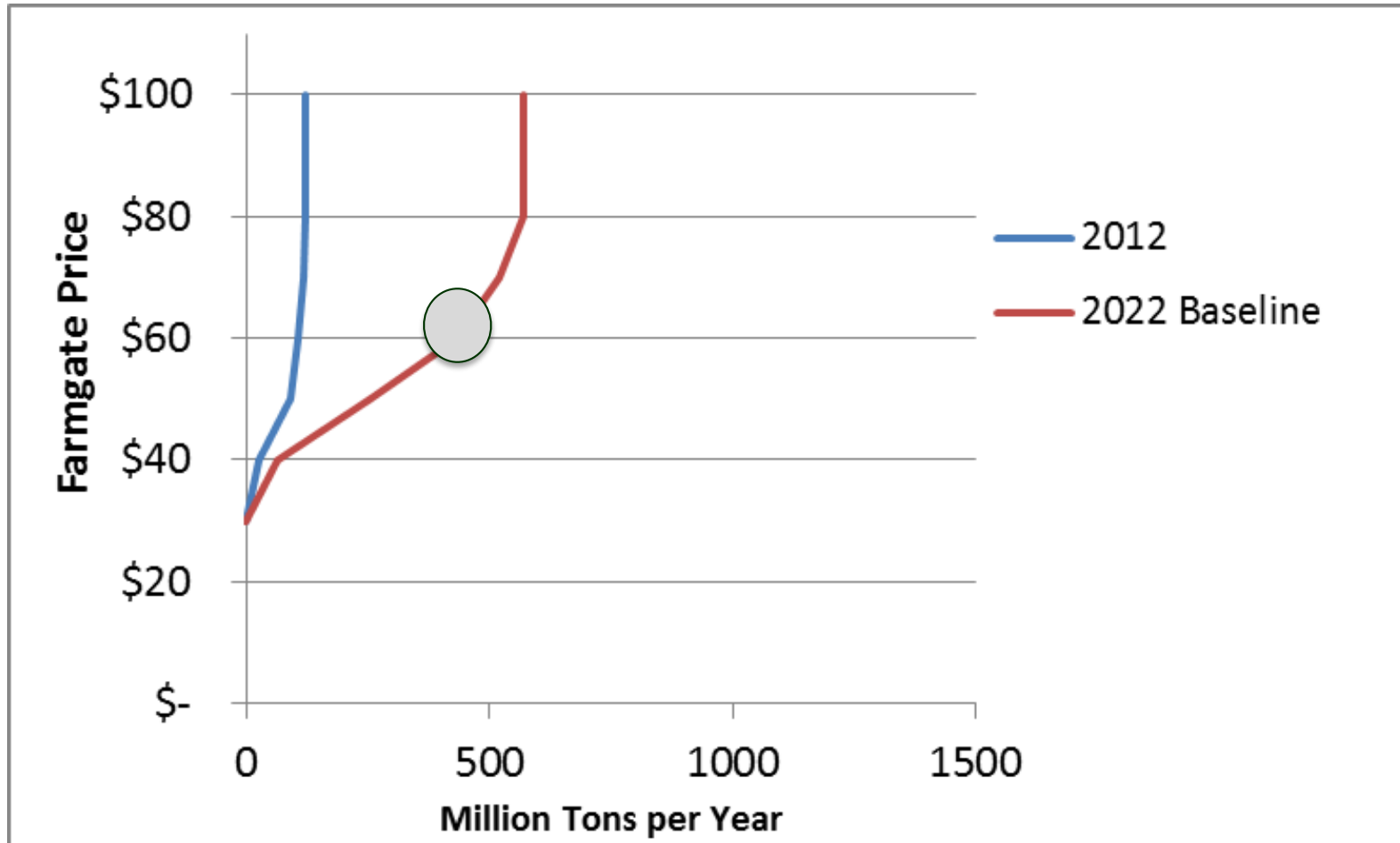


Source: U.S. Department of Energy, 2011. U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p. Data Accessed from the Bioenergy Knowledge Discovery Framework, www.bioenergykdf.net.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

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

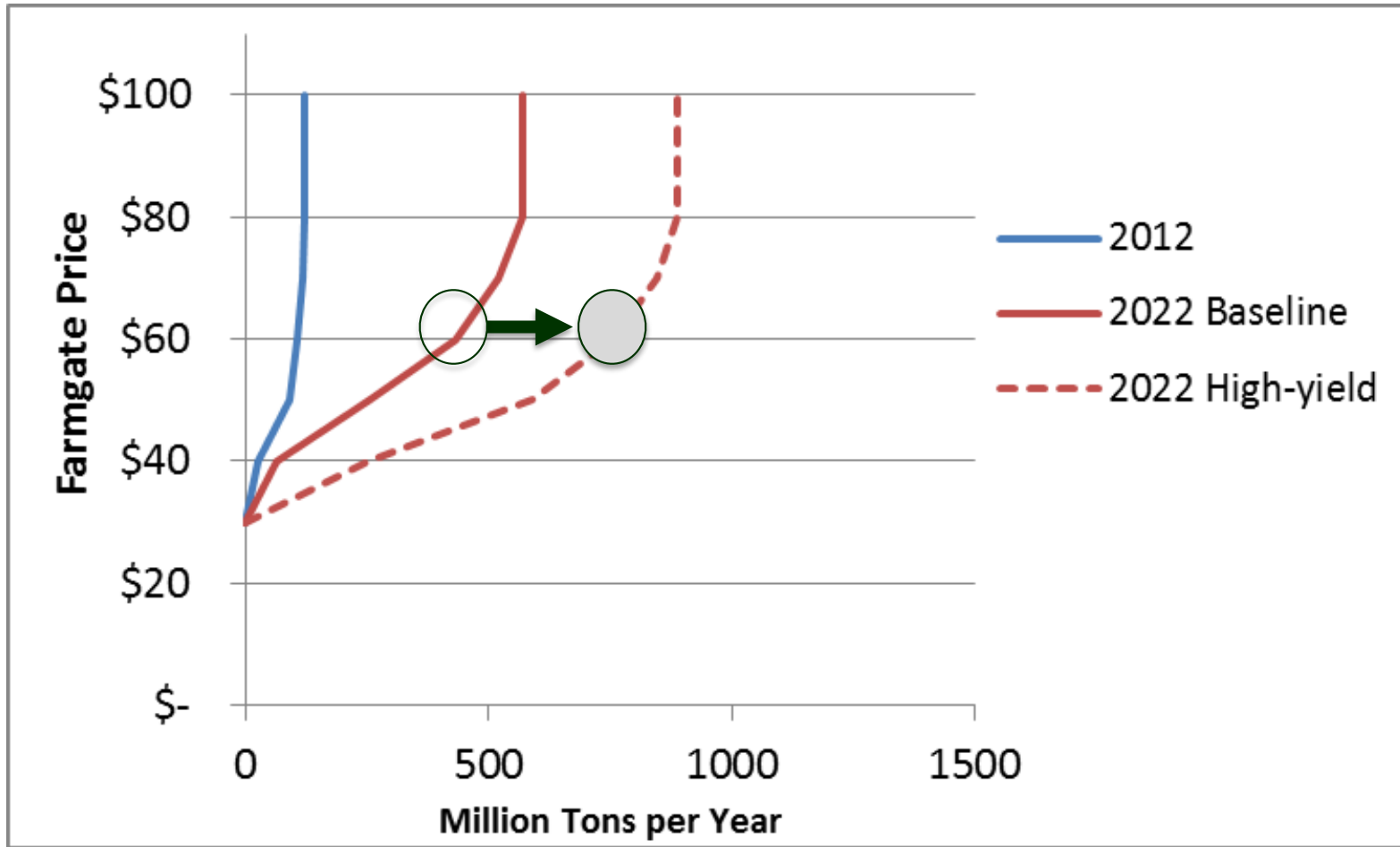
Biomass Supply Curve Results from BT2: Baseline vs. High-yield

Supply of Primary Agricultural and Forestry Resources



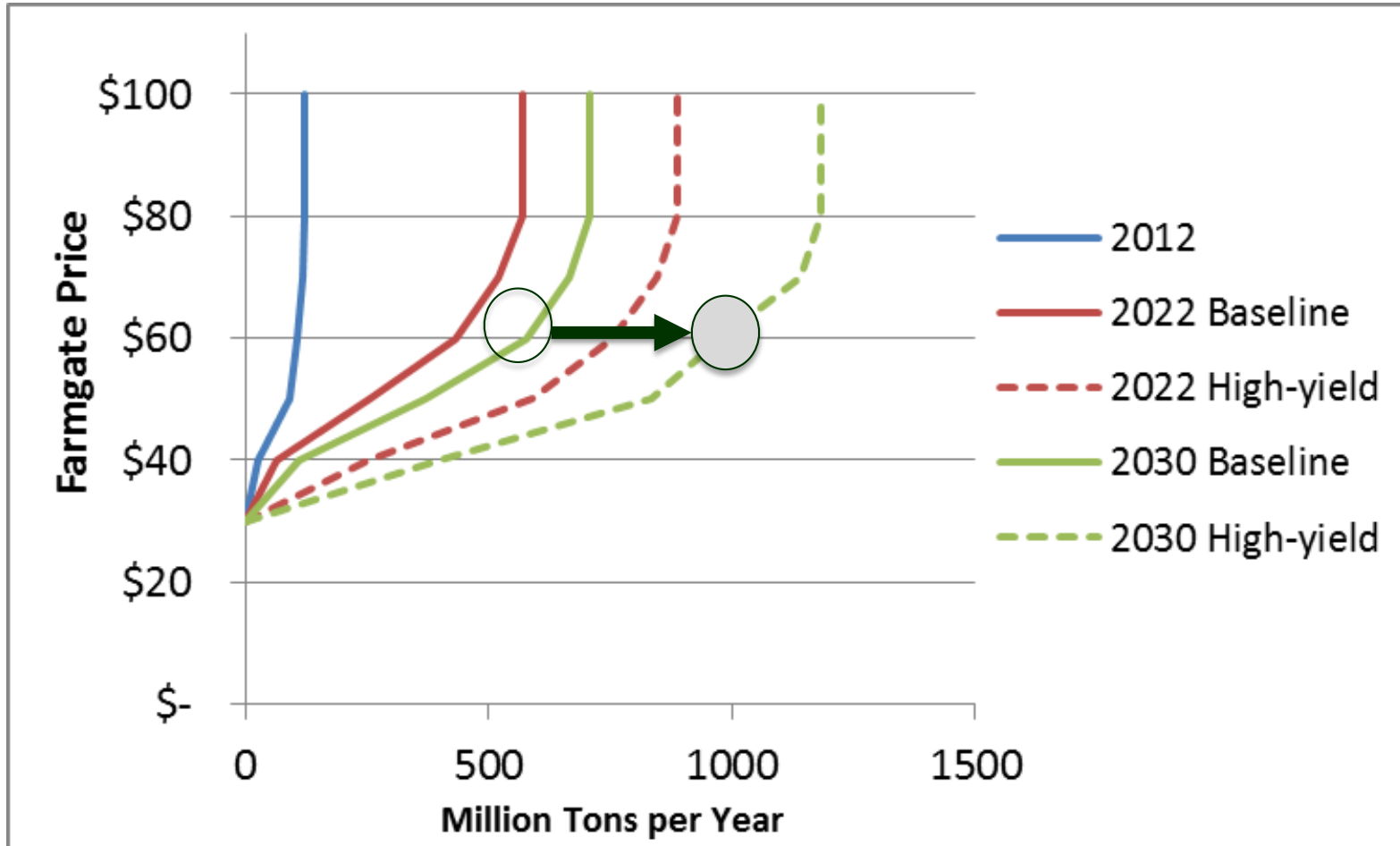
Biomass Supply Curve Results from BT2: Baseline vs. High-yield

Supply of Primary Agricultural and Forestry Resources



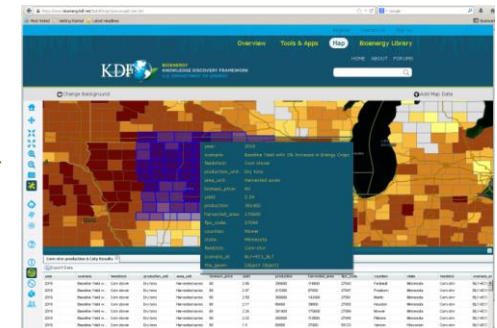
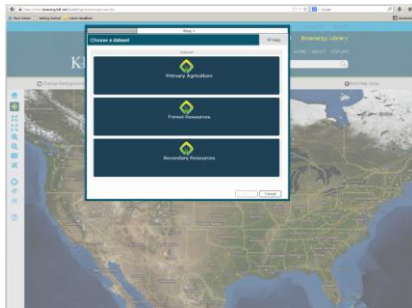
Biomass Supply Curve Results from BT2: Baseline vs. High-yield

Supply of Primary Agricultural and Forestry Resources



BT2 Public Data Release via Bioenergy KDF

- Online content delivered successfully to stakeholders via Billion-ton Data Exchange
- Electronic data discovery tools saved hundreds of hours of researcher time (\$1.3M) and provided ease of access



Explore Billion-Ton data in the BioenergyKDF: <http://www.bioenergykdf.net>

Impact and Feedback from BTS and BT2

- **Analysis suggests a robust potential biomass supply of wastes and dedicated energy crops**
- **Cost and supply information is industry standard for bioenergy stakeholders across supply chain**
- **Domestic and international renewable energy analysis require supply modeling that BT2 effort provides**
- **Combined 2000+ academic citations (Google Scholar)**
- **Relevant feedback**
 - **Impact of algal supply on total supply**
 - **Effects of national biomass supply on biodiversity**
 - **Effects of storage and transportation losses and costs on farmgate supply and cost**

High-Level Goals of 2016 Billion-Ton Report (BT16)

- **Assess current demand of commercial biomass- to-energy feedstocks**
- **State-of-science biomass potential supply to 2040**
 - **Agricultural, forestry, algal, and waste resources**
 - **From farm to roadside to facility throat**
- **Environmental sustainability analysis of potential supply**



Genera Energy/UT-Knoxville Bioenergy Field Day, 2013. Credit: Laurence Eaton



Photo Credit: Sapphire Energy
(<http://zebrapartners.net/sapphiremedia/Green-Crude-Farm-2013.html>)

Two-Volume Approach

- **Volume 1: Resource analysis**
 - **Supply curves at field/forest level and to biorefinery**
 - **June 2016 publish target**
- **Volume 2: Sustainability analysis**
 - **Air quality, water, GHG, biodiversity analysis**
 - **Climate change impacts**
 - **September 2016**



Five USDA-ARS energycane varieties planted at a Mississippi State University field site sponsored by DOE in the Regional Feedstock Partnership. (award# GO85041). Photo Credit: Steve Thomas

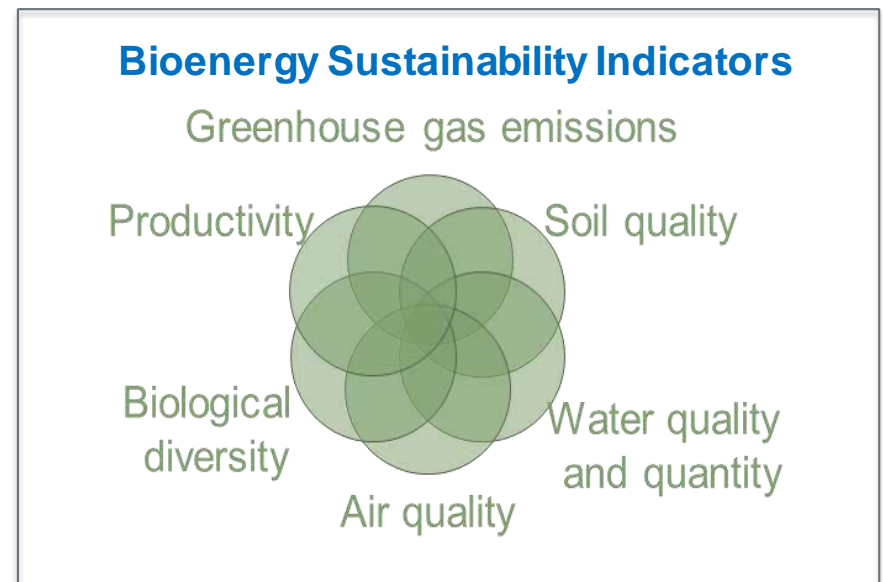
2016 Billion-Ton Report Scope

Volume 1

- Costs of production, harvesting, and logistics, potential yield range, and economic supply for 30 candidate feedstocks (>1 million dry tons/year)

Volume 2

- Environmental sustainability analysis of *potential delivered supply* with metrics reported for:
 - GHG emissions
 - Air quality impacts
 - Water quality and quantity
 - Biodiversity
 - Soil carbon
 - Nutrient profiles

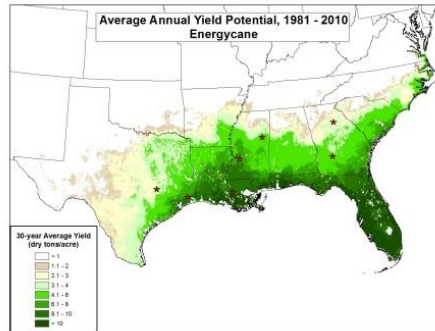
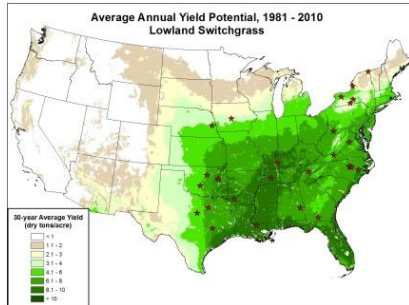
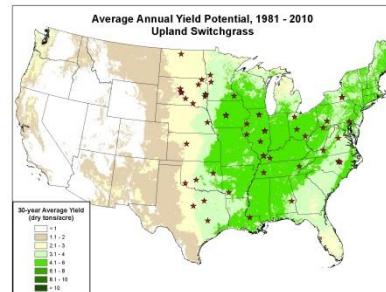
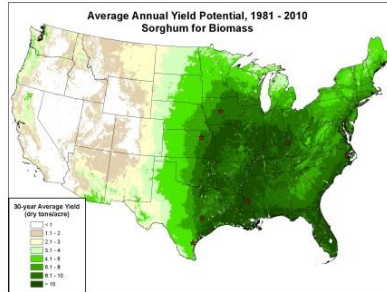
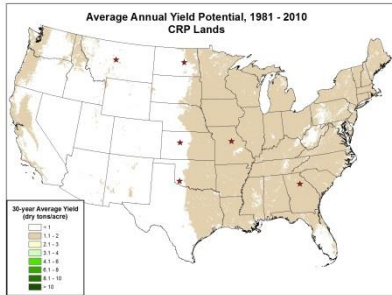


Stakeholder Meetings and Workshops since BT2

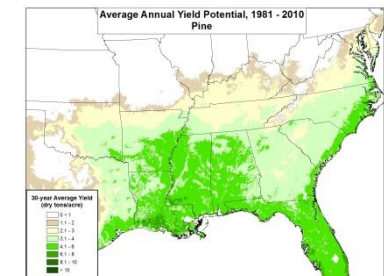
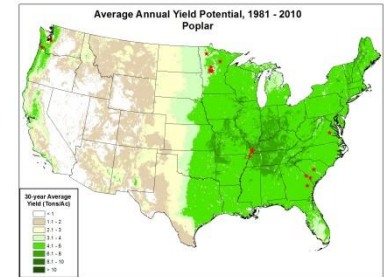
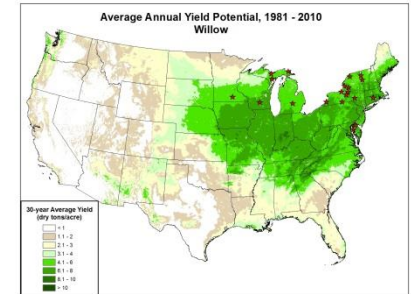
- **Billion Ton Study: What can be Learned about Bioenergy Sustainability.** December 6, 2011. Oak Ridge, TN.
- **Sun Grant Regional Feedstock Partnership Yield Mapping and Field Trial Expert Review.** Five meetings, April 2013-September 2014. Jackson, MS; Corvallis, OR (2); Kansas City, MO; Oak Ridge, TN.
- **Integrating Bioenergy into Sustainable Landscapes.**
Forestry Workshop, New Bern, NC March 3-4, 2014.
Agricultural Workshop, Chicago, IL, June 24-26, 2014.
- **Advanced Supply System Workshop.** February 3-4, 2015. Golden, CO.

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

Collaborators



Hybrid Poplar Stand in Oregon

Photo Credit: Laurence Eaton and Mike Halbelib

- Lead organization: ORNL
- Sustainability analysis led by national labs: ANL, INL, NREL, ORNL



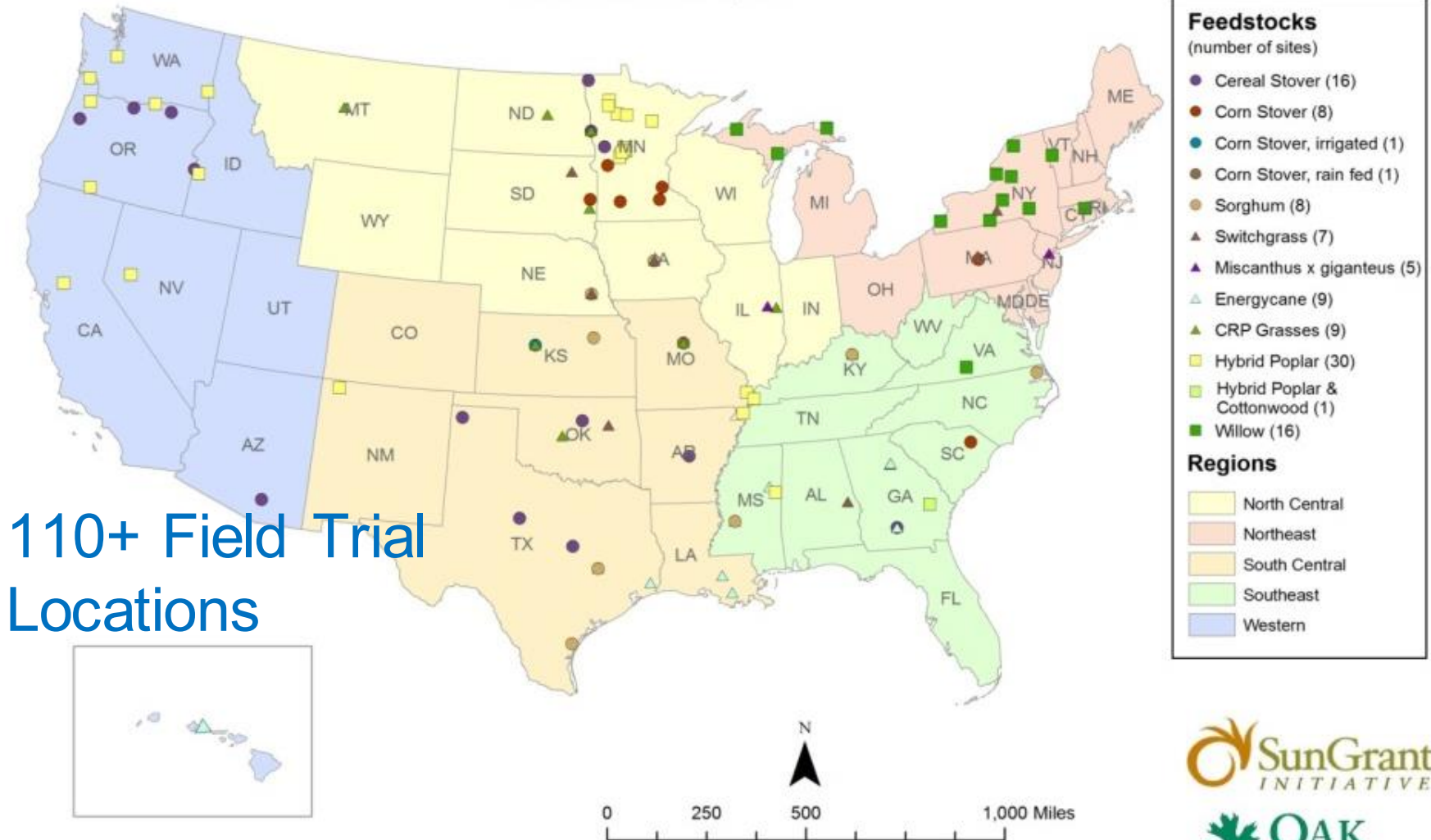
Energy Efficiency & Renewable Energy

The Sun Grant Initiative (SGI)

- The Sun Grant initiative is a partnership to solve America's energy needs and revitalize rural communities with land-grant university research, education, and extension programs on renewable and biobased, non-food industries
- Regional Centers:
 - Oregon State University with University of Hawaii
 - South Dakota State University
 - Oklahoma State University
 - Cornell University
 - The University of Tennessee



SGI Regional Feedstock Partnership Field Trial Network



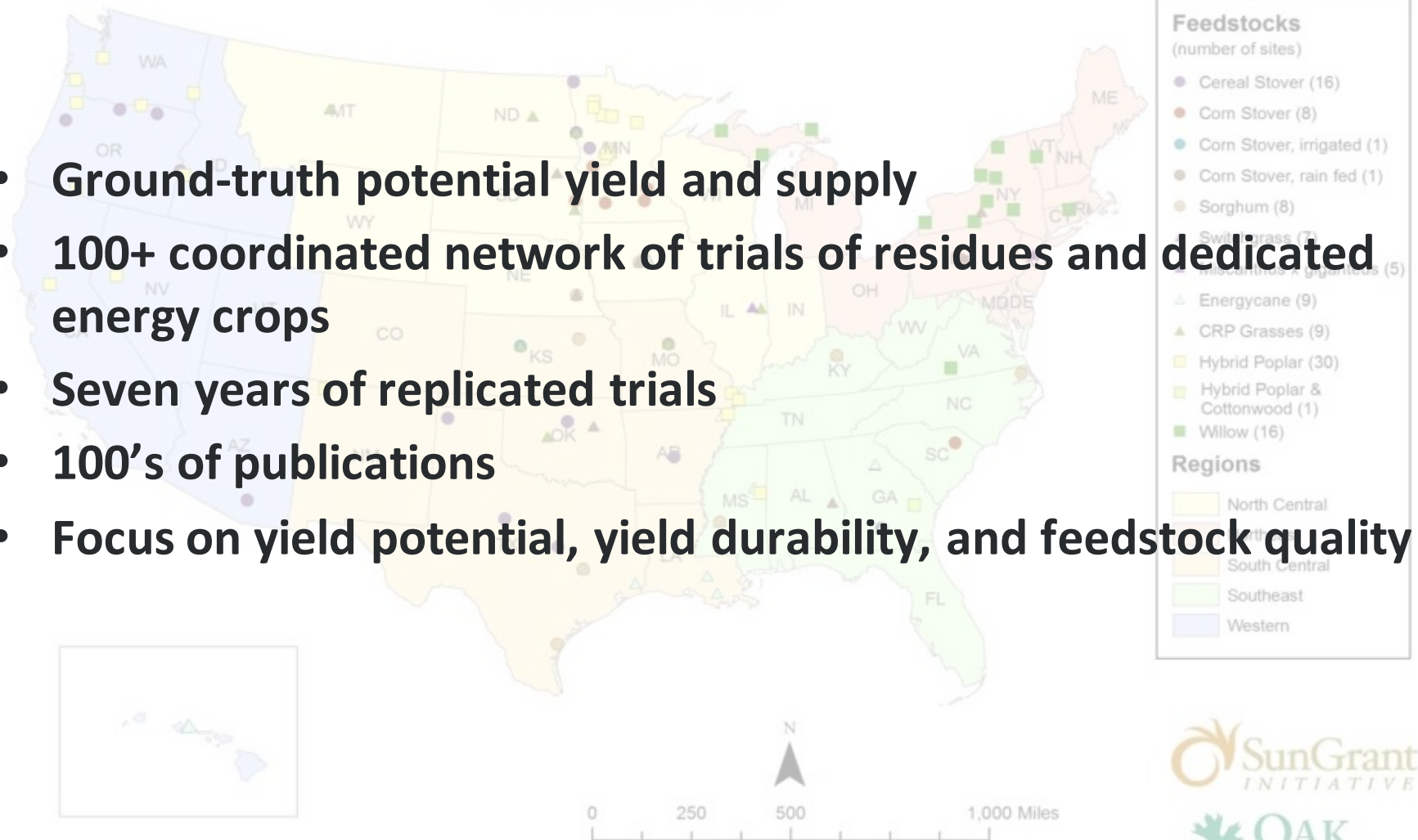
Disclaimer: This map is intended for visual representation only. Many field trials occur within the same research location and may not be indicated on the map. Users of this information should contact the Department of Energy Golden Field Office for additional data information.



Energy Efficiency & Renewable Energy

SGI Regional Feedstock Partnership Field Trial Network

- Ground-truth potential yield and supply
- 100+ coordinated network of trials of residues and dedicated energy crops
- Seven years of replicated trials
- 100's of publications
- Focus on yield potential, yield durability, and feedstock quality



Disclaimer: This map is intended for visual representation only. Many field trials occur within the same research location and may not be indicated on the map. Users of this information should contact the Department of Energy Golden Field Office for additional data information.

SunGrant
INITIATIVE

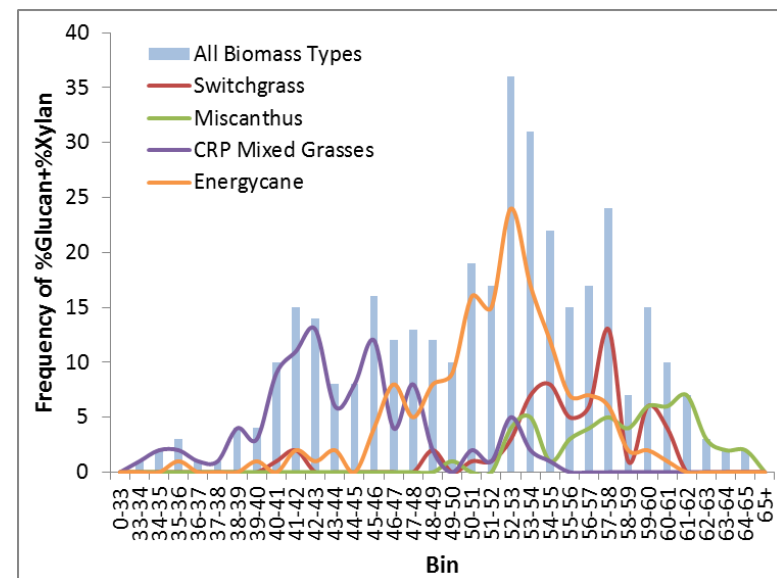
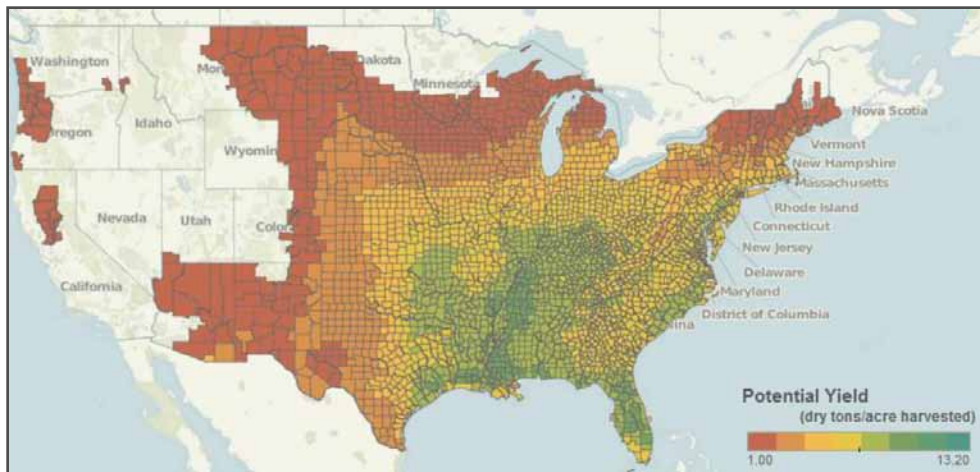
OAK
RIDGE
National Laboratory

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Sun Grant Regional Feedstock Synthesis Report

- A value-add report that summarizes the impact of results of the partnership, including yield and quality results
 - Note the original source for data
- PIs will be authors of the report, along with national laboratory researchers
- Report to be released along with BT16



Future Events and More Information

- **Visit the Feedstock Supply and Logistics Breakout Session at Bioenergy 2015**
- **Important report release dates:**
 - **2016 Billion-Ton Report**
 - Volume 1 target date: June 2016
 - Volume 2 target date: September 2016
 - **Sun Grant Regional Feedstock Partnership Synthesis Report**
 - Target date June 2016



2011 Billion-Ton Update Report Landing Page
<http://bioenergykdf.net/content/billiontonupdate>

Additional Slides

A BILLION DRY TONS OF BIOMASS

HAS THE POTENTIAL TO PRODUCE

1.5 MILLION JOBS
and keep about
\$200 BILLION
dollars in the U.S.
every year.

92 BILLION
kWh of electricity
to power
8 MILLION
households.

60 BILLION
gallons of biofuels
displacing almost
30%
of all transportation
fuels.

50 BILLION POUNDS
of biobased
chemicals and bio-
products, replacing
a significant portion
of the chemical
market.

reductions of
CO₂ emissions by
500
MILLION TONS
a year.



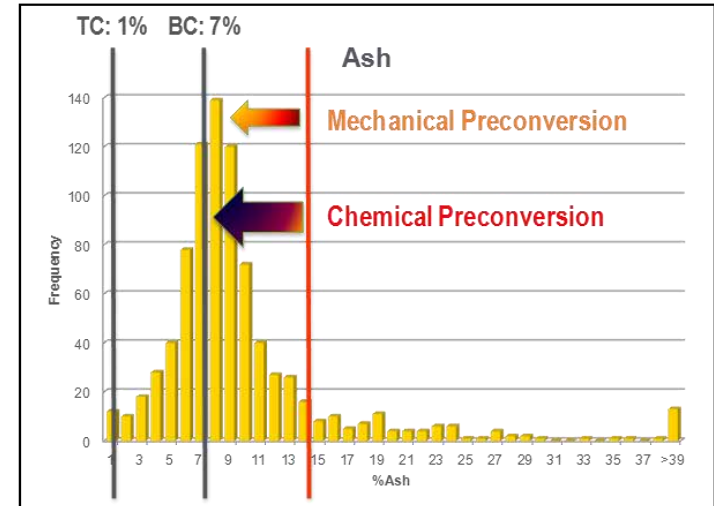
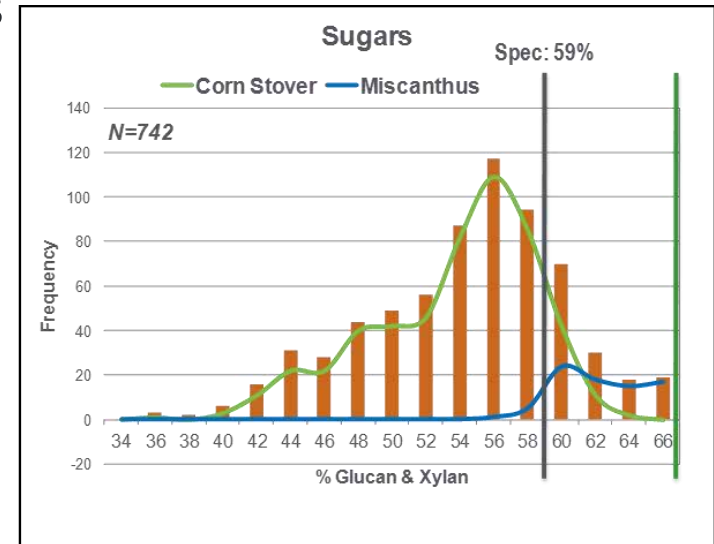
STEPS TO BUILDING THE BIOECONOMY

- 1 Accelerate research & technology development
- 2 Develop production, conversion and distribution infrastructure
- 3 Deploy technology
- 4 Create markets and delivery methods

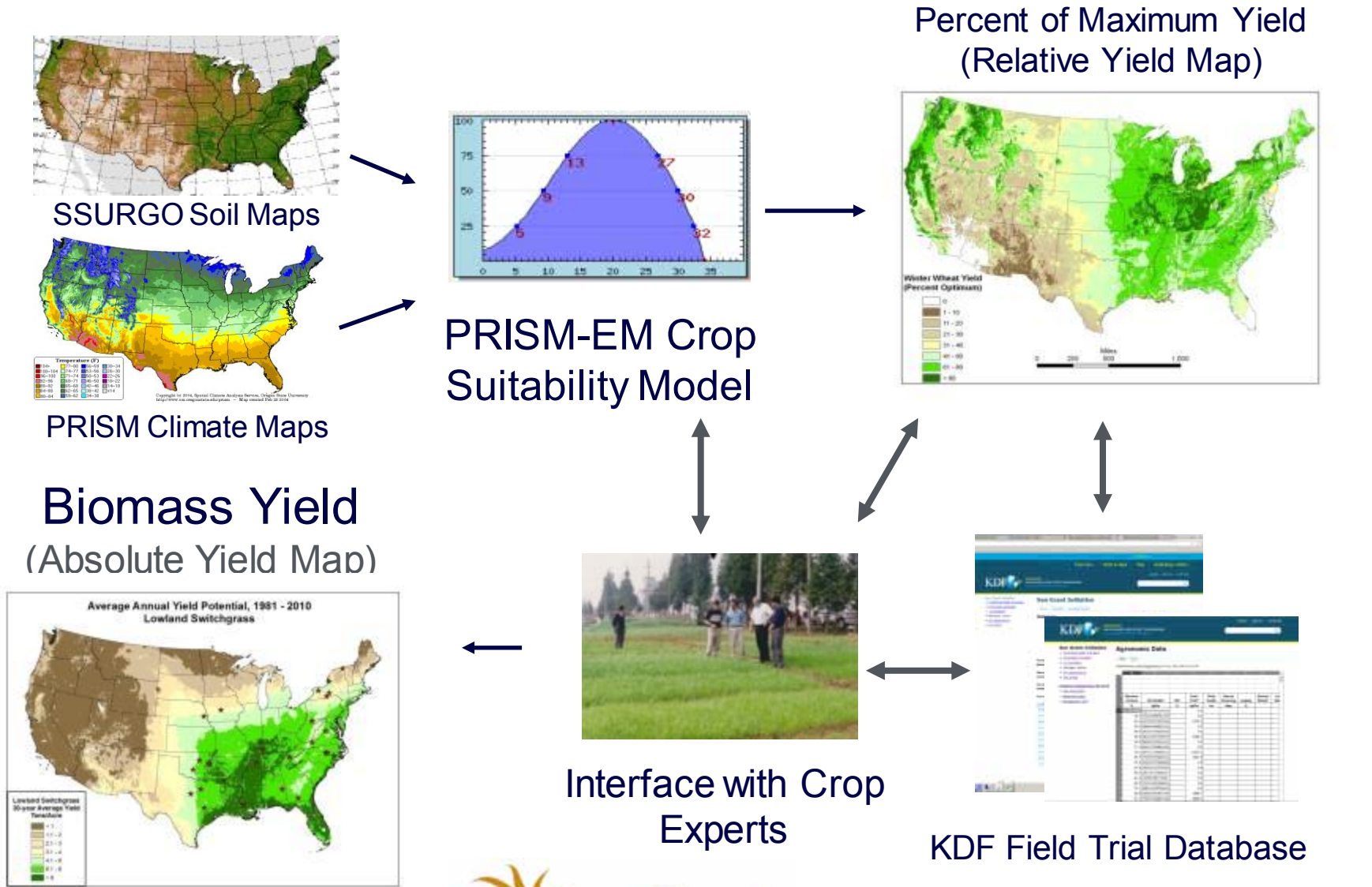
Projection based
on the 2011 Billion
Ton Study Report

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



Models

- CENTURY: Soil carbon, nitrogen, phosphorus, and sulfur model.
- F-PEAM: Feedstock Production Emissions to Air Model
- ForSEAM: Forest Sustainable and Economic Analysis Model
- GREET: The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model
- POLYSYS: Policy Analysis System
- SRTS: Subregional Timber Supply Model
- SWAT: Soil and Water Assessment Tool
- WATER: Water Assessment for Transportation Energy Resources