



Overview of the 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy

MGA Webinar

July 20, 2017



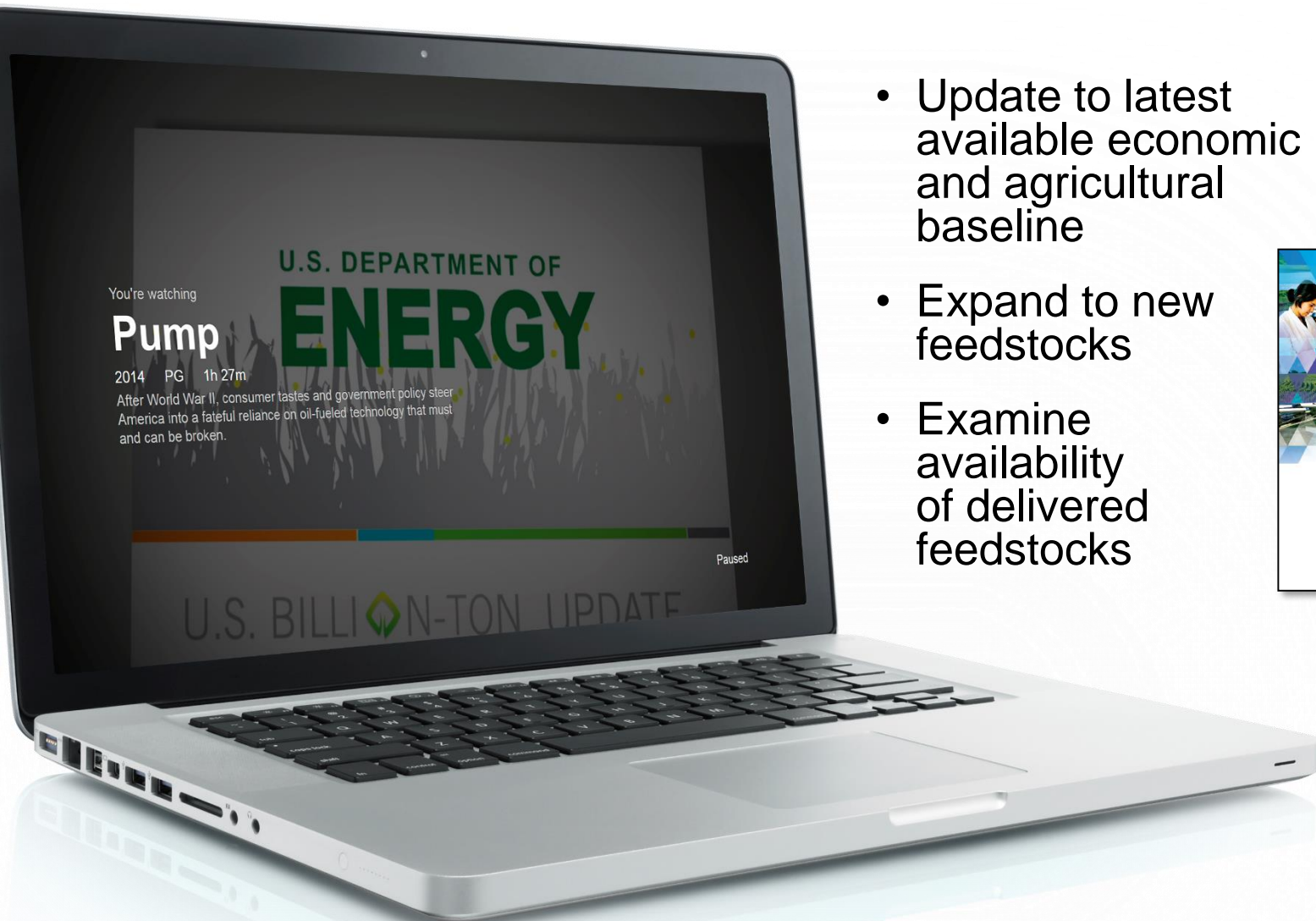
Outline

- Currently used resources
- Additional available and potentially available resources
- Advancing resources
- Environmental effects and Bioenergy KDF online data discovery tools

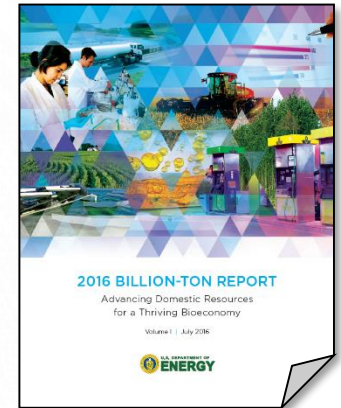
Contributors



Why a third assessment?

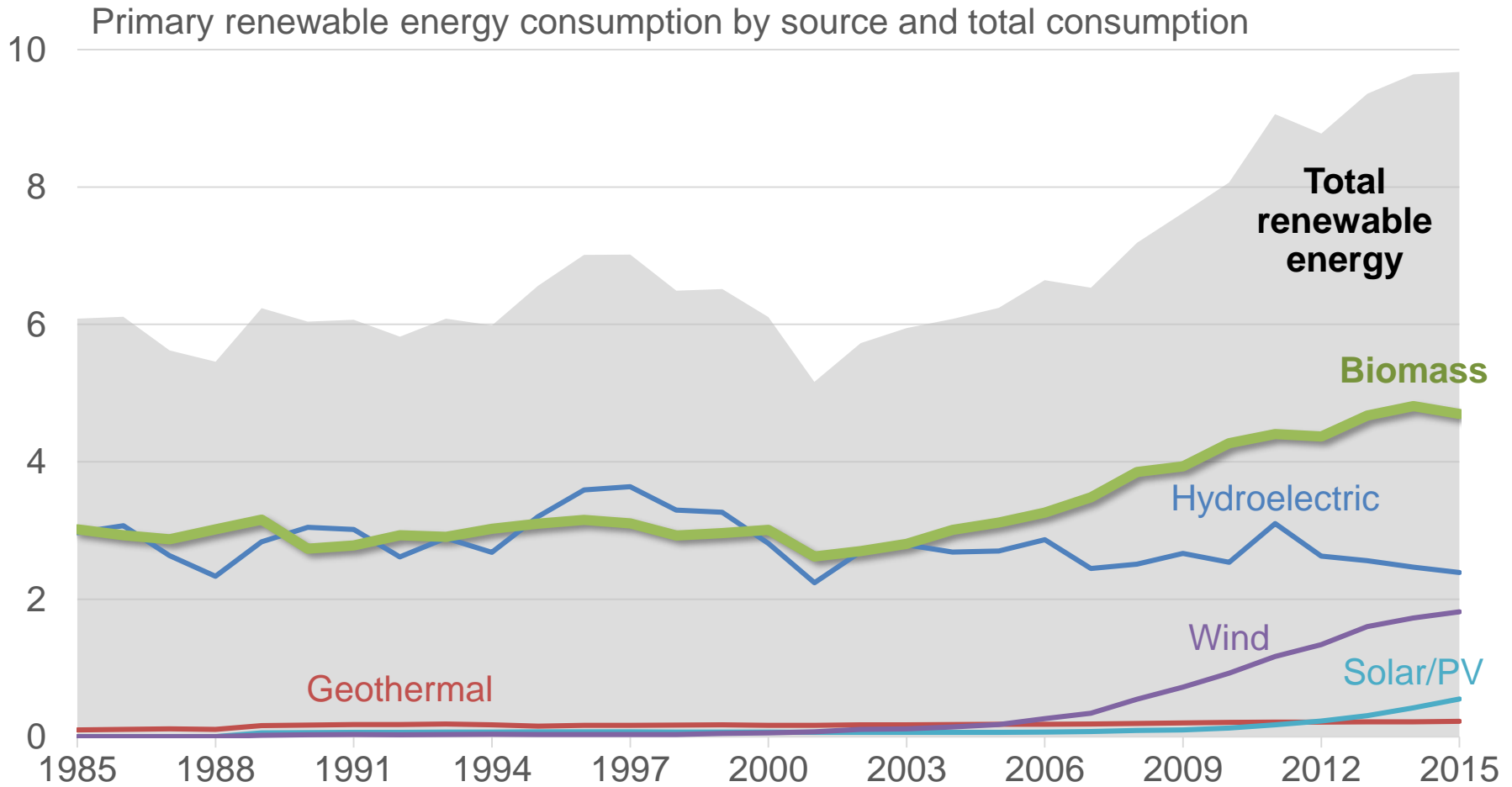


- Update to latest available economic and agricultural baseline
- Expand to new feedstocks
- Examine availability of delivered feedstocks

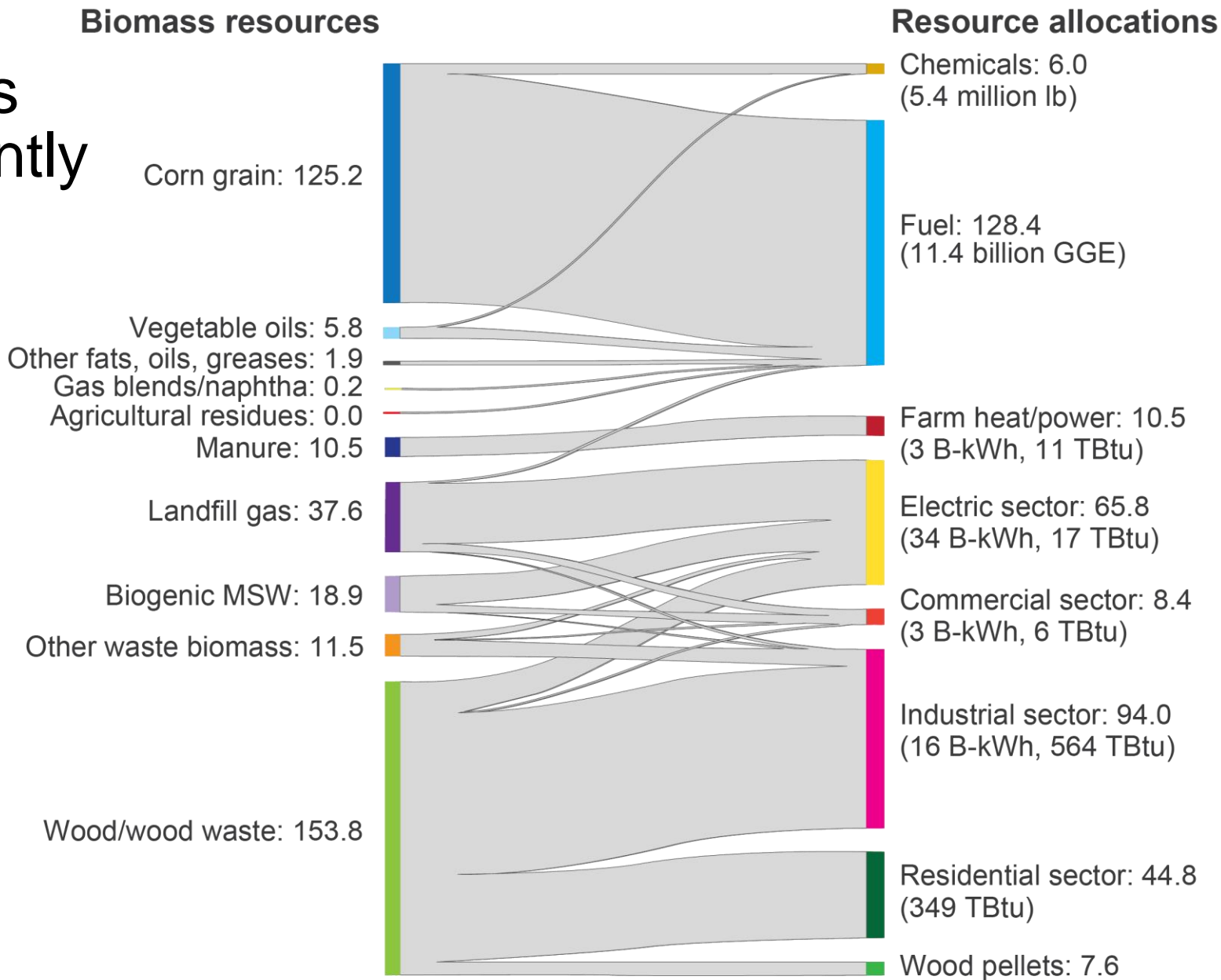


BT16

Biomass is our largest source of domestic renewable energy

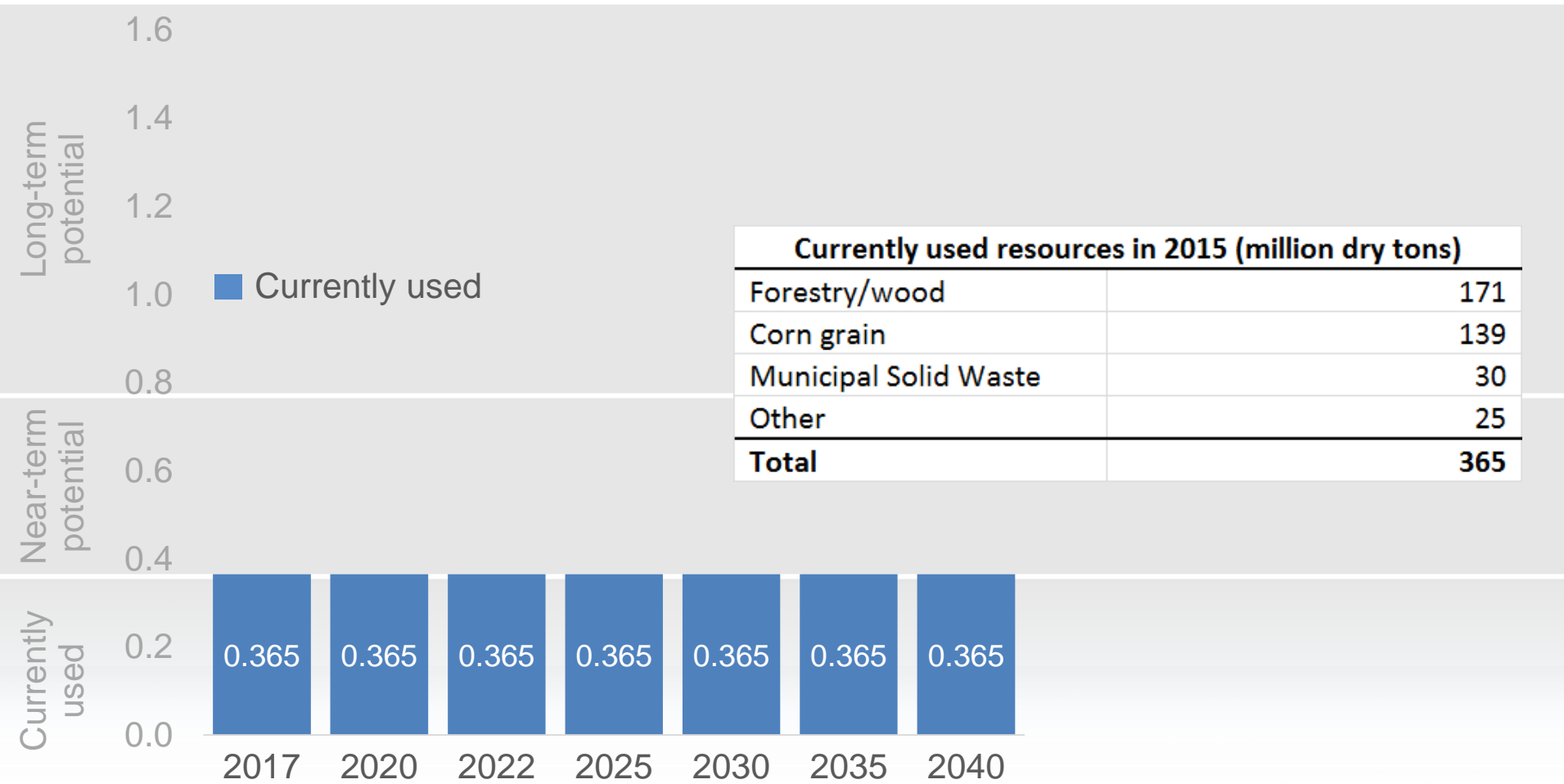


How biomass is currently used

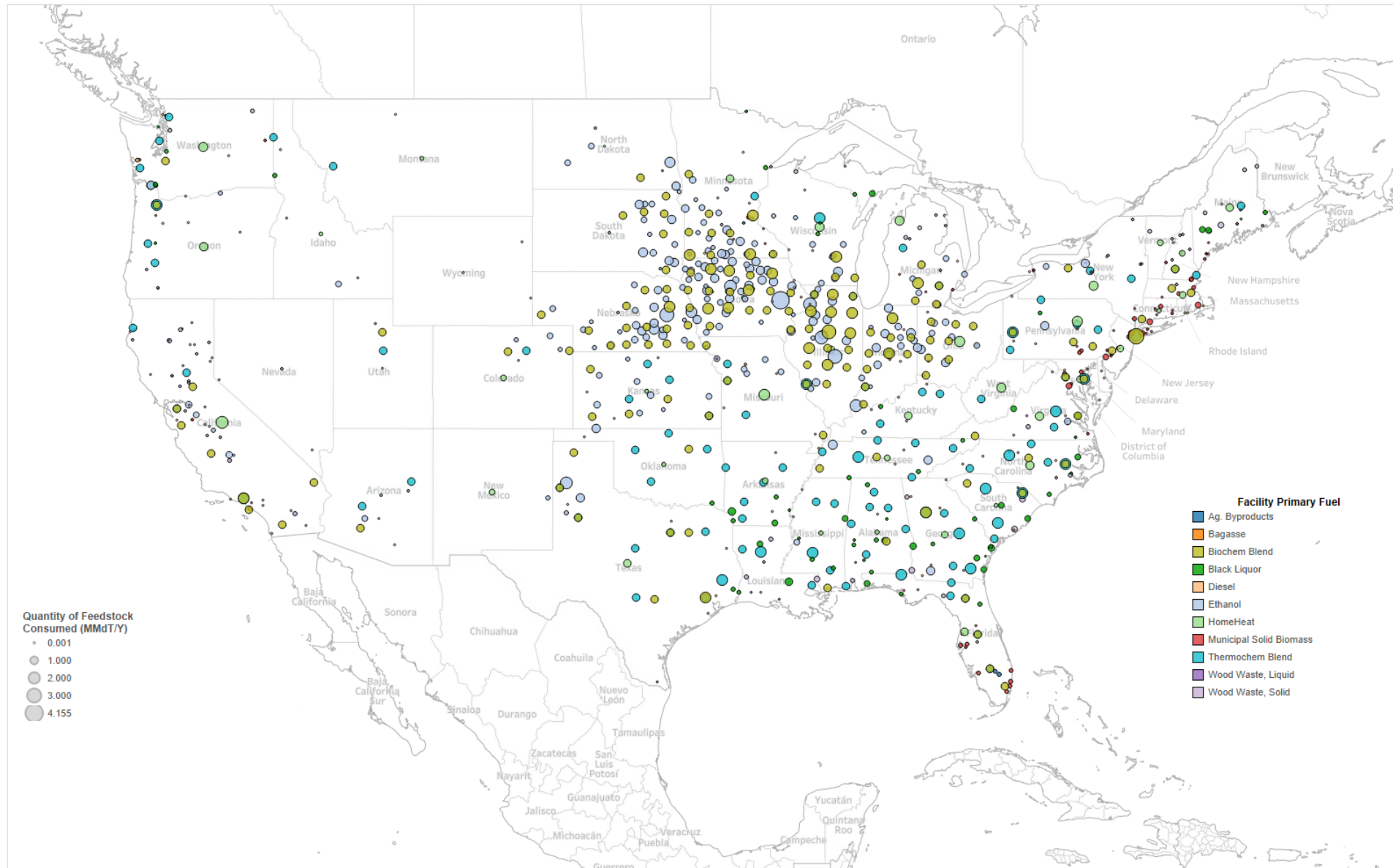


Current and Potential, Base Case

Billions of Dry Tons per year



Biomass-to-Energy Facilities (2014)



Current and Potential, Base Case at \$60/dt

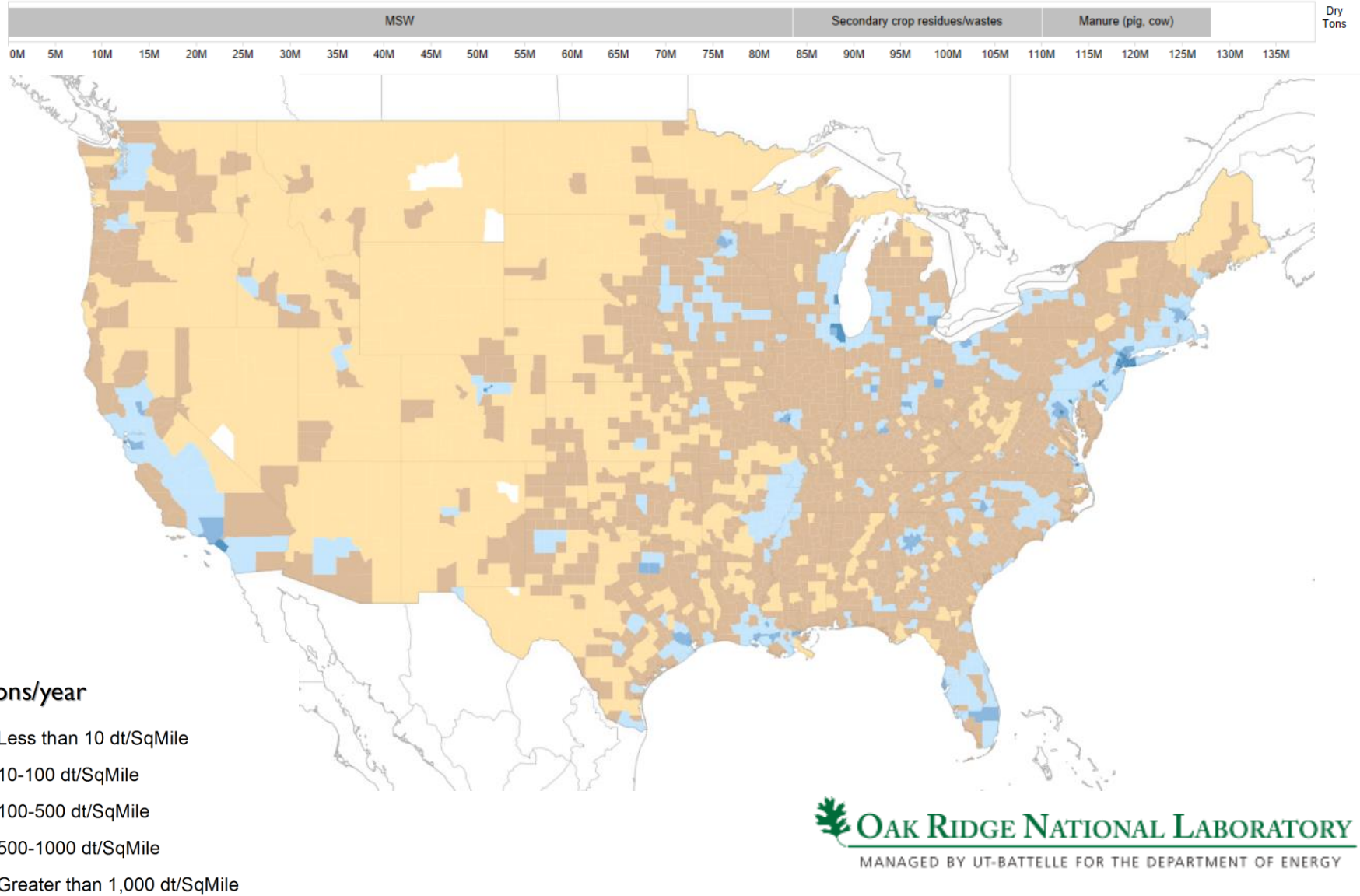
Billions of Dry Tons per year



Waste Resources	2017	2040
(million dry tons)		
C&D waste	22.8	22.8
Plastics	19.9	19.9
Paper and paperboard	16.1	16.1
Hog manure	10.2	10.9
Fats, oils, and greases	10.0	10.0
Textiles	8.2	8.2
Milk cow manure	7.9	7.5
MSW wood	6.3	6.3
Rice straw	4.9	5.6
Cotton residue	3.7	4.9
Rubber and leather	4.4	4.4

Waste Resources	2017	2040
(million dry tons)		
Secondary mill residue	4.1	4.1
Sugarcane bagasse	3.6	3.8
Yard trimmings	3.3	3.3
Noncitrus residues	2.5	2.7
Other	2.6	2.6
Cotton gin trash	1.7	2.1
Tree nut residues	1.5	1.6
Citrus residues	1.5	1.6
Rice hulls	1.4	1.6
Sugarcane trash	1.0	1.0
Primary mill residue	0.5	0.5
Total	138	142

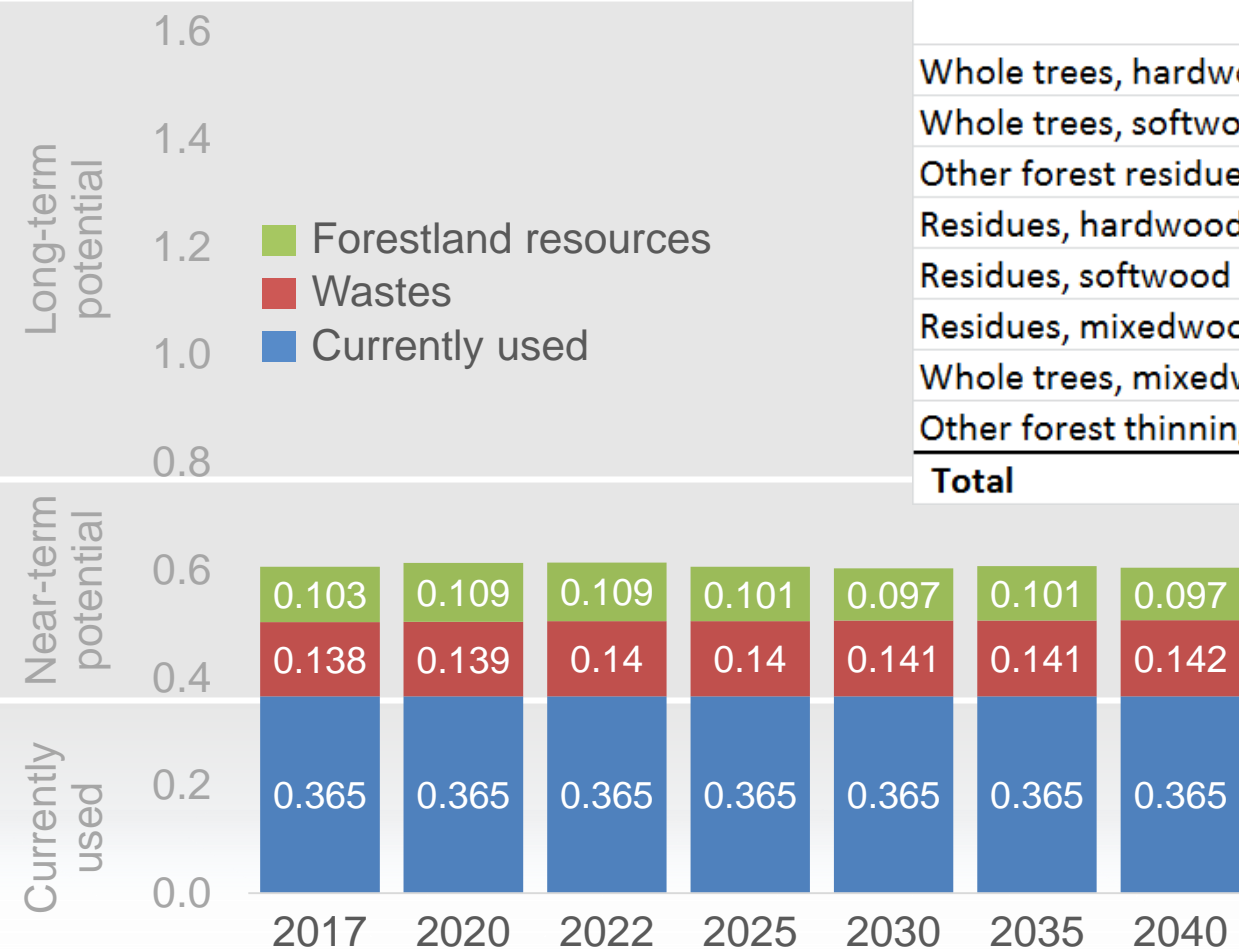
Base-case scenario, \$60 offered price, waste resources, year 2017



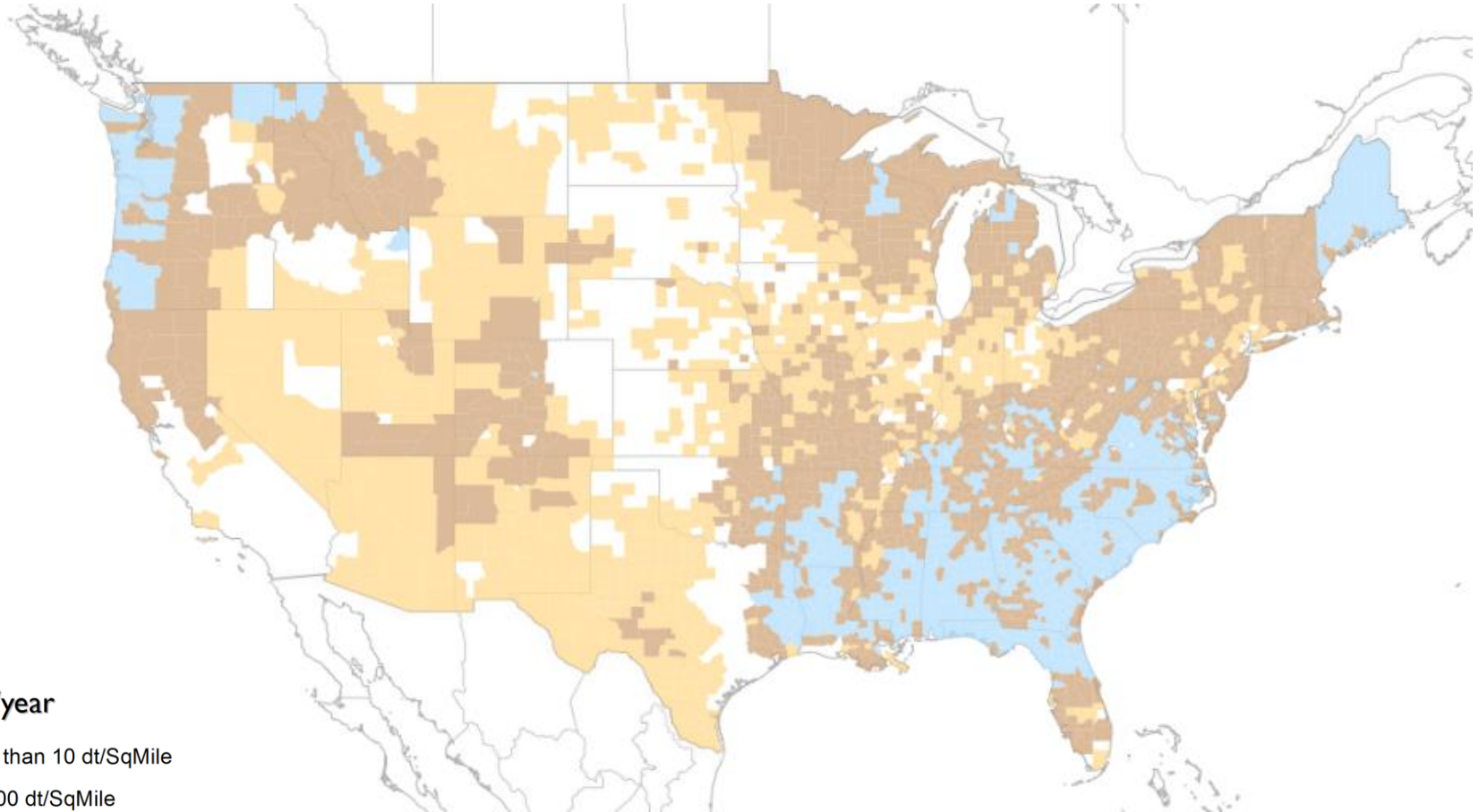
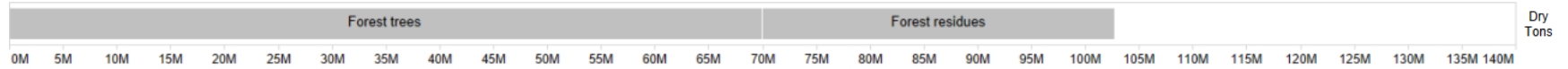
Current and Potential, Base Case at \$60/dt

Billions of Dry Tons per year

Forestland Resources	2017	2040
	(million dry tons)	
Whole trees, hardwood	39.0	24.9
Whole trees, softwood	28.1	33.4
Other forest residue	12.2	13.0
Residues, hardwood	6.9	8.0
Residues, softwood	6.8	10.0
Residues, mixedwood	4.2	2.7
Whole trees, mixedwood	2.8	2.4
Other forest thinnings	2.6	2.6
Total	103	97



Base-case scenario, \$60 offered price, forestry resources, year 2017



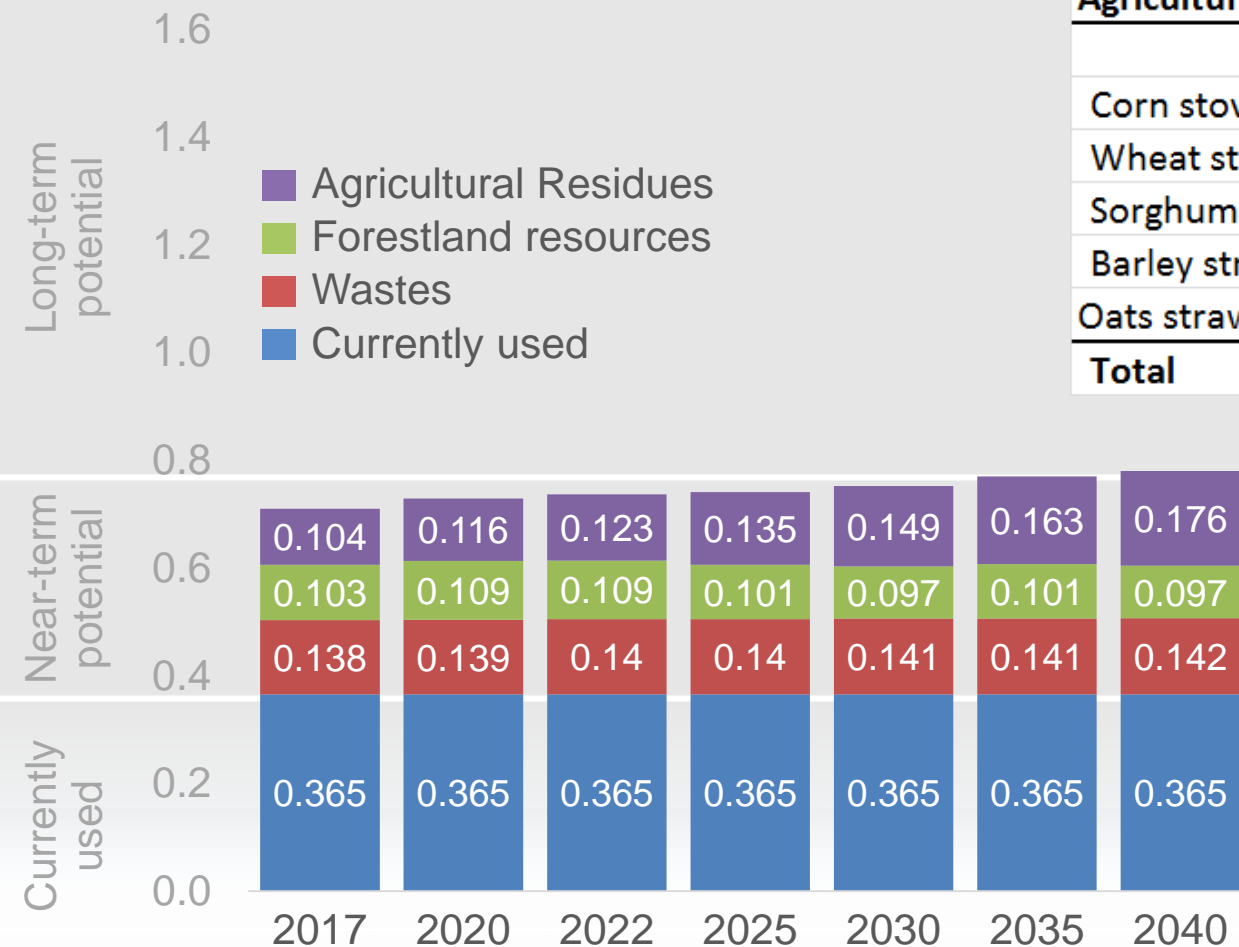
Dry tons/year

- Less than 10 dt/SqMile
- 10-100 dt/SqMile
- 100-500 dt/SqMile
- 500-1000 dt/SqMile
- Greater than 1,000 dt/SqMile

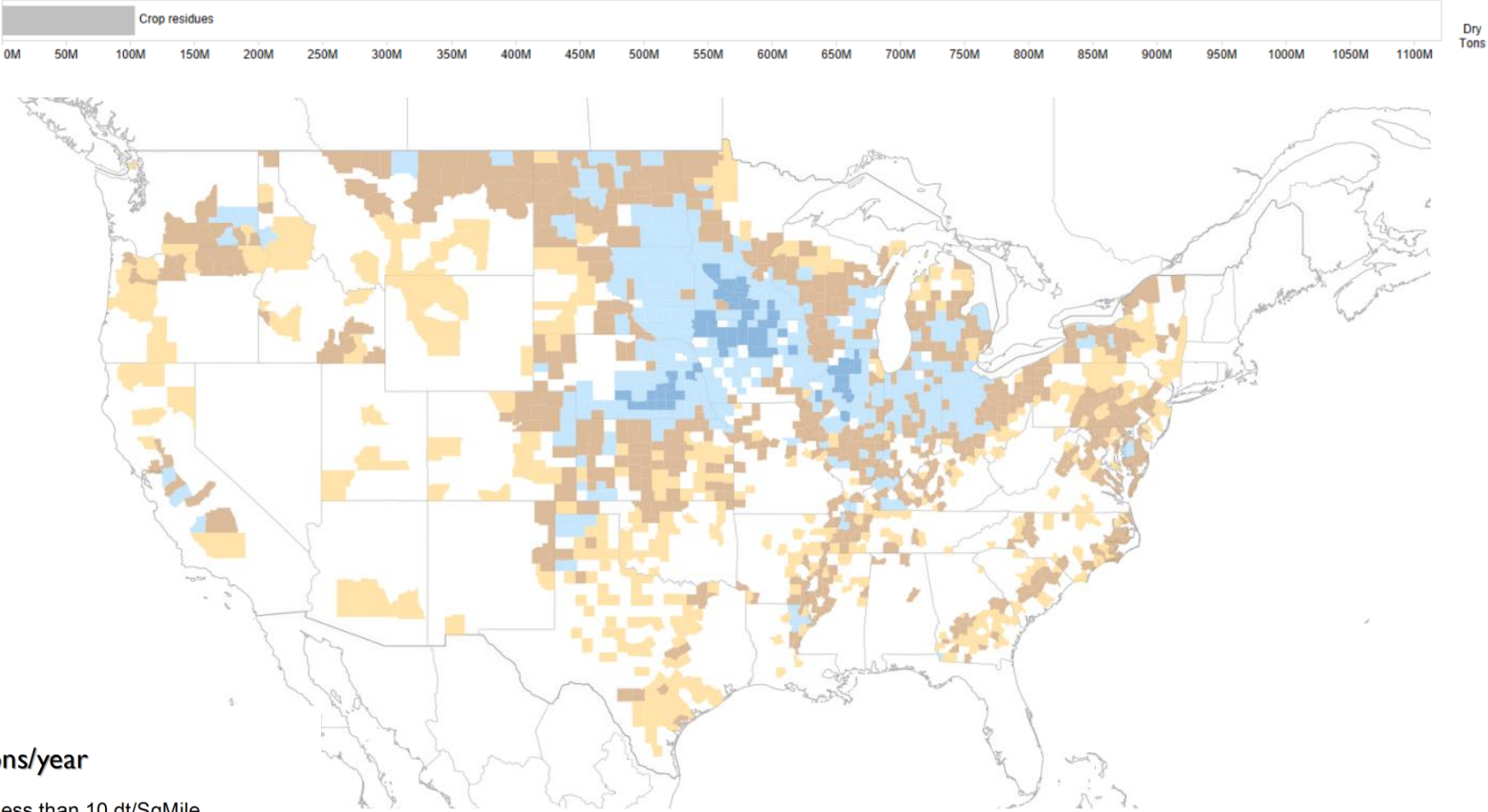
Current and Potential, Base Case at \$60/dt

Billions of Dry Tons per year

Agricultural Residues	2017	2040
	(million dry tons)	
Corn stover	89.4	153.9
Wheat straw	13.0	20.9
Sorghum stubble	0.7	1.1
Barley straw	0.4	0.6
Oats straw	<0.1	<0.1
Total	104	176

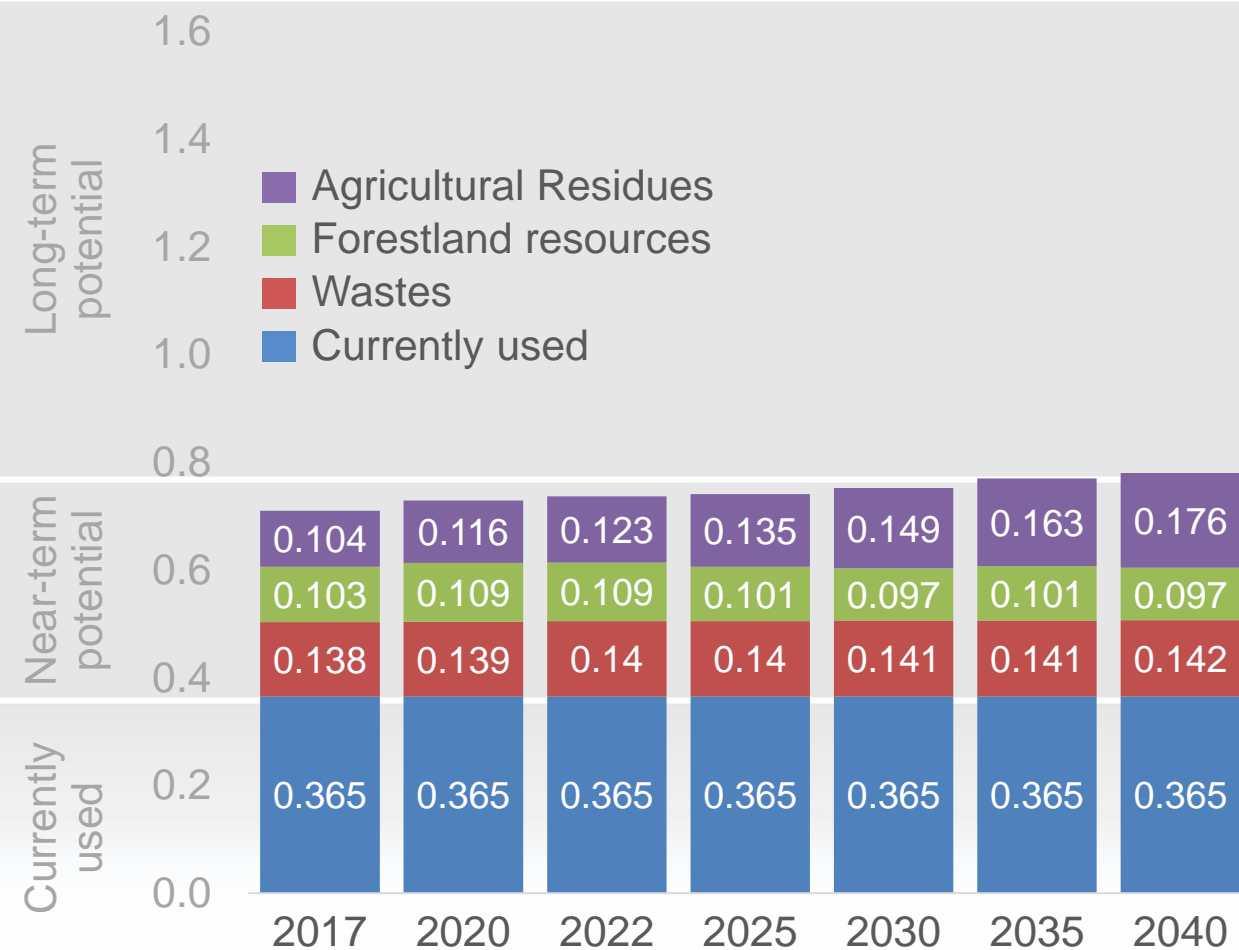


Base-case scenario, \$60 offered price, agricultural resources, year 2017



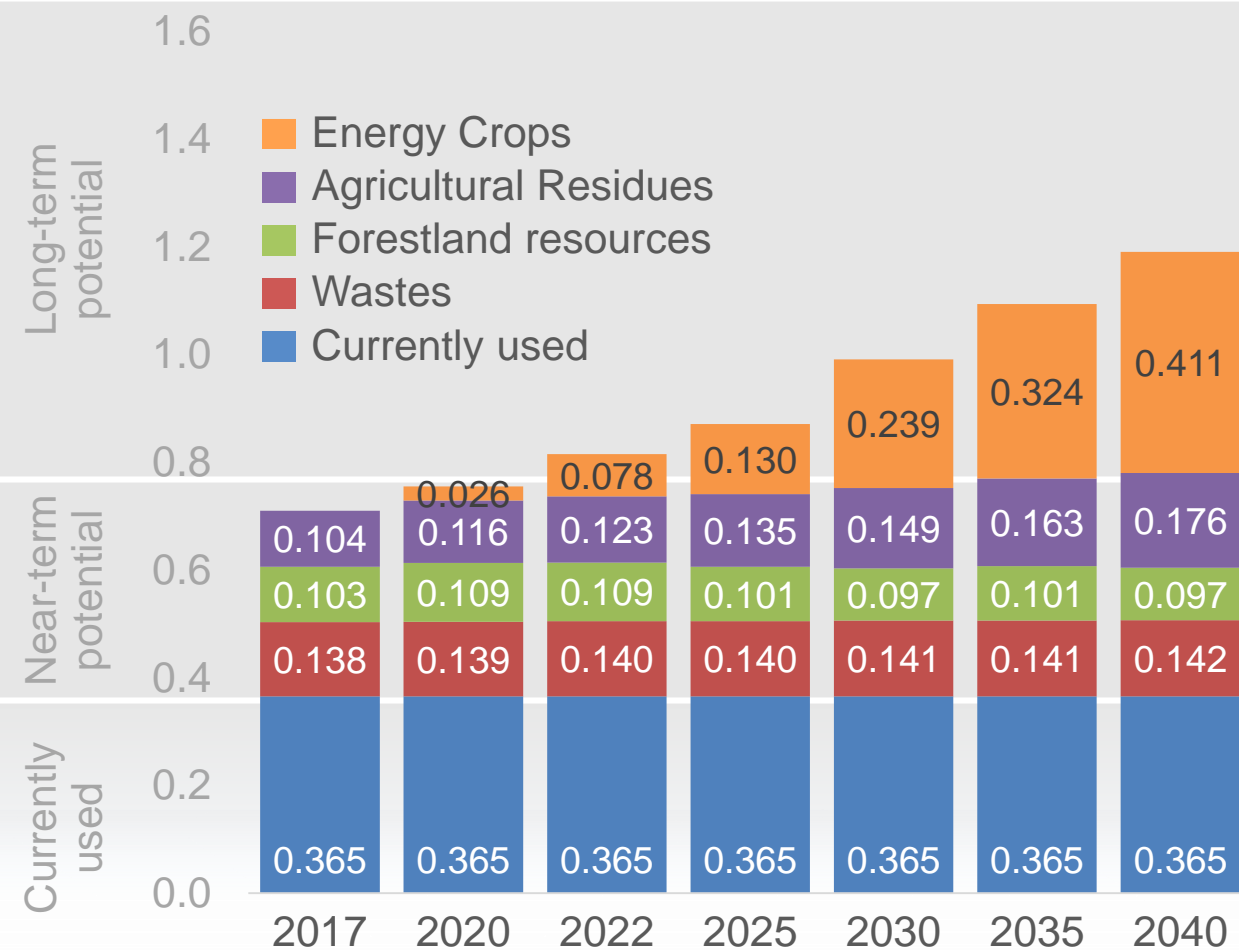
Current and Potential, Base Case at \$60/dt

Billions of Dry Tons per year



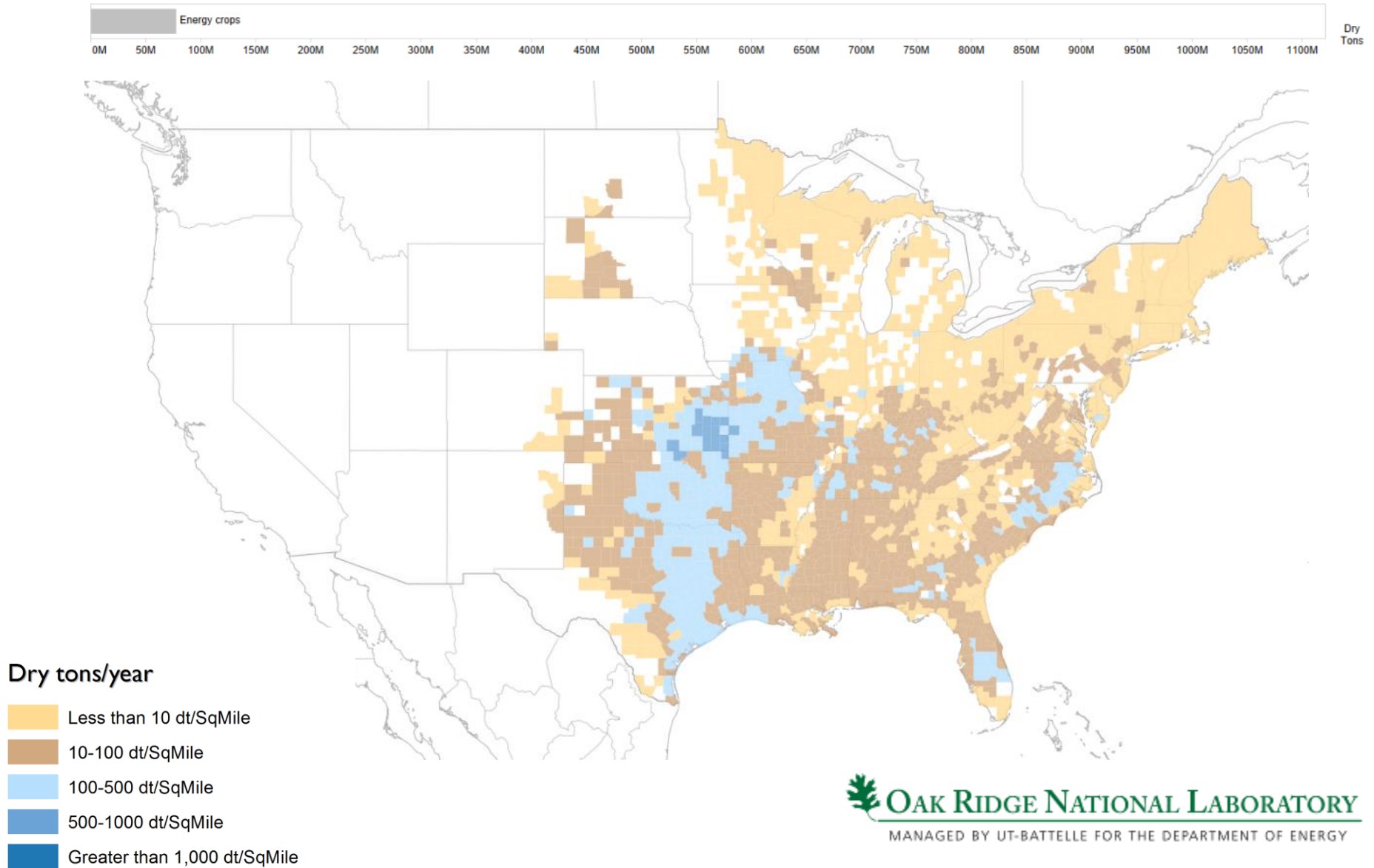
Current and Potential, Base Case at \$60/dt

Billions of Dry Tons per year

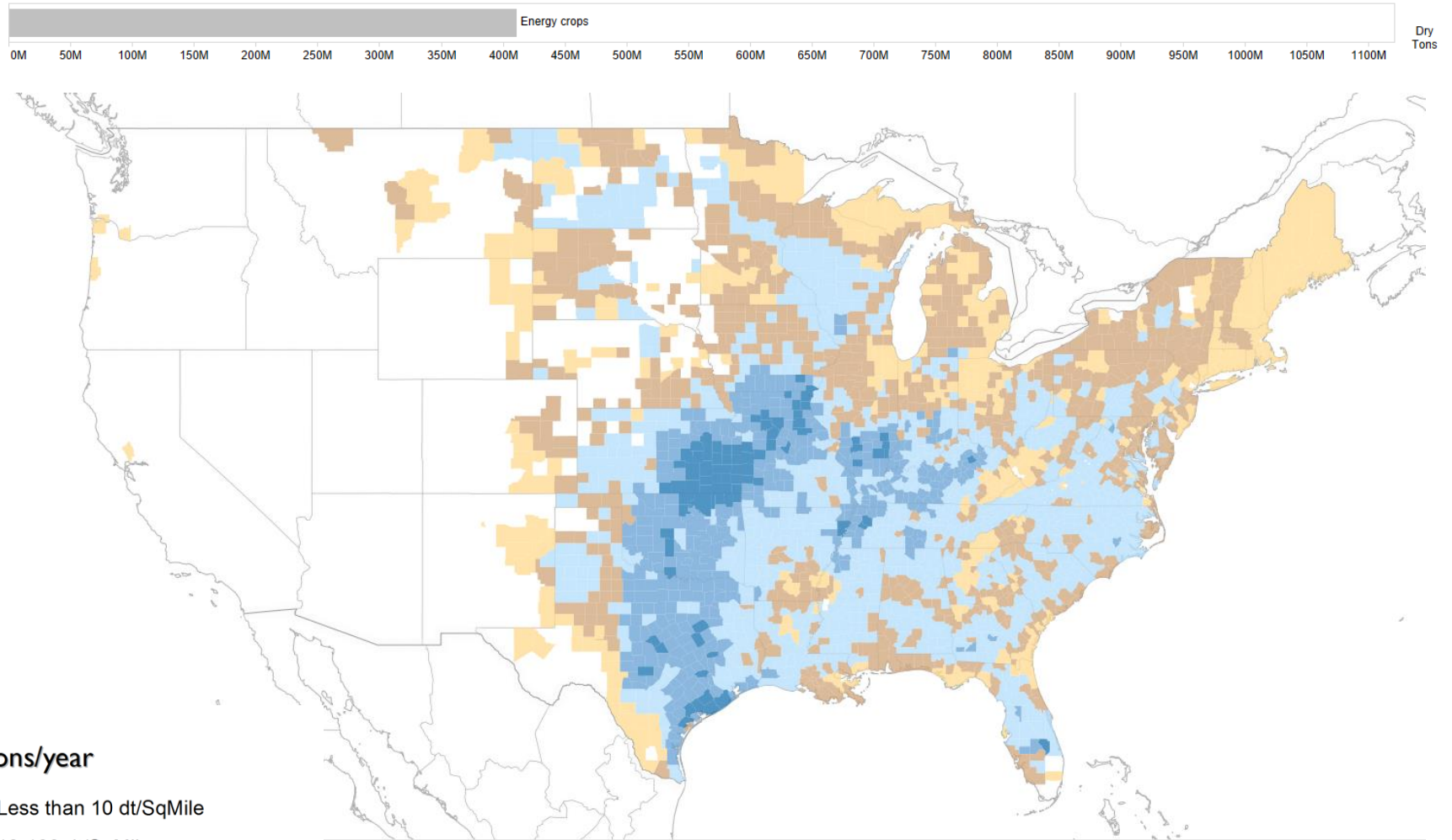


Energy crops	2017	2040
(million dry tons)		
Switchgrass	-	160.5
Miscanthus	-	160.0
Poplar	-	44.9
Willow	-	25.1
Biomass sorghum	-	19.3
Eucalyptus	-	0.9
Energy cane	-	0.3
Pine	-	0.1
Total	-	411

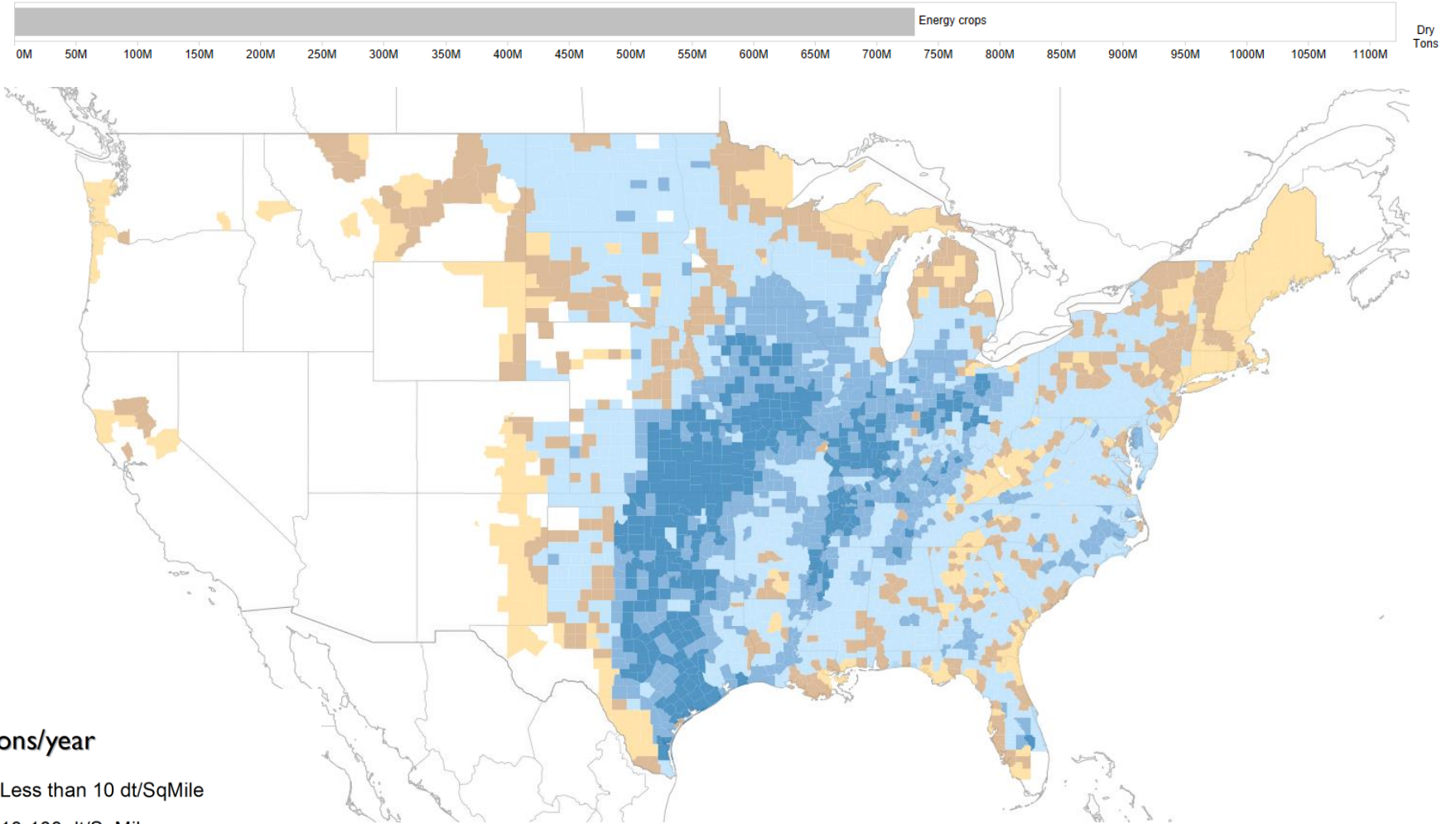
Base-case scenario, \$60 offered price, energy crops, year 2022



Base-case scenario, \$60 offered price, energy crops, year 2040



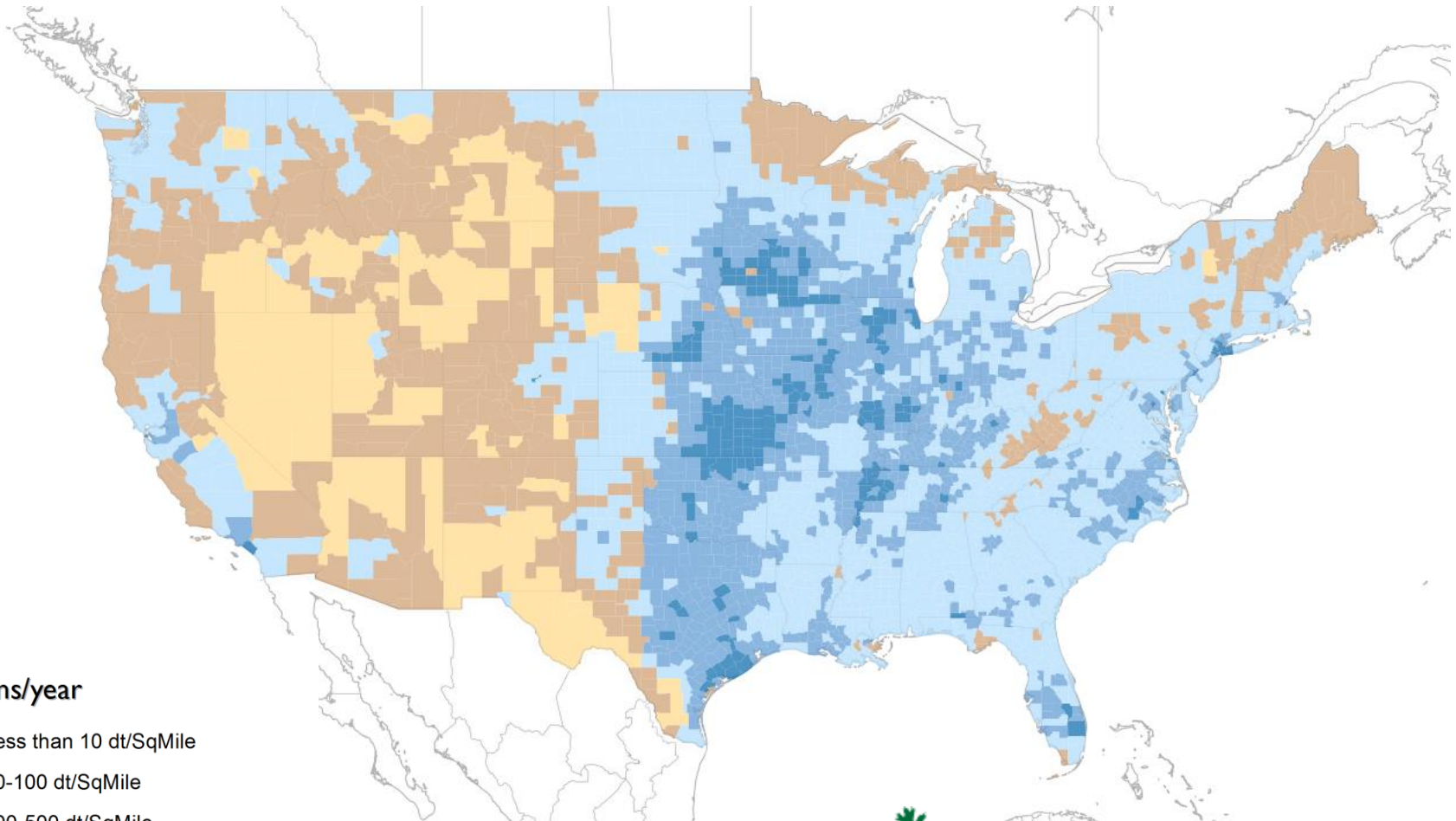
High-yield scenario, \$60 offered price, energy crops, year 2040



Base-case scenario, \$60 offered price, combined resources, year 2040

0M 100M 200M 300M 400M 500M 600M 700M 800M 900M 1000M 1100M 1200M 1300M 1400M Dry 14Tons

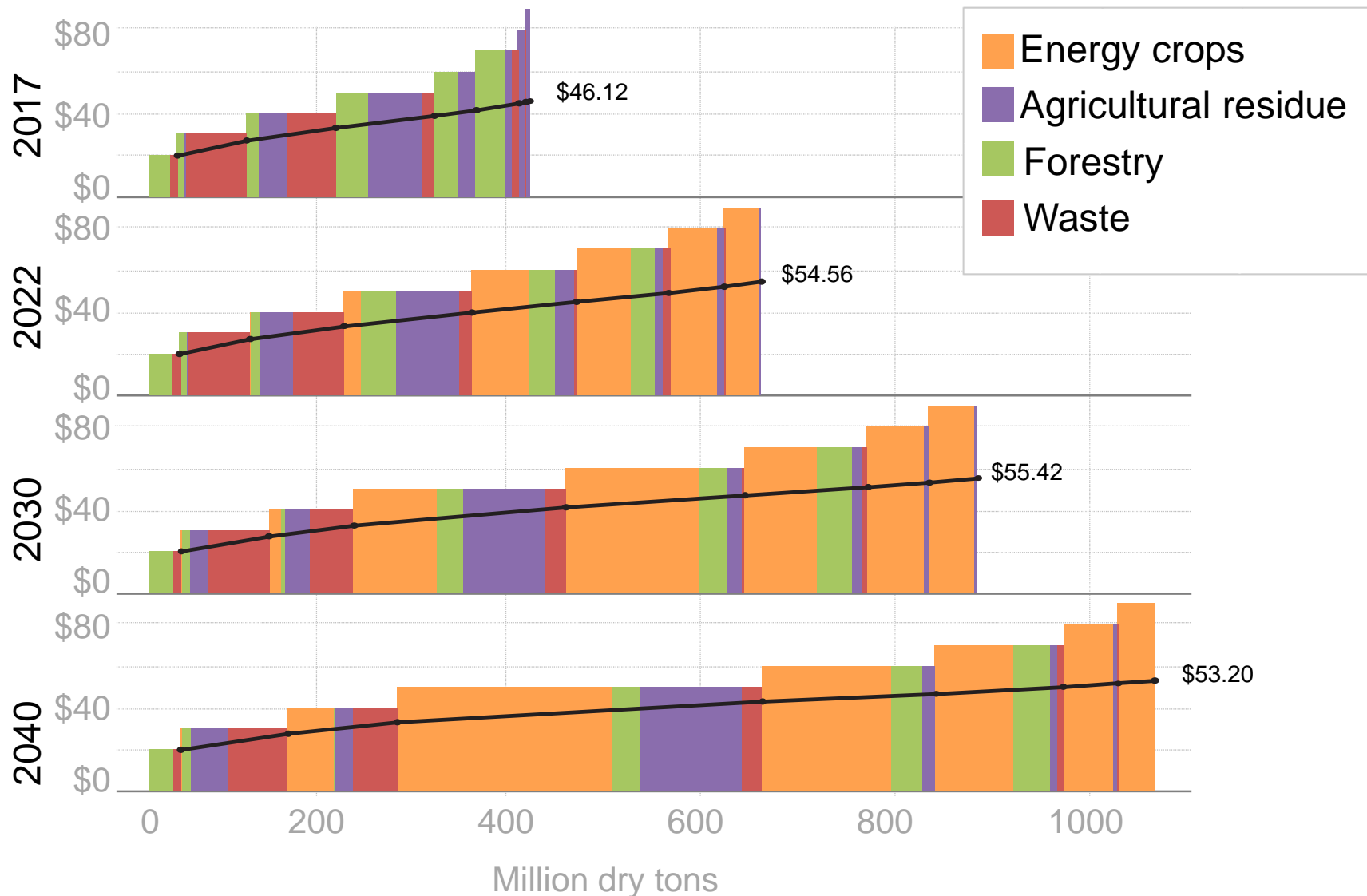
Forestry Wastes Agriculture



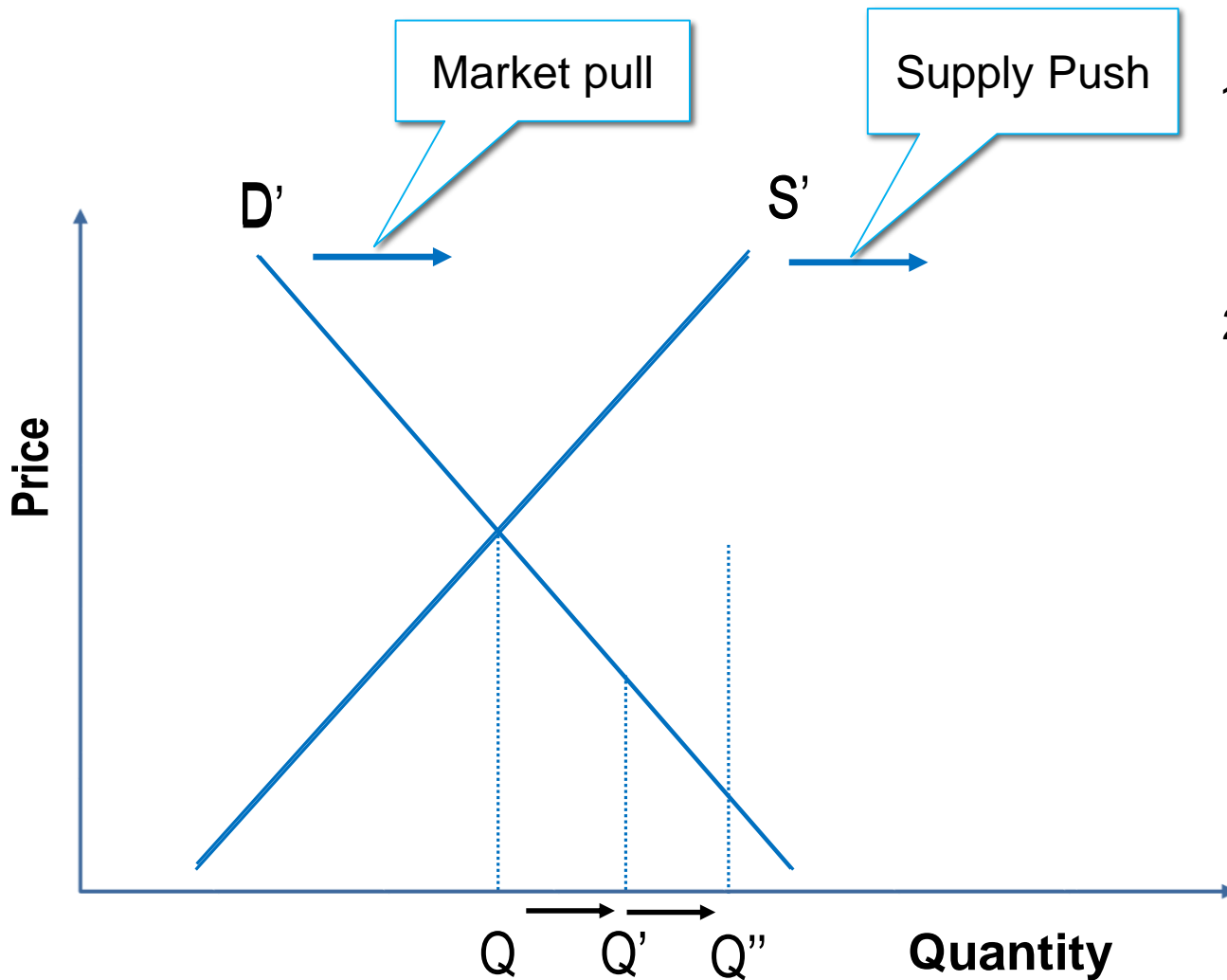
Dry tons/year

- Less than 10 dt/SqMile
- 10-100 dt/SqMile
- 100-500 dt/SqMile
- 500-1000 dt/SqMile
- Greater than 1,000 dt/SqMile

Supplies vary with price and time



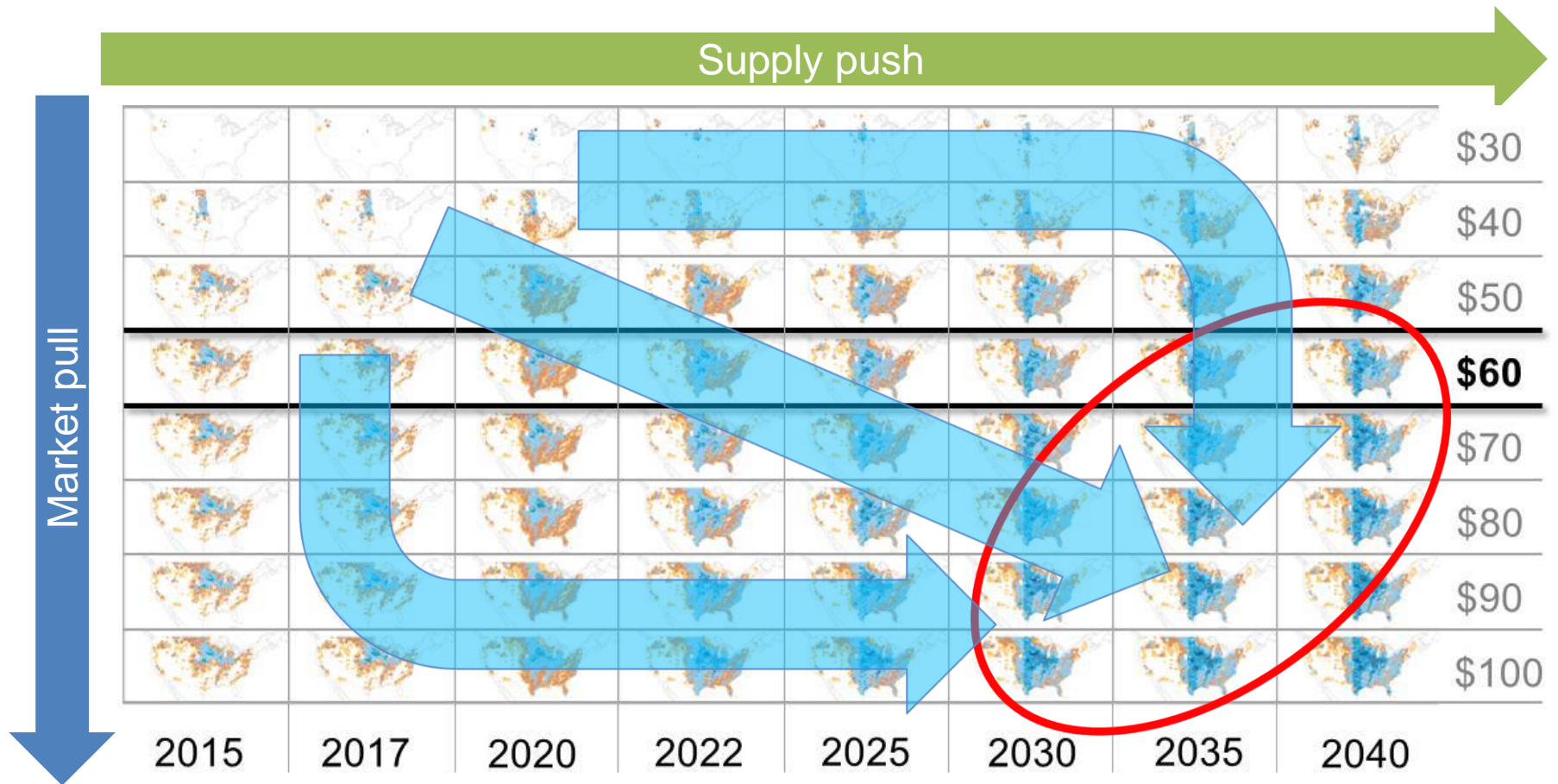
Advancing Resources

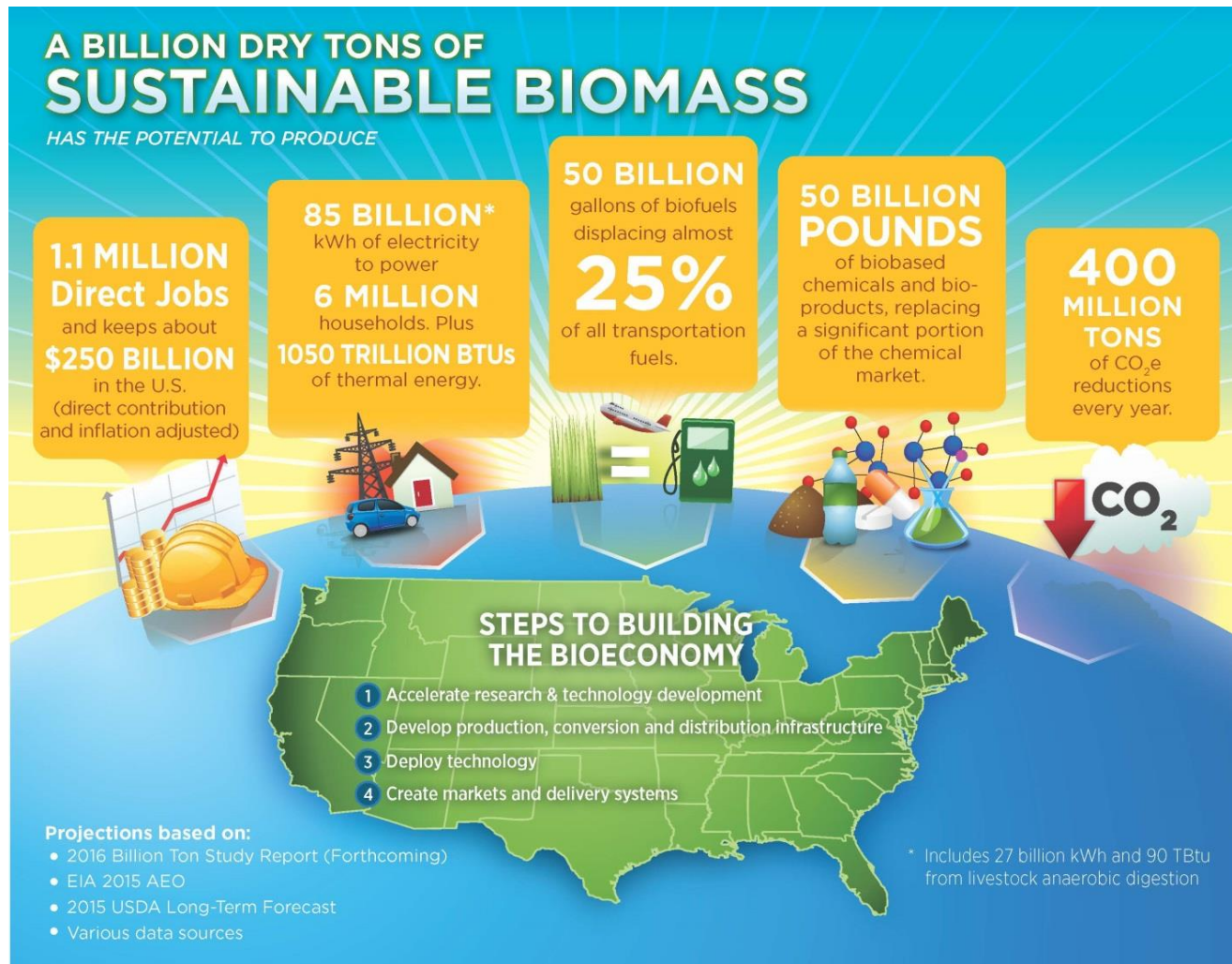


Future research:

- 1) Supply push
 - a) Crop improvement
 - b) Advanced logistics
 - c) Precision agriculture
- 2) Market pull
 - a) Conversion processes
 - b) Co-optimization
 - c) Co-products
 - d) Aviation biofuels
 - e) International markets
 - f) Policy impacts

Advancing resources: Supply and demand



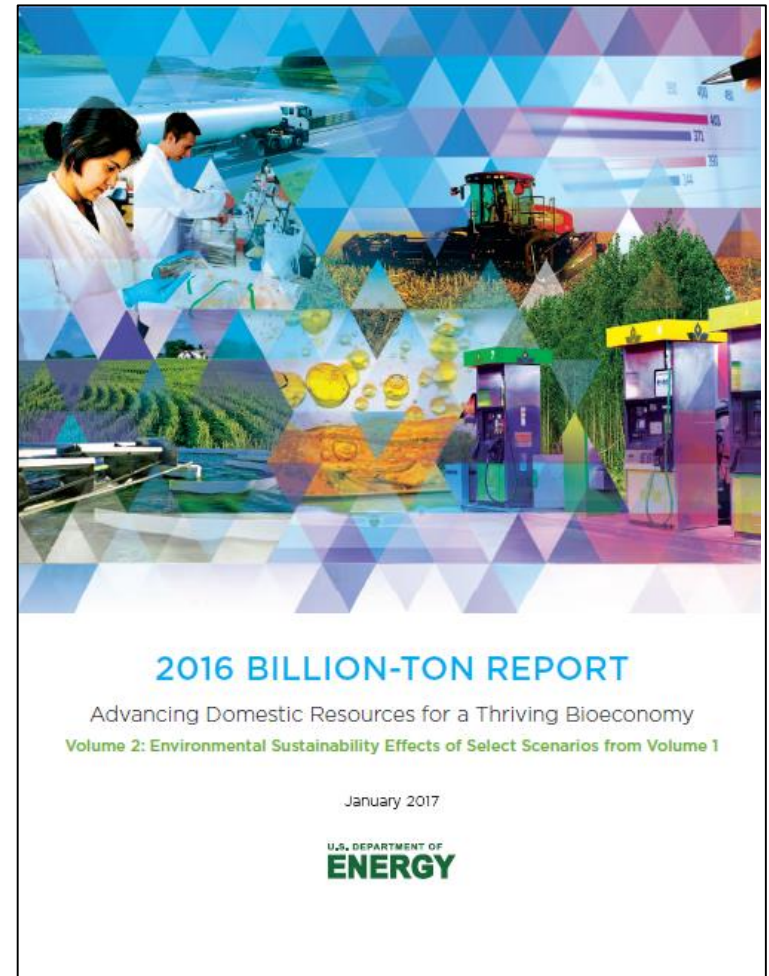


Graphic: BCS, Incorporated in support of DOE’s Bioenergy Technologies Office; Biomass Research and Development (R&D) Board, 2016.

Source: Rogers, J. N., Stokes, B., Dunn, J., Cai, H., Wu, M., Haq, Z. and Baumes, H. (2017), An assessment of the potential products and economic and environmental impacts resulting from a billion ton bioeconomy. *Biofuels, Bioprod. Bioref.*, 11: 110–128. doi:10.1002/bbb.1728

BT16 volume 2: Environmental Sustainability Effects of Select Scenarios from Volume 1

- Volume 2 is the first effort to address a critical knowledge gap about potential environmental implications.
- Volume 2 provides an extensive online resource to enable additional analyses and inform future R&D.



Summary

Resource assessments indicate vast national sustainable potential: >1 billion tons/year

Future biomass utilization is a function of supply and demand interactions

Resource assessments can help to:

- Evaluate impacts of supply push and market pull
- Inform strategies to increase biomass utilization

Future research should advance from “how much is there?” to “how can it happen?”



Interactive components of BT16

<http://bioenergykdf.net/billionton>



The screenshot shows a web browser window displaying the Bioenergy KDF website. The page title is "2016 BILLION-TON REPORT INTERACTIVE VERSION". The header includes the Bioenergy KDF logo and navigation links: OVERVIEW, TOOLS & APPS, MAP, BIOENERGY LIBRARY, and CONTRIBUTE. The main content area features a large blue banner with the report title and a brief description. Below the banner are three tabs: "Access Report", "Data Explorer", and "Data Download Tool". The main content is organized into a grid of seven numbered sections (01-07) with corresponding icons and descriptions:

- 01 Executive Summary/Overview**: This 2016 Billion-Ton Report, Volume 1, includes an assessment of the potential economic availability of biomass resources delivered to biorefineries, with supplies quantified under specific sustainability constraints.
- 02 Biomass Consumed in the Current Bioeconomy**: View detail for feedstocks that contribute to current biofuel production and energy production in the industrial sector.
- 03 Forest Resources**: View estimates of primary biomass from forest resources, including wood wastes, harvest from forest thinning, and purpose-grown forest as well as logging residues.
- 04 At the Farmgate**: See an updated assessment of the potential economic availability of biomass, including crop residues and dedicated energy crops, from agricultural lands.
- 05 Waste Resources**: Access data on secondary and waste resources that may be mobilized to grow the bioeconomy, including agricultural production waste, municipal solid waste, and other waste streams.
- 06 To the Biorefinery**: Leverage data to estimate the costs and quantities of feedstocks that could be available at biorefineries.
- 07 Microalgae**: Estimate the site-specific and national economic availability of algae biomass under on-location scenarios.

The footer contains links for "From the Bioenergy KDF", "Maps and Data", and "Questions".

Discussion

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Backup slides

Sustainability criteria: Forestry

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

BT16 includes an analysis of the biomass potential of microalgae

Cultivating algae strains near CO₂ facilities

Coal-fired and natural gas electric generating units (EGUs)

Ethanol production plants

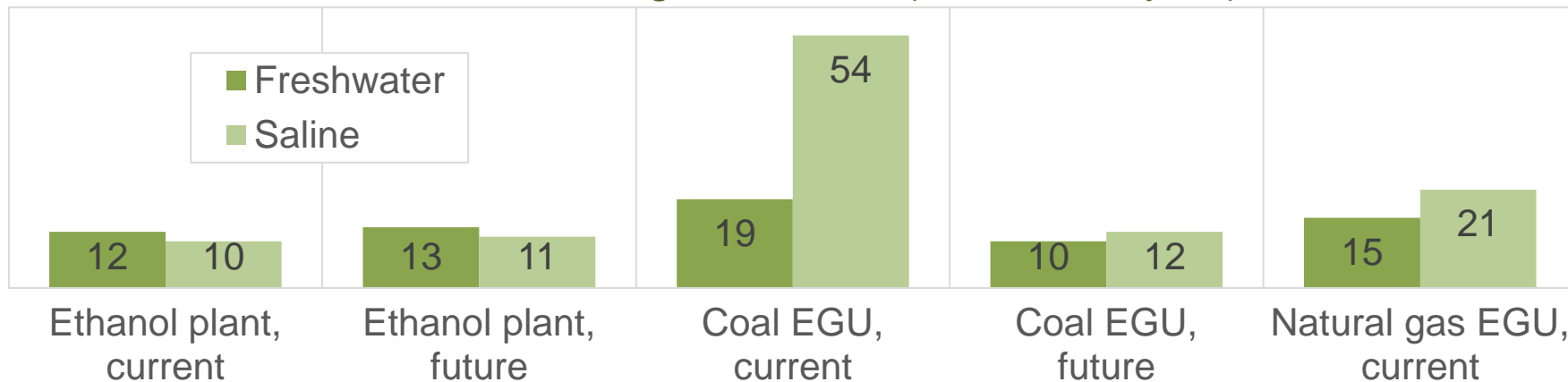
2 productivity scenarios

Current rate

Future high-productivity case (not considered for natural gas)



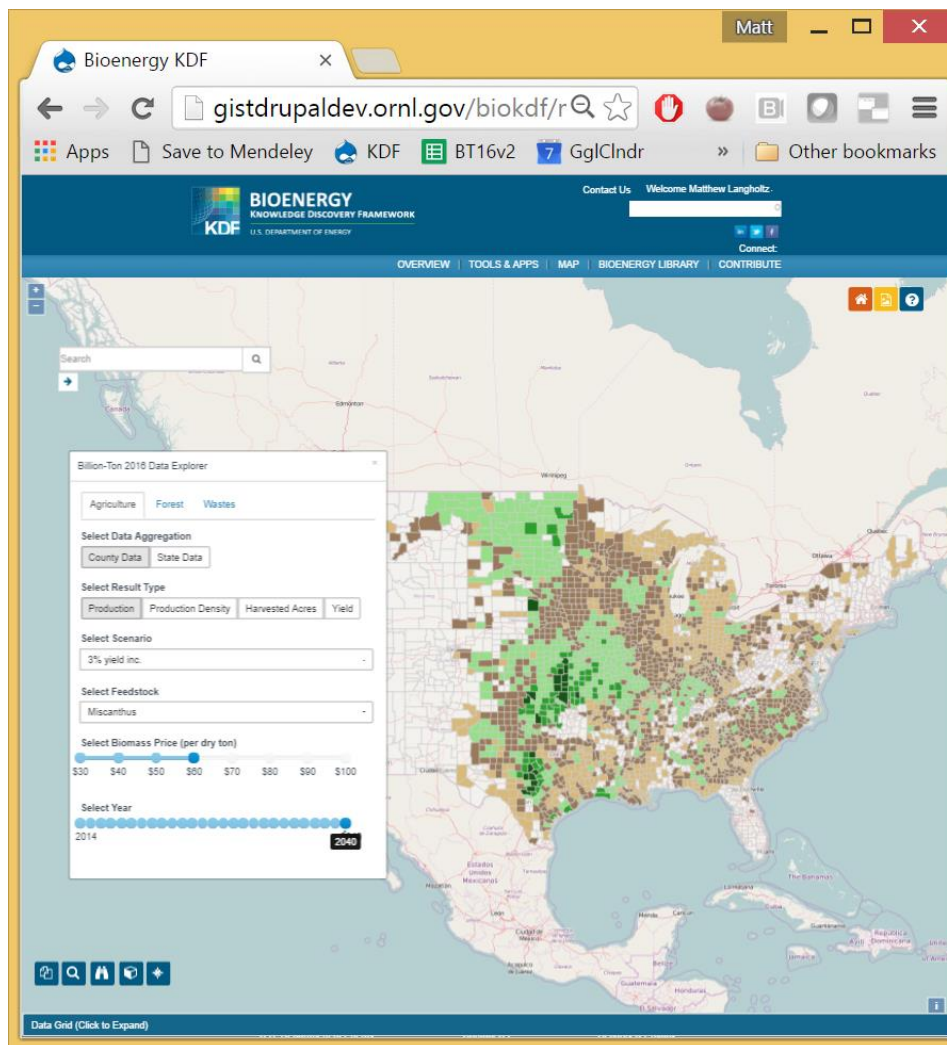
Potential algae biomass (million tons/year)



Sustainability Criteria: Agriculture

Category	Sustainability assumption or constraint	Implementation
Soil quality, water quality	Trend toward reduced/no till for corn, wheat	Management assumptions
	High fraction of no-till crop acres	
	No residue removal on conventionally tilled acres	
	Acceptable residue removal different for reduced/no till	
	Crop residue removal based on wind, water erosion estimates, and soil carbon loss	Residue removal tool used to estimate retention coefficients
	Multi-county NRCS crop management zones (e.g., tillage assumptions)	
	No residue removal for soy	Excluded land area
Annual energy crops on land with low erosion potential and assumed part of multicrop rotation		
Water quantity	Irrigated cropland or pasture excluded	Excluded land area
	No use of pastureland west of 100th meridian	
	No supplemental irrigation of energy crops	Management assumptions
GHG emissions	No transition of non-agricultural lands to energy crops	Excluded land area

Data resources



Navigating BT16



Bioenergy KDF

gistdrupaldev.ornl.gov/biokdf/t

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1

Executive Summary/Overview

The 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy (BT16) evaluates the most recent estimates of potential biomass that could be available for new industrial uses in the future. Volume 1 of this report, presented here, focuses on resource analysis projecting biomass potentially available at specified prices. Volume 2, targeted for release at the end of 2016, evaluates changes in environmental sustainability indicators associated with select production scenarios in volume 1. Building on previous analyses, BT16 (1) updates the farmgate/roadside analysis using the latest available data and specified enhancements; (2) adds more feedstocks, including algae and specified biomass energy crops; and (3) expands the analysis to include a scenario study to illustrate the cost of transportation to biorefineries under specified logistical assumptions. Here are key summary results and conclusions of BT16 volume 1.

1 2 3 4 5 6 7 8 9 10 11 12 13

Access Chapter Download Data Help

Table ES.1: Summary table of national supplies of biomass over time, including currently used and potential biomass resources, across forestry, agricultural, and waste biomass sectors. Select farmgate biomass crop price and agricultural and forestry simulation scenarios. Currently used biomass resources remain fixed with choice of scenario and price. Waste resources are estimated for a base-case scenario only.

Biomass Price (\$/dry ton) \$00 Agriculture Scenario Basecase, all energy crops Forestry Scenario Medium housing, low energy demands

Feedstock	Million Dry Tons																									
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	
Currently Used Resources																										
Forestry Resources Currently Used	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154	154
Agricultural Resources Currently Used	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
Waste Resources Currently Used	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08	08
Total Currently Used	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366
Potential Resources (For Selected Scenarios)																										
Forestry Resources Potential (all timberland) ^a	97	101	103	106	109	111	109	108	104	101	100	101	100	101	97	97	94	90	87	101	102	103	104	97		
Forestry Resources Potential (no federal timberland) ^b	81	83	83	80	80	80	88	87	83	81	79	80	80	81	77	77	75	77	78	82	83	85	85	79		
Agricultural Residues	03	101	104	108	111	110	119	123	127	131	135	138	140	144	140	140	152	154	158	161	163	166	168	171	174	

Bioenergy KDF

gistdrupaldev.ornl.gov/biokdf/t

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1

Executive Summary/Overview

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1 2 3 4 5 6 7 8 9 10 11 12 13

Access Chapter Download Data Help

Figure ES.4: County-level map and national bar graph of potential biomass resources (excluding currently used) across the lower 48 states, defaulted to \$60 per dry ton per year for the base-case scenario. Feedstock supply is reported by default as a density value, potential county-level supply divided by county land area. Supply quantities in blue are correlated to having a feedstock density of 100 dry tons per square mile or more, which corresponds to the approximate minimum quantity to supply a hypothetical facility at 2,000 dry tons per day.

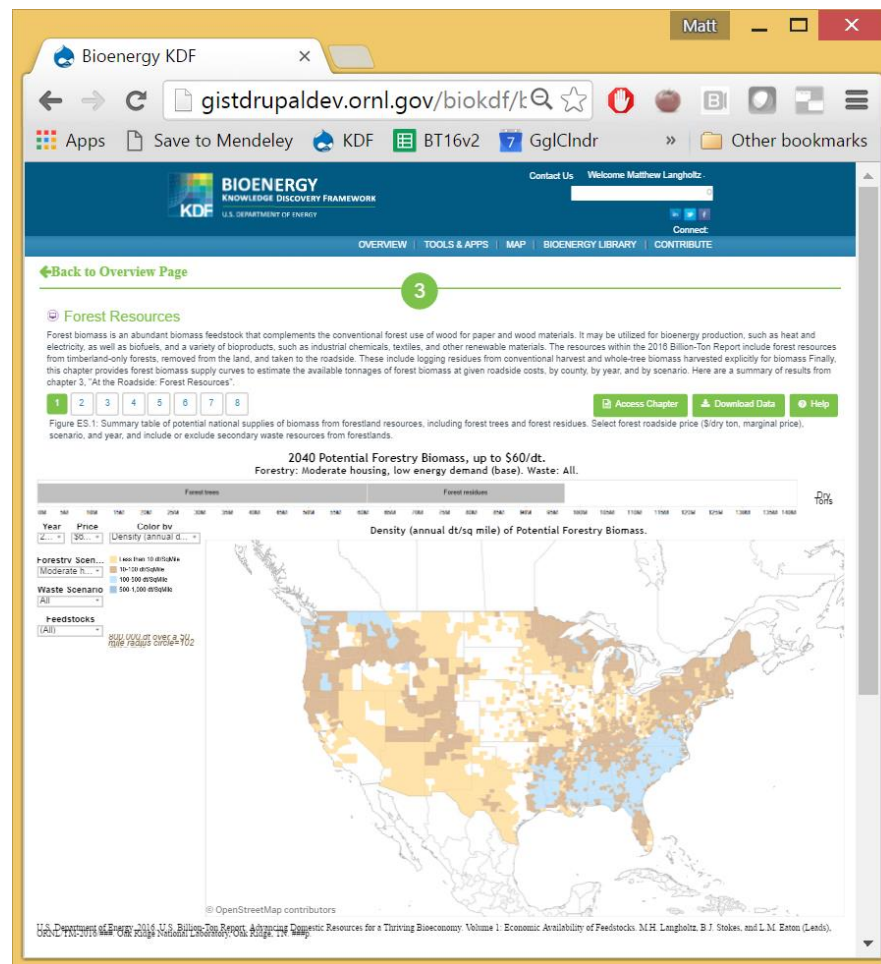
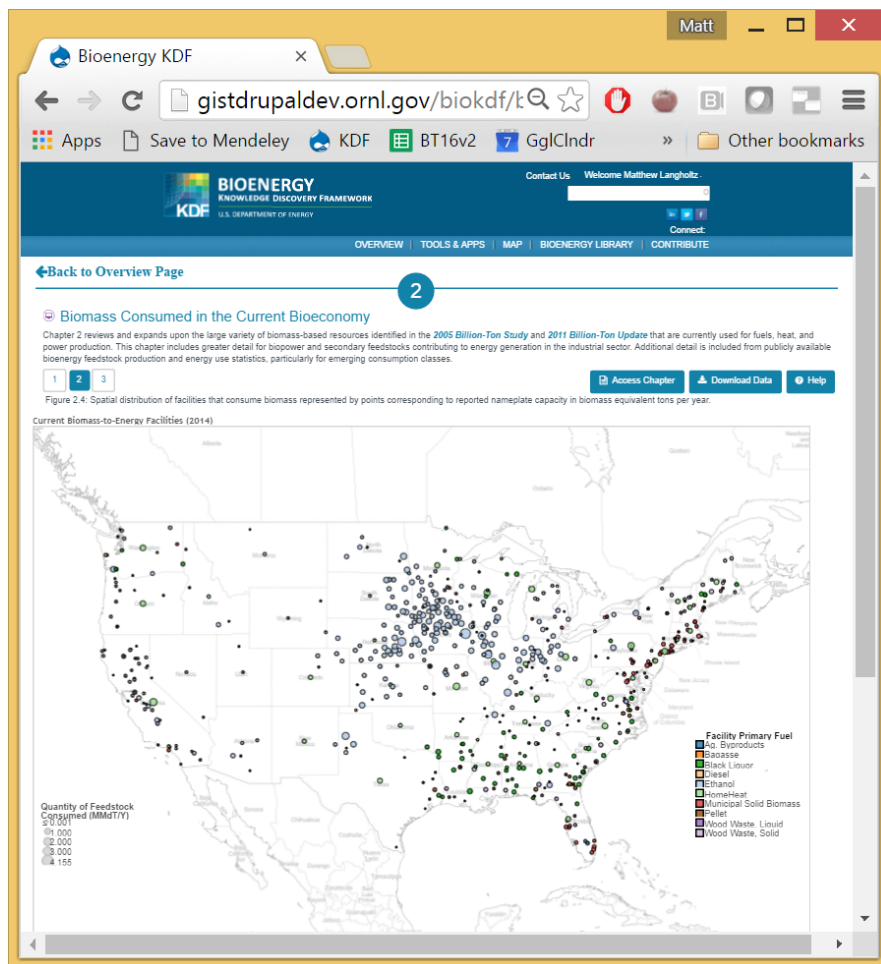
2040 Combined potential supplies at \$60/dt or less, roadside.
Forestry: Moderate housing, low energy demand (base). Agriculture: 1% yield increase (BC1). Wastes: All.

0M 100M 200M 300M 400M 500M 600M 700M 800M 900M 1000M 1100M 1200M 1300M 1400M Dry Tons

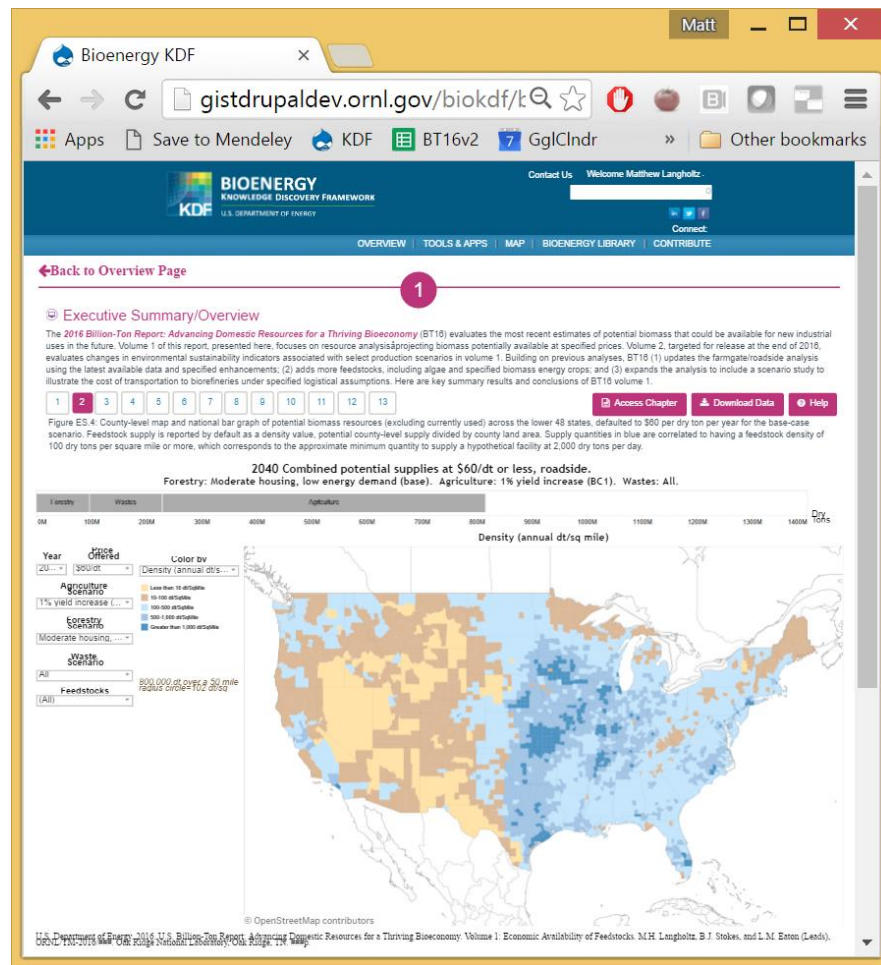
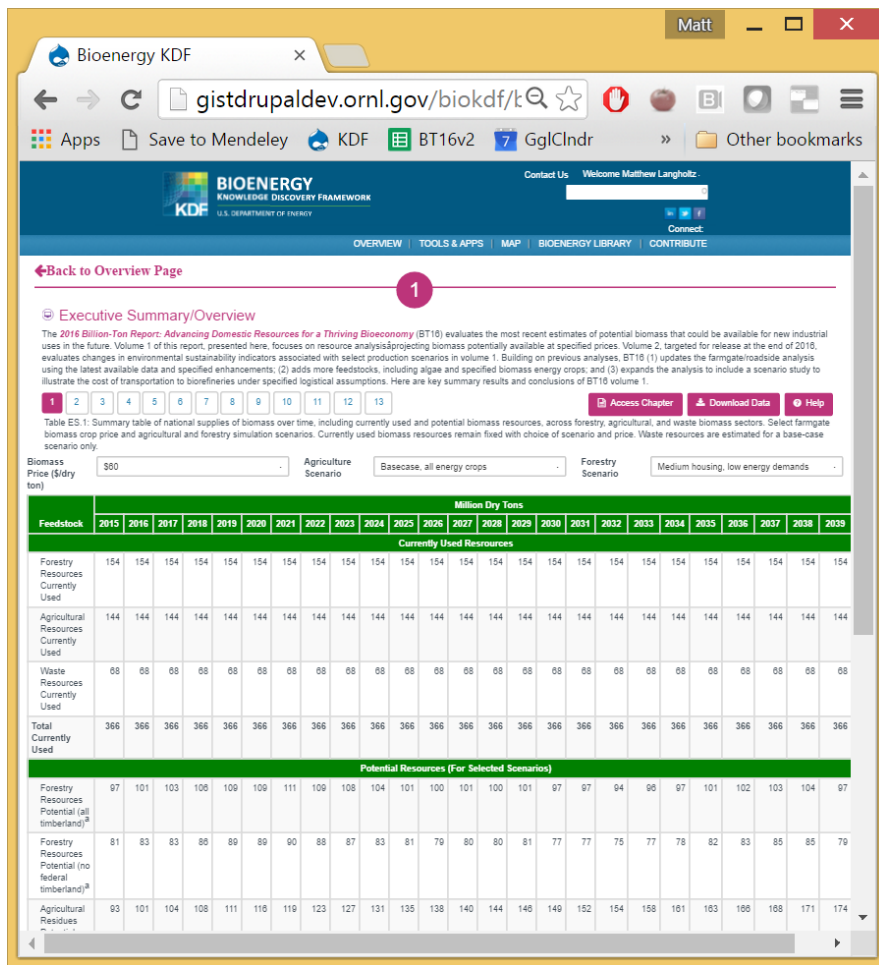
Year 20...
Price Offered \$/dry ton
Source
Color by Density (annual dt/sq mile)
Agriculture 1% yield increase (BC1)
Forestry Moderate housing, low energy demand (base)
Waste All
Feedstocks (All)

U.S. Department of Energy 2016. 11.6 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy Volume 1. Economic Availability of Feedstocks. M.H. Langholtz, B.J. Stokes, and L.M. Eaton (Leads). ORNL/TN-2016-188. ORNL is managed by UT-Battelle, LLC, for the U.S. Department of Energy.

BT16: Chapters 2 and 3



BT16: Chapters 4 and 5



BT16: Chapters 6 and 7

6 To the Biorefinery

Reliable supply chains that cost-effectively deliver high-quality feedstocks are an important aspect of building a billion-ton bioeconomy. BT16 features scenario analyses of the logistics and transport costs of select feedstocks from chapters 3, 4, and 5 delivered to a commercial biorefinery. A near-term scenario considers the potential of existing commercially available equipment to collect, store, grind, and transport biomass to a single-feedstock biorefinery. The longer-term scenario evolves to a depot-based system where raw biomass is converted to a commodity and allowed to blend with other feedstocks. The long-term scenario also considers the impacts of a high-yield scenario (3% increase per year for most crops) in addition to the base-case yield increase of 1% per year.

National map of weighted average cost of delivered supply by year of analysis, delivered feedstock case design, maximum delivered price of interest, and supply scenario. Counties in green represent weighted average price of delivered supply less than \$24 per dry ton, in orange represent weighted average supply between \$24 and 100 per dry ton, and in red represent weighted average cost of biomass supply exceeding \$100 to a maximum of \$150 per dry ton. Total usable delivered supply based upon choices is represented in the upper left hand of the visualization (delivered is delivered and processed to the biorefinery throat)

366.8M Total dry tons
\$84.53 Average Cost

Quantity Used by Distance (miles)

Distance (miles) by County for Delivered Feedstock

7 Microalgae

BT16 is the first in the Billion-Ton series to include algae in the biomass resource potential assessment. This resource assessment estimates the site-specific and national economic availability of microalgae biomass co-located with one of three CO2 sources for cultivation-coal-fired power plants, natural gas power plants, or ethanol production plants. Co-location reduces costs and focuses attention on appropriate technologies and locations for commercialization. All scenarios use open ponds, with examples of freshwater and saline water use. The following are key results from chapter 7, "Microalgae".

Users can select the cost range per dry ton to view the quantity and distribution of biomass. Maps of co-located algae farms at present productivities and future productivities are depicted for three types of ponds.

Potential algae production. Co-location: All

Cost per dry ton

Co-location Strategy

Annual Dry Tons

Please cite: U.S. Department of Energy, 2016, U.S. Billion-Ton Feedstock Resource for a Thriving Bioeconomy, Volume 1: Economic Availability of Feedstocks, M. H. Stokes, and L. Estroff (Eds.), ORNL/TN-2016-020, United States National Laboratory, Oak Ridge, TN.

Models/Data Used in BT16 Volume 1

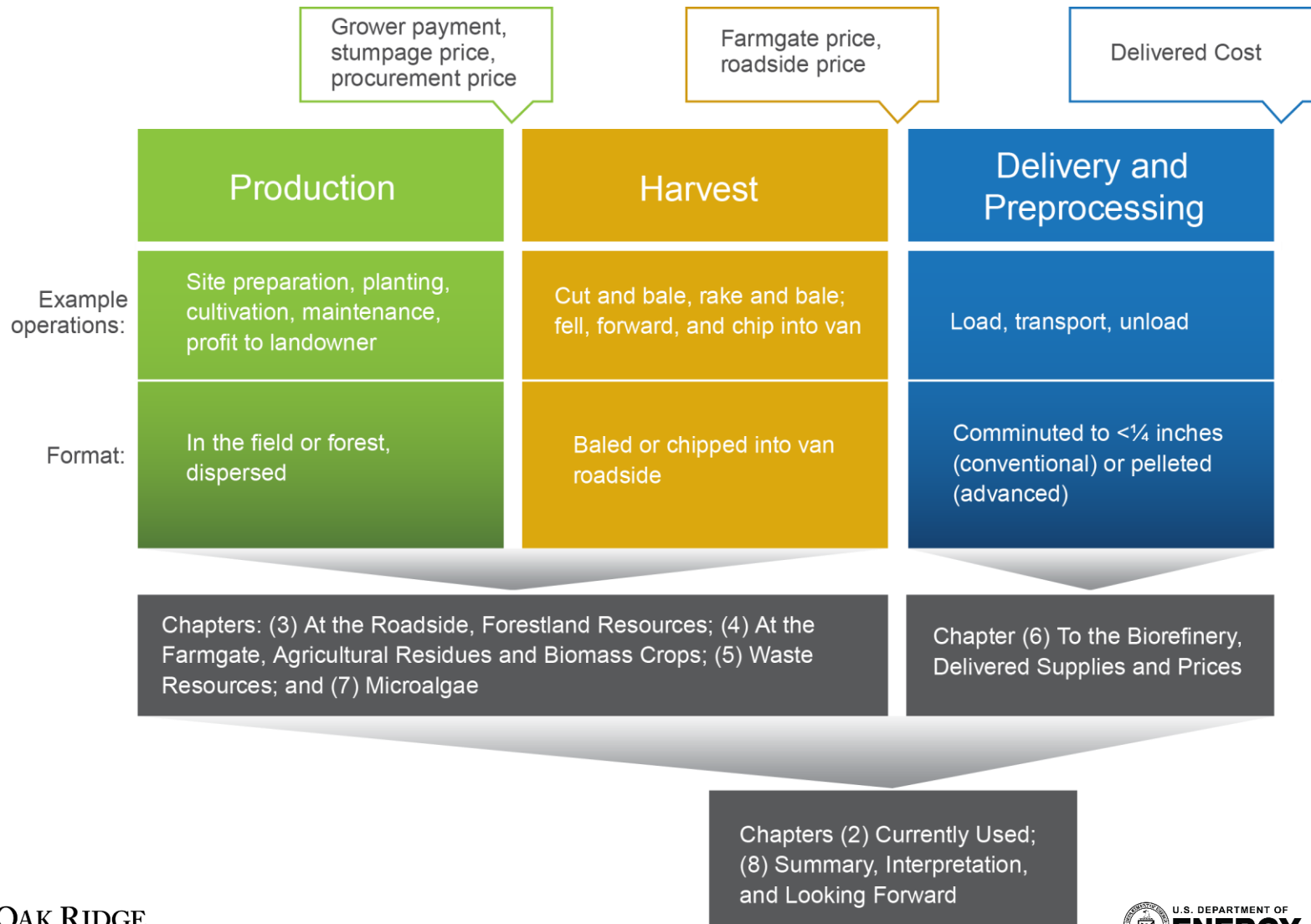
Models

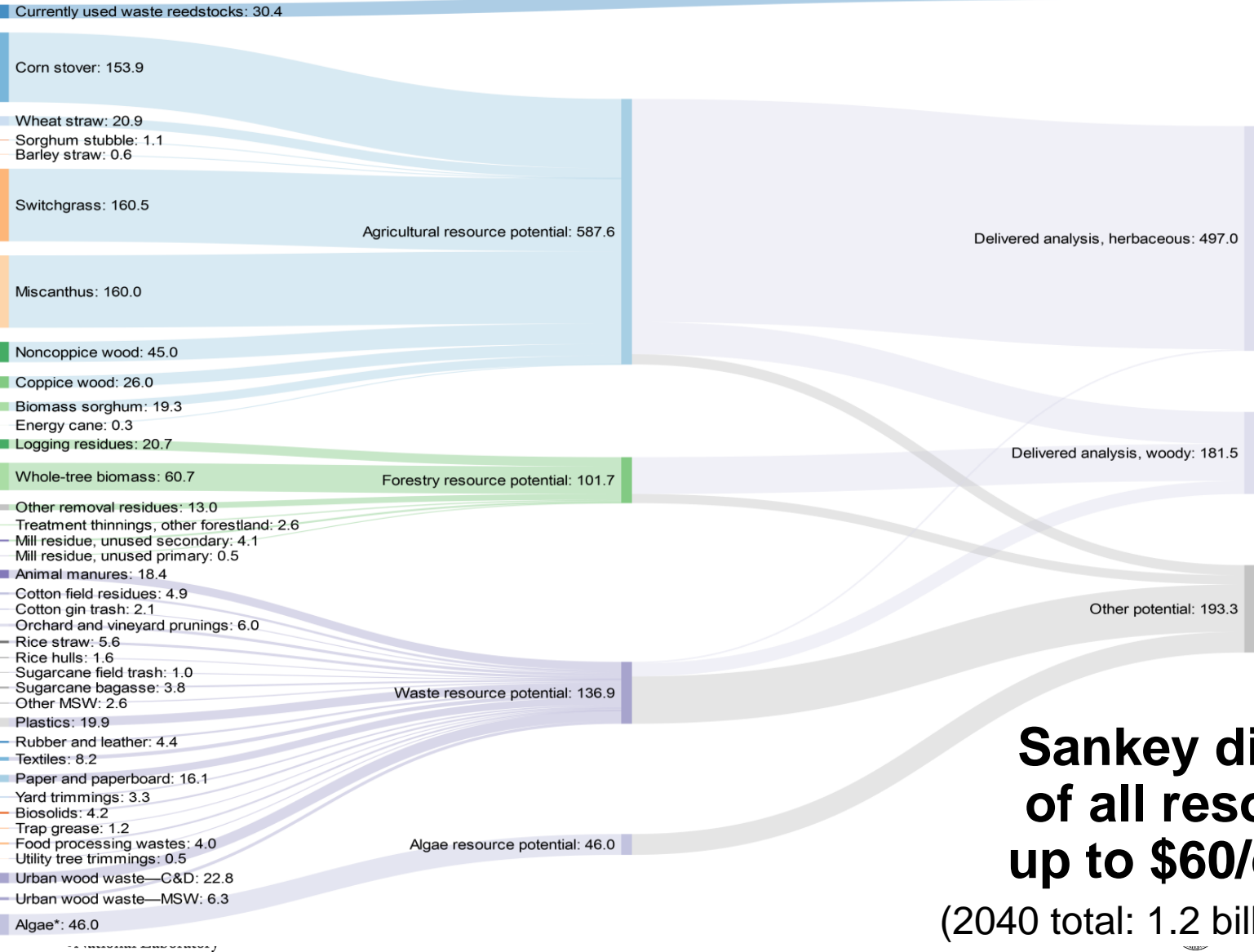
- POLYSYS: Policy Analysis System
 - ForSEAM: Forest Sustainable and Economic Analysis Model
 - SRTS: Subregional Timber Supply Model
 - USFPM/GFPM: U.S. Forest Products Module/Global Forest Products Model
 - PRISM-EM: Parameter-elevation Relationships on Independent Slopes Model
 - SCM: Supply Characterization Model
-

Data

- USDA Long-Term Agricultural Projections
- U.S. Forest Service RPA (10-year forest assessment) and FIA
- EIA Monthly Energy Review, Annual Energy Outlook, Consumption Surveys and other data
- PRISM (climate) and SSURGO (soils) high resolution data
- Sun Grant Regional Feedstock Partnership and Historical Field Trial data of energy crops

The report addresses all stages of the biomass supply chain





**Sankey diagram
 of all resources
 up to \$60/dry ton**
 (2040 total: 1.2 billion tons/year)

DEPARTMENT OF ENERGY
ENERGY | Energy Efficiency & Renewable Energy