2016 Billion-ton Report

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***On behalf of many (see contributors slide)**

Biomass R&D Technical Advisory Committee Meeting

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Arlington, VA

OAK RIDGE National Laboratory

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Outline

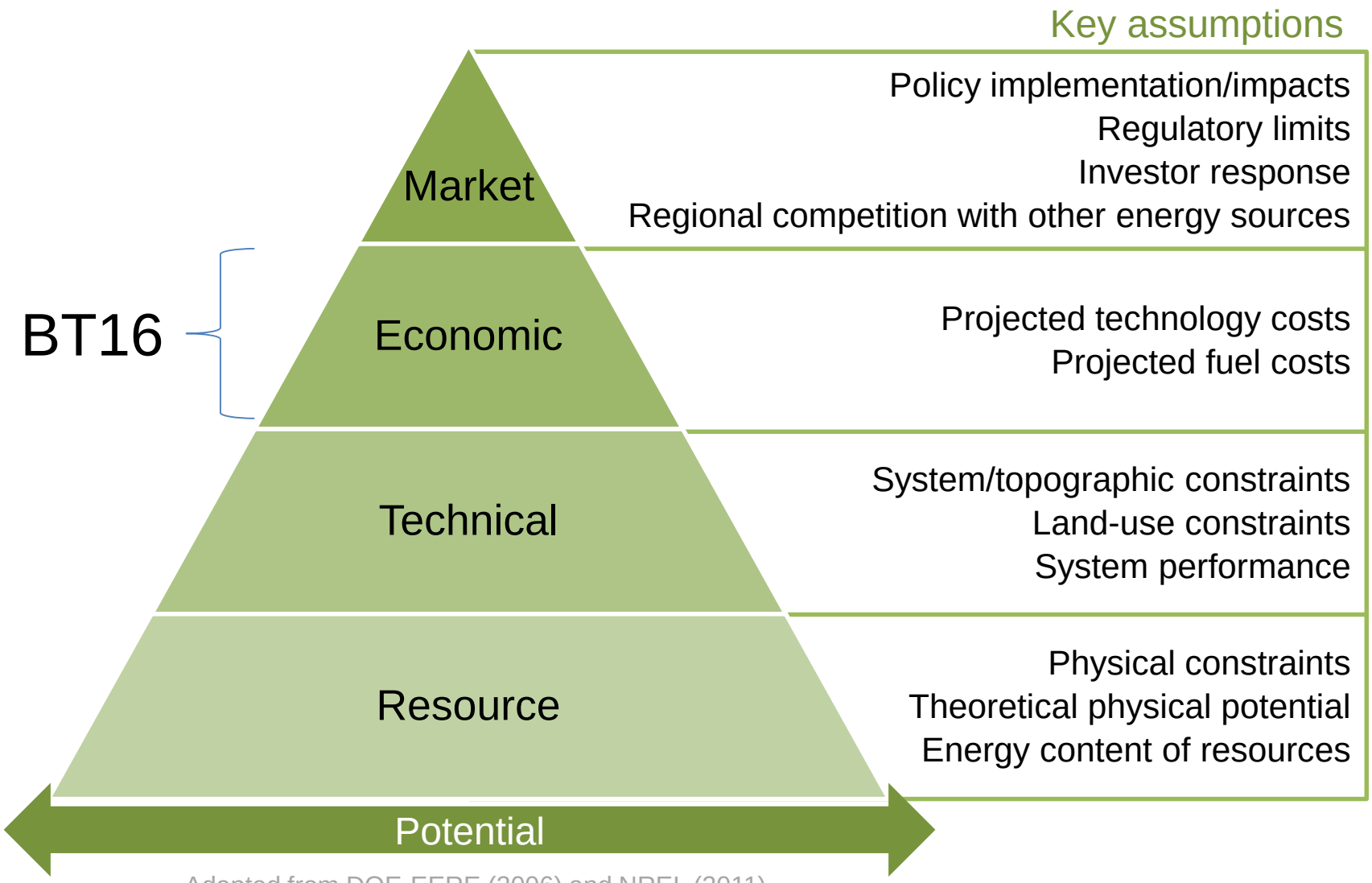
- Introduction; Motivation
- Contributors and methods
- Spatial and temporal results
- Advancing resources
- Online data discovery tools

Motivation: provide stakeholders information on biomass feedstock supply to support technology commercialization for the bioeconomy

Preamble

- Excludes policy and end use
- Prioritizes food, forage, feed, fiber, and export to ensure social sustainability
- Underlying conservative assumptions with environmental sustainability considerations

Potential supplies



Adapted from DOE-EERE (2006) and NREL (2011).
See also Batidzirai, Smeets, and Faaij (2012)

Contributors

BT16 Volume 1: Topics addressed

Chapter 2
Current Use of Biomass Resources

Chapter 3
Forest Resources

Chapter 4
Agricultural Resources

Chapter 5
Secondary and Waste Resources

Chapter 6
Delivered Resources

Chapter 7
Microalgae

Models/Data Used in BT16 Volume 1

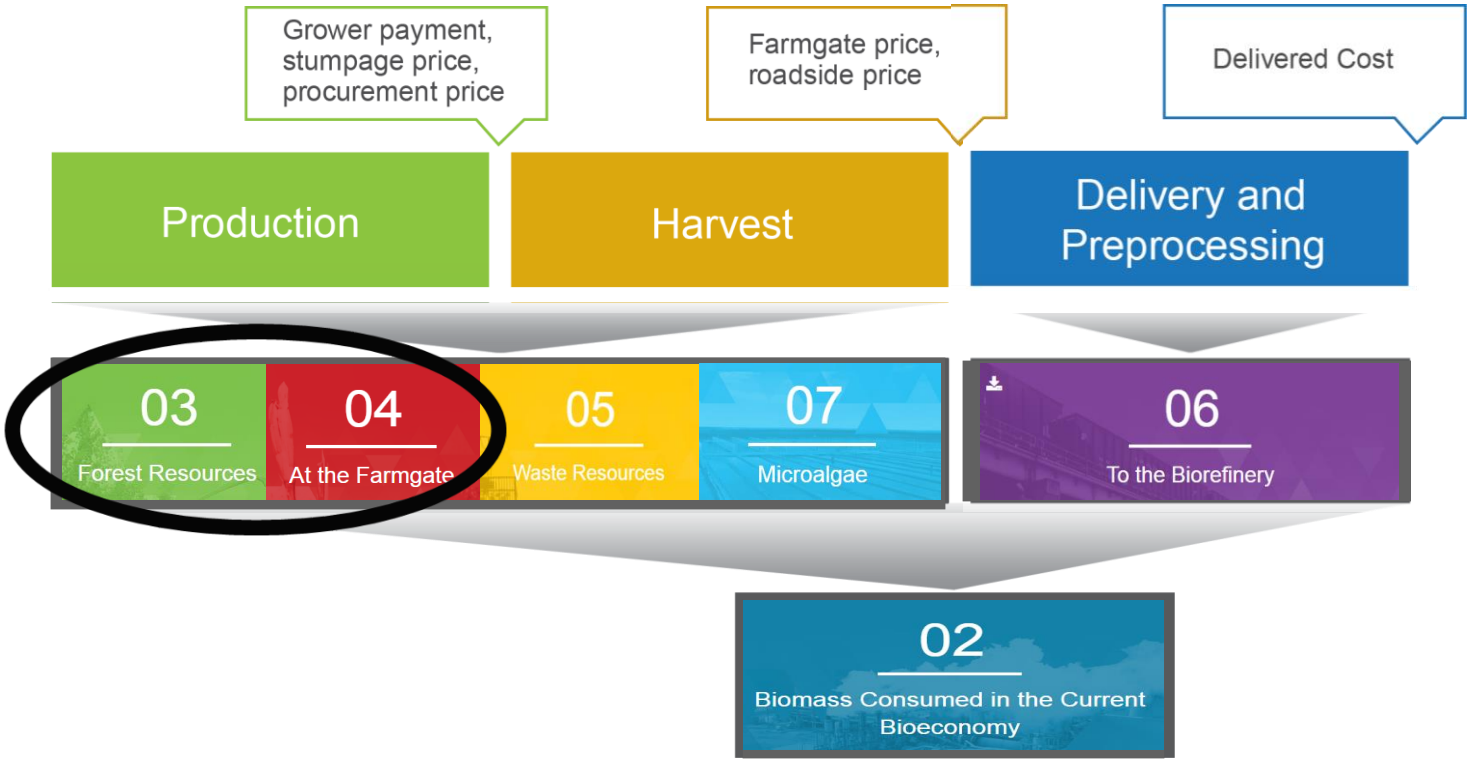
Models

- ForSEAM
- SRTS
- USFPM/GFPM
- POLYSYS
- PRISM-EM
- SCM

Data

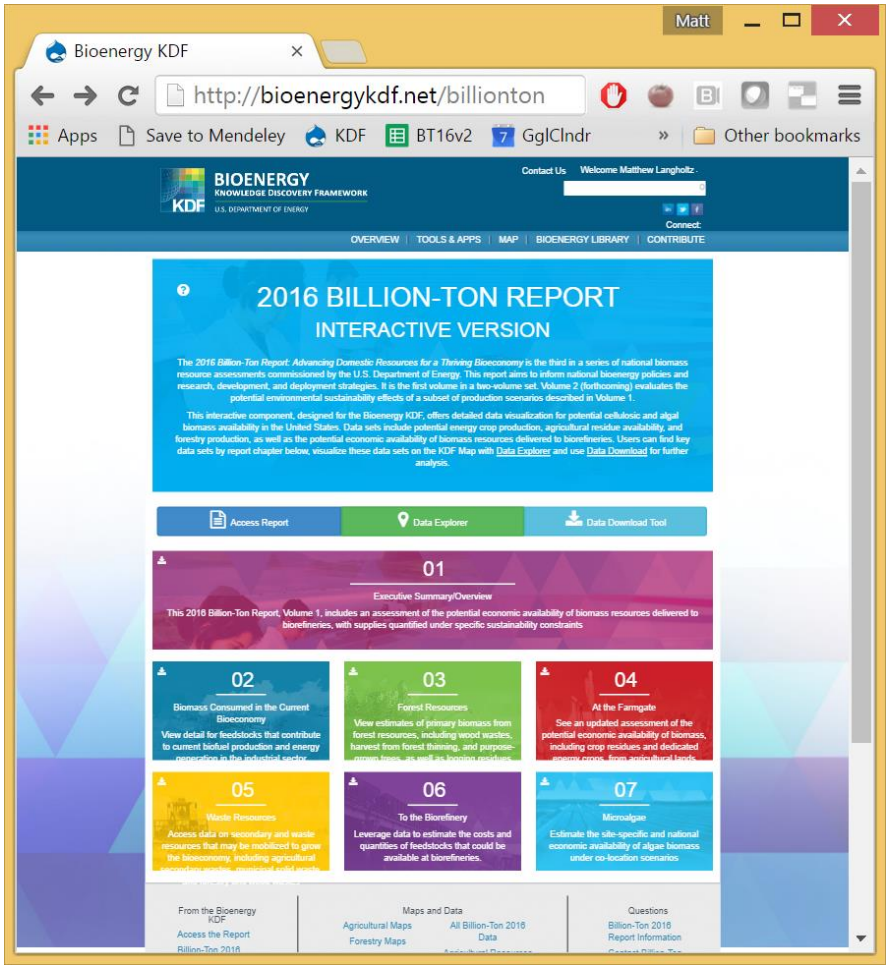
- EIA Monthly Energy Review, Annual Energy Outlook, Consumption Surveys and other data
- U.S. Forest Service RPA (10-year forest assessment) and FIA
- USDA Long-Term Agricultural Projections (“baseline”)
- PRISM (climate) and SSURGO (soils) high resolution data
- Sun Grant Regional Feedstock Partnership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

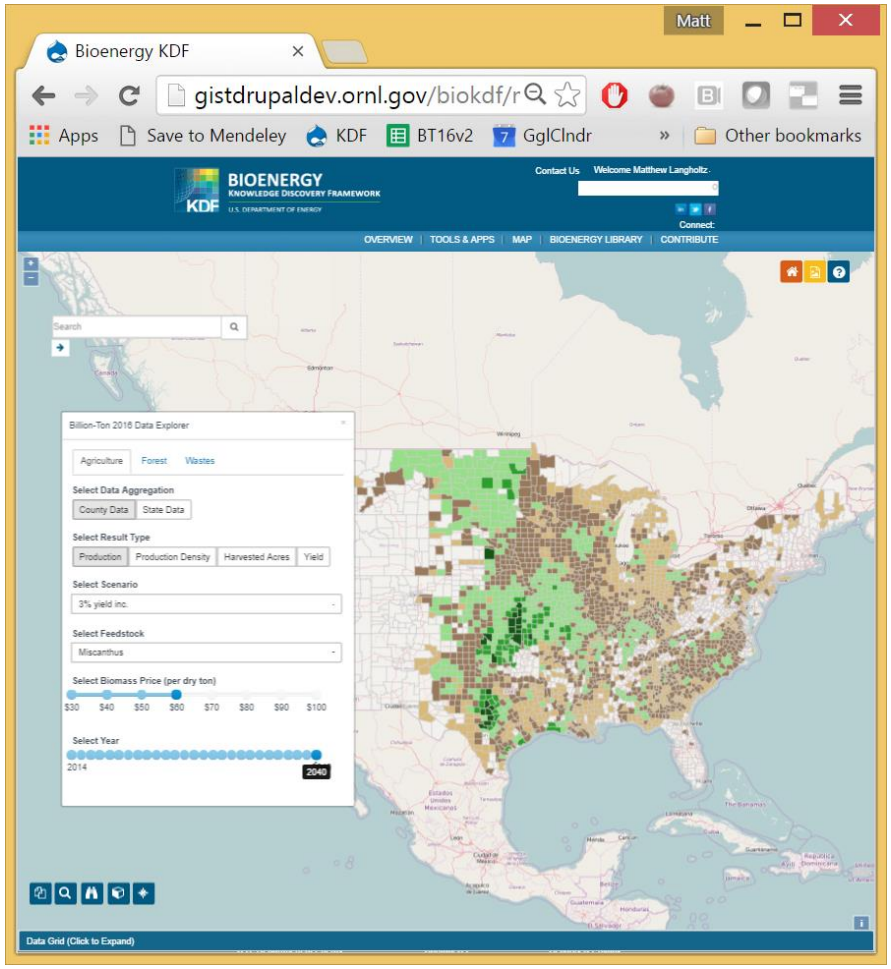
The report addresses all stages of the biomass feedstock supply chain



Interactive resources

http://bioenergykdf.net/billionton

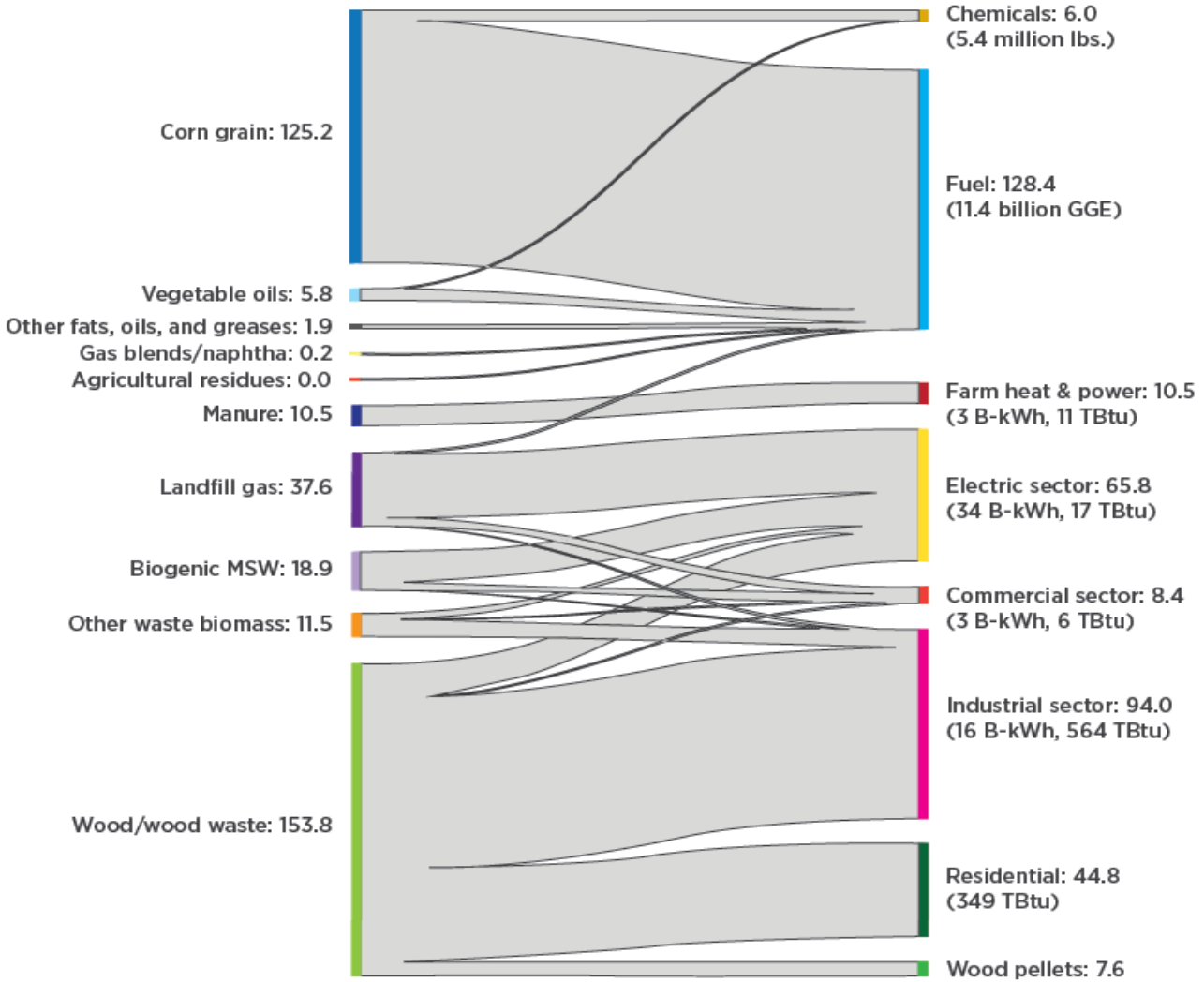




How Biomass is Currently Used

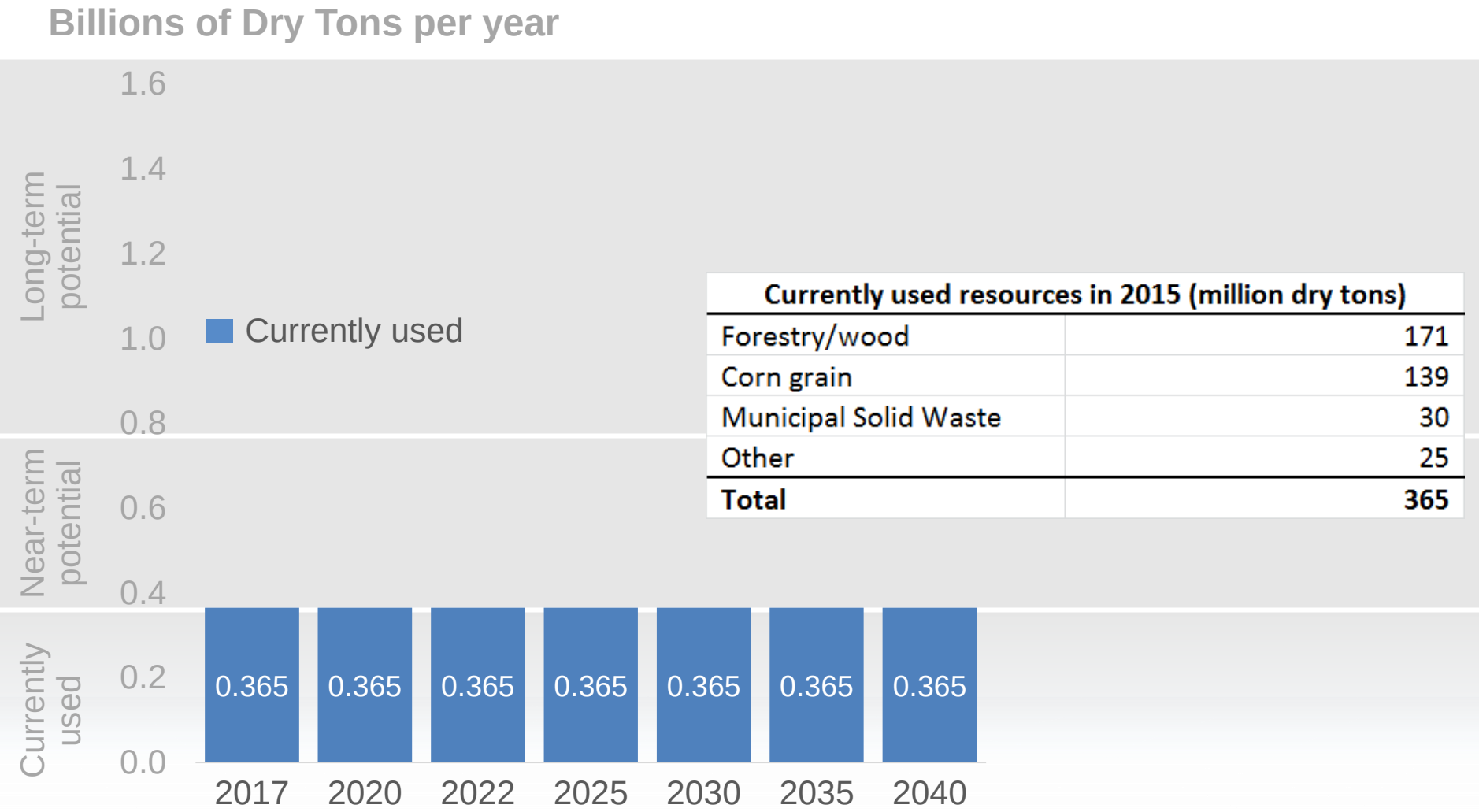
1 million “bioenergy equivalent” dry ton per day (2014)

Figure 2.5 | Sankey diagram of feedstock, sector consumption, and final product distribution, in million dry tons per year[14]



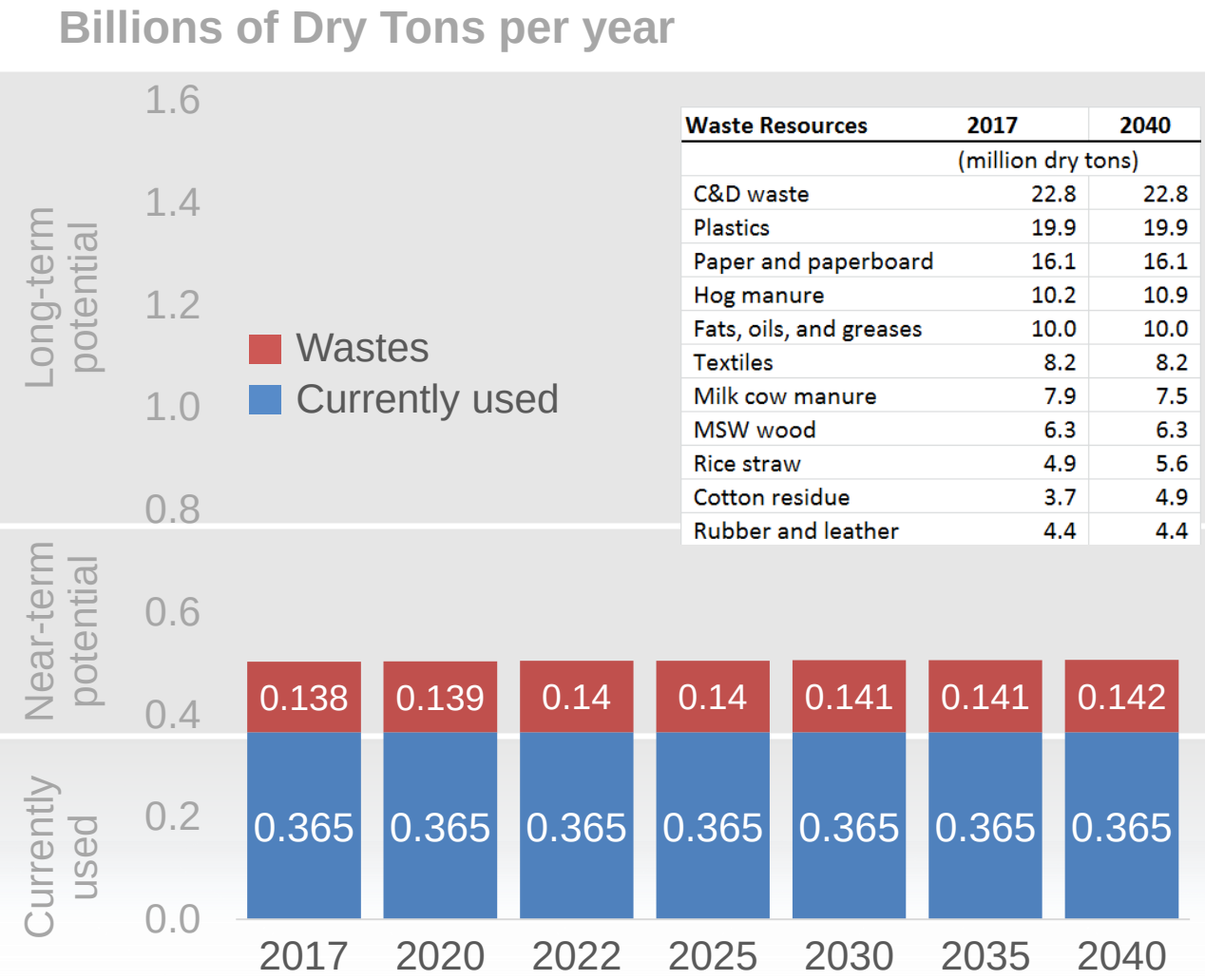
Note: Biomass resources are shown on the left and their allocations are shown on the right. The size of the flow is representative of the amount of biomass allocated to that end use. For this figure, contributions from landfill gas are represented as tons of biomass equivalent by applying a conversion factor of 0.2665 lb/scf.

Current and Potential, Base Case



Currently used resources in 2015 (million dry tons)	
Forestry/wood	171
Corn grain	139
Municipal Solid Waste	30
Other	25
Total	**365**

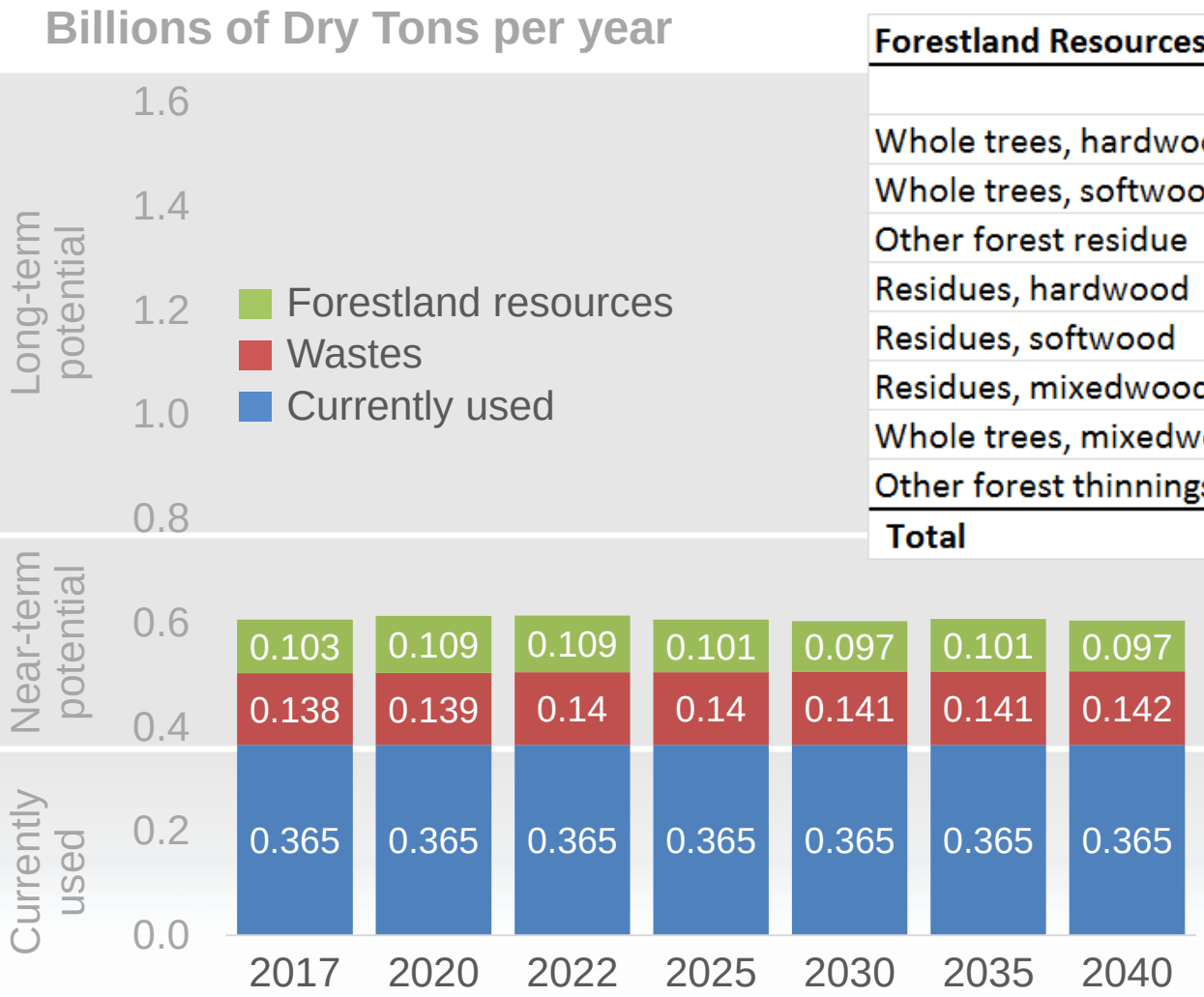
Current and Potential, Base Case at $60/dt



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

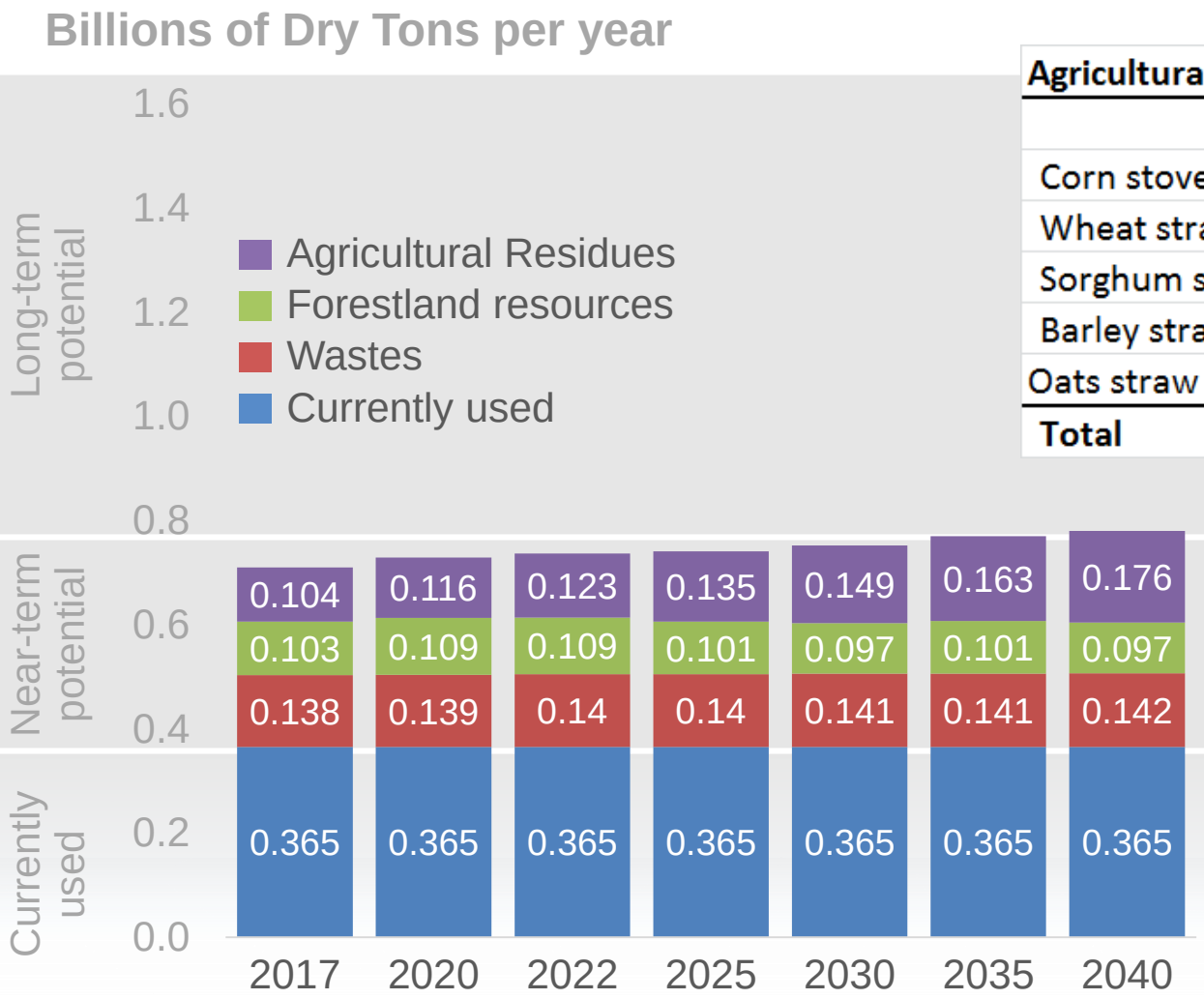
Waste Resources	2017	2040
	(million dry tons)	
Secondary mill residue	4.1	4.1
Sugarcane bagasse	3.6	3.8
Yard trimmings	3.3	3.3
Noncitrus residues	2.5	2.7
Other	2.6	2.6
Cotton gin trash	1.7	2.1
Tree nut residues	1.5	1.6
Citrus residues	1.5	1.6
Rice hulls	1.4	1.6
Sugarcane trash	1.0	1.0
Primary mill residue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

Current and Potential, Base Case at $60/dt



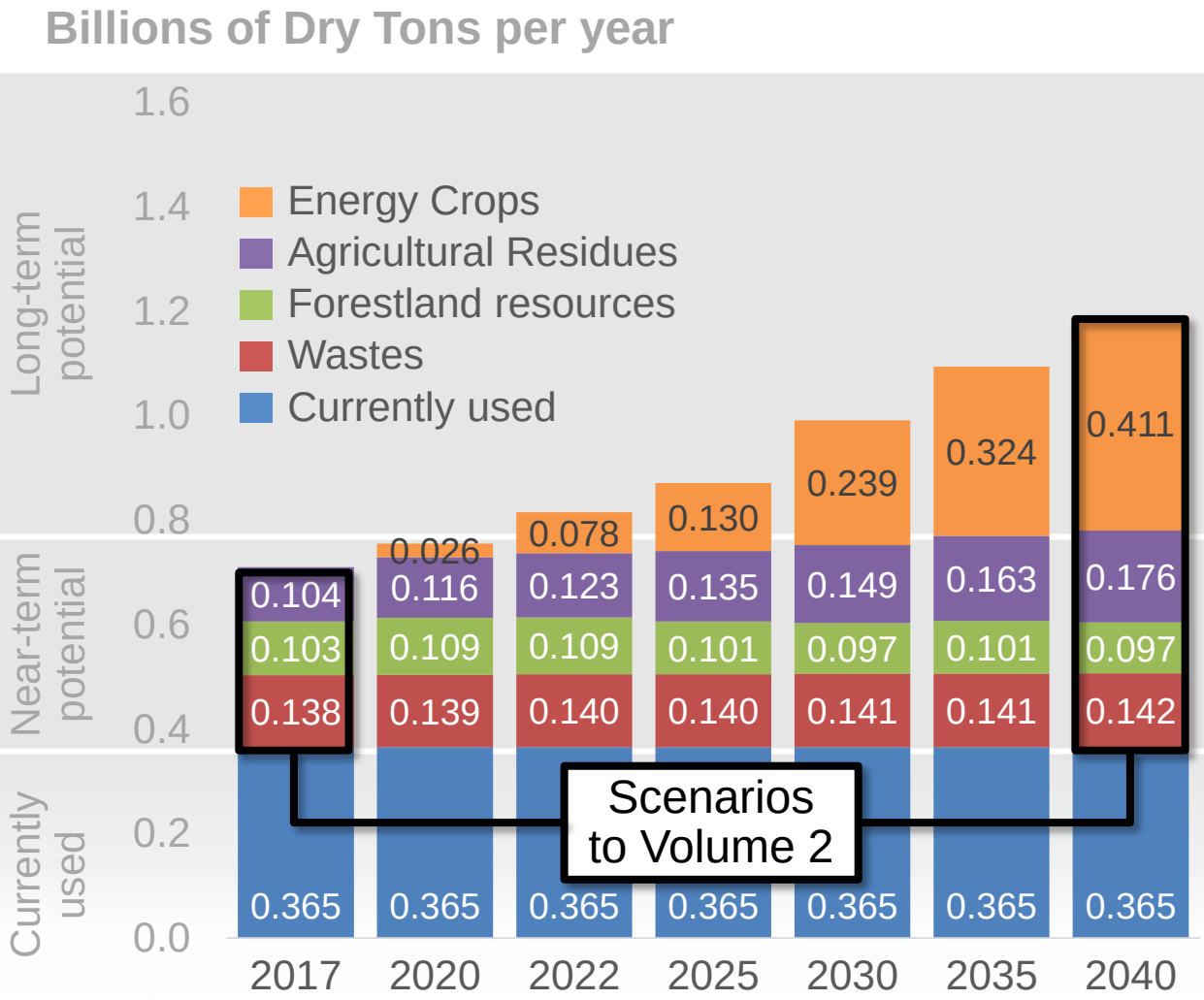
Forestland Resources	2017	2040
	(million dry tons)	
Whole trees, hardwood	39.0	24.9
Whole trees, softwood	28.1	33.4
Other forest residue	12.2	13.0
Residues, hardwood	6.9	8.0
Residues, softwood	6.8	10.0
Residues, mixedwood	4.2	2.7
Whole trees, mixedwood	2.8	2.4
Other forest thinnings	2.6	2.6
Total	**103**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

Current and Potential, Base Case at $60/dt



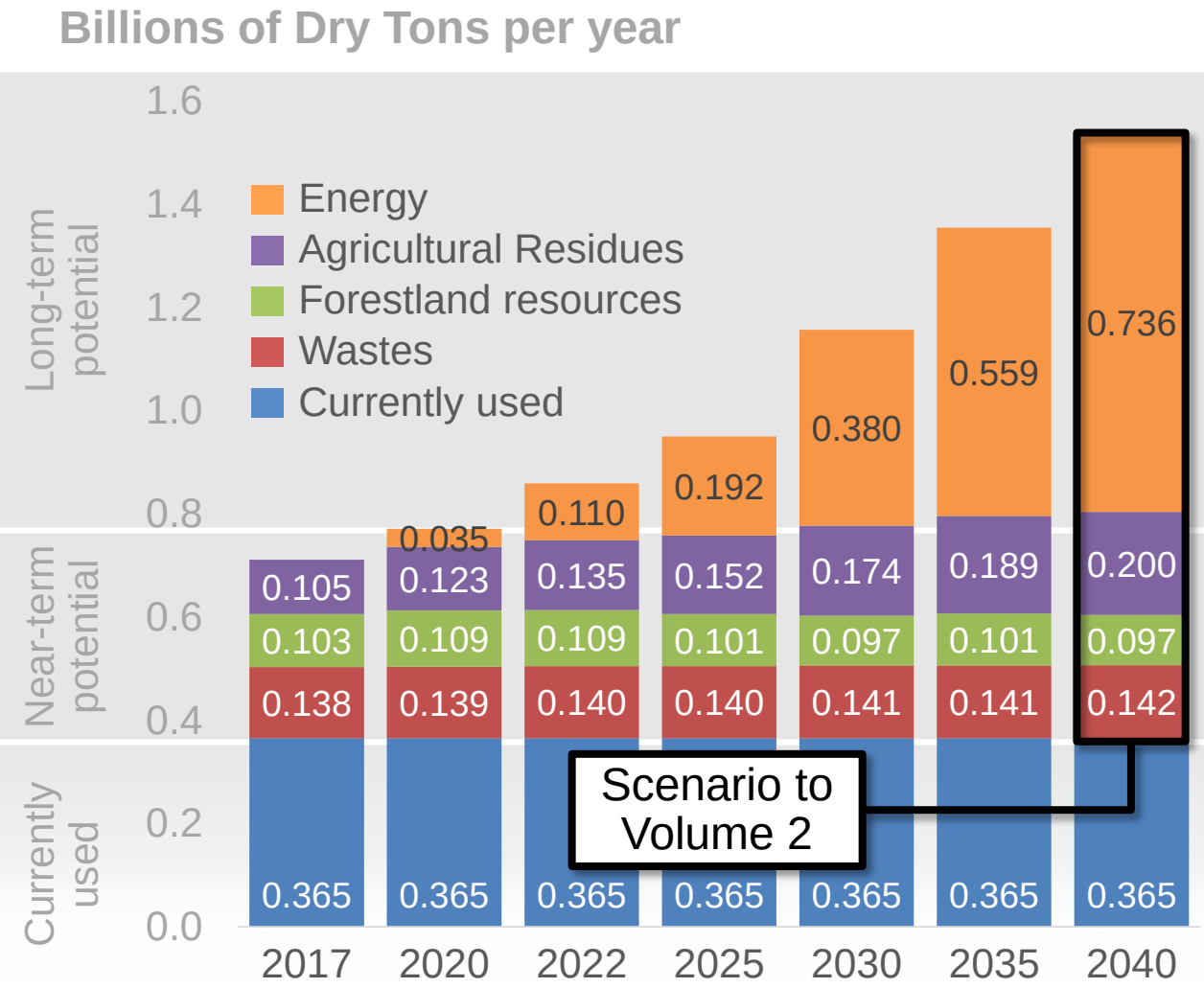
Agricultural Residues	2017	2040
	(million dry tons)	
Corn stover	89.4	153.9
Wheat straw	13.0	20.9
Sorghum stubble	0.7	1.1
Barley straw	0.4	0.6
Oats straw	<0.1	<0.1
Total	**104**	**176**

Current and Potential, Base Case at $60/dt



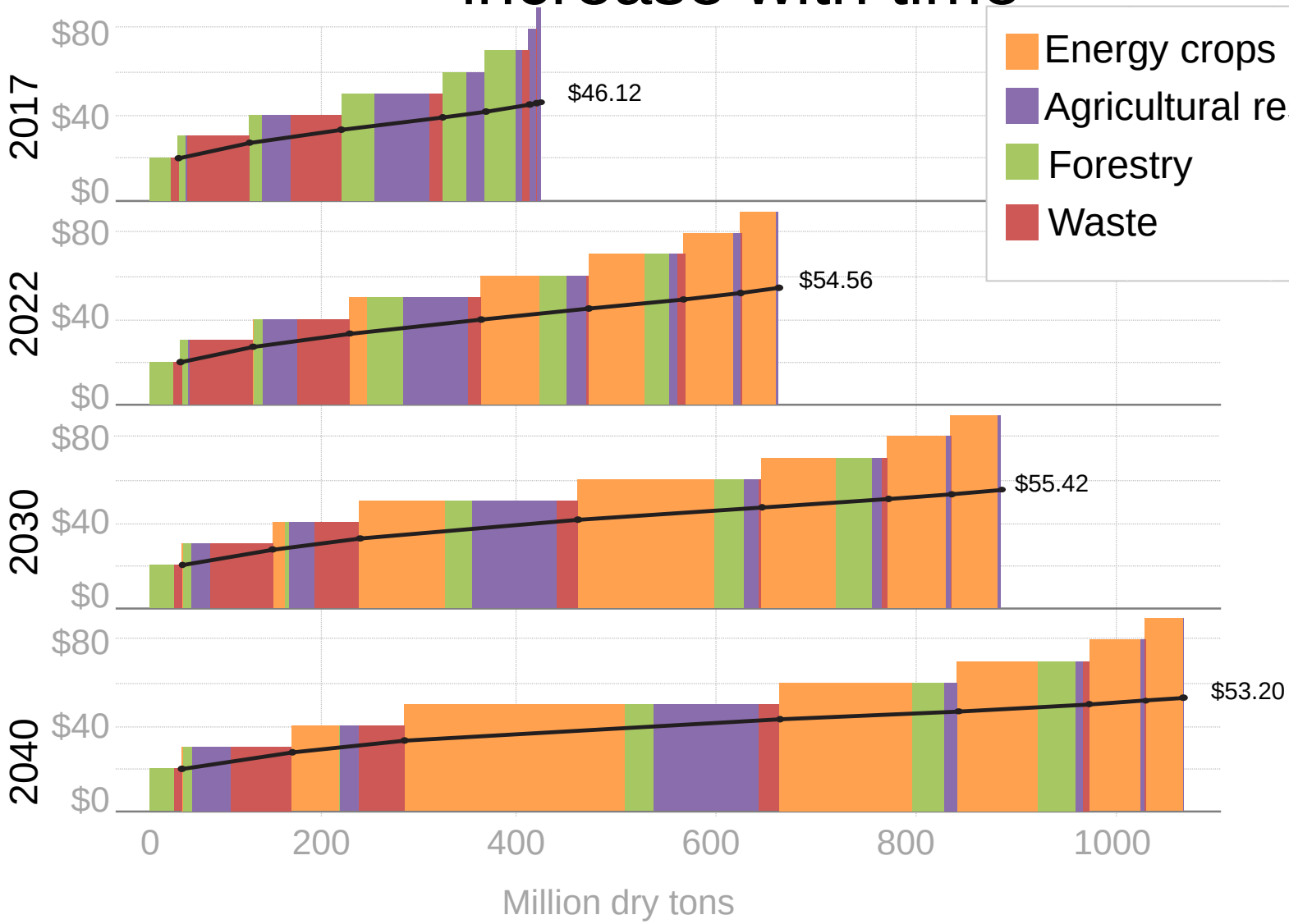
Energy crops	2017	2040
	(million dry tons)	
Switchgrass	-	160.5
Miscanthus	-	160.0
Poplar	-	44.9
Willow	-	25.1
Biomass sorghum	-	19.3
Eucalyptus	-	0.9
Energy cane	-	0.3
Pine	-	0.1
Total	-	**411**

Current and Potential, High-yield at $60/dt

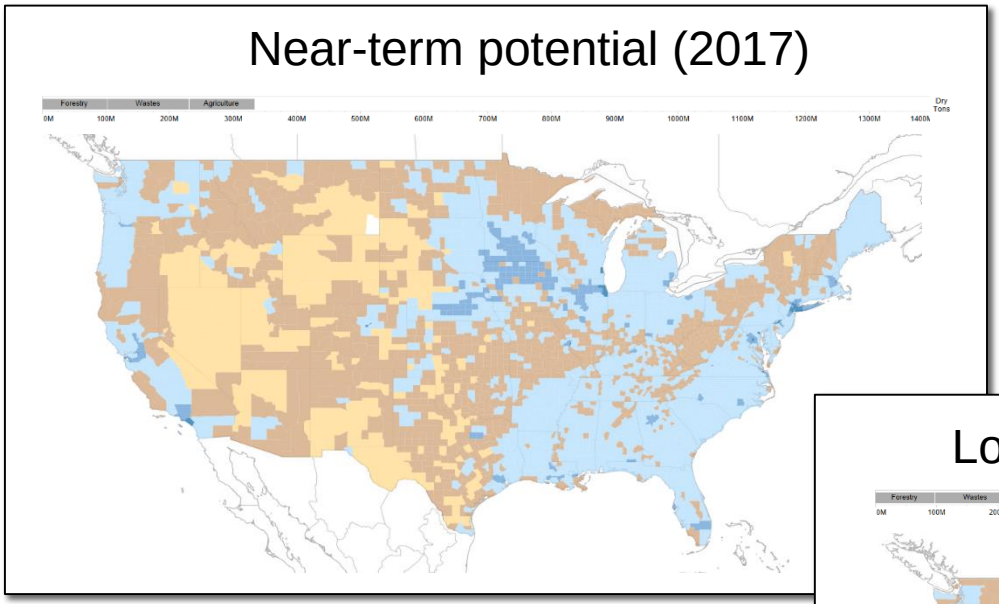


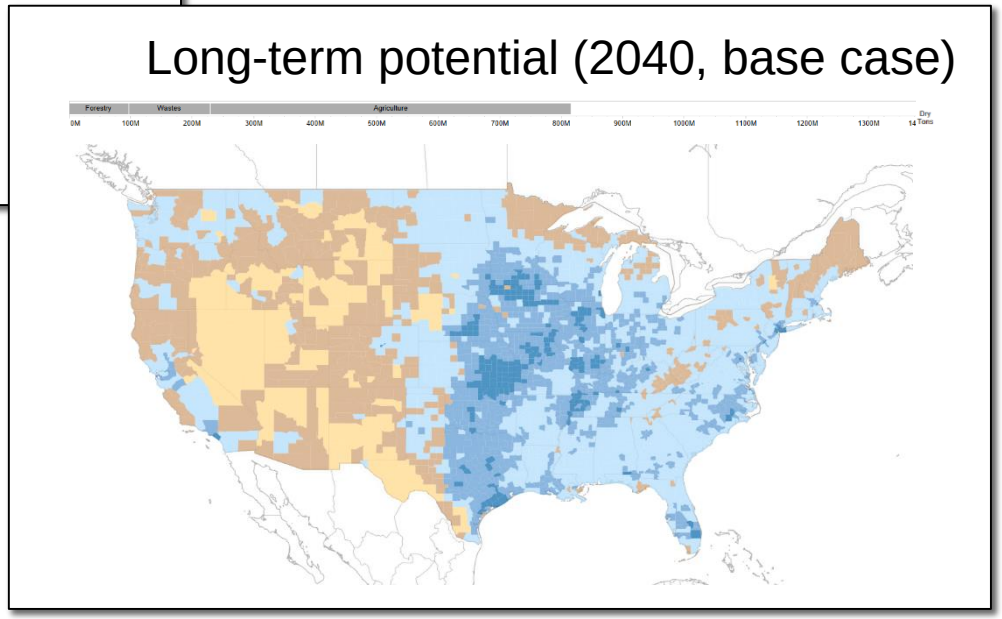
Energy crops, High yield	2017	2040
	(million dry tons)	
Miscanthus	-	369.6
Switchgrass	-	188.7
Poplar	-	74.5
Willow	-	65.1
Biomass sorghum	-	30.8
Energy cane	-	5.2
Eucalyptus	-	2.1
Pine	-	0.2
Total	-	**736**

Supplies increase with price; energy crops increase with time



Supplies vary spatially and temporally

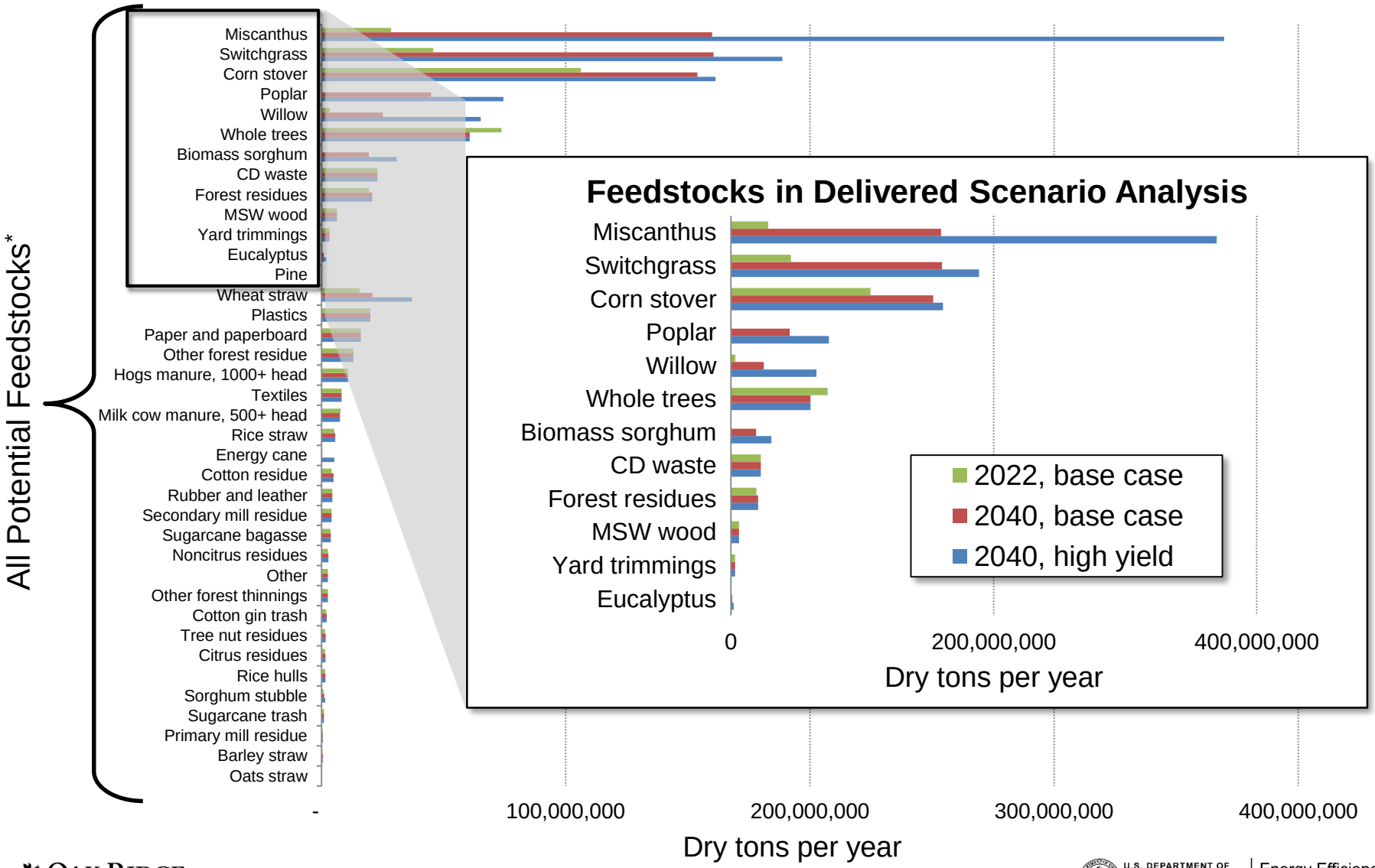




Dry tons/year

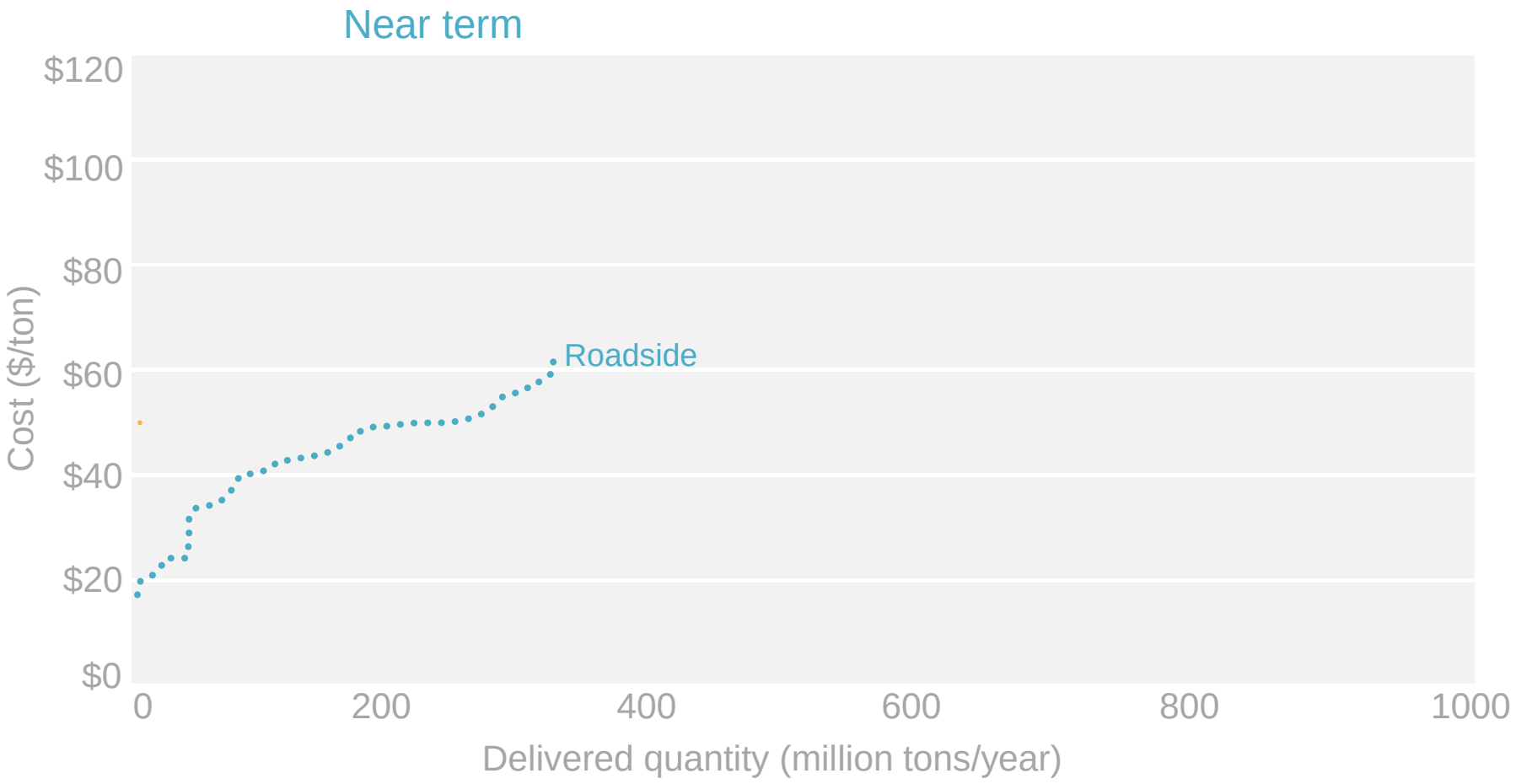
- Less than 10 dt/SqMile
- 10-100 dt/SqMile
- 100-500 dt/SqMile
- 500-1000 dt/SqMile
- Greater than 1,000 dt/SqMile

Feedstocks to the Delivered Analysis

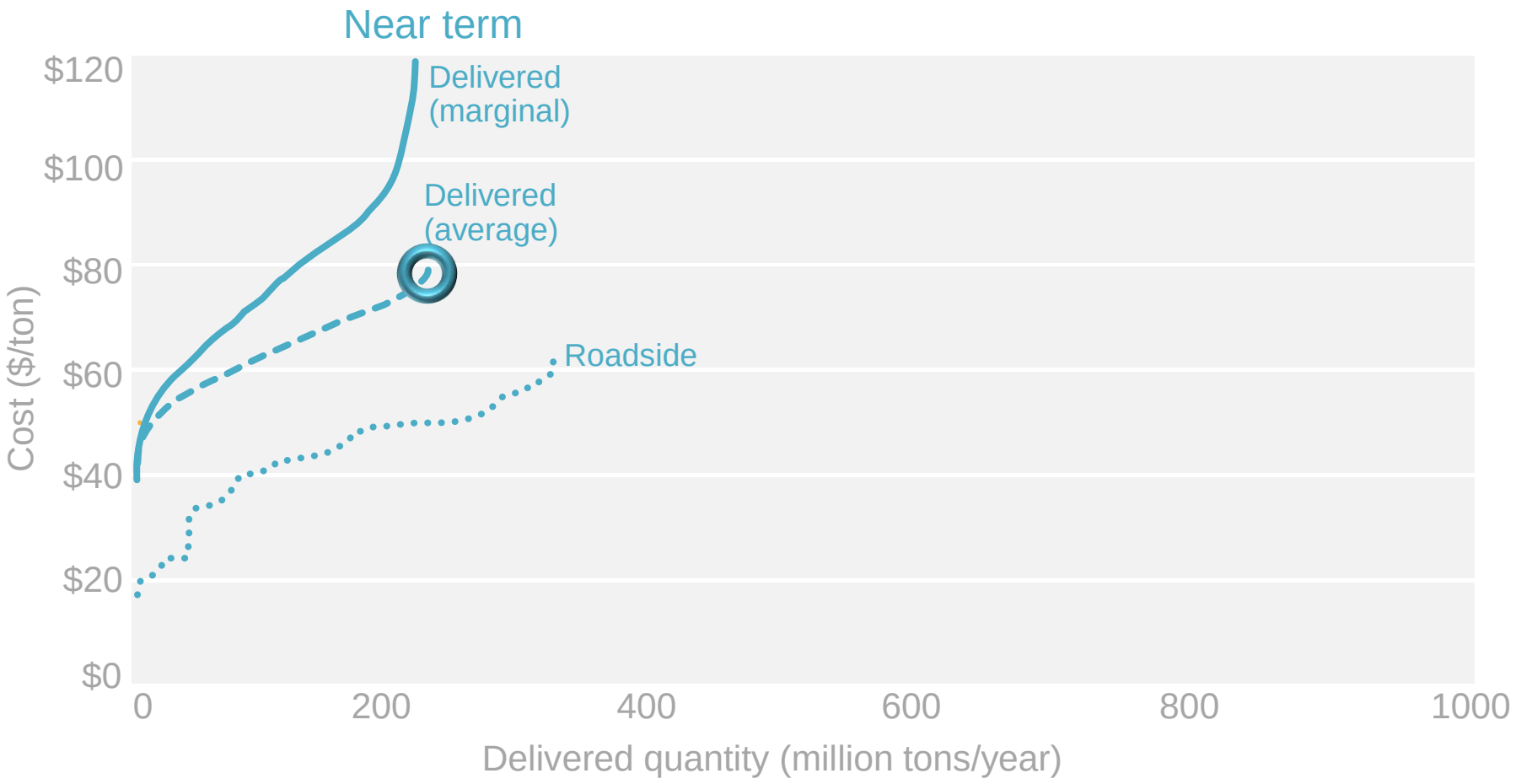


*Potentially available at up to $60/dry ton

Delivered Scenario Analysis



Delivered Scenario Analysis



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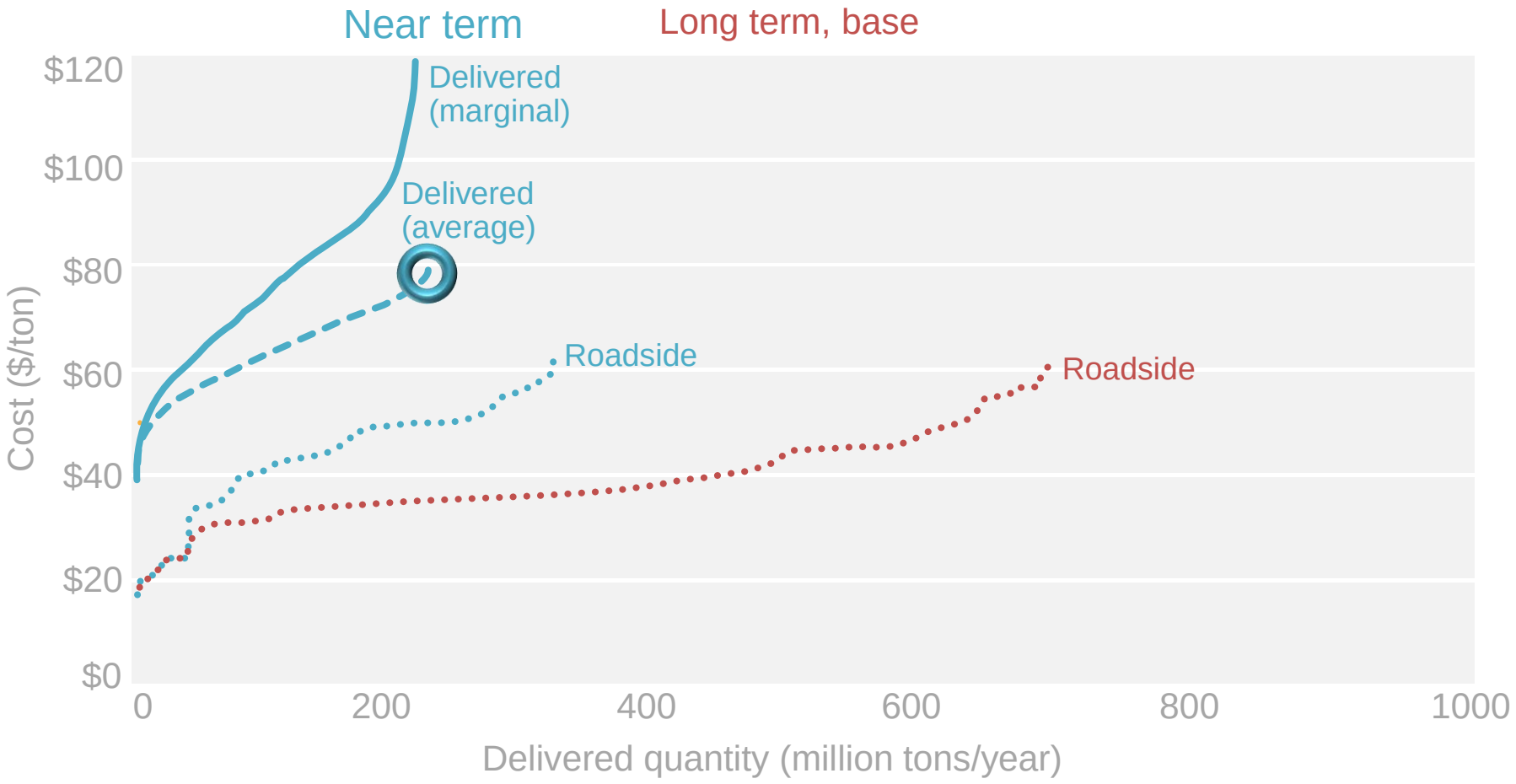
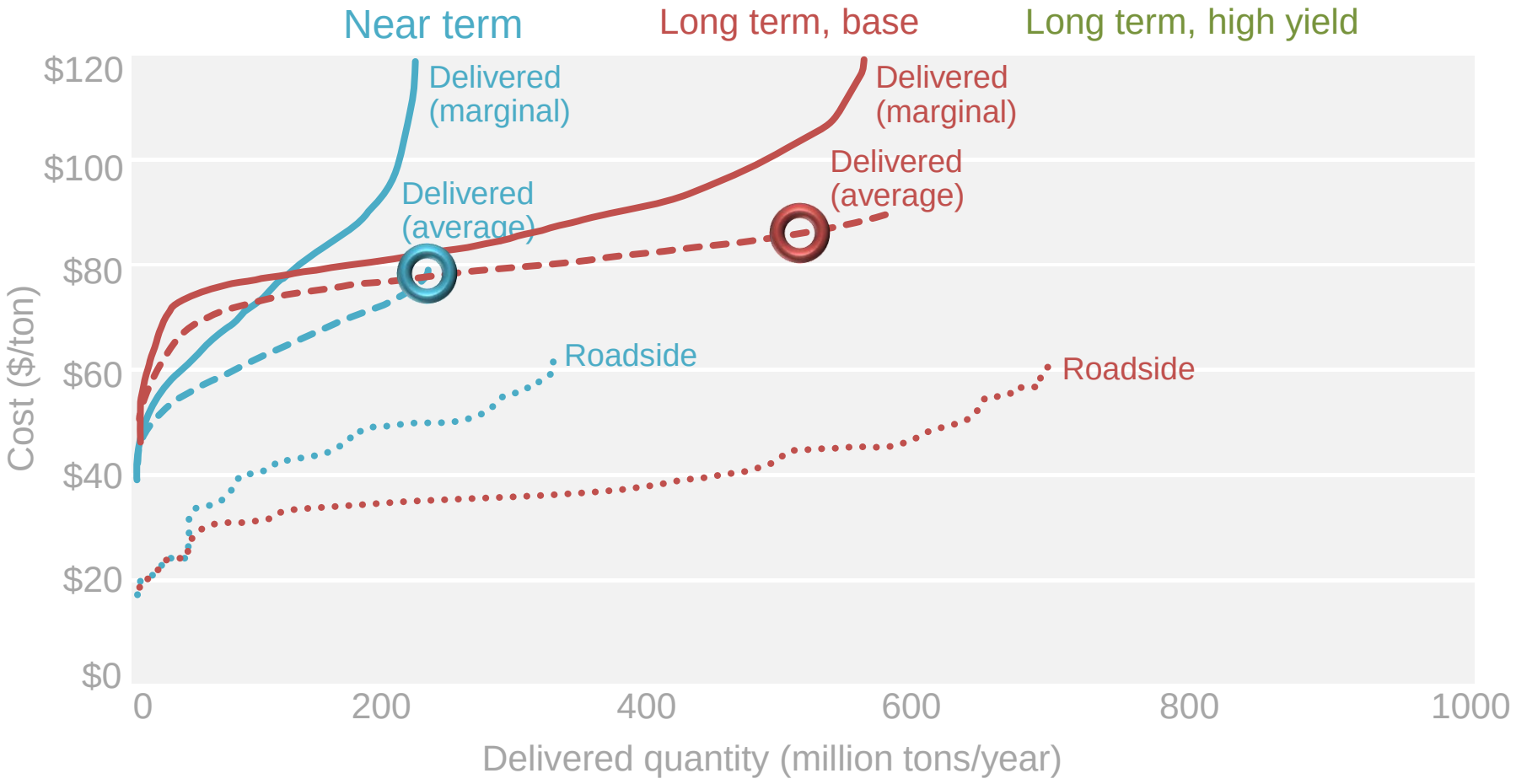


Delivered Scenario Analysis



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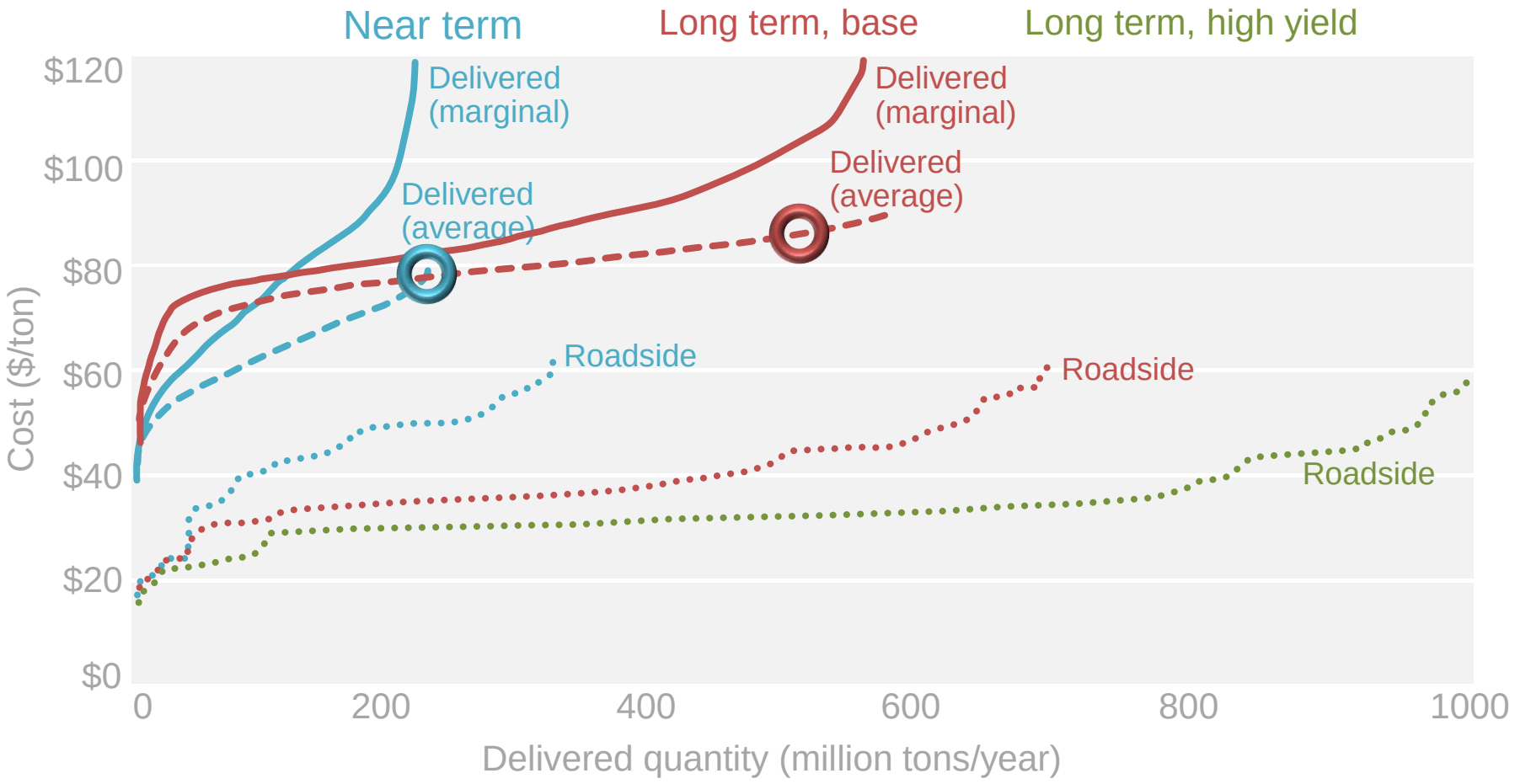

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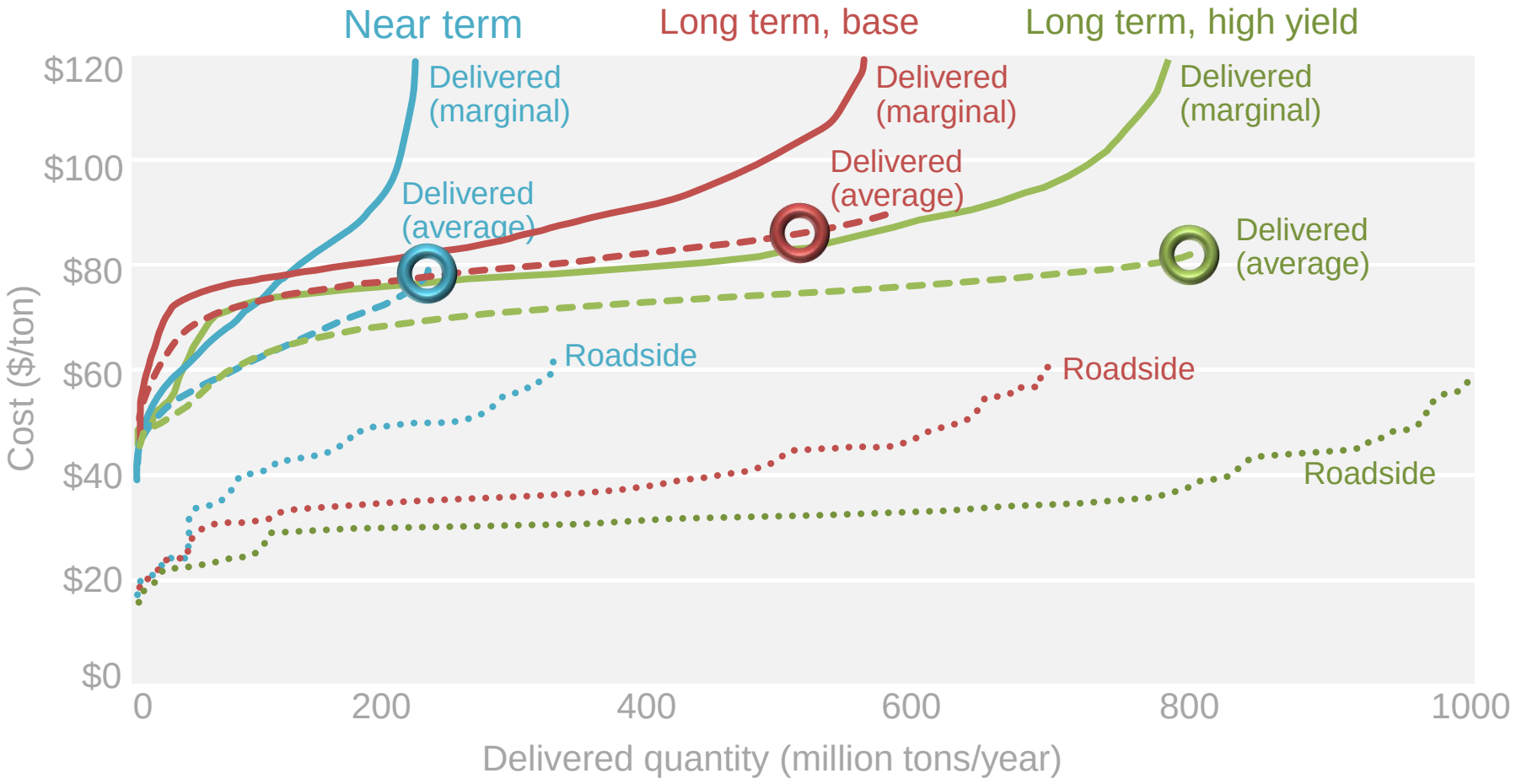

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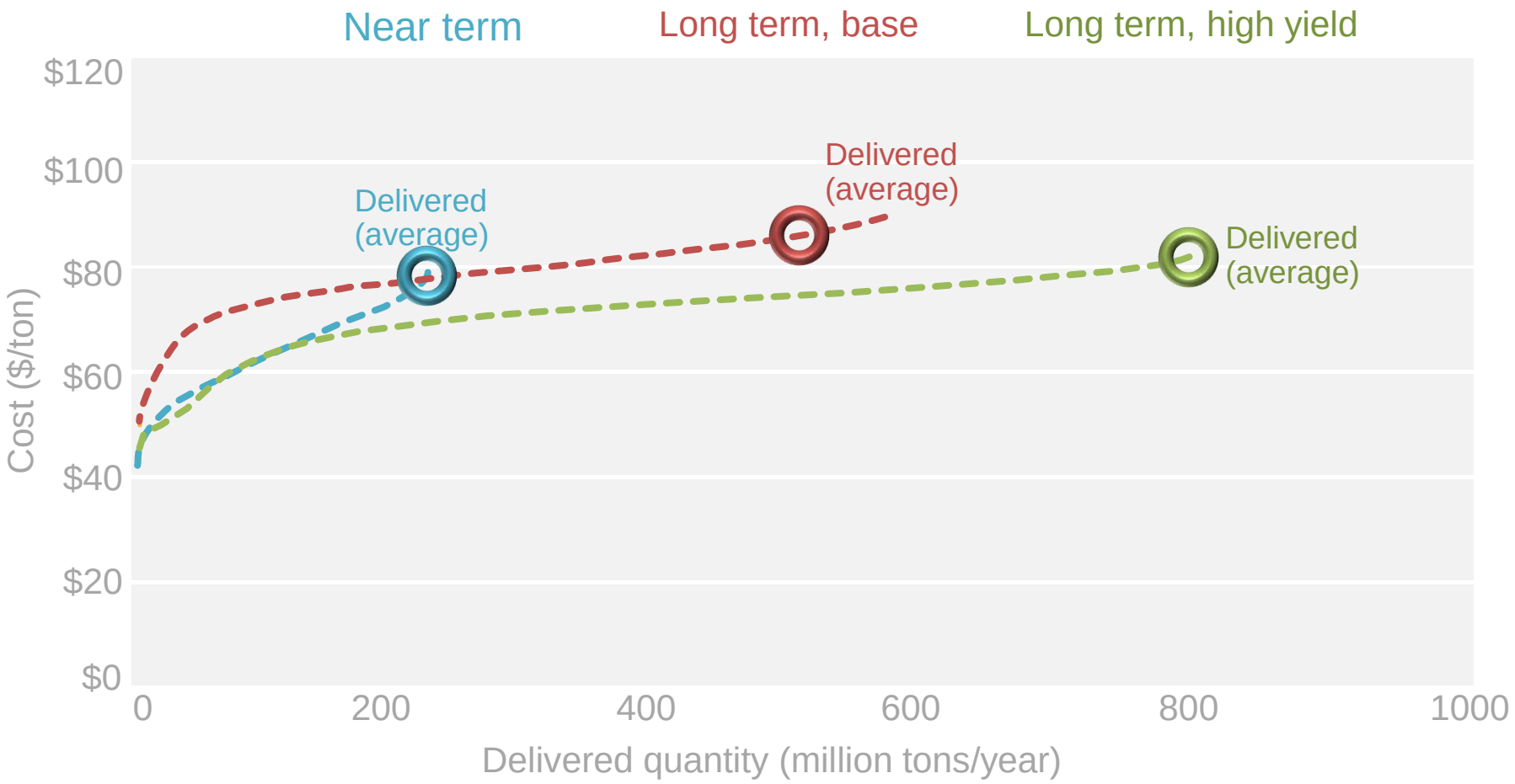
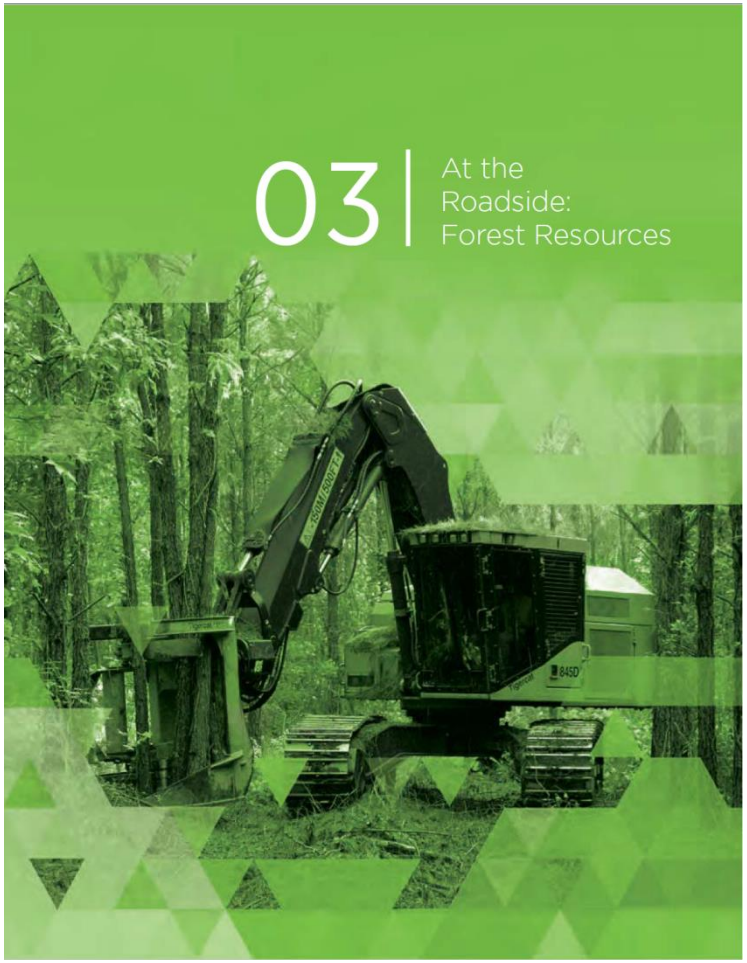


At the Roadside: Forest Resources



Contributors

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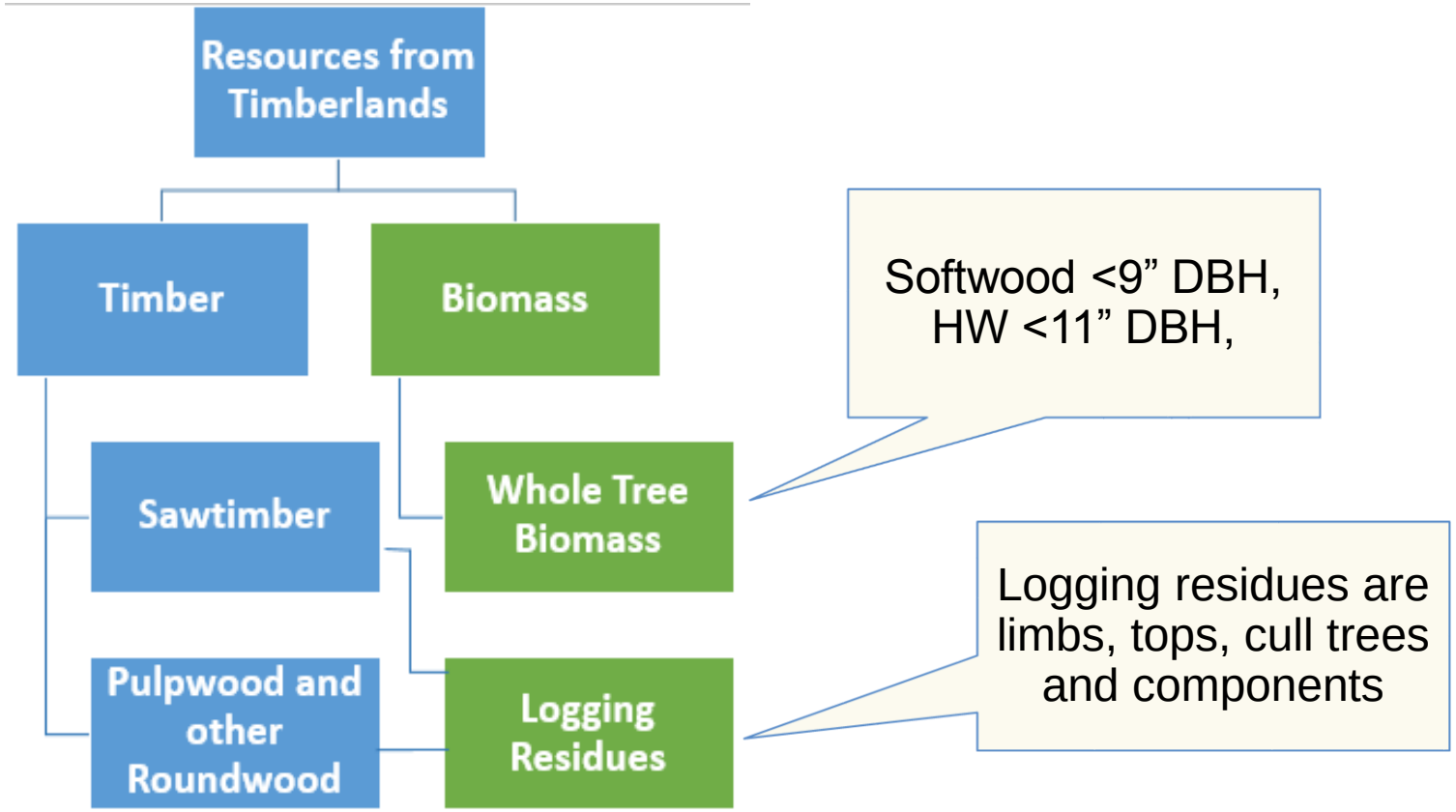
Forest Resources Scope



Forest Sustainable and Economic Analysis Model (ForSEAM)

- Modeled in competition with conventional forest products.
- Uses aggregate demand scenarios from U.S. Forest Products Module/Global Forest Products Model (USFPM/GFPM) for North, South, and West (Ince et al 2012).
- Unique harvest costs from Consortium for Research on Renewable Industrial Materials (CORRIM) for 5 regions, 5 stand types, 3 stand diameter classes, 2 silvicultural operations, 3 products, 2 harvest methods, 2 slope conditions (chap 3 page 49).

ForSEAM assumptions continued

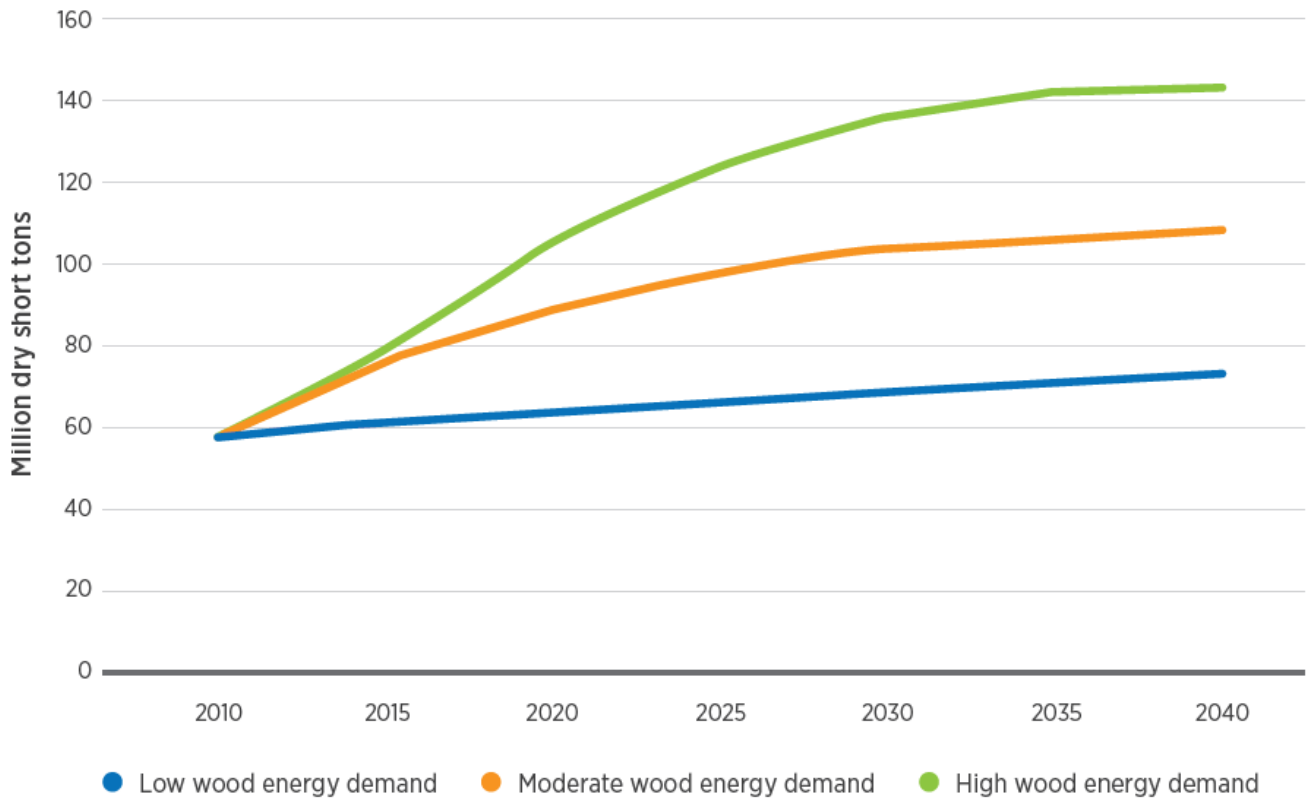
- Naturally regenerated stands not replaced with plantations.
- No residues from slopes >40% or cut-to-length systems.
- Logging residues incur 10% of harvest costs, plus chipping costs; 15% system costs added for overhead costs & BMPs.

ForSEAM scenarios

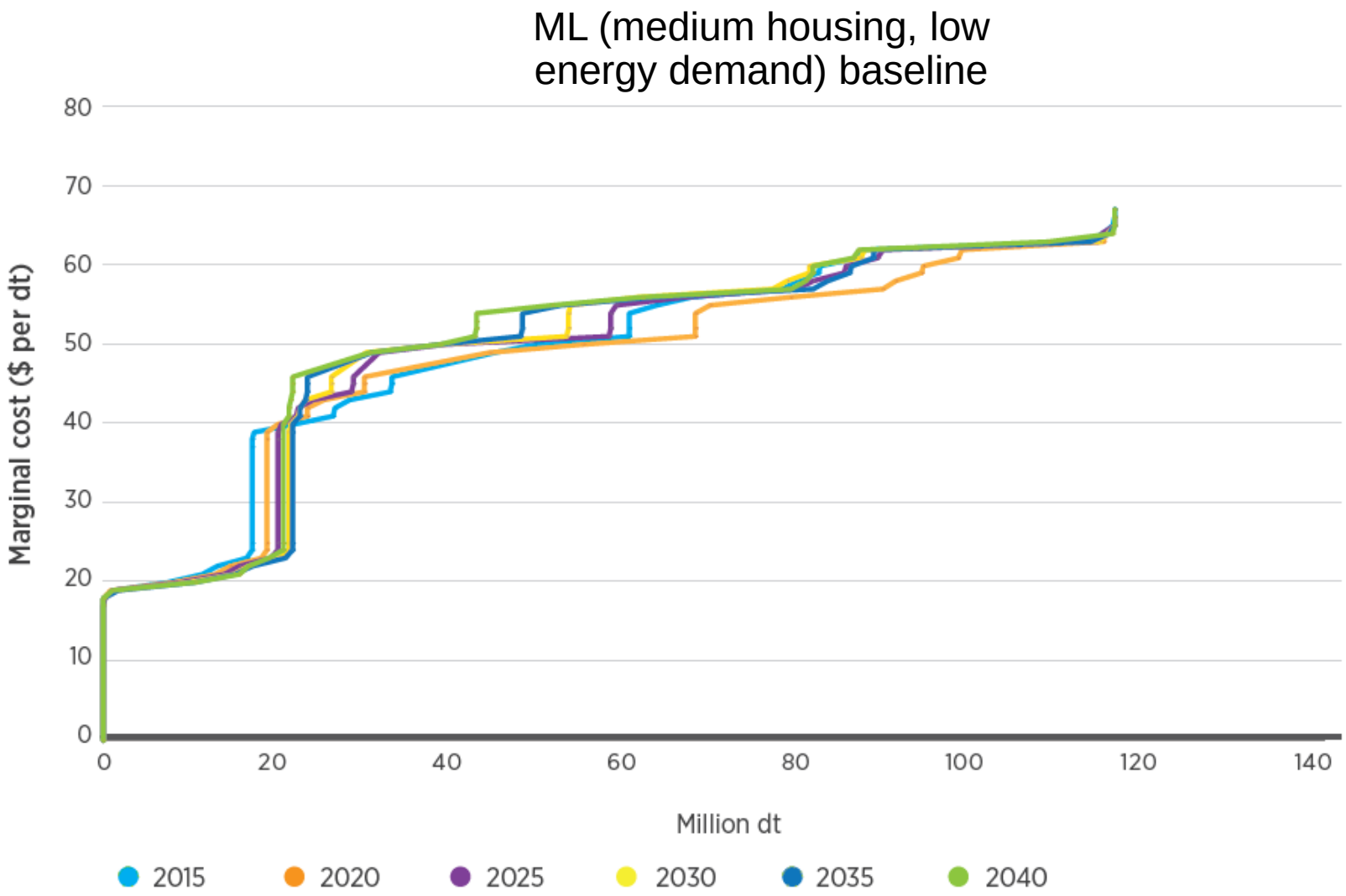
Table 3.6 | Description of Wood Energy, Housing, and Plantation Investment Scenarios

	Scenario[a]	Growth in housing starts[b]	Growth in wood biomass demand for energy[c]	New plantation management intensity in the South[d]
(ML)	Moderate housing–low wood energy (baseline)	Returns to long-term average by 2025	Increases by 26% by 2040	Based on current FIA pine plantation growth rate
(HL)	High housing–low wood energy	Adds 10% to baseline in 2025 and beyond	Increases by 26% by 2040	Based on current FIA pine plantation growth rate
(MM)	Moderate housing–moderate wood energy	Returns to long-term average by 2025	Increases by 86% by 2040	Based on current FIA pine plantation growth rate
(HM)	High housing–moderate wood energy	Adds 10% to baseline in 2025 and beyond	Increases by 86% by 2040	Based on current FIA pine plantation growth rate
(MH)	Moderate housing–high wood energy (and high plantation growth)	Returns to long-term average by 2025	Increases by 150% by 2040	Increases by 50% over current FIA growth rate by 2040
(HH)	High housing–high wood energy (and high plantation growth)	Adds 10% to baseline in 2025 and beyond	Increases by 150% by 2040	Increases by 50% over current FIA growth rate by 2040

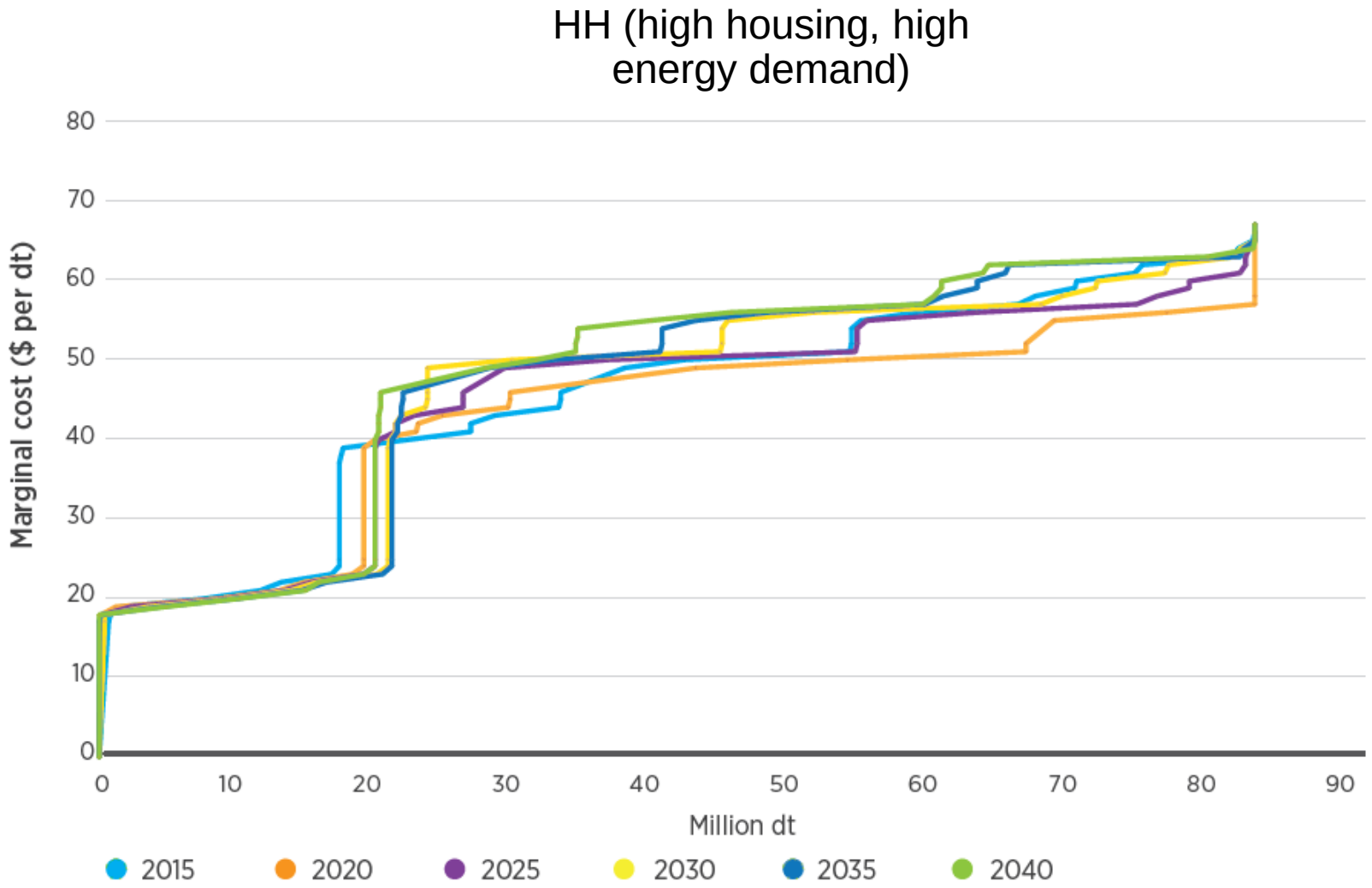
ForSEAM wood energy demand scenarios



ForSEAM Results



ForSEAM Results



ForSEAM Results

Table 3.27 | Summary of Baseline and High Forest Resources by Cost, Year, and Feedstock Type

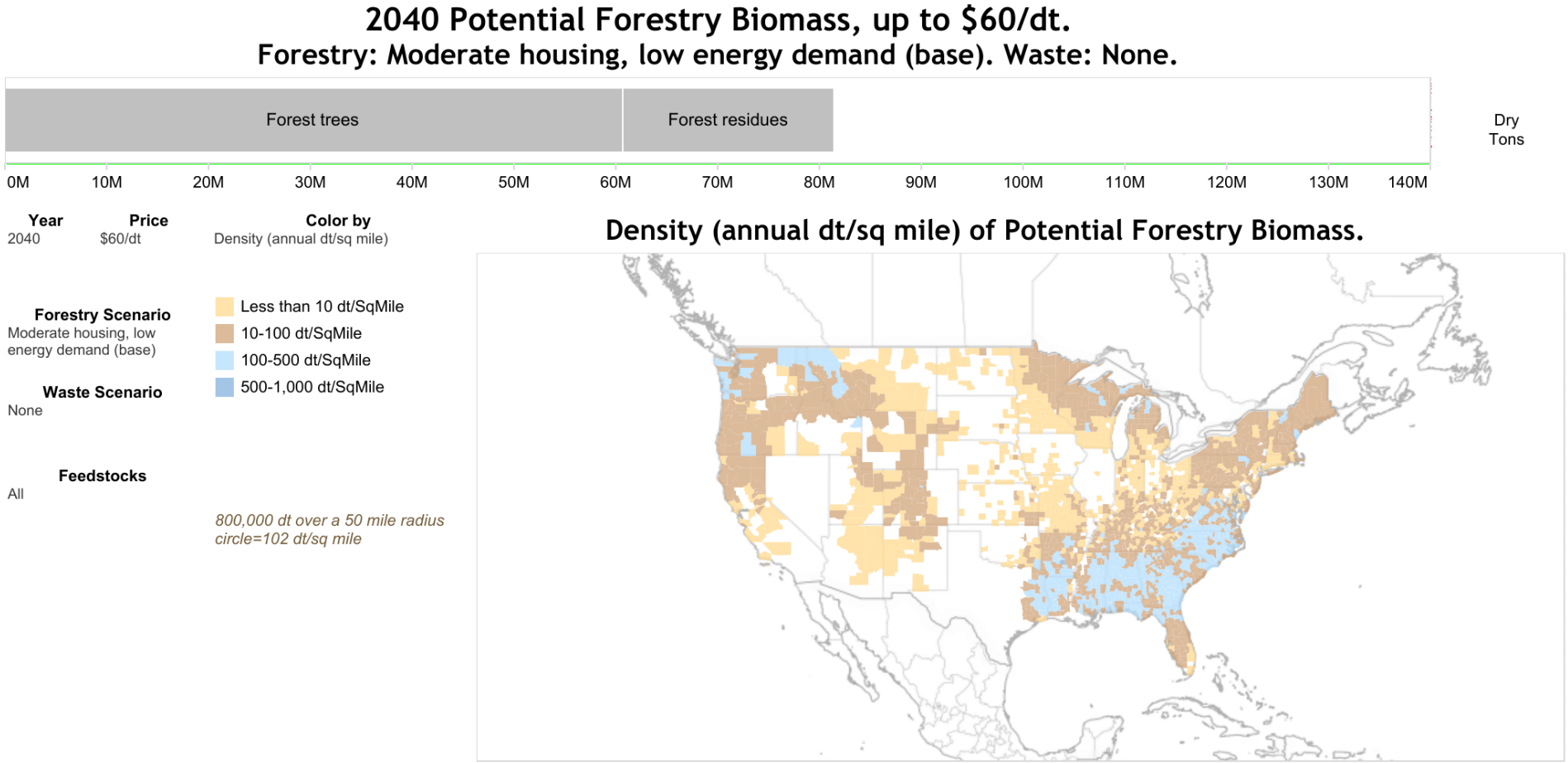
Feedstock	$40				$60				$80			
	2017	2022	2030	2040	2017	2022	2030	2040	2017	2022	2030	2040
	Million dry tons											
Baseline_ML[a] (Baseline scenario)[b]												
Logging residues	17.9	19.4	21.4	20.8	17.9	19.4	21.4	20.7	17.9	19.4	21.4	20.8
Whole-tree biomass	3.1	1.0	0.3	0.0	69.9	73.7	59.8	60.7	98.1	96.6	94.6	95.2
Total: Baseline	**21.0**	**20.5**	**21.7**	**20.8**	**87.8**	**93.1**	**81.1**	**81.5**	**116.0**	**116.0**	**116.0**	**116.0**
HH[c] (High-yield scenario)												
Logging residues	18.0	19.3	20.7	19.9	18.0	19.3	20.7	19.8	18.0	19.3	20.7	19.9
Whole-tree biomass	2.7	0.7	0.1	0.0	61.3	63.7	51.0	40.7	65.0	63.7	62.3	63.1
Total: High scenario	**20.6**	**20.0**	**20.8**	**19.9**	**79.3**	**83.0**	**71.7**	**60.6**	**83.0**	**83.0**	**83.0**	**83.0**

[a]The baseline is "moderate low": Moderate growth in housing starts, plantation intensity, paper, and foreign demand and low growth in biomass for energy.

[b]Baseline_ML is comparable to the base-case scenario in chapter 4.

[c]The HH scenario is "high high" scenario: high growth in housing starts and planation intensity, moderate growth in paper and foreign demand, and high growth in biomass for energy. HH does not produce the most biomass because there was no conversion of natural stands to plantations in the model. HH is comparable to the high-yield scenario for agriculture at 3% in chapter 4.

Base-case scenario: $60 offered price, forestry resources, year 2040



Please cite as: U.S. Department of Energy. 2016. 2016 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/TM-2016/160. Oak Ridge National Laboratory, Oak Ridge, TN. 448p. doi: 10.2172/1271651.

Accessed: https://www.bioenergykdf.net/billionton2016/3/1/tableau

100 million tons in context of USDA FS data

Million dry tons, 2012, timberland

	All US, HW and SW	South Softwood only
Volume	17,956	2,128
Growth	486	145
Removals	231	88
Mortality	214	21
Growth minus (removals+mortality)	41	37

Data source: Oswalt, S. Smith, B., 2014. *USDA Forest Service Resource Facts and Historical Trends.* USDA Forest Service. Assumes 33 and 43 bone-dry pounds per cubic foot for softwood and hardwood respectively.

Growing Stock Volume, 2011/2012, USDA Forest Service Forest Inventory and Analysis Data

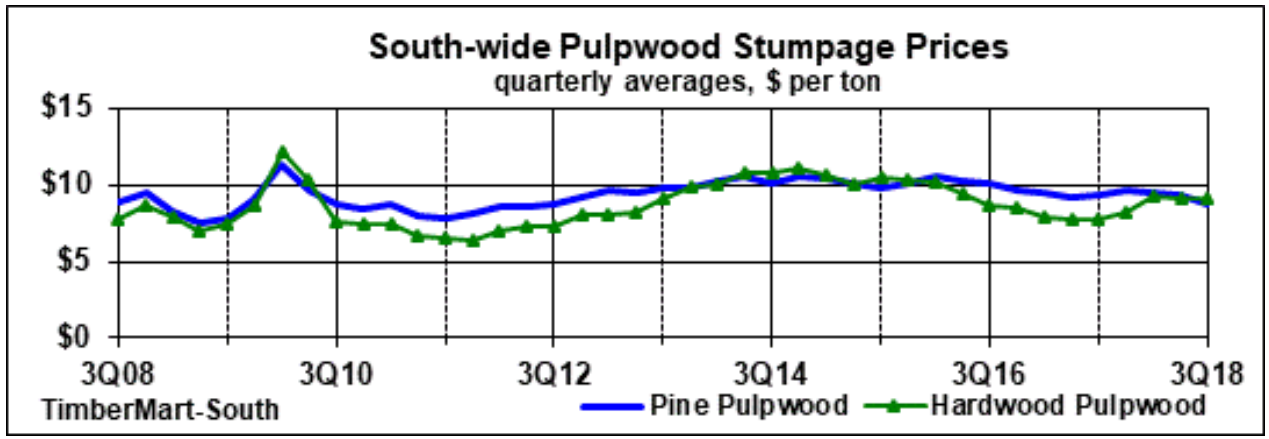
Oswalt, S. Smith, B., 2014. *USDA Forest Service Resource Facts and Historical Trends.* USDA Forest Service. https://www.fia.fs.fed.us/library/brochures/docs/2012/ForestFacts_1952-2012_English.pdf

Growing Stock Volume

U.S. timber land growing stock inventory, growth, removals, and mortality, by region and species group, 1952–2012.

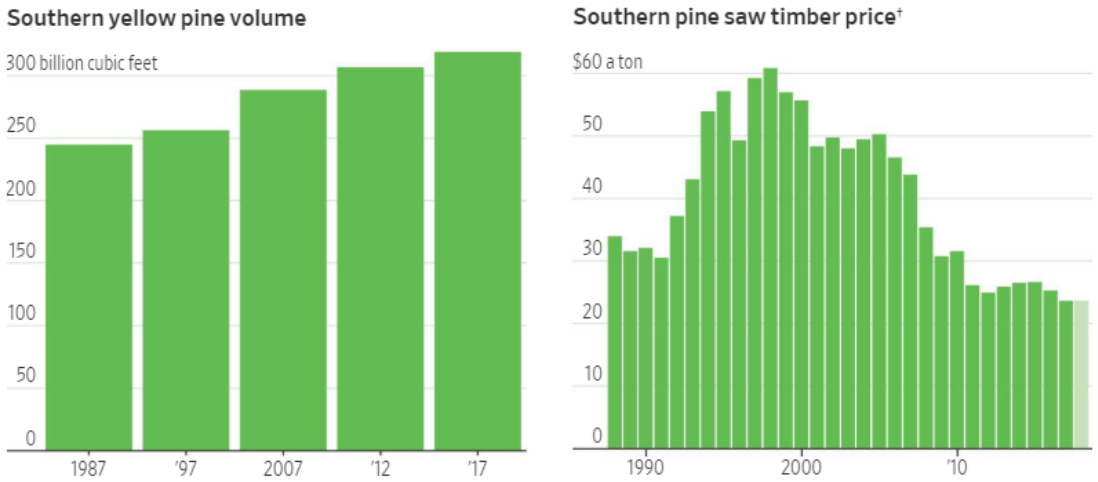
Volume category	Year	Region			
		U.S.	North	South	West
All species			*Million cubic feet*		
Inventory	2012	972,395	267,803	306,623	397,968
	2007	932,089	248,005	288,521	395,563
	1997	835,669	214,246	256,359	365,063
	1987	781,656	190,038	244,641	346,977
	1977	733,056	163,008	223,373	346,675
	1963	665,600	128,288	174,072	363,240
	1953	615,884	103,748	148,470	363,666
Growth	2011	26,413	6,516	13,809	6,088
	2006	26,744	6,576	13,272	6,896
	1996	23,577	5,420	10,712	7,445
	1986	22,636	5,512	9,986	7,138
	1976	21,237	5,349	11,323	4,565
	1962	16,705	4,424	8,093	4,188
	1952	13,910	3,716	6,683	3,511

Other indications of abundant forestland resources



Source:
www.wsj.com
Oct 9th, 2018

=5 billion dry tons.
(×2%=100 million tons)

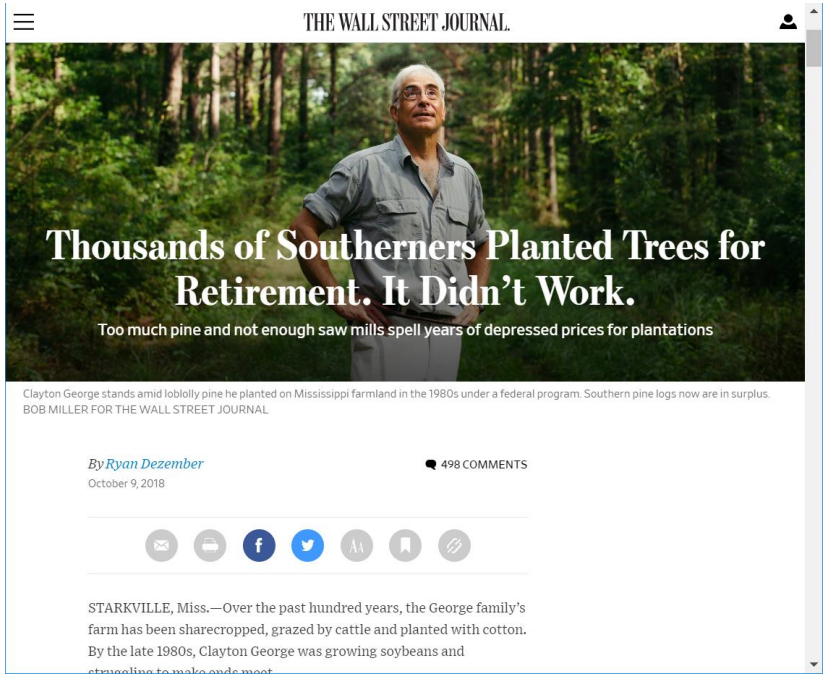


*Seasonally adjusted annual rate †adjusted for inflation, 2018 price for second quarter

Sources: FactSet (lumber price); Commerce Department via St. Louis Fed (housing starts); U.S. Agriculture Department (volume); Daowei Zhang, Auburn University School of Forestry & Wildlife Sciences, 2018 prices TimberMart-South (Southern timber prices)

Sources: http://www.timbermart-south.com/prices.html
www.wsj.com Oct 9th, 2018

Indications of abundant forestland resources



THE WALL STREET JOURNAL.

Thousands of Southerners Planted Trees for Retirement. It Didn't Work.

Too much pine and not enough saw mills spell years of depressed prices for plantations

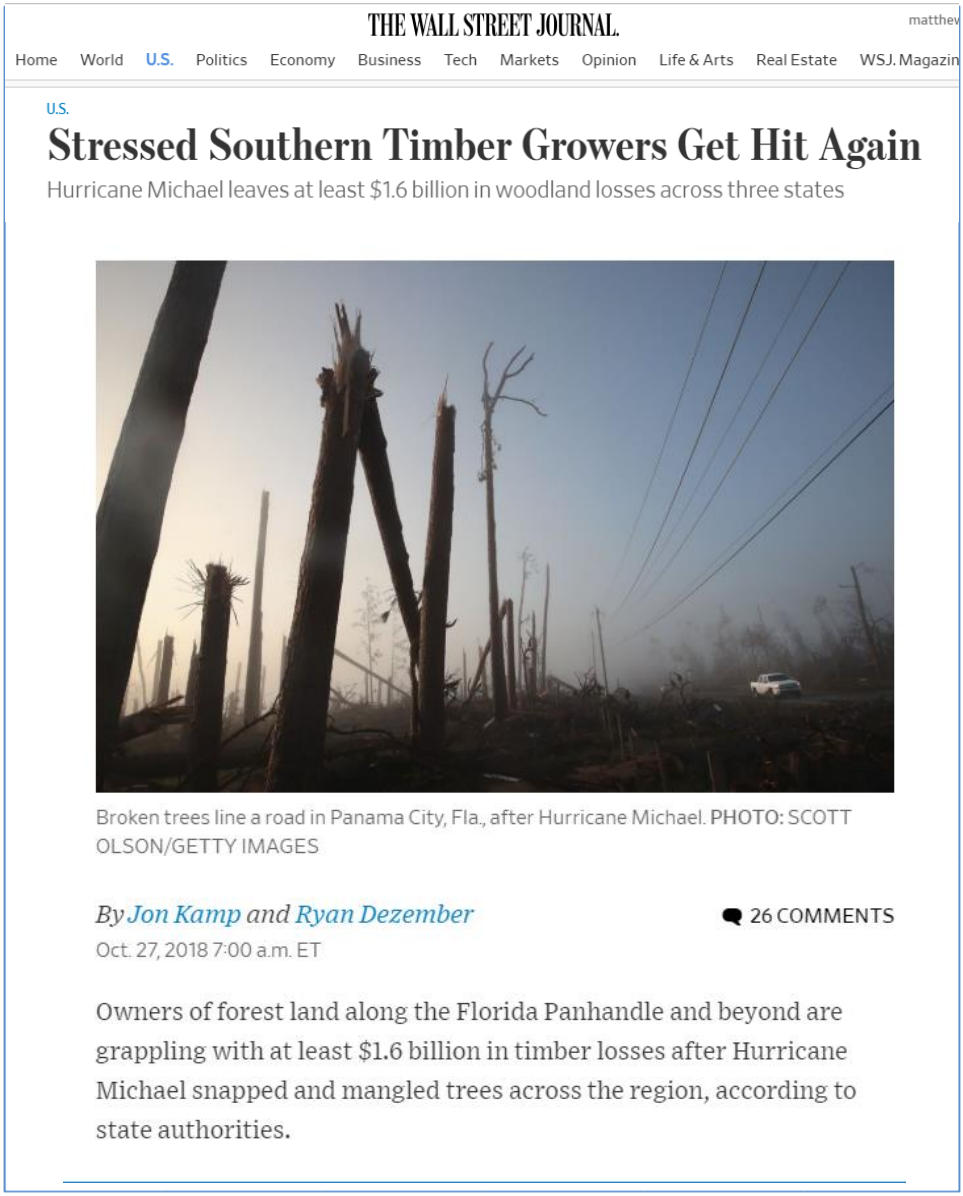
Clayton George stands amid loblolly pine he planted on Mississippi farmland in the 1980s under a federal program. Southern pine logs now are in surplus.
BOB MILLER FOR THE WALL STREET JOURNAL

By Ryan Dezember
October 9, 2018

498 COMMENTS

STARKVILLE, Miss.—Over the past hundred years, the George family's farm has been sharecropped, grazed by cattle and planted with cotton. By the late 1980s, Clayton George was growing soybeans and

www.wsj.com Oct 9th, 2018



THE WALL STREET JOURNAL.

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U.S.

Stressed Southern Timber Growers Get Hit Again

Hurricane Michael leaves at least $1.6 billion in woodland losses across three states

Broken trees line a road in Panama City, Fla., after Hurricane Michael. PHOTO: SCOTT OLSON/GETTY IMAGES

By Jon Kamp and Ryan Dezember

26 COMMENTS

Oct. 27, 2018 7:00 a.m. ET

Owners of forest land along the Florida Panhandle and beyond are grappling with at least $1.6 billion in timber losses after Hurricane Michael snapped and mangled trees across the region, according to state authorities.

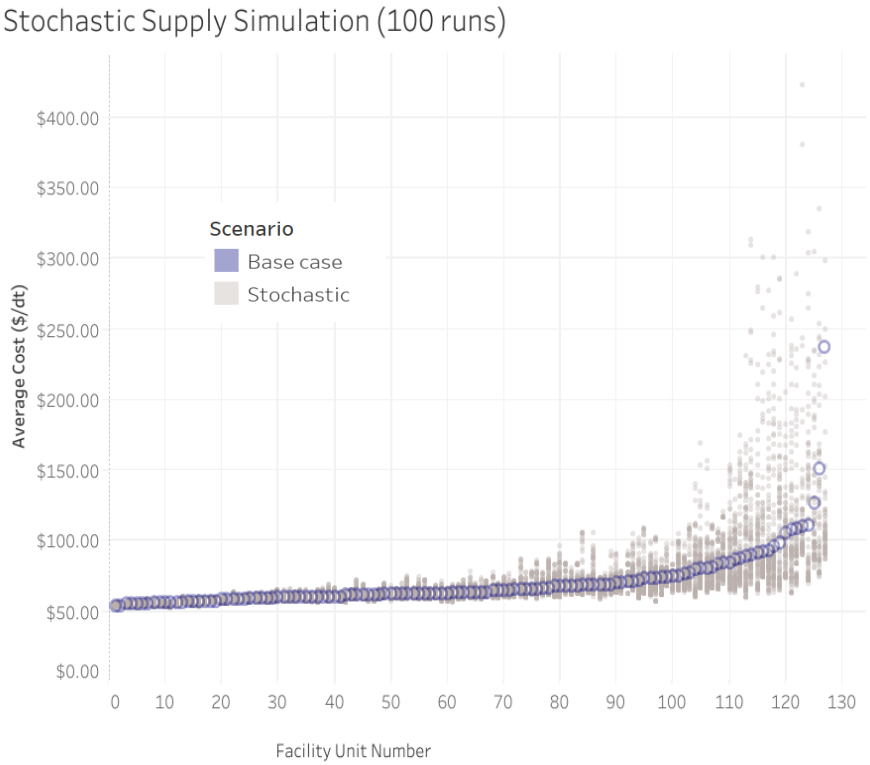
www.wsj.com Oct 27th, 2018

OAK RIDGE National Laboratory

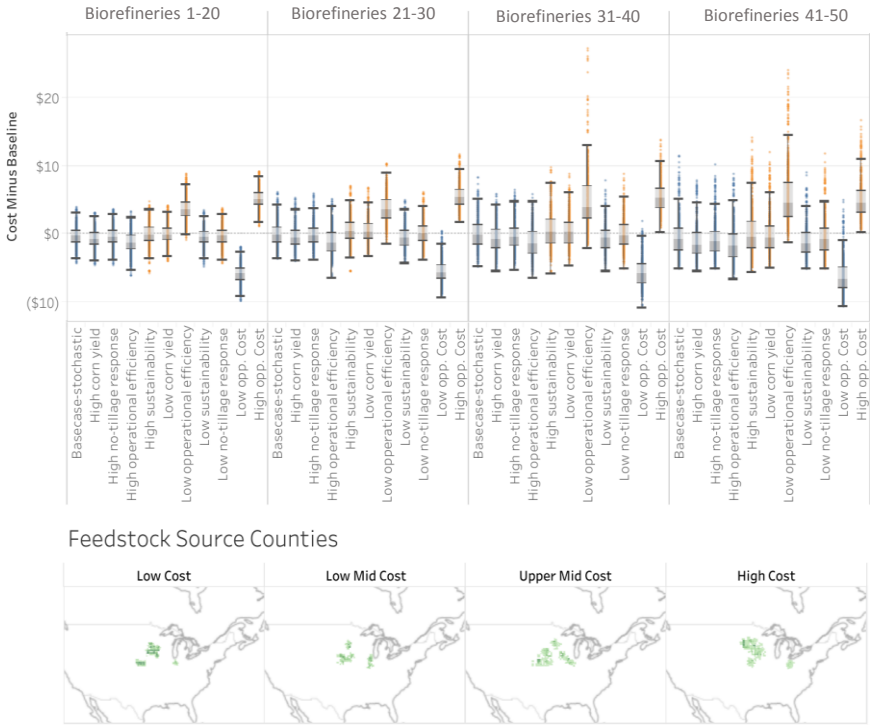
Feedstock price and risk

Feedstock price risk can increase with the number of biorefineries of corn stover (submitted) and energy crops under conventional and advanced logistic systems (in preparation).

Corn stover delivered price, base case deterministic and stochastic:



Corn stover delivered price, stochastic scenarios, difference from the base case:



Key messages

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 resources

http://bioenergykdf.net/billionton