

# U.S. BIOMASS AS FEEDSTOCK FOR A BIOENERGY AND BIOPRODUCTS INDUSTRY: AN UPDATE TO THE BILLION-TON ANNUAL SUPPLY

**Bob Perlack –  
Oak Ridge National Laboratory**

**Bryce Stokes –  
CNJV (DOE Golden Field Office)**

**and Others**

**June 2011**



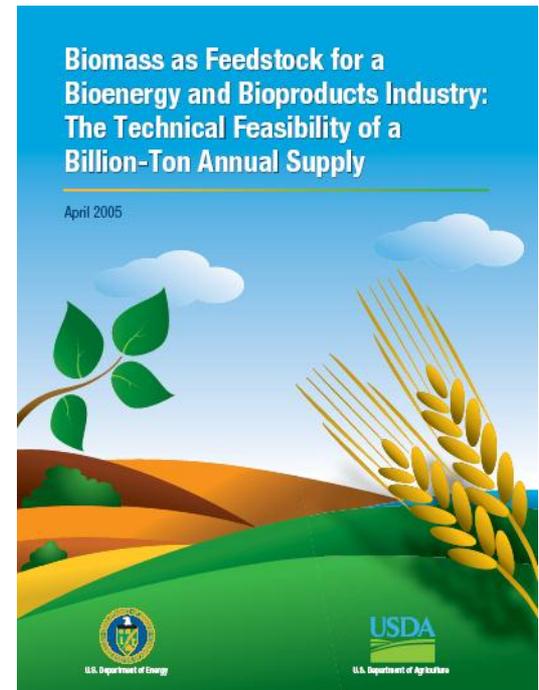
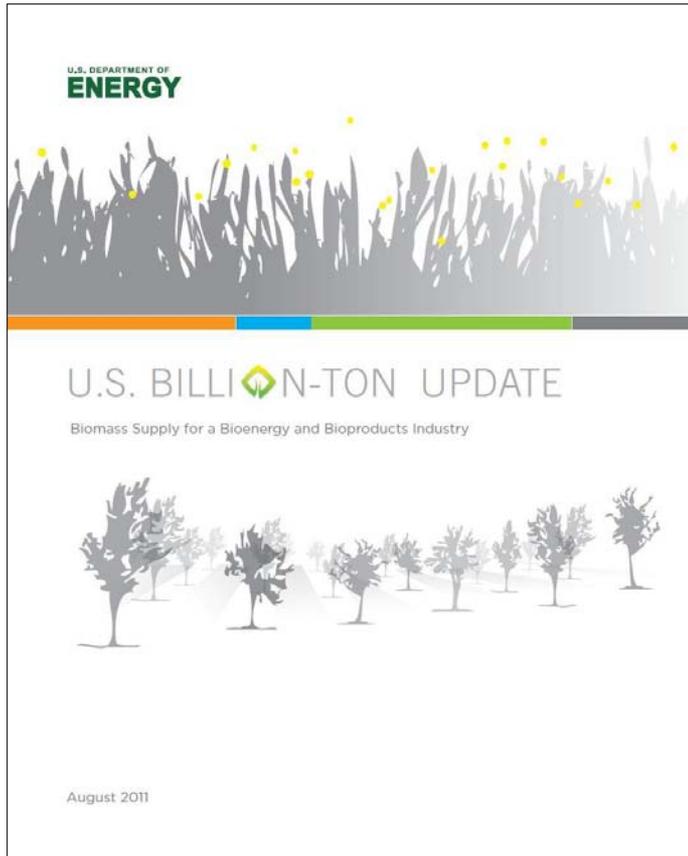
# WHAT IS THE 2005 BILLION TON STUDY?

- **First national assessment of agricultural and forestry biomass resources potentially available for energy production**
- **Heralded as a seminal report that**
  - **provided evidence of a real and substantial resource**
  - **nudged federal government policy shifts**
  - **accelerated renewable fuels policies**
- **Cited numerous times and subject of many commentaries, several theses and dissertations, and even a workshop**

# WHAT IS THE 2005 BILLION TON STUDY (Continued)?

- **Scrutinized in detail**
- **Criticized as**
  - **too conservative/optimistic**
  - **unrealistic without economics and sustainability criteria**
  - **missed the mark on some technical assumptions**
  - **confusion over currently used biomass**
- **Often debated but generally accepted as starting point for further analysis**

# BILLION-TON RESOURCE ASSESSMENT



- Review original study
- Preview Billion-Ton Update:
  - Scope of study
  - Analyses approach
  - Summary results

# CONTRIBUTORS

## *Oak Ridge National Laboratory*

**Robert D. Perlack\***  
Craig C. Brandt  
Anthony F. Turhollow  
Lynn L. Wright  
Laurence M. Eaton  
Anna M. Shamey  
Jacob M. Kavkewitz  
Matt H. Langholtz  
Mark E. Downing  
Robin L. Graham

## *Idaho National Laboratory*

David J. Muth  
J. Richard Hess  
Jared M. Abodeely

## *Kansas State University*

Richard G. Nelson

## *State University of New York*

Timothy A. Volk  
Thomas S. Buchholz  
Lawrence P. Abrahamson

## *Iowa State University*

Robert P. Anex

## *CNVJ LLC*

**Bryce J. Stokes\***

## *University of Tennessee*

Chad Hellwinckel  
Daniel De La Torre Ugarte  
Daniel C. Yoder  
James P. Lyon  
Timothy G. Rials

## *USDA Agricultural Research Service*

Douglas L. Karlen  
Jane M. F. Johnson  
Robert B. Mitchell  
Kenneth P. Vogel  
Edward P. Richard  
John Tatarko  
Larry E. Wagner

## *University of Minnesota*

William Berguson  
Don E. Riemenschneider

## *Texas A&M University*

William L. Rooney

## *USDA Forest Service*

Kenneth E. Skog,  
Patricia K. Lebow  
Dennis P. Dykstra  
Marilyn A. Buford  
Patrick D. Miles  
D. Andrew Scott  
James H. Perdue  
Robert B. Rummer  
Jamie Barbour  
John A. Stanturf  
David B. McKeever  
Ronald S. Zalesny  
Edmund A. Gee

## *USDA National Institute of Food and Agriculture*

P. Daniel Cassidy

## *USDA Natural Resources Conservation Service*

David Lightle

## *University of Illinois*

Thomas B. Voigt

**\* Co-leads**

# ENERGY CROP BACKGROUND AUTHORS

## *Willow*

Lawrence P. Abrahamson, Ph.D. – Senior Research Associate, State University of New York, College of Environmental Science and Forestry, Syracuse, NY

Timothy A. Volk, Ph.D. – Senior Research Associate, State University of New York, College of Environmental Science and Forestry, Syracuse, NY

## *Eucalyptus*

Matt H. Langholtz, Ph.D. – Economist, Oak Ridge National Laboratory, Bioenergy Resource and Engineering Systems Group, Environmental Sciences Division, Oak Ridge, TN

## *Switchgrass and Other Perennial Grasses*

Robert B. Mitchell, Ph.D. – Research Agronomist, USDA Agricultural Research Services, Grain, Forage & Bioenergy Research Unit, Lincoln, NB

Kenneth P. Vogel, Ph.D. – Supervisory Research Geneticist, USDA Agricultural Research Services, Grain, Forage & Bioenergy Research Unit, Lincoln, NB

## *Sugarcane*

Edward P. Richard Jr., Ph.D. – Research Leader, USDA Agricultural Research Services, Sugarcane Research Unit, Houma, LA

## *Sorghum*

William L. Rooney, Ph.D. – Professor, Texas A&M University, Department of Soil and Crop Sciences, College Station, TX

## *Giant Miscanthus*

Thomas B. Voigt, Ph.D. – Extension Specialist, University of Illinois, Department of Crop Sciences, Urbana, IL

## *Southern Pines*

Lynn L. Wright – Consultant, Oak Ridge National Laboratory, Bioenergy Resource and Engineering Systems Group, Environmental Sciences Division, Oak Ridge, TN

# REVIEWERS

## ***Dr. Harry Baumes***

Director  
Office of Energy Policy and New  
Uses

## ***U.S. Department of Agriculture***

Washington, DC

## ***Dr. Mary Bohman***

Division Director, Resource and  
Rural Economics Division  
Economics Research Service

## ***U.S. Department of Agriculture***

Washington, DC

## ***Dr. Craig Frear***

Bioproducts Specialist, Biological  
Systems Engineering

## ***Washington State University***

Pullman, WA

## ***Dr. Göran Berndes***

Leader, International Energy  
Agreement Bioenergy Task 43  
and Docent

Department of Energy and  
Environment

## ***Chalmers University of Technology***

Gothenburg, Sweden

## ***Dr. Bryan Jenkins***

Professor  
Biological & Agricultural  
Engineering

## ***University of California***

Davis, CA

## ***Dr. Alan Lucier***

Senior vice President

## ***National Council on Air and Stream Improvement***

Research Triangle Park, NC

## ***Dr. Ken Moore***

Professor  
Department of Agronomy

## ***Iowa State University***

Ames, IA

## ***Jim Richardson***

Leader (Retired), International  
Energy Agreement Bioenergy  
Task 31

## ***J. Richardson Consulting***

Ottawa, ON, Canada

## ***Dr. V. Alaric Sample***

President

## ***Pinchot Institute for Conservation***

Washington, DC

## ***David Sjoding***

Renewable Energy Specialist

## ***Washington State University***

Olympia, WA

## ***Dr. David Wear***

Project Leader  
Southern Research Station

## ***U.S. Forest Service***

Research Triangle Park, NC



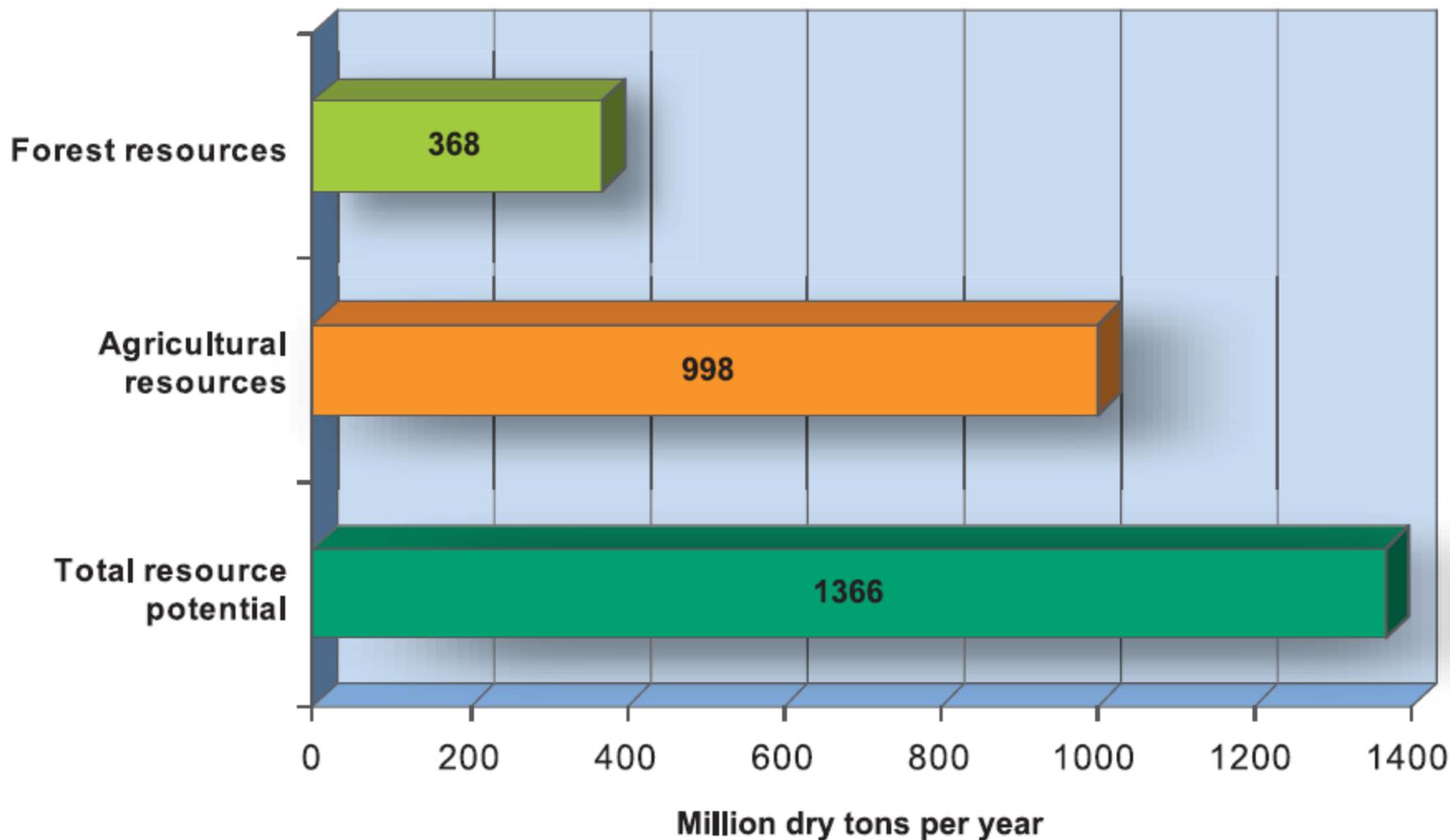
# BIOMASS FEEDSTOCK RESOURCE BASE

- About one-half of the land in the contiguous U.S.
  - Forestland resources: 504 million acres of timberland, 91 million acres of other forestland
  - Agricultural resources: 342 million acres cropland, 39 million acres idle cropland, 68 million acres cropland pasture
- Forest resources
  - Logging residues
  - Forest thinnings (fuel treatments)
  - *Conventional wood*
  - Fuelwood
  - Primary mill residues
  - Secondary mill residues
  - Pulping liquors
  - Urban wood residues
- Agricultural resources
  - Crop residues
  - Grains to biofuels
  - Perennial grasses
  - Perennial woody crops
  - Animal manures
  - Food/feed processing residues
  - MSW and landfill gases
  - *Annual energy crop*

Added  
in 2011  
Update

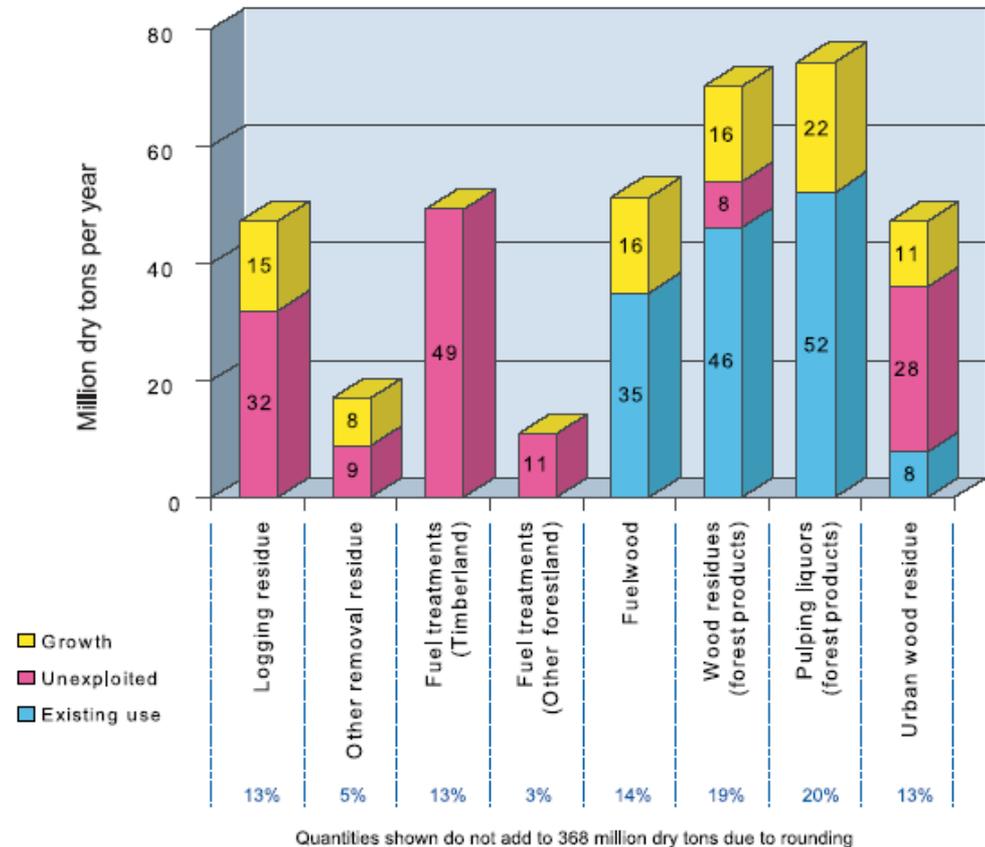
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in 2011  
Update

# 2005 BILLION TON ASSESSMENT



# WHAT WAS THE U.S. FORESTLAND BIOMASS POTENTIAL IN THE 2005 BTS?

- **Forestland residue potential is about 370 million dry tons**
  - Most currently used biomass comes from forestlands
  - Unused primary sources easily exceed 100 million dry tons (logging, other removals, & fuel treatment thinnings)
  - Conservative assumptions based on accessibility, recoverability, and merchantability

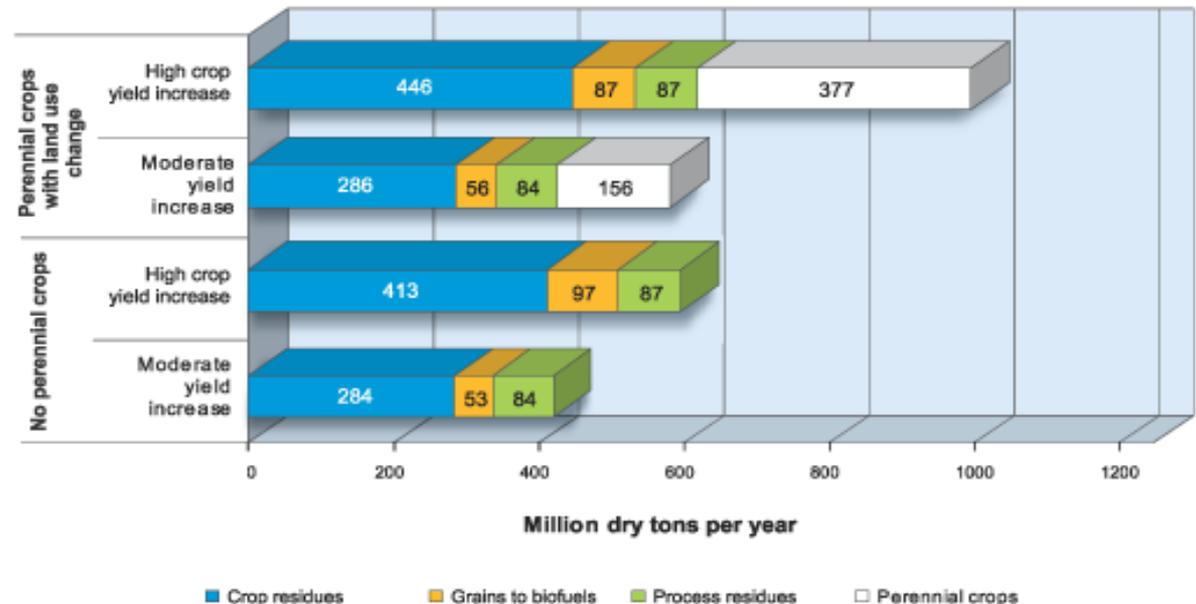


Note: no scenarios; differentiated current, potential, and growth for types of woody feedstocks

# WHAT WAS THE U.S. CROPLAND BIOMASS POTENTIAL IN THE 2005 BTS?

- Total cropland resource approaches 1 billion dry tons/year including perennial energy crops
  - Continuation in yield growth trend for corn and small grains
  - Shift to conservation tillage and no-till
  - Improvements in residue collection equipment
  - Perennial energy crops (40 - 60 million acres)

Note: yield and land use change scenarios; inclusion/exclusion of “perennial” crops at selected acreage



# WHAT ARE THE GOALS OF THE UPDATE?

- **To address biomass resource availability, sustainability, and costs collectively and spatially**
- **To improve the data, the methodology, and future projections**
- **To make the data and analysis transparent and available to others**
- **To address concerns and issues from the 2005 study**

# KEY DIFFERENCES BETWEEN THE 2005 STUDY AND THE BILLION-TON UPDATE

## 2005 Original

- National estimates – no spatial information
- No cost analyses
- Environmental sustainability addressed nationally
- 2005 USDA agricultural baseline and 2000 forestry RPA/TPO
- No explicit land use change modeling
- Long-term time horizon (2005, 2025 – 2050)

## 2012 Update

- County to national level
- Supply curves by feedstock by county
- Environmental sustainability included at field and stand level
- 2012 USDA agricultural baseline and 2007 forestry RPA/TPO
- Land use change modeled for energy crops
- 2012 - 2030 timeline

### KEY COMMONALITY

AN ASSESSMENT OF BIOMASS POTENTIAL UNDER A GIVEN SET OF ASSUMPTIONS AND AVAILABLE DATA

# SUMMARY OF APPROACH

- **Estimate availability and costs for major feedstocks to the farmgate or roadside**
  - Update and new data
  - Model and framework development
  - NASS, USDA Baseline, FIA, TPO, RPA, etc.
- **Resource costs**
  - Grower payments for crop residues
  - Stumpage costs for forest residues and resources
  - Production (establishment and agronomic or silviculture) costs for perennial and annual dedicated energy crops
- **Collection and harvest costs**
  - IBSAL model and INL for cropland resources
  - FRCS model for forestland resources
  - Shifted to “integrated” harvest
- **Supply curve estimation**
  - Cost-quantity by county
  - POLYSYS model (BTS2 version operating at a county-level)
  - **Forestry was exogenously completed**
    - Forest sector component in POLYSYS under development (not for BTS2)

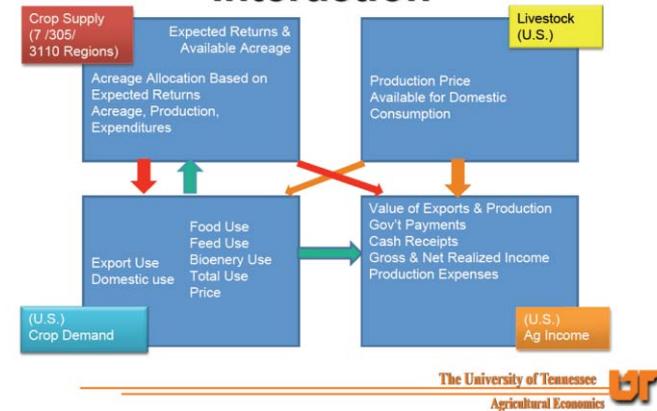
# GENERAL APPROACH

- **County feedstock supply curves for major primary cropland and forestland resources**
  - **Agricultural policy model (POLYSYS) used to estimate supply curves and land use change for crop residues and energy crops**
    - **USDA baseline forecast and projections and NASS data (yields, acres, crop prices, production, exports, etc.) to 2030**
    - **Requirements for resource sustainability – crop residue retention coefficients, tillage options, crop rotations; costs include good management practices**
    - **Energy crop yield**
  - **Resource cost analysis used to estimate supply curves (cost-quantities) for forestland resources**
    - **USDA/FS data (FIA, TPO, RPA, ...)**
    - **Forest residue access, recovery, and merchantability**
    - **Requirements for resource sustainability – land classes, residue retention, slope and stand types, no road construction**

# GENERAL APPROACH (cont.)

- **POLYSYS - dynamic model of the U.S. agricultural sector**
  - Anchored to USDA 10-year projections & extrapolated to 2030 by ORNL
  - 8 major crops (corn, soybeans, wheat, sorghum, oats, barley, rice, cotton) and hay, livestock, food/feed markets
  - Model requires meeting projected demands for food, feed, forage, fuel (grain ethanol and oils in RFS2), and exports
  - Added stover, straw, energy crops (perennial grass, woody, annual): switchgrass, other grasses, miscanthus, sugarcane, sorghum, poplar, willow, eucalyptus, southern pines
  - 3,110 counties to assess land use change
  - Land base includes cropland (250 million acres), cropland pasture (22 million acres), hay (61 million acres), permanent pasture (118 million acres)
    - Pasture can convert to energy crops if forage made up through intensification
    - Restraints limiting land use change
      - No CRP
      - 10% cropland and 25% total
    - No forestland conversion to energy crops
  - Forest resources exogenous to the model

## POLYSYS Modules and Interaction



For model background see: De la Torre Ugarte, Daniel G., and Darrell E. Ray. 2000. "Biomass and Bioenergy Applications of the POLYSYS Modeling Framework," *Biomass and Bioenergy* 4(3):1-18, May.

University of Tennessee - Agricultural Policy Analysis Center (APAC) (<http://www.agpolicy.org/>)

# GENERAL APPROACH (cont.)

- **Secondary processing residues and wastes are estimated using technical coefficients**
- **Coordination among partners to develop key technical and factor input cost data, enhancement of models (e.g., POLYSYS), and analyses**
- **Use of the KDF (Knowledge Discovery Framework) to provide and visualize county-level data and results**

# SCENARIOS

## Baseline scenario

- **USDA Baseline forecast for crop yields, acres, etc., extended to 2030**
- **National corn yield of 160 bu/ac in 2010, increases to 201 bu/ac in 2030**
- **Assumes a mix of conventional till, reduced till, and no-till**
- **Stover to grain ratio of 1:1**
- **No residue collected from conventionally tilled acres**
- **Energy crop yields increase at 1% annually attributable to experience in planting energy crops and limited R&D**

## High-yield scenario(s)

- **Same as Baseline Scenario except for the following**
- **Corn yields increase to a national average of 265 bu/acre in 2030**
- **Higher amounts of cropland in no-till to allow greater residue removal**
- **Energy crop yields increase at 2%, 3%, and 4% annually (attributable to more aggressive R&D)**

# FOREST RESIDUES SUSTAINABILITY

- Land base – 504 million acres of timberland & 91 million acres of “other forestland”
- Evaluated biomass removal sustainability (erosion, soil nutrients, biodiversity, soil-organic carbon, and long-term soil productivity); developed retention levels as function of slope
- Removed reserve lands, roadless areas, steep slopes, wet areas, and biomass requiring road building
- Used new USFS FIA (Forest Inventory & Analysis) tree biomass equations
- Never harvested more than growth
- Supply curves for integrated operations for logging residues and fuel treatment thinnings on timberland, i.e., biomass is part of mix of products
- Estimated supply curves for conventionally sourced wood (i.e., pulpwood) from additional harvests and shift from current uses to bioenergy (conservatively)

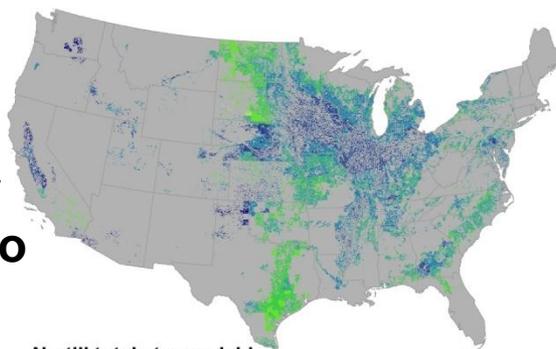
# CROP RESIDUE SUSTAINABILITY

- Yields and acres planted and harvested (baseline forecast)
- Stover to grain ratio
- Tillage (conventional, reduced, no-till) and rotations
- Sustainability - residue retention coefficients estimated using RUSLE2, WEPS, and SCI for erosion and soil carbon using “Residue Removal Tool”
  - Separate coefficients for reduced till and no-till; no residue removal under conventional till
  - Nutrient replacement

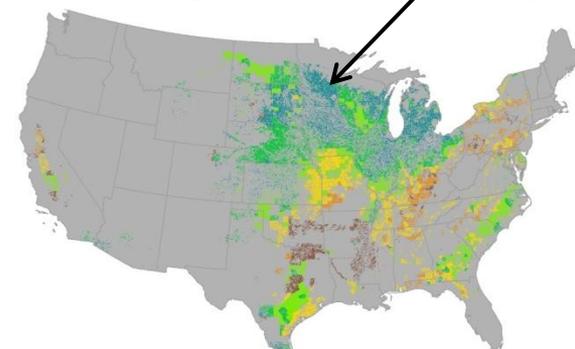
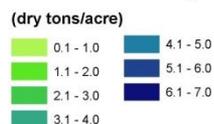
Crop management zones



High residue availability



No-till total stover yield (dry tons/acre)



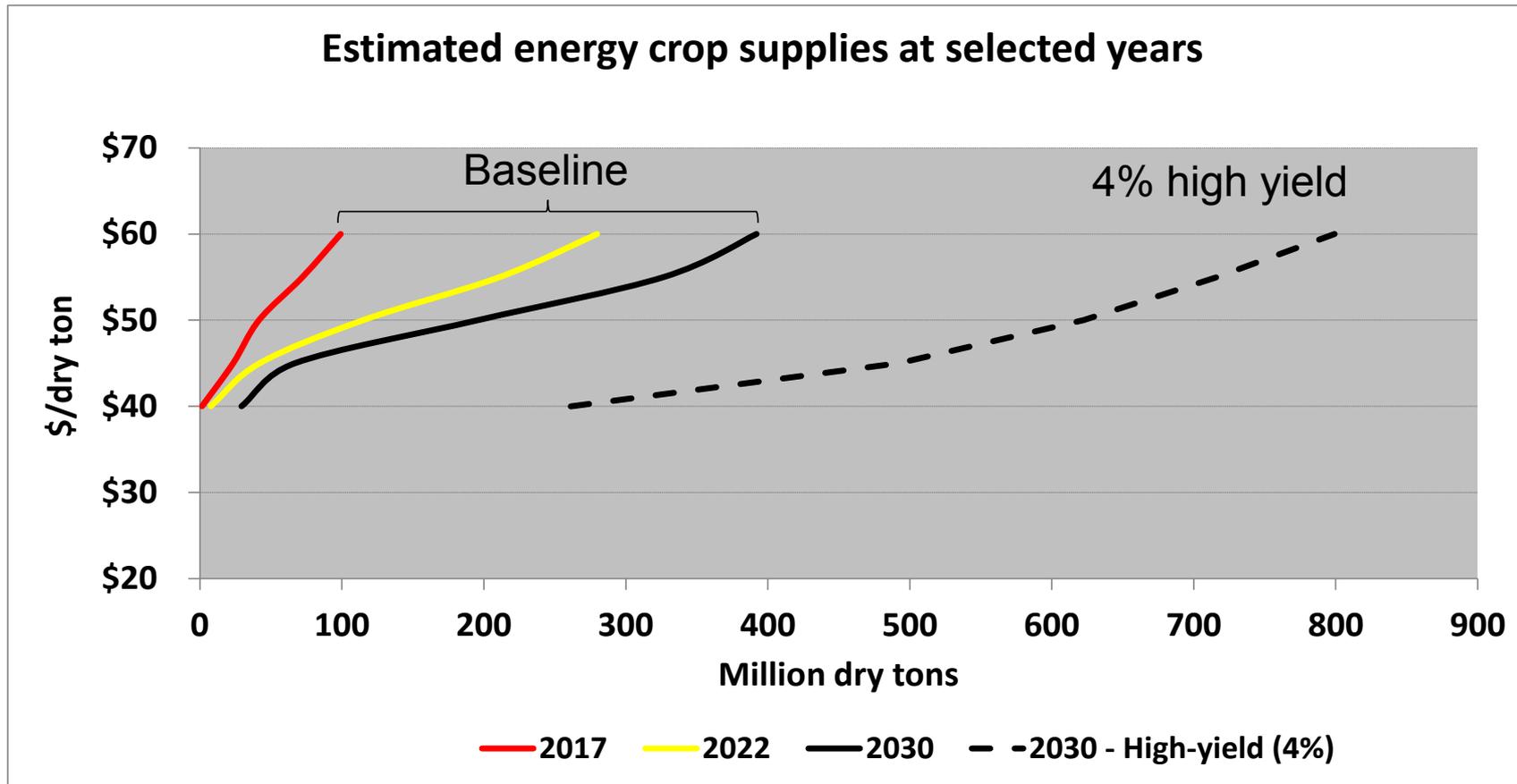
Sustainable Retention Coefficient



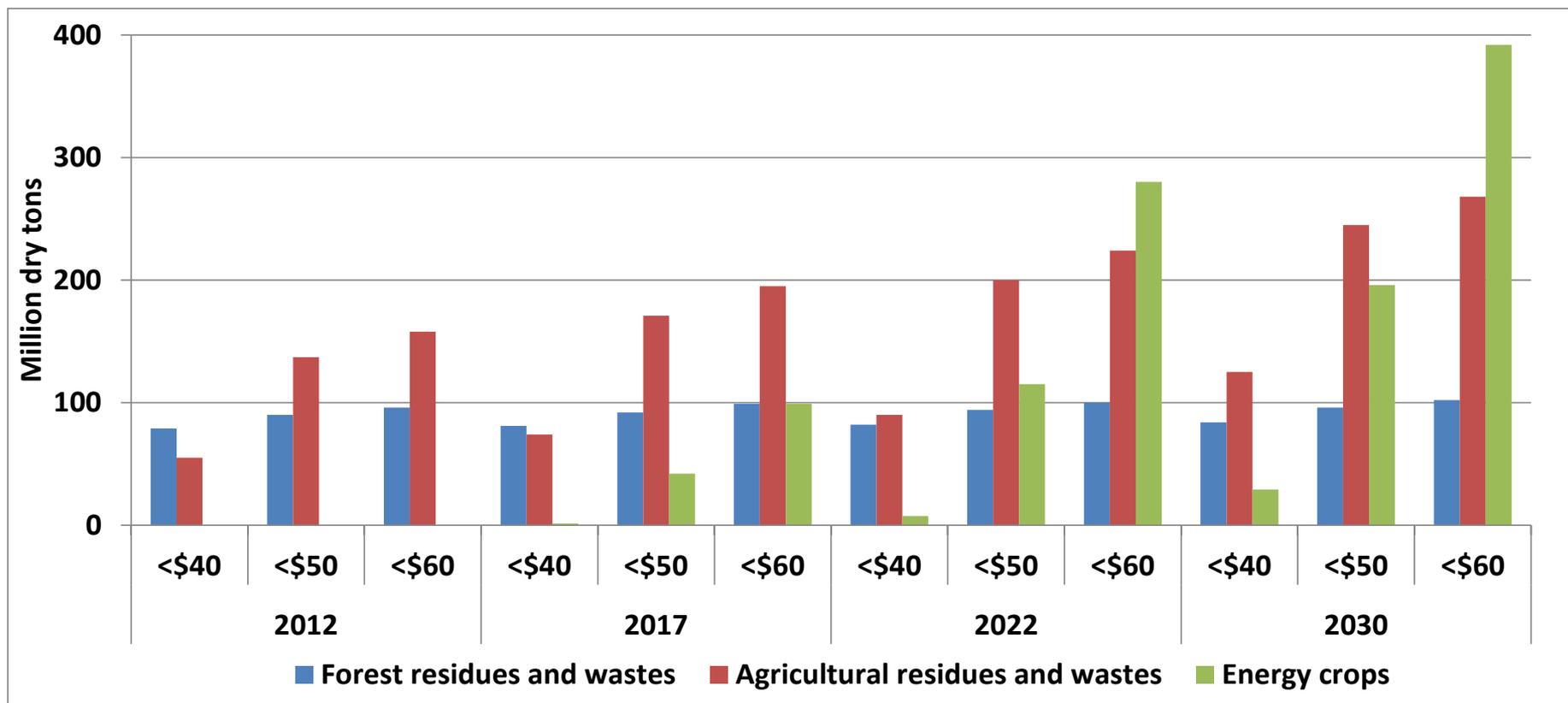
# ENERGY CROP SUSTAINABILITY

- **Allowed on cropland, cropland pasture, and some permanent pasture – not on forestland**
- **Cultural practices based on minimal tillage and recommended fertilizer and herbicide applications**
- **Used BMPs for establishment, cultivation, and harvesting**
- **Some intensification of pasture land required to meet lost forage**
- **Retained low-levels of biomass for long-term site productivity with nutrient replacement**
- **Generally assumed landscape diversity of energy crops with other agricultural and forestry activities**
- **Energy crops not allowed on irrigated cropland & pasture**
- **Annual energy crops (i.e., energy sorghum) limited to non-erosive cropland and part of multi-crop rotation**

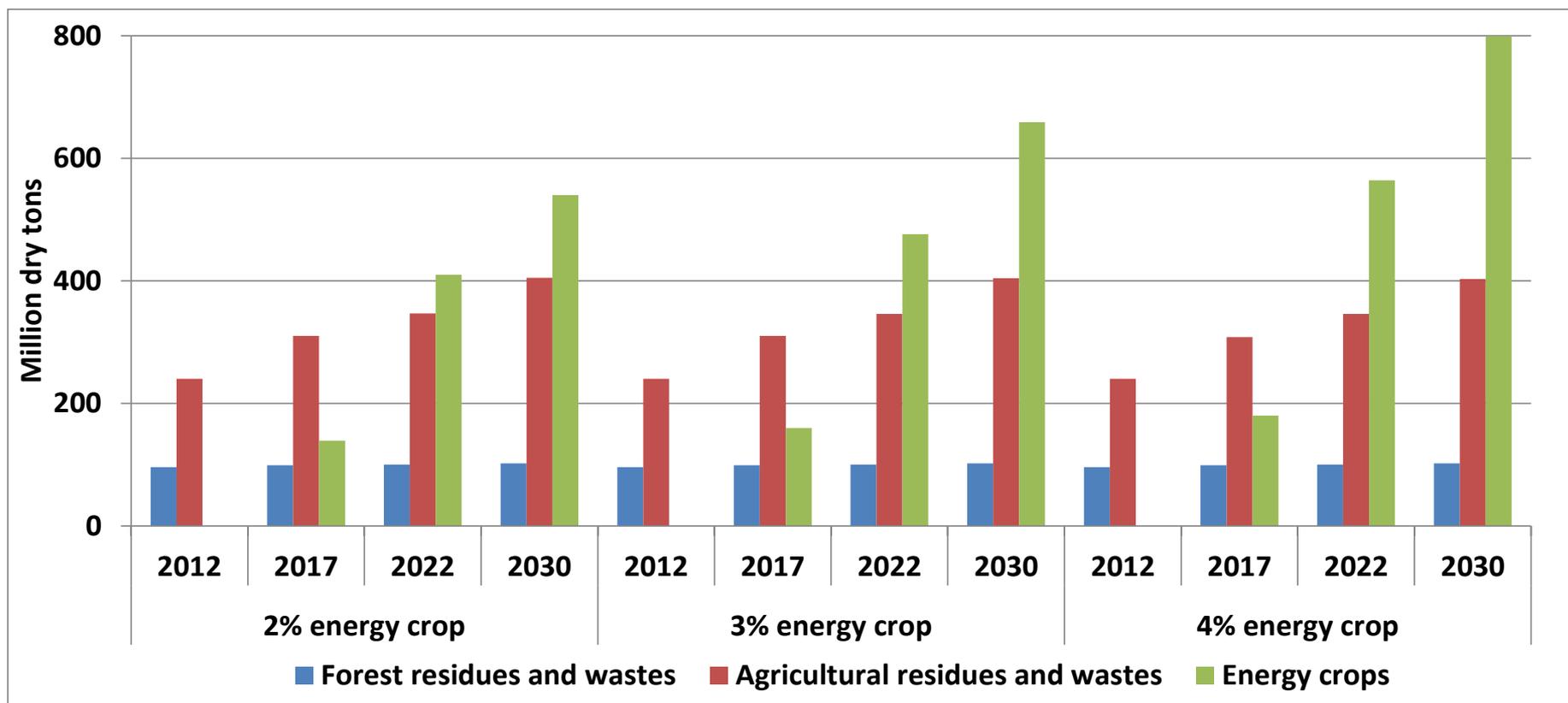
# ENERGY CROPS SUPPLY CURVES



# FOREST AND AGRICULTURAL RESIDUES AND WASTES AND ENERGY CROPS AT SELECTED PRICES AND YEARS UNDER BASELINE ASSUMPTIONS

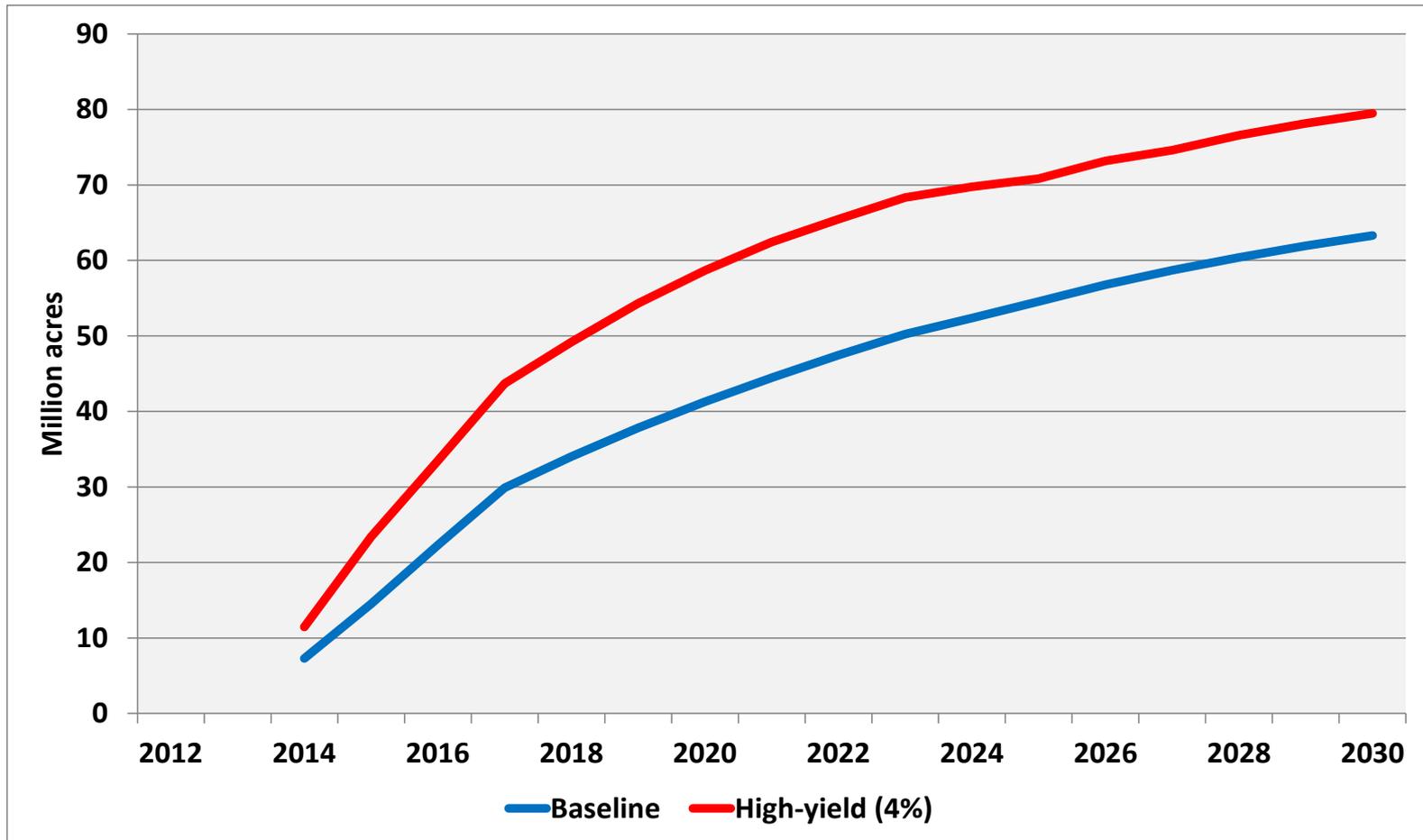


# FOREST AND AGRICULTURAL RESIDUES AND WASTES AND ENERGY CROPS AT SELECTED PRICES AND YEARS UNDER HIGH-YIELD ASSUMPTIONS

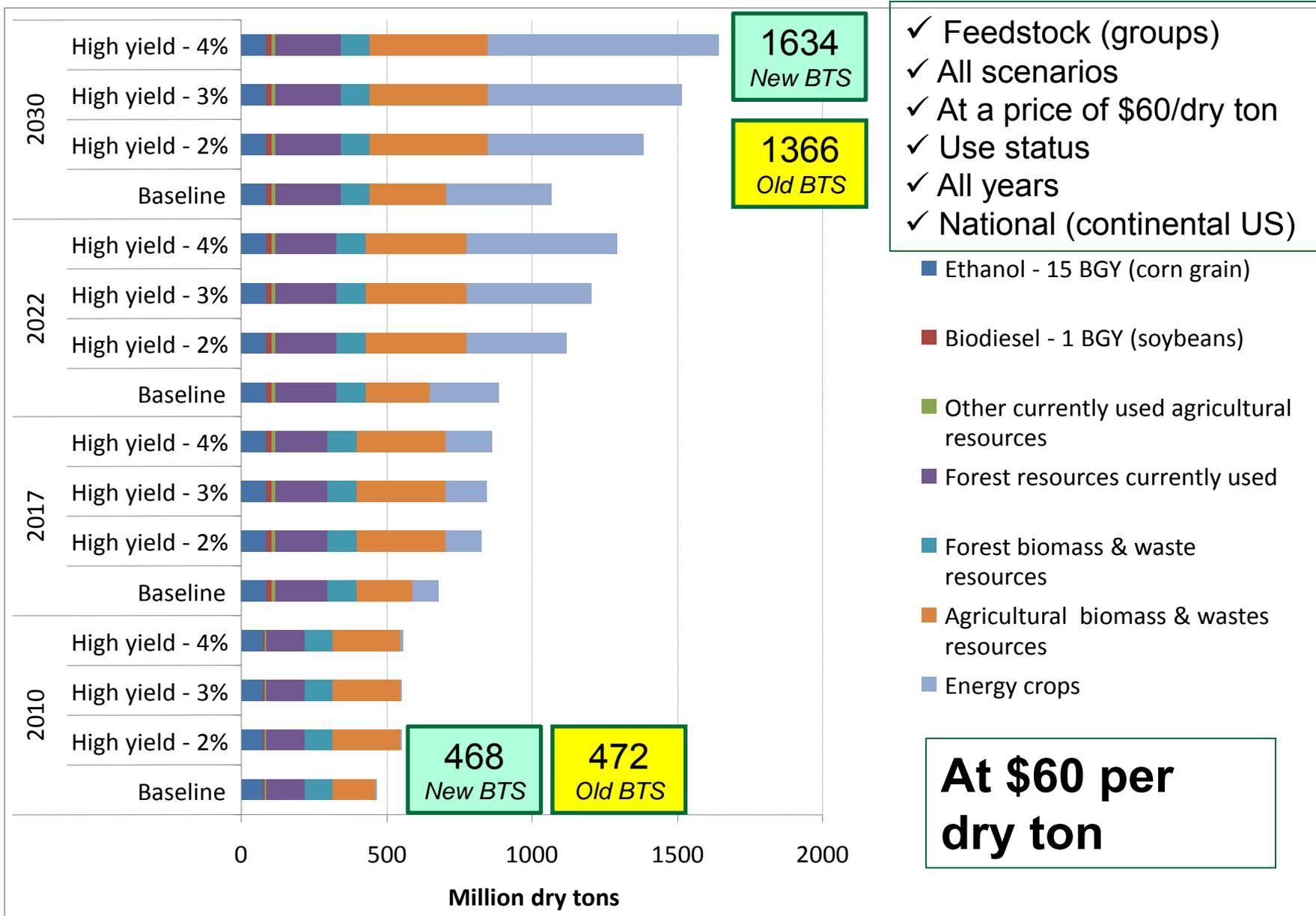


# LAND-USE CHANGE

Total land use change (\$60/dry ton) is 63 million acres under the baseline scenario and 79 million acres under the high-yield scenario (4% annual growth in energy crop yield) by 2030



# Summary of Available Biomass Per Year



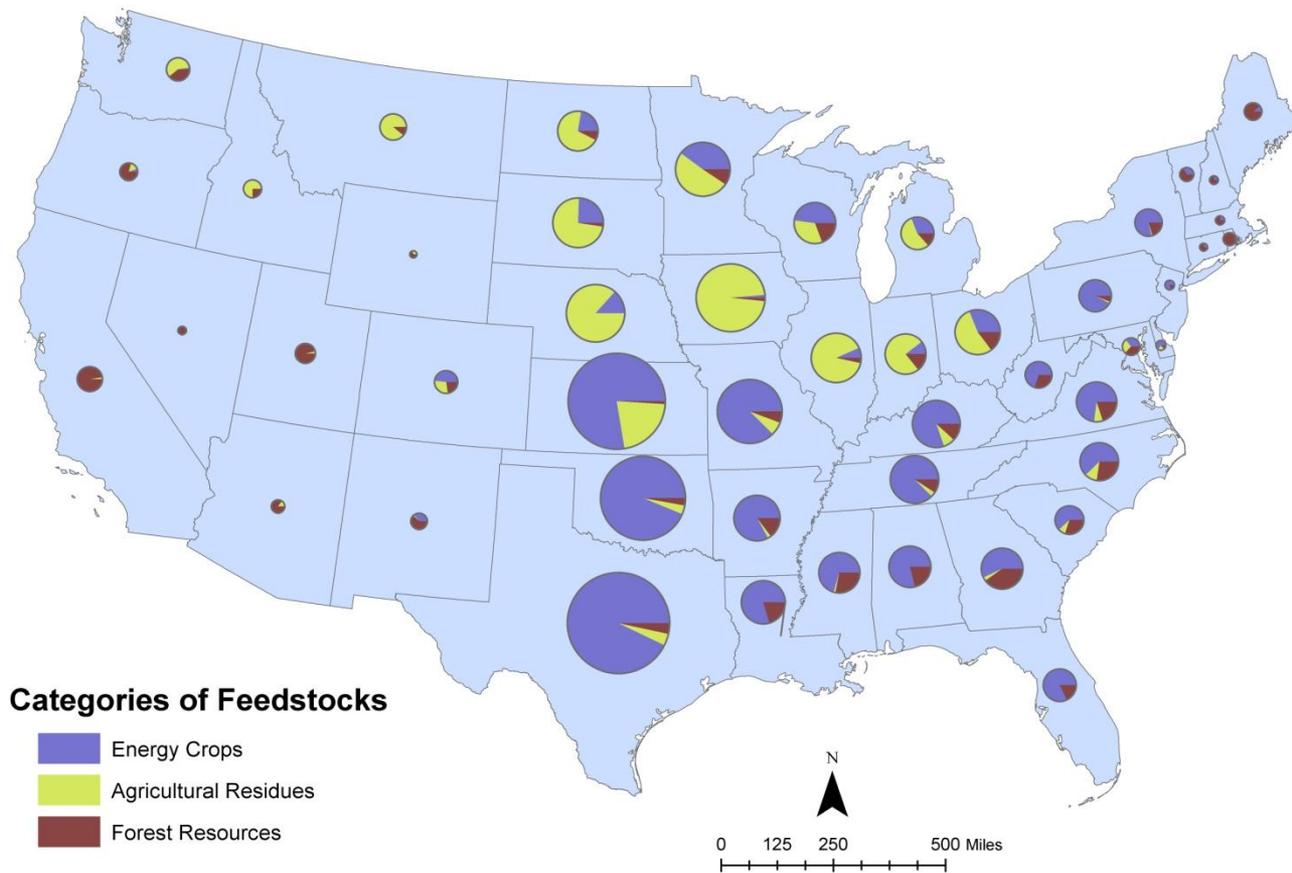
**Table ES.1** Summary of Currently Used and Potential Forest and Agriculture Biomass at \$60 per Dry Ton or Less under Baseline and High-Yield Assumptions

Feedstock	2012	2017	2022	2030
<b>Million dry tons</b>				
<b>Baseline scenario</b>				
Ethanol - 15 BGY (corn grain)	76	88	88	88
Biodiesel - 1 BGY (fats and oils)	2	4	4	4
Other currently used agricultural resources	7	11	11	11
Forest resources currently used	129	182	210	225
Forest biomass & waste resources	96	99	100	102
Agricultural biomass & wastes resources	158	195	224	268
Energy crops <sup>1</sup>	0	99	280	392
<b>Total currently used resources</b>	<b>214</b>	<b>285</b>	<b>313</b>	<b>328</b>
<b>Total potential resources</b>	<b>254</b>	<b>393</b>	<b>604</b>	<b>762</b>
<b>Total – baseline</b>	<b>468</b>	<b>678</b>	<b>917</b>	<b>1090</b>
<b>High-yield scenario</b>				
Ethanol – 15 BGY (corn grain)	76	88	88	88
Biodiesel – 1 BGY (fats and oils)	2	4	4	4
Other currently used agricultural resources	7	11	11	11
Forest resources currently used	129	182	210	225
Forest biomass & waste resources	96	99	100	102
Agricultural biomass & wastes resources	240	310	347	405
Energy crops	0	139-180	410-564	540-799
<b>Total potential resources</b>	<b>336</b>	<b>548-589</b>	<b>857-1011</b>	<b>1047-1306</b>
<b>Total – high-yield</b>	<b>550</b>	<b>833-874</b>	<b>1170-1324</b>	<b>1375-1634</b>

*Note: Under the high-yield scenario, energy crops are shown for 2% to 4% annual increase in yield.*

<sup>1</sup> Energy Crops are planted starting in 2014.

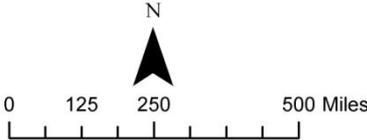
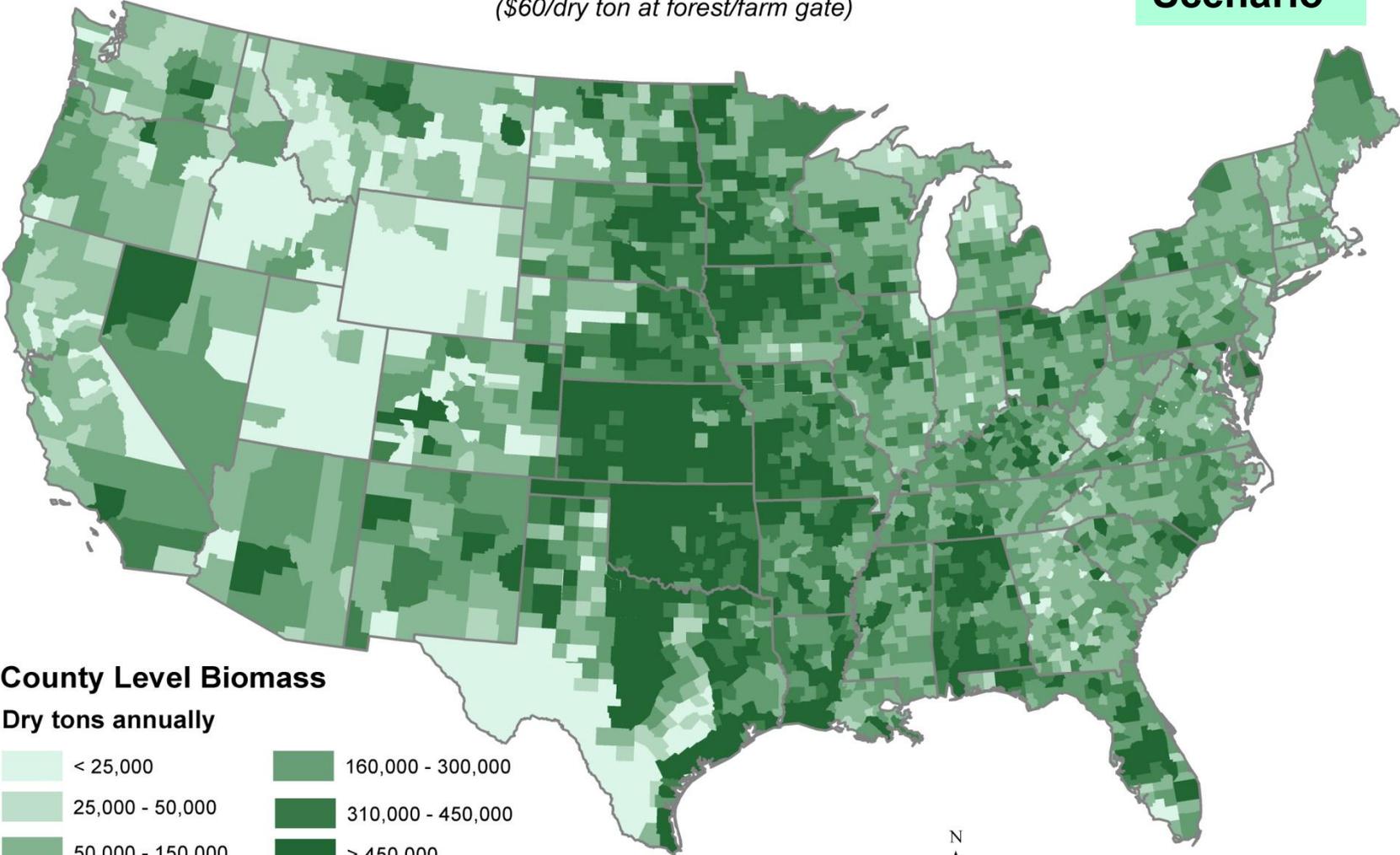
# SHARES OF ENERGY CROPS, AGRICULTURAL RESIDUES, AND FOREST RESOURCES POTENTIALLY AVAILABLE AT \$60 PER DRY TON OR LESS IN 2030 UNDER BASELINE SCENARIO ASSUMPTIONS



# Total Potential Resources, 2030

(\$60/dry ton at forest/farm gate)

**Baseline Scenario**



**Thank you!**

**Questions?**