Overview of the U.S. Billion-ton Update

Billion-Ton Study: What Can Be Learned About Bioenergy Sustainability?

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U.S. DEPARTMENT OF ENERGY

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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: 340 million acres cropland, 40 million acres idle cropland, 404 million acres pasture (cropland pasture & permanent pasture)

- Forest resources
  - Logging residues
  - Forest thinnings (fuel treatments)

  Combined into composite
  - ***Conventional wood (added for 2011)***
  - 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 for 2011)***

Major Differences Between the 2005 BTS Study and the 2011 Billion-ton Update

- Purpose of the 2011 *Billion-Ton Update*
  - Evaluate biomass resource potential
  - Improve upon the 2005 *BTS*
    - Adds in-depth production and cost analyses and sustainability studies
    - Explicitly models land-use change and demand for food, feed, industry, and exports
- Significant findings of the 2011 study
  - Enough resource potential to meet the 2022 advanced biofuel goals
  - Potential resources are widely distributed
  - Energy crops are the single largest source of new feedstock

2005 BTS	2011 Update
National estimates – no spatial information	County-level with aggregation to state, regional and national levels
No cost analyses – just quantities	Supply curves by feedstock by county – farmgate/forest landing
No explicit land use change modeling	Land use change modeled for energy crops
Long-term, inexact time horizon (2005; ~2025 & 2040-50)	2012 – 2030 timeline (annual)
2005 USDA agricultural projections; 2000 forestry RPA/TPO	2010 USDA agricultural projections: 2010 FIA inventory and 2007 forestry RPA/TPO
Crop residue removal sustainability addressed from national perspective; erosion only	Crop residue removal sustainability modeled at soil level (wind & water erosion, soil C)
Erosion constraints to forest residue collection	Greater erosion plus wetness constraints to forest residue collection

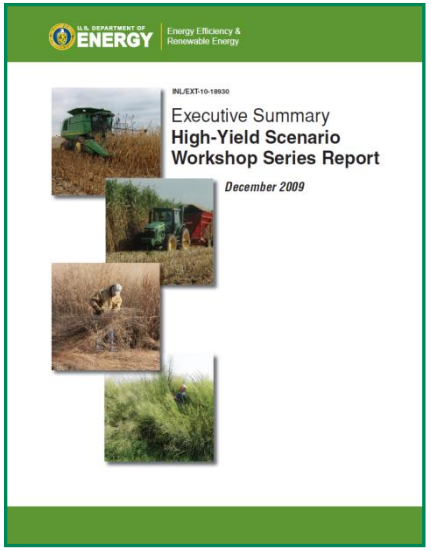
Billion-Ton Update Scenarios

Baseline

- USDA Projections extended to 2030
- National corn yield: 160 bu/ac (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

- 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 reduced and no-till
  - Energy crop yields increase at 2%, 3%, and 4% annually (more R&D)



https://inlportal.inl.gov/portal/server.pt/community/bioenergy/421/high_yield_scenario/8985

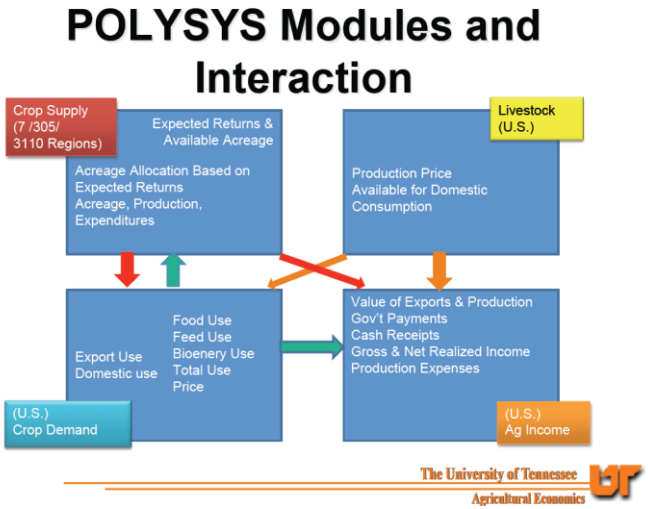
Approach to Supply Curve Estimation

- Separate methods for agriculture and forest resources
- Agricultural land resources
  - POLYSYS used to estimate supply curves and land use change for crop residues & energy crops
    - USDA data – Baseline Projections, Census, NASS extended to 2030
    - Requirements for resource sustainability – crop residue retention, tillage, crop rotations
    - Energy crop – perennial grasses, woody crops, annuals
    - Costs
      - Grower payments for crop residues & production costs for energy crops
      - Collection and harvest costs based on INL and ORNL assumptions/modeling
  - Secondary processing residues and wastes estimated using technical coefficients
  - Contributing authors helped develop technical assumptions and input data and workshops used to develop scenarios
- Forest resources – Resource cost analysis (Bryce)

- **Focus on major cellulosic feedstocks**
- **Farmgate or roadside analysis**
- **No supply chain considerations (e.g., no losses beyond farm or forest)**
- **No end-use or conversion processes specified**

POLYSYS Modeling Framework

- County model anchored to USDA 10-year projections and extended to 2030
  - 8 major crops (corn, soybeans, wheat, sorghum, oats, barley, rice, cotton) and hay, livestock, food/feed markets
  - Projected demands for food, feed, industry, and exports
  - Biomass resources include stover, straws, energy crops (perennial grass, coppice and non-coppice woody, annual energy crop)
  - 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



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Other model versions:
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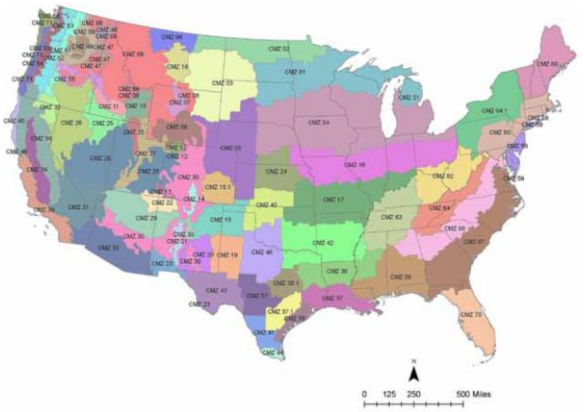
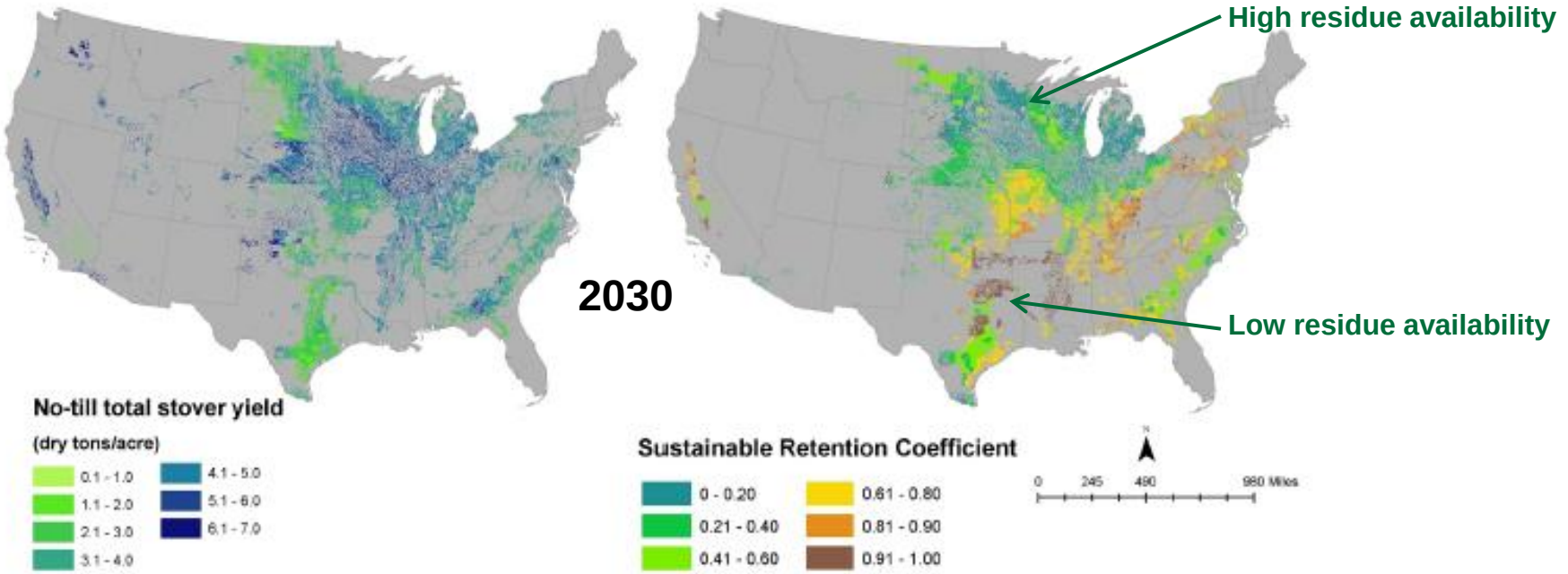
Crop Residue Sustainability

Retention coefficients estimated for wind and water erosion and soil C

- Separate coefficients for reduced till and no-till
- No residue removal under conventional till
- Yield and time dependent in POLYSYS
- Dave Muth (INL), Richard Nelson (KSU), Doug Karlen (ARS) and others (ARS, NRCS, UTK)

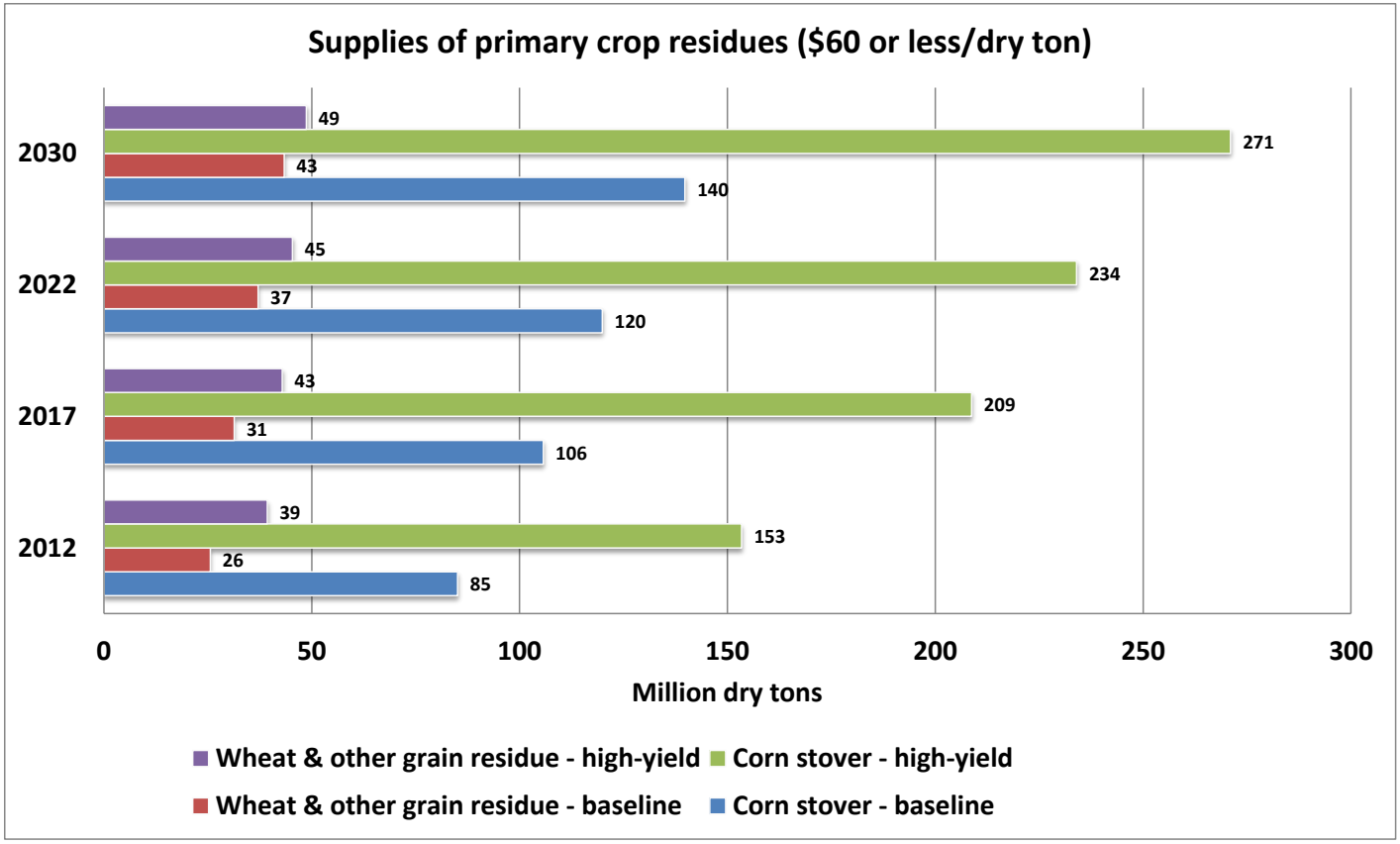
NRCS CMZs





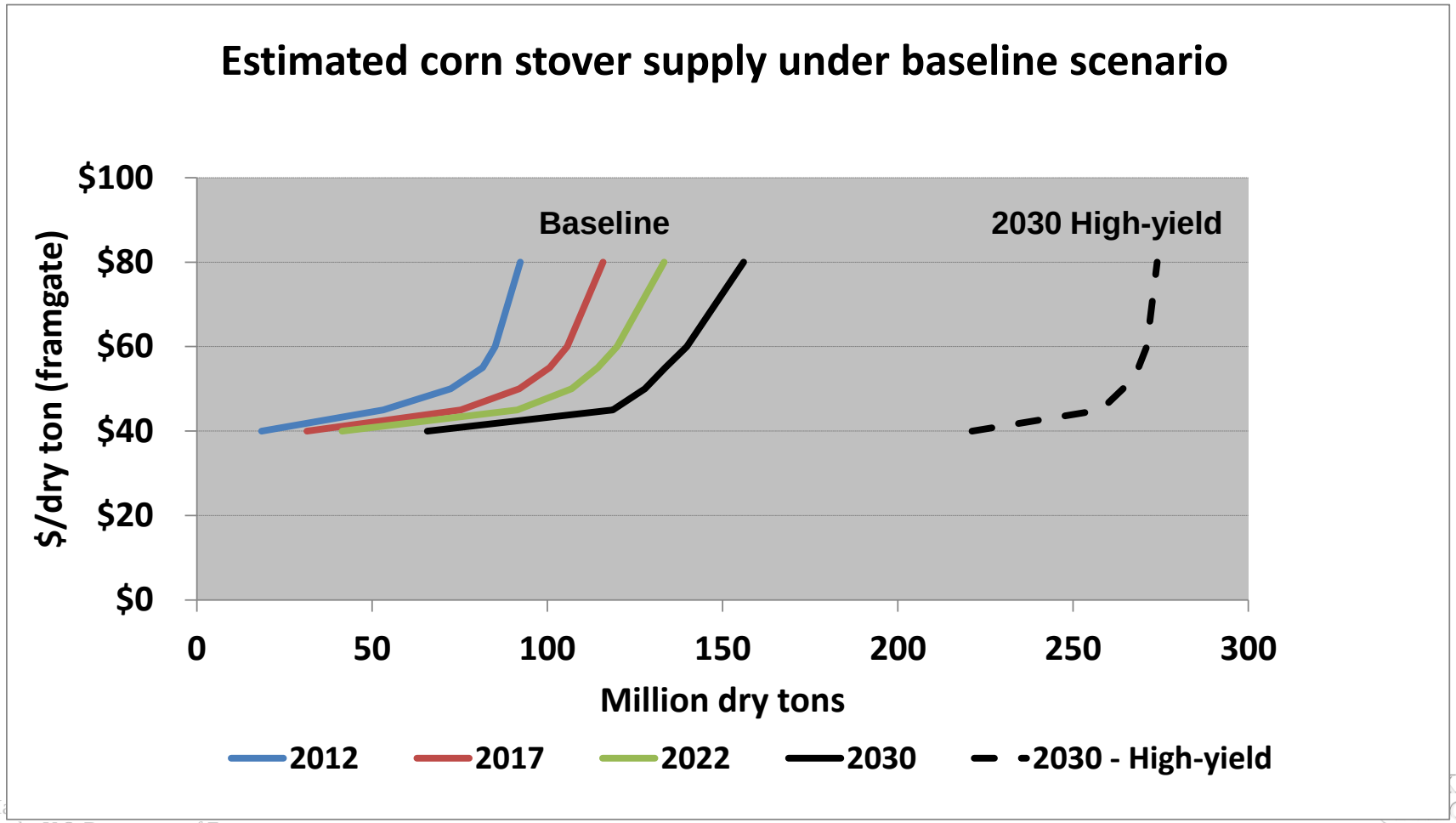
Crop Residue Supply Potential

- Baseline scenario ~ 111 million dry tons (mostly stover)
  - By 2030, supplies exceed 180 million dry tons due to yield growth
- High-yield scenario (much higher corn yields and reduced- & no-till)
  - By 2030, total primary residue is 320 million dry tons ~ 85% corn stover



Crop Residue Supply Potential

- Supplies increase over time due primarily to yield growth
- Much higher quantities under high-yield due to tillage and corn yields



Energy Crop Assumptions

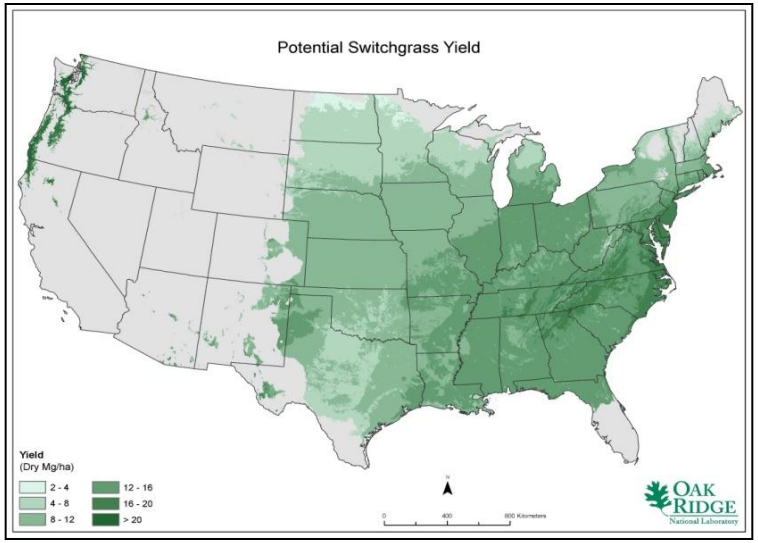
- Crops include
  - Perennial grasses (switchgrass, and other grasses)
  - Woody Crops (eucalyptus, southern pine, poplar, willow)
  - Annual Energy Crop (sorghum)
- Allowed on cropland, cropland pasture, and permanent pasture
- No irrigation and not allowed on irrigated cropland & pasture
- Cultural practices based on minimal tillage and recommended fertilizer and herbicide applications
- Intensification of pasture land required to meet lost forage
- Conversion of permanent pasture and cropland used as pasture constrained to counties east of the 100th meridian except for Northwest
- Energy crops returns must be greater than pasture rent plus additional establishment and maintenance costs

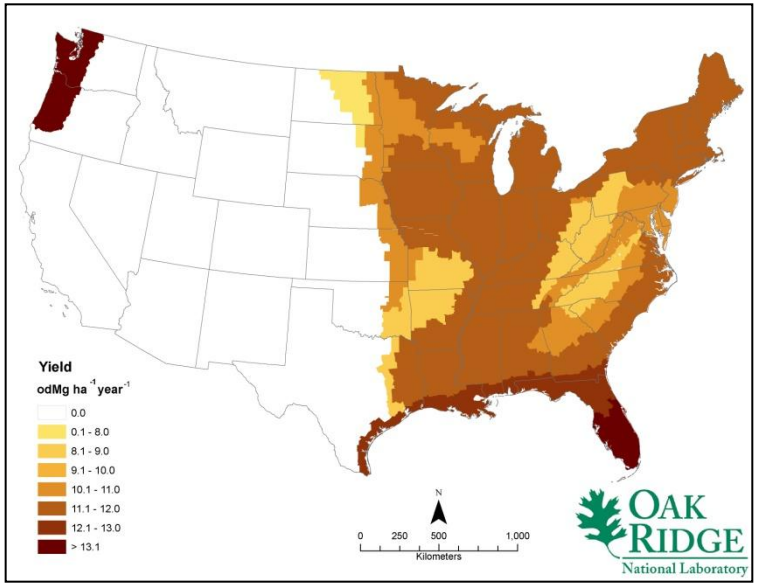
Energy Crop Sustainability & Restrictions

- Assumed BMPs for establishment, cultivation, maintenance, and harvesting of energy crops
  - Soil erosion from wind and water
  - Soil carbon sequestration
  - Soil productivity
  - Water quality and quantity
  - Invasive plants
- Generally assumed landscape diversity of energy crops with other agricultural and forestry activities
  - A set of restraints used to limit the amount of cropland, cropland used as pasture, and permanent pasture switching to energy crops in a given year and in total (e.g., 10% of cropland per year and 25% in total)
- Annual energy crops (i.e., energy sorghum) limited to non-erosive cropland and part of multi-crop rotation
- Retained low-levels of biomass for long-term site productivity with nutrient replacement

Energy Crop Productivity

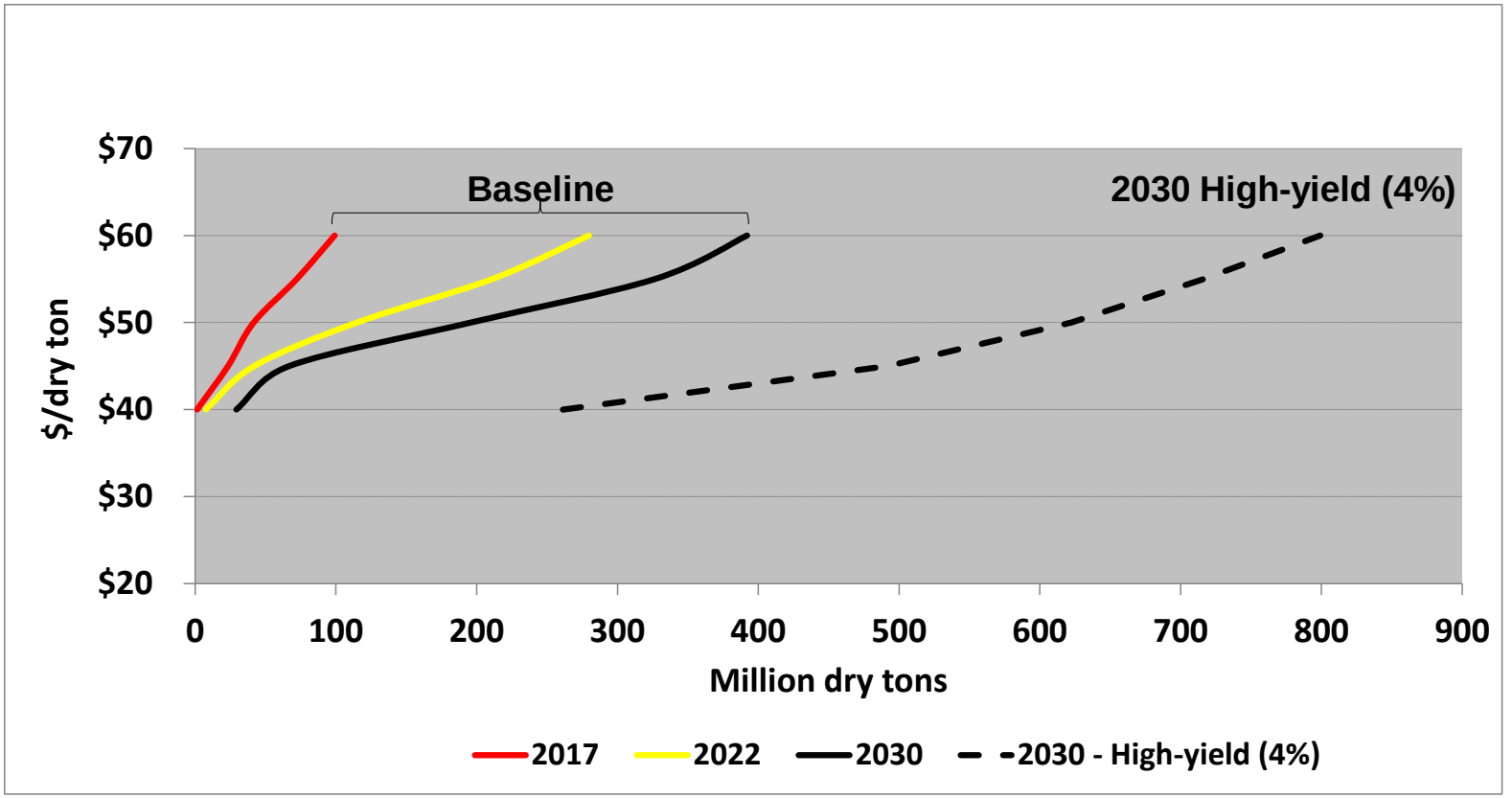
- Herbaceous crop productivity
  - Baseline yields (dry tons/acre)
    - 2014 – 3.0 - 9.9
    - 2030 – 3.6 - 12.0
- Woody crop productivity
  - Baseline yields (dry tons/acre)
    - 2014 – 3.5 - 6.0
    - 2030 – 4.2 - 7.2





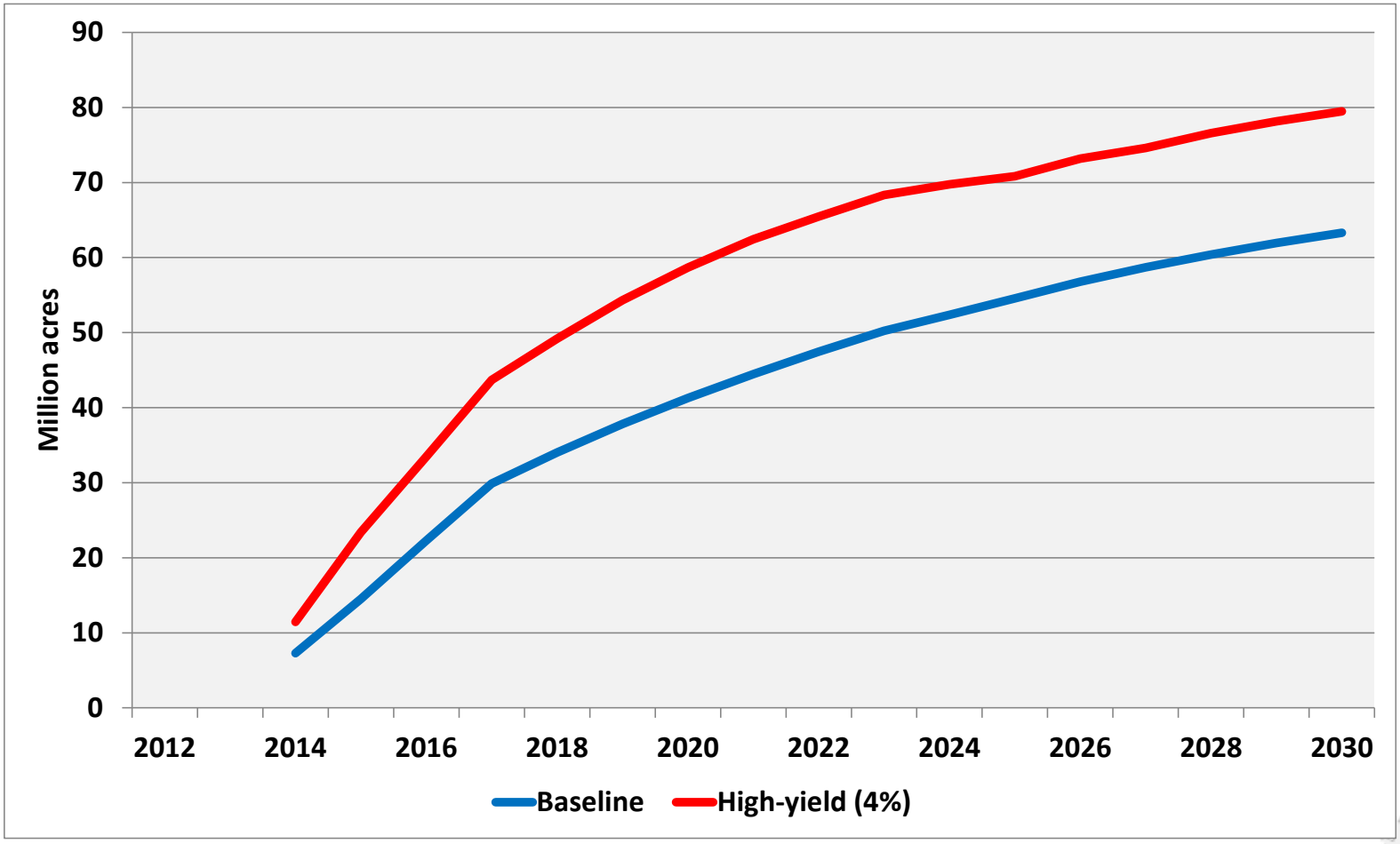
Energy Crop Supply Potential

- Supplies increase over time due to yield growth and woody crop production
- Energy crops displace mostly commodity crops at low supply curve prices and move onto pasture at higher prices



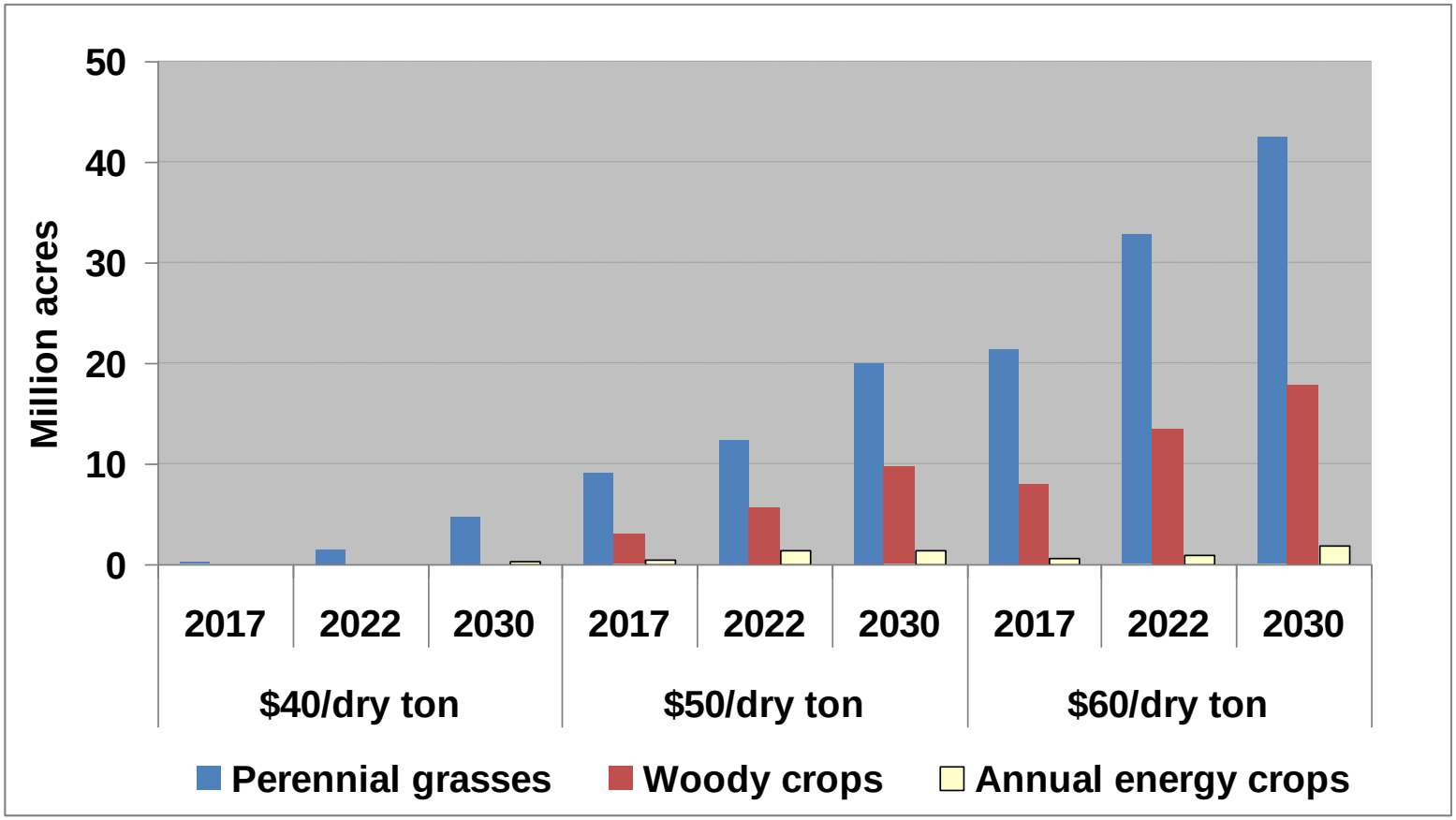
Land-use Change

- 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



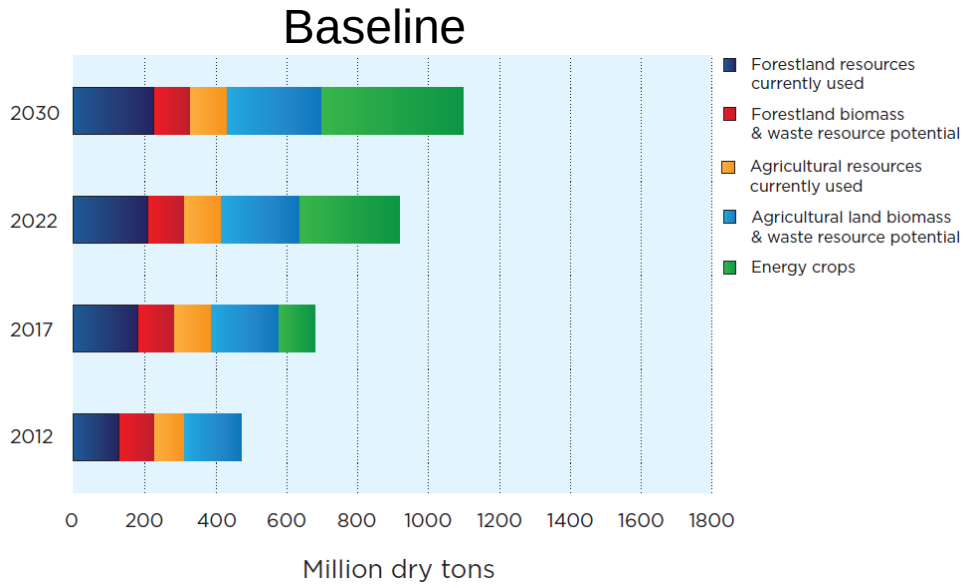
Land Use Change by Energy Crop

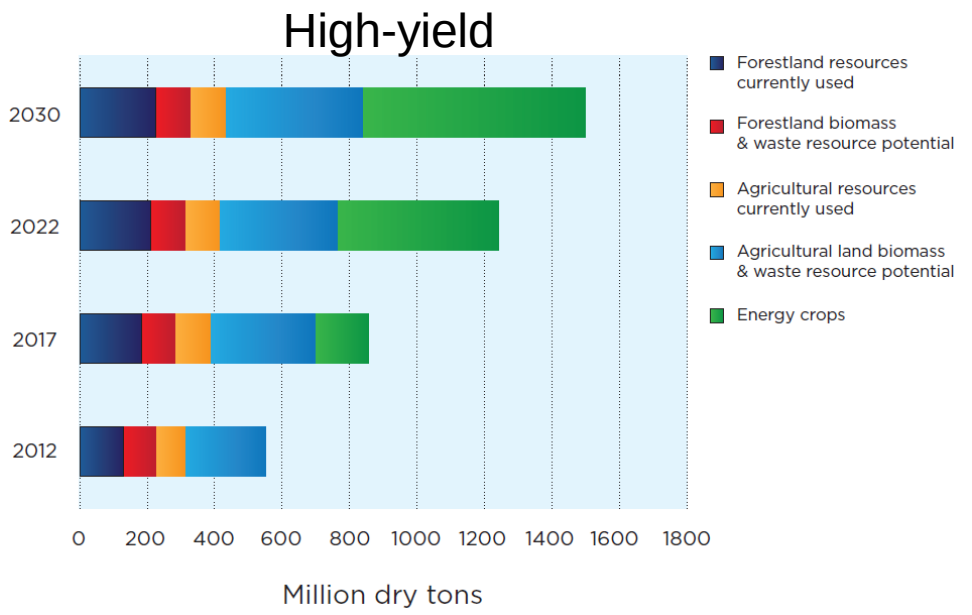
- At highest simulated price
  - ~ 22 to 30 million acres cropland
  - ~ 40 to 50 million acres pasture



U.S. Billion-Ton Update: Findings

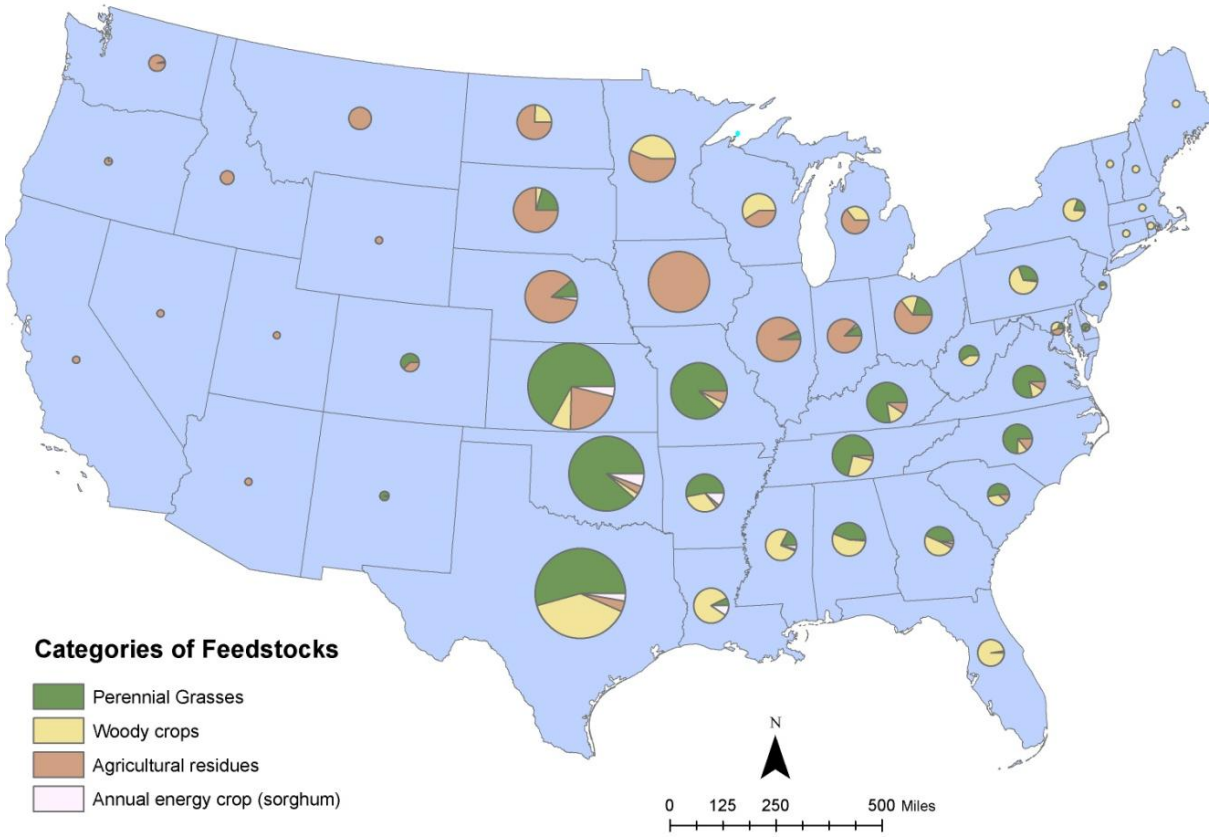
- Baseline scenario
  - Current combined resources from forests and agricultural lands total about 473 million dry tons at $60 per dry ton or less (about 45% is currently used and the remainder is potential additional biomass)
  - By 2030, estimated resources increase to nearly 1.1 billion dry tons (about 30% would be projected as already-used biomass and 70% as potentially additional)
- High-yield scenario
  - Total resource ranges from nearly 1.4 to over 1.6 billion dry tons annually of which 80% is potentially additional biomass
  - No high-yield scenario was evaluated for forest resources, except for the woody crops



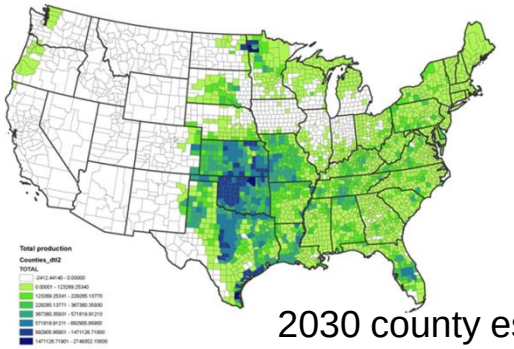


Potential to Supply Crop Residues and Energy Crops by State

- Potential supplies are generally widely distributed
  - Considerable perennial grass potential in Southern Plains
  - Residue in Midwest and Northern Plains
  - Woody crops in the North and South



Baseline scenario - $60/dry ton; year 2030

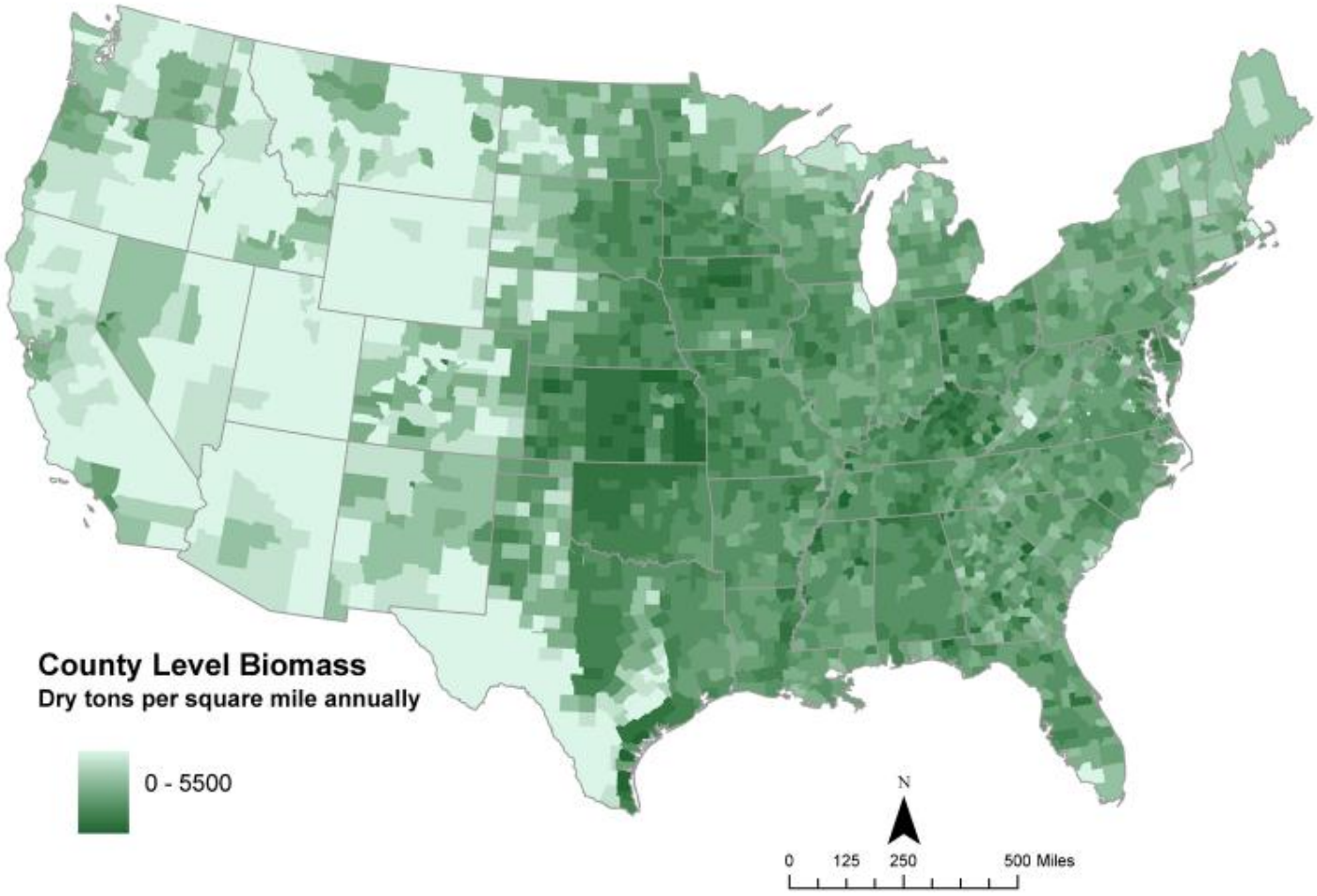


2030 county estimates

Potential to Supply Forest Residues by State

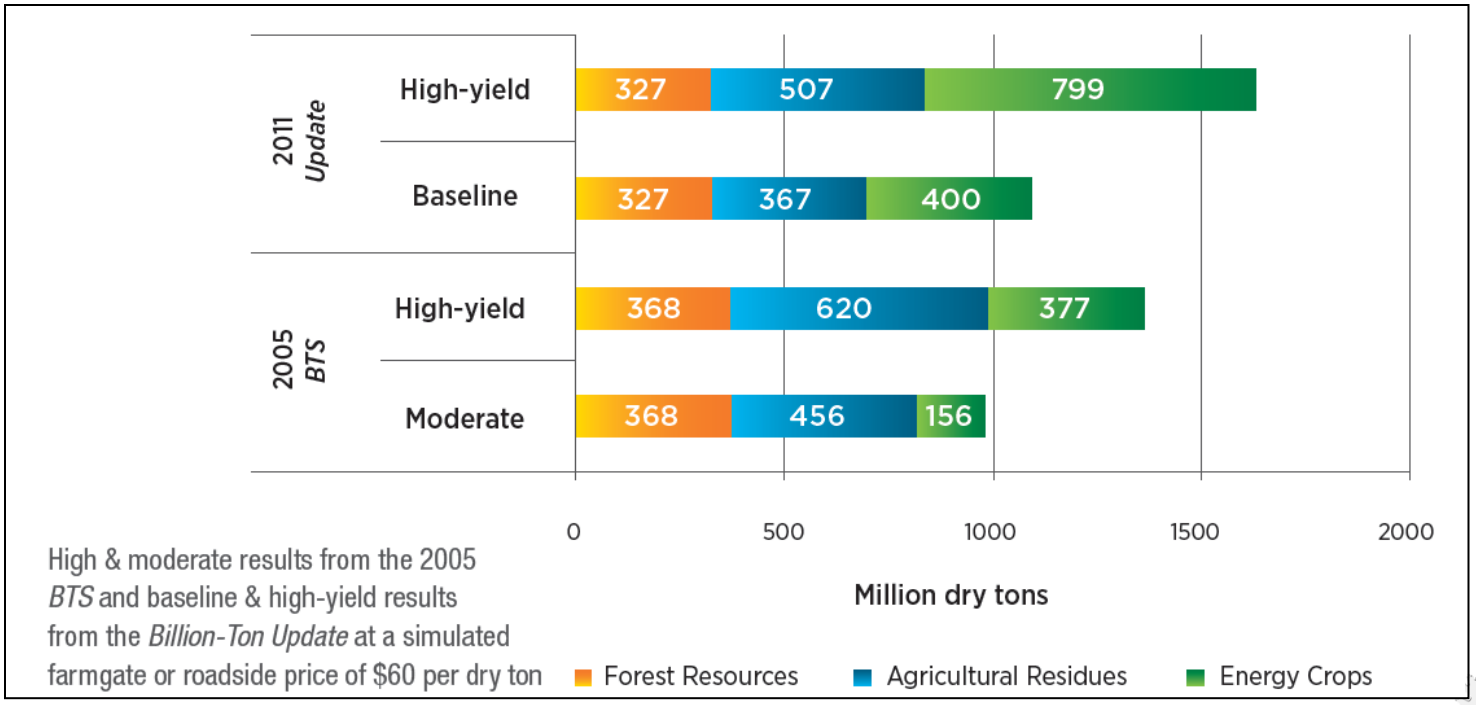
- Forest residue resources are where expected

Potential County-level Resources at $60 Per Dry Ton or Less in 2030 (Baseline Scenario)



Comparison with the 2005 BTS

- Forest residue biomass potential is less – composite operations, decline in pulpwood and sawlog markets
- Crop residue potential is less – consideration of soil carbon, no residue from conventionally tilled acres
- Energy crop potential is greater – addition of pastureland, land use change modeling



High & moderate results from the 2005 *BTS* and baseline & high-yield results from the *Billion-Ton Update* at a simulated farmgate or roadside price of $60 per dry ton

Summary

- Biomass feedstock resources in 2030 range from 1.1 to 1.6 billion dry tons at $60/dry ton or less with 70 to 80% of the total available for new uses
- Biomass resources are widely distributed across the United States with the exception of some arid parts of the west
- Enough resource potential to meet the 2022 advanced biofuel goals as well as significant additional biomass for electricity, chemicals, transportation fuels, and other uses
- Energy crops are the single largest source of new feedstock potential, a natural extension of current farm systems, offering landowners opportunities for additional profits while enhancing sustainability.
- Bioenergy KDF provides specific results of the update – feedstock categories, years, prices and quantities, and spatial interest