AGENDA: Billion-Ton Update Webinar

John Ferrell, DOE
- Welcome and Introductions

Bryce Stokes, CNJV
- Preview

Bob Perlack, ORNL
- Background and Overview
- General Approach
- Scenarios

Doug Karlen, ARS
- Residue Removal Tool
- Crop Residue Sustainability

Bob Perlack, ORNL
- Crop Residue
- Energy Crops

Bryce Stokes, CNJV
- Forest Resources

Ken Skog, FS
- Forest Supply Curves

Bob Perlack
- Results

Aaron Crowell, BCS, Inc.
- Bioenergy KDF demonstration


U.S. DEPARTMENT OF ENERGY

U.S. BILLION-TON UPDATE

Biomass Supply for a Bioenergy and Bioproducts Industry

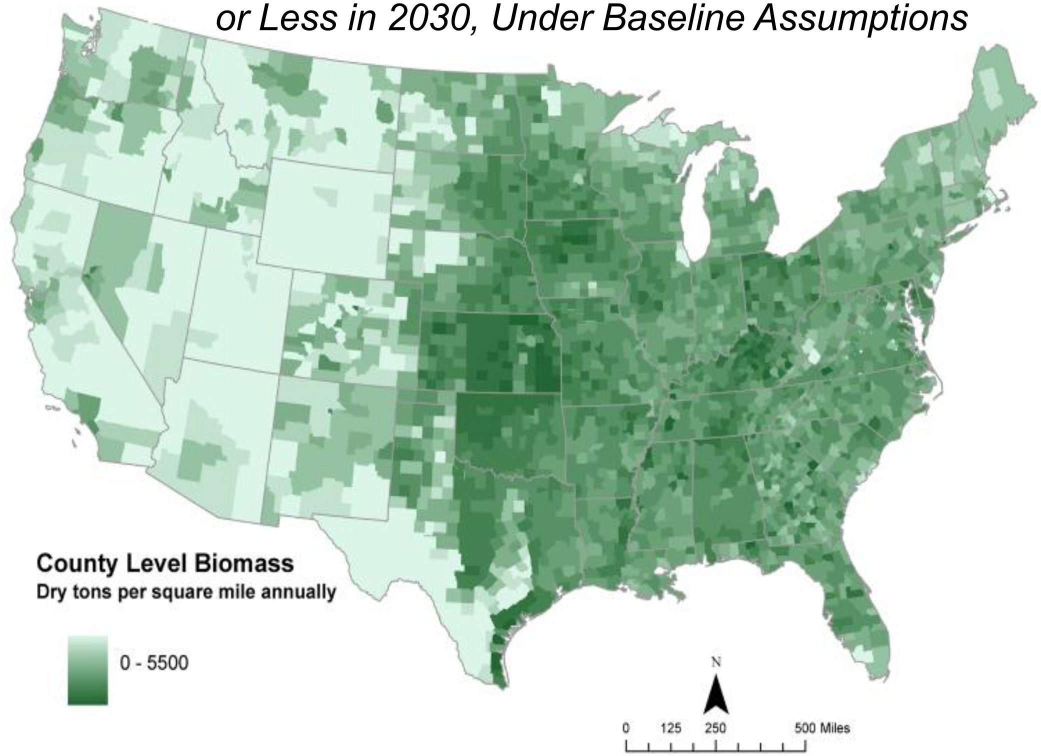
August 2011

The webinar will begin at 2pm EDT and end at 4pm

Opening Introduction – John Ferrell, DOE

- Purpose of the 2011 *Billion-Ton Update*
  - Evaluate biomass resource potential nationwide
  - Improve upon the 2005 *Billion-Ton Study*
- Significant findings of the 2011 study
  - Enough resource potential to meet the 2022 RFS2 advanced biofuel goals
  - Potential resources are widely distributed
  - Purpose-grown energy crops are the single largest source of new feedstock potential

Potential County-level Resources at $60 Per Dry Ton or Less in 2030, Under Baseline Assumptions



Outline/Presenters

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Bryce Stokes - CNJV, Washington, DC

U.S. Billion-ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry

Bob Perlack – Oak Ridge National Lab

Bryce Stokes – CNJV (DOE Golden Field Office)

Doug Karlen – USDA Agricultural Research Service

Ken Skog – U.S. Forest Service, Forest Products Lab

September 2011

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

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Biomass Feedstock Resource Base

Lower 48 States Only

- 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 in 2011 Update

  - 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

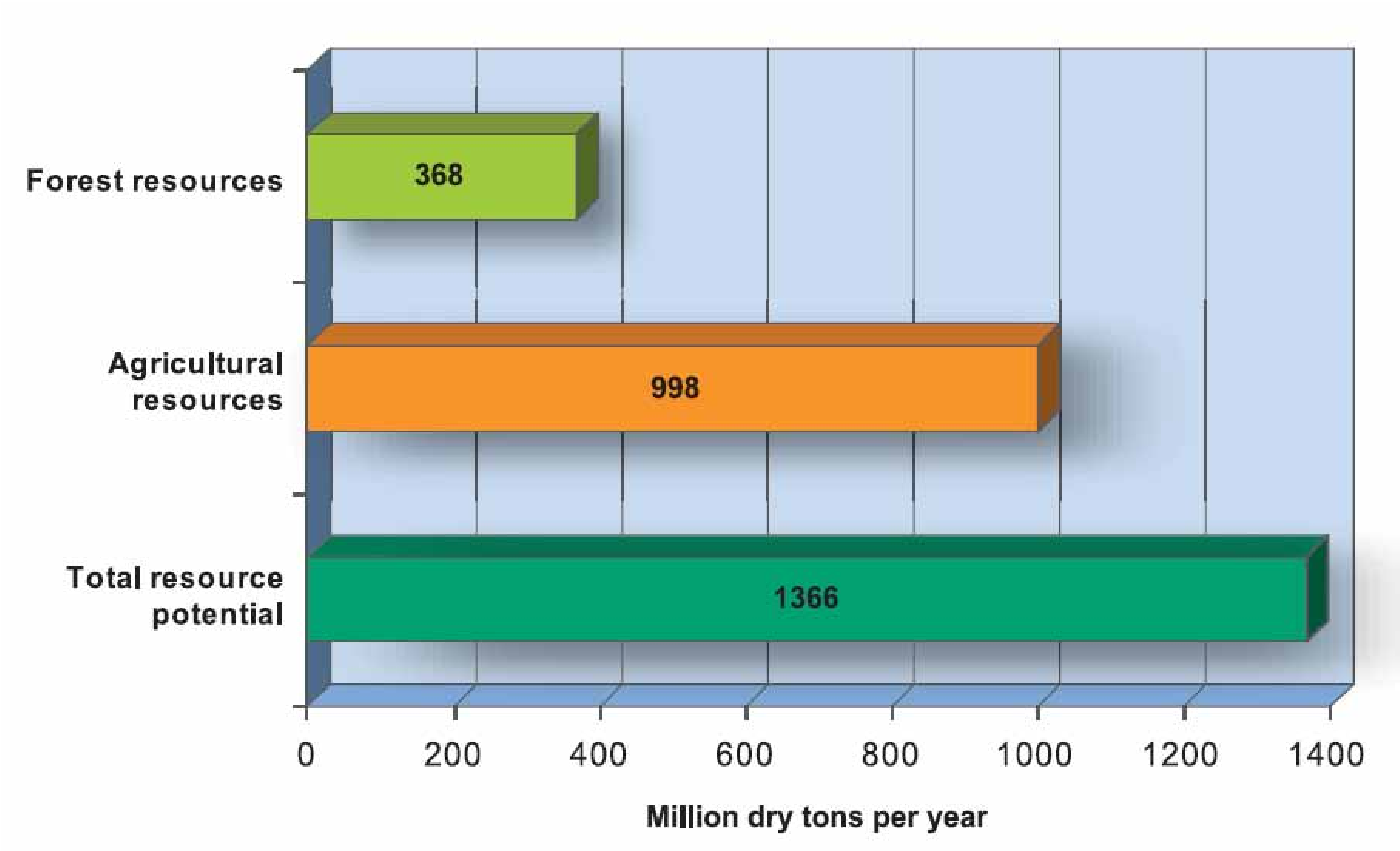
Algal Feedstocks

- **Not included at this time**
- **Insufficient data a county scale**
- **Algal biofuels roadmap[1]**
- **Separate assessments[2]**

[1]National algal biofuels technology roadmap. U.S. Department of Energy, May 2010. http://www1.eere.energy.gov/biomass/pdfs/algal_biofuels_roadmap.pdf

[2]Wigmosta, M. S., A. M. Coleman, R. J. Skaggs, M. H. Huesemann, and L. J. Lane (2011), National microalgae biofuel production potential and resource demand, *Water Resour. Res.*, 47, W00H04, doi:10.1029/2010WR009966. https://bioenergykdf.net/node/322

2005 BILLION TON ASSESSMENT



How Much Biomass is Available According to the New 2011 Update?

- **It all depends**
  - Specific feedstock or feedstock category
  - Sorts – currently used or potential
  - Spatial interest
  - Selected price
  - Specific year
  - Scenario
- **How to find**
  - Update report is national summaries at selected prices and years for all feedstocks, sorts, and scenarios
  - KDF for desired spatial analyses, prices, and years for all feedstock categories, sorts, and scenarios

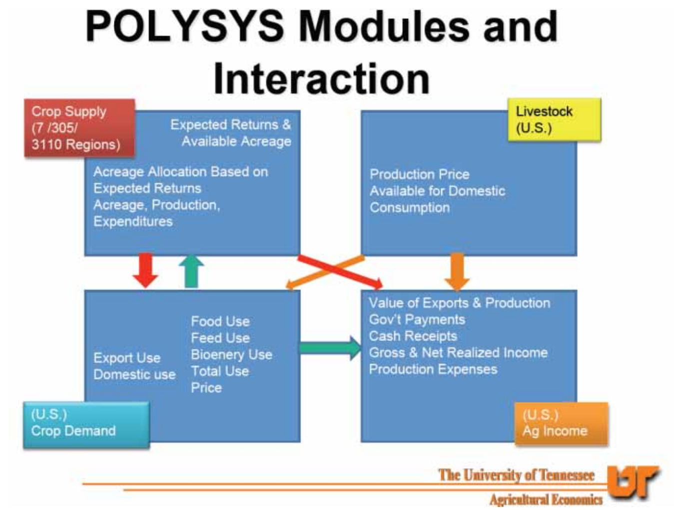
Bob Perlack – ORNL, Oak Ridge, TN

Approach to Supply Curve Estimation

- **Separate methods for agriculture and forest resources**
- **Agricultural land resources**
  - **Agricultural policy model (POLYSYS) utilized to identify supply curves and land use change for crop residues and energy crops**
    - **USDA and NASS data (yields, acres, crop prices, production, exports, etc.) to 2030**
    - **Requirements for resource sustainability – crop residue retention coefficients, tillages, rotations**
    - **Energy crop productivity**
- **Forestland resources**
  - **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**

POLYSYS Modeling Framework

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



Chad Hellwinckel – University of Tennessee - Agricultural Policy Analysis Center (APAC) (http://www.agpolicy.org/)

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

Baseline Scenario

- 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 Scenario

- 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)

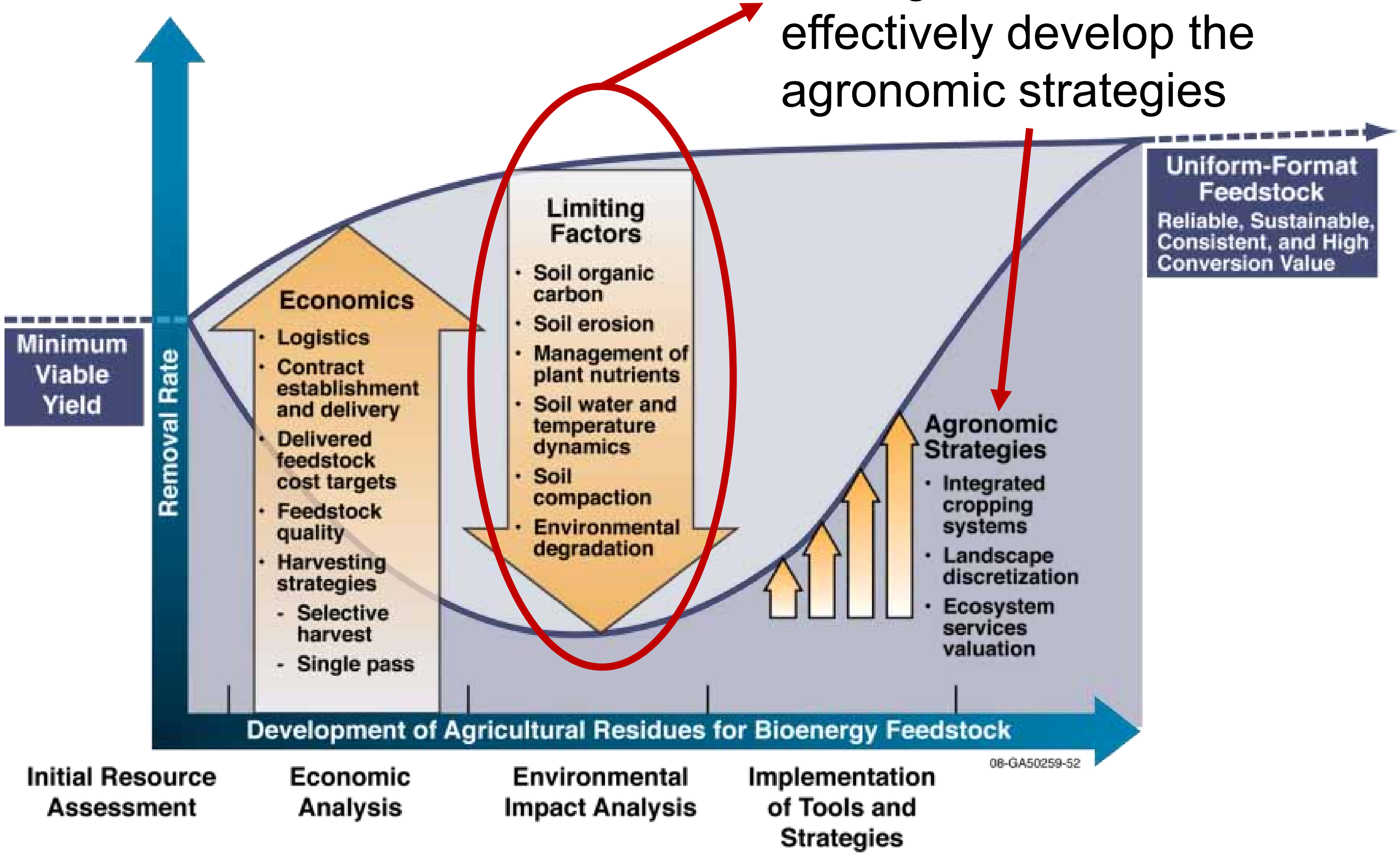
Agricultural Resources Modeling

- POLYSYS model (OBP version operating at a county-level)
  - Data from NASS, USDA Baseline, Census of Agriculture
  - Key technical assumptions and environmental sustainability
    - Crop residue retention, tillage, rotations
    - Energy crop productivity
  - 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 are estimated using technical coefficients
- Contributing authors helped develop technical assumptions and input data and workshops used to develop scenarios

Doug Karlen – ARS, Ames, IA

Residue Removal Tool

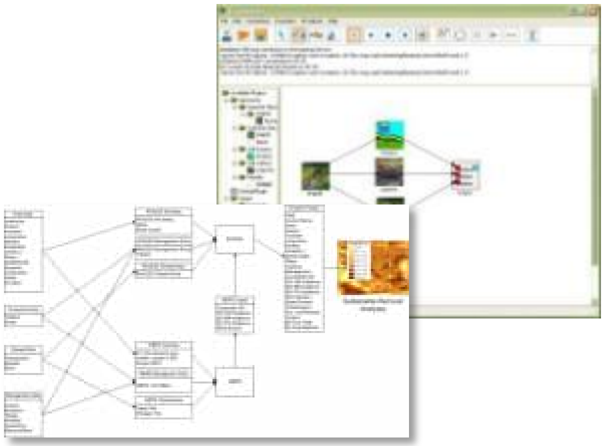
Focused on quantifying the limiting factors, so we can effectively develop the agronomic strategies



Establishing the Framework

Agronomic factors limiting the quantity of corn stover available for sustainable harvest as an alternative fuel feedstock		
Limiting factor	**Affected soil properties/processes**	**Characterization methods**
Soil organic carbon	Soil structure, nutrient cycling, water entry and retention, and biological activity	Measurement or simulation models such as CQESTR, DayCent, and EPIC
Wind and water erosion	Soil, nutrient, and agrichemical loss and water and air quality degradation	Simulation models such as RUSLE2 and WEPS
Plant nutrient balance	Productivity and fertilizer requirements	Measurement or simulation models such as IFARM
Soil water and temperature dynamics	Seedbed condition, plant emergence, crop growth and development, leaching, drought resistance, workable days, load-bearing capacity, water-use efficiency, and other factors	Measurement and simulation models such as those based on the concept of least limiting water range
Soil compaction	Seedbed quality, plant emergence, tillage energy requirements, soil structure, runoff, plant rooting volume, fertilizer-use efficiency, and other factors	Measurement and possible use of simulation models based on the concept of least limiting water range
Off-site environmental impacts	Nutrient leaching, runoff, stream-bank erosion, sedimentation, water and air quality contamination, impaired wildlife habitat, and other factors	Measurement and use of simulation models such as EPIC, SWAT, IFARM, ALMANAC, and others

Residue Analysis Applications

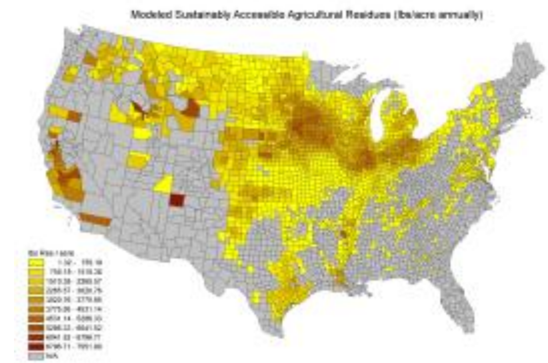


Sustainable Feedstock Production Analysis:

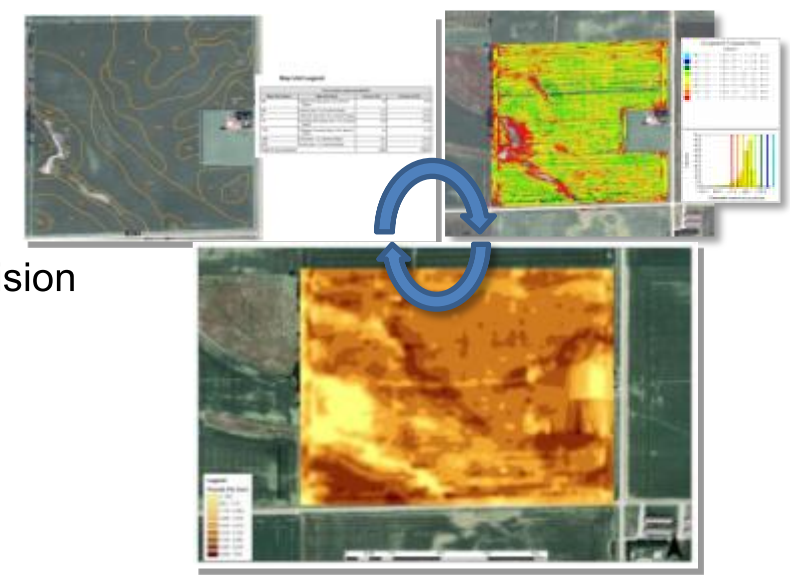
Integrated Models Include-

- •RUSLE2
- •WEPS
- •I-Farm
- •DayCent
- •CQESTR

Large Spatial Assessments



Management Unit Decision Support



Large Scale Assessment: Spatial Discretization

Adair County, Iowa
212 Kennebec Silt Loam 0% to 2% Slope

1.25 Miles

10 Year Average Yield:

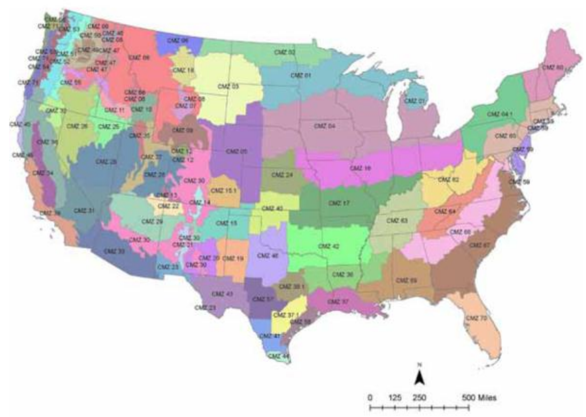
Management + Removal Rate	Calculated Erosion	SCI OM Subfactor	Annual Average Residue (lbs)	Corn Grain Yield
Continuous corn grain; NT, Harvest grain and cobs	0.1660717	0.320423	1891.345	149.9
Continuous corn grain; NT, High residue Harvest	1.1931644	-0.60299	7070.866	149.9
Continuous corn grain; NT, Moderate Residue Harvest	0.2281336	0.13634	2905.457	149.9
Continuous corn grain; NT, Moderately High residue Harvest	0.5972384	-0.12565	4542.535	149.9
Continuous corn grain; NT no stover harvest	0.0889718	0.784717	0	149.9

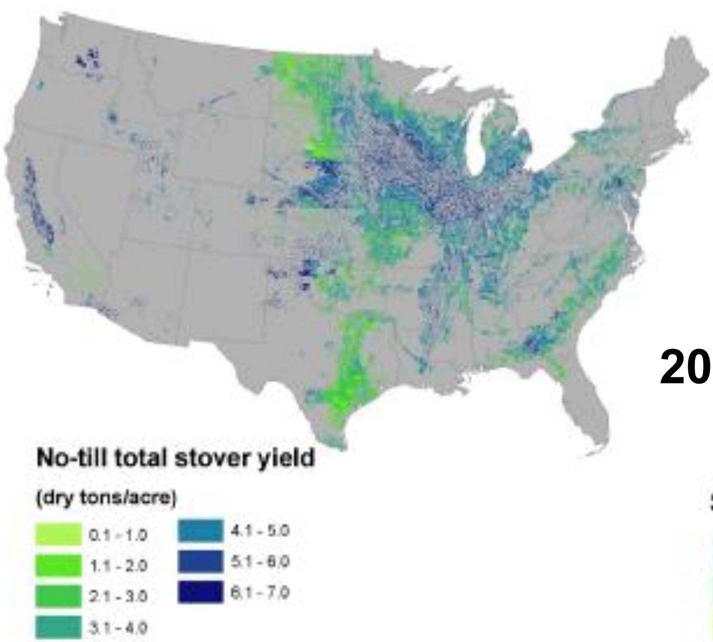
CROP RESIDUE SUSTAINABILITY

Retention coefficients estimated for erosion and soil C

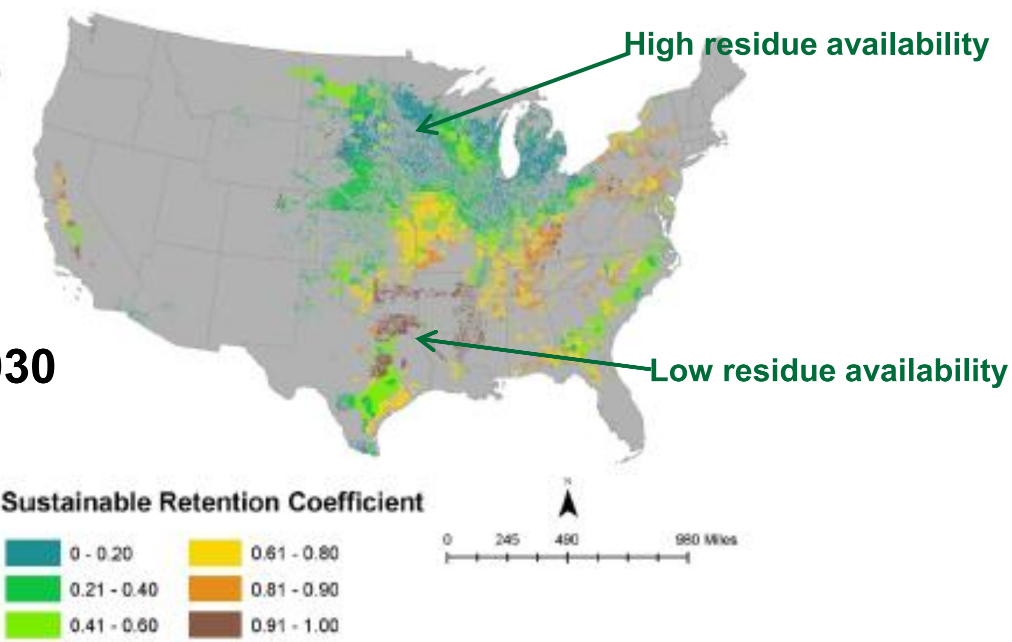
- Separate coefficients for reduced till and no-till
- No residue removal under conventional till
- Yield and time dependent in POLYSYS
- Dave Muth (INL), Richard Nelson (KSU), Doug Karlen (ARS) and others (ARS, NRCS, UTK)

NRCS CMZs





2030



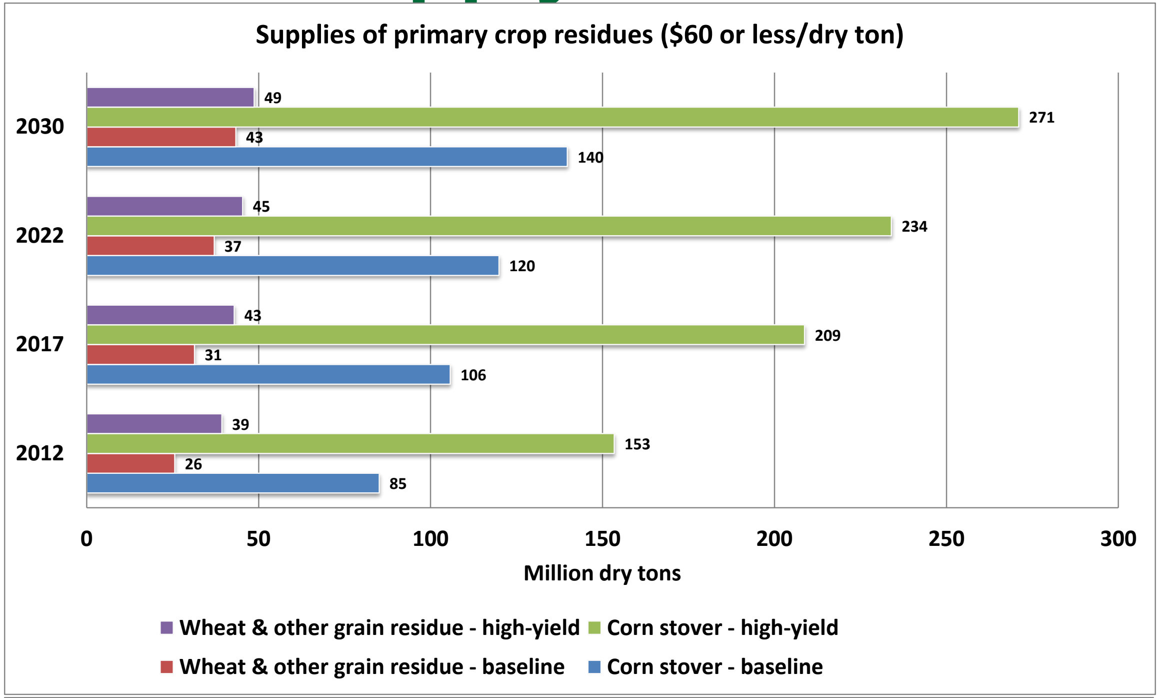
Key Assumptions

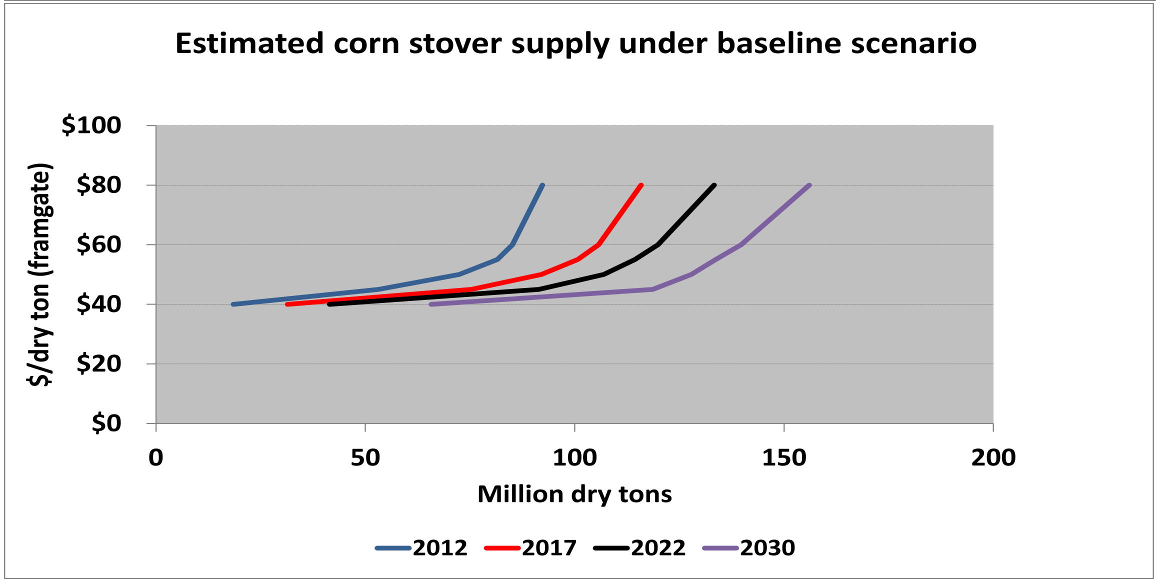
- Static harvest index (0.5 for corn stover)
- NRCS developed crop rotations
- SSURGO soils with capability class 1-4 considered
- SSURGO soils with greater than 1000 acres in each county considered
- Rotations assumed to be evenly distributed across soils
- Erosion limited to less than T-value in SSURGO for each soil
- SCI (Soil Conditioning Index) greater than 0

Bob Perlack – ORNL, Oak Ridge, TN

Crop Residue Estimated Supply

- Baseline scenario
  - About 111 million dry tons (mostly corn stover)
  - By 2030, supplies exceed 180 million dry tons (higher crop yields and higher use of reduced- and no-till
- High-yield scenario
  - Amount of corn stover increases significantly
  - By 2030, total primary residue is 320 million dry tons with 85% of this quantity corn stover





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
- All non-irrigated production
- 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 Pacific 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
- Energy crops not allowed on irrigated cropland & pasture
- 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 Yield Growth

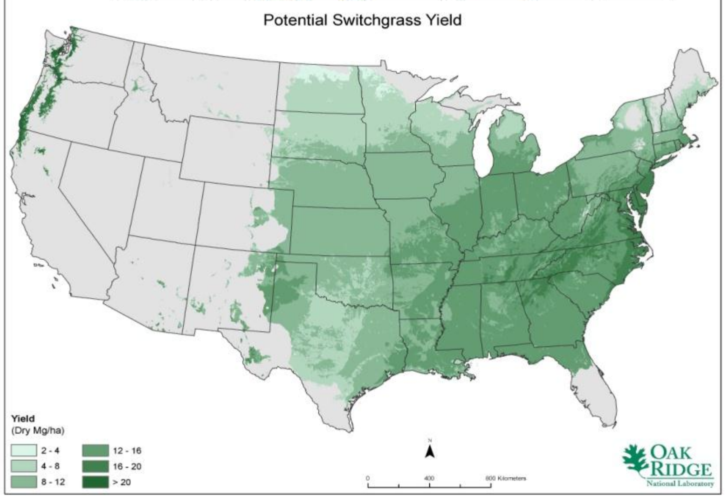
	2012	2017	2022	2030	2017	2022	2030
Crop	**Yield**	**Baseline 1% annual growth**			**High-yield 2%–4% annual growth**		
		Dry tons/acre/year			Dry tons/acre/year		
Low end of yield range	2	2.1	2.2	2.4	2.2 – 2.4	2.4 – 3.0	2.9 – 4.1
	3	3.2	3.3	3.6	3.3 – 3.6	3.7 – 4.4	4.3 – 6.1
	4	4.2	4.4	4.8	4.4 – 4.9	4.9 – 5.9	5.7 – 8.1
	5	5.3	5.5	6.0	5.5 – 6.1	6.1 – 7.4	7.1 – 10.1
	6	6.3	6.6	7.2	6.6 – 7.3	7.3 – 8.9	8.6 – 12.2
Middle of yield range	7	7.4	7.7	8.4	7.7 – 8.5	8.5 – 10.4	10.0 – 14.2
	8	8.4	8.8	9.6	8.8 – 9.7	9.8 – 11.8	11.4 – 16.2
High end of yield range	9	9.5	9.9	10.8	9.9 – 10.9	11.0 – 13.3	12.9 – 18.2
	10	10.5	11.0	12.0	11.0 – 12.2	12.2 – 14.8	14.3 – 20.3
	11	11.6	12.2	13.2	12.1 – 13.4	13.4 – 16.3	15.7 – 22.3
	12	12.6	13.3	14.4	13.2 – 14.6	14.6 – 17.8	17.1– 24.3

Notes: The yields shown for 2017–2030 for the baseline and high-yield scenarios reflect the standing yield of the energy crop before losses. It is the yield for the energy crop planted in that particular year. For example, if the 2009–2012 yield for a particular crop is 5 dry tons per acre, the yield for that crop would be 5.5 dry tons per acre if planted in 2022 under the baseline and 6.1 to 7.4 dry tons per acre under the high-yield scenario.

Perennial Grasses – Production Costs and Productivity

Item	Units	North-east	Appalachia	South-east	Delta	Corn Belt	Lake States	Southern Plains	Northern Plains
Stand life	Years	10	10	10	10	10	10	10	10
Productivity	dry tons/acre	4.0–7.5	5–9.5	3.5–9.5	3–7	4–7	3.5–5	2–6.5	2–6.5
Establishment									
Seed	$/lb.	$10	$22	$22	$22	$10	$10	$22	$10
Planting	lb./acre	5	5	5	5	5	5	5	5
Replants	percent	25	25	25	25	25	25	25	25
No-till drill	-	1-time	1-time	1-time	1-time	1-time	1-time	1-time	1-time
Total kill herbicide	No. applications	1-time	1-time	1-time	1-time	1-time	1-time	1-time	1-time
Pre-emergent herbicide	No. applications	1-time	1-time	1-time	1-time	1-time	1-time	1-time	1-time
Phosphorous	lbs P205/acre	40	40	40	40	40	40	40	40
Potassium	lbs K20/ac	80	80	80	80	80	80	0	0
Lime	tons/acre	1	2	2	2	1	1	0	0
Total establishment costs	**$/acre**	**$210**	**$340**	**$330**	**$330**	**$200**	**$200**	**$220**	**$150**
Maintenance years									
Reseeding	year applied	2	2	2	2	2	2	2	2
Pre-emergent herbicide	No. applications	0	0	0	0	0	0	0	0
Nitrogen	lbs/acre	60	70	70	50	60	40	40	40
Phosphorous	lbs P205/acre	0	0	80	0	80	0	0	0
Potassium	lbs K20 /acre	0	0	80	0	80	0	0	0
Harvest costs	**$/dry ton**	**$19.50 – $21.00**	**$18.50 – $19.90**	**$18.00- $20.20**	**$18.60 – $20.60**	**$19.20 – $20.60**	**$20.60 – $21.90**	**$19.20 – $22.10**	**$19.40 – $22.30**

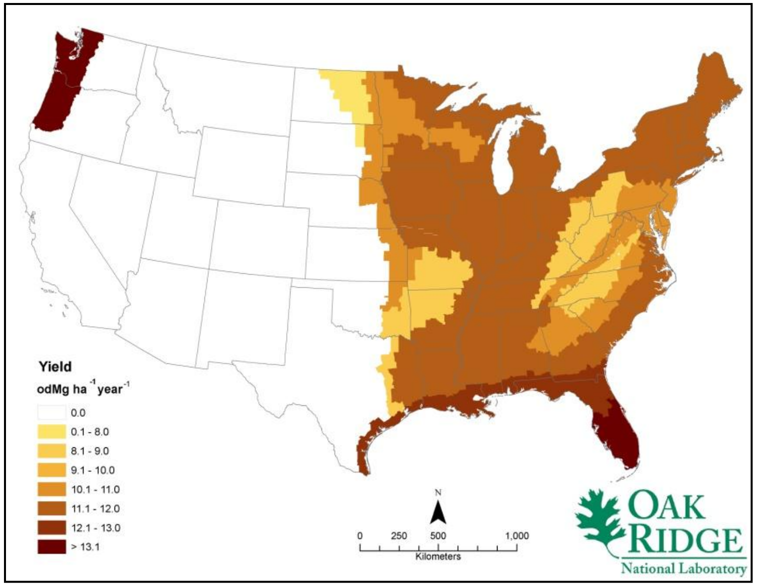
ID	SITE	DD_LAT	DD_LONG	CULTIVAR	ECOTYPE	YIELD_MG_HA	YEAR_PLNTD	YEAR_HAR	STAND_AGE
24	Site 2	43.33	-89.38	Dacotah	Upland	6.16	1997	1998	2
24	Site 2	43.33	-89.38	Dacotah	Upland	6.93	1997	1999	3
24	Site 2	43.33	-89.38	Forestburg	Upland	7.19	1997	1998	2
24	Site 2	43.33	-89.38	Dacotah	Upland	7.81	1997	2000	4
24	Site 2	43.33	-89.38	Sunburst	Upland	8.45	1997	1998	2
24	Site 2	43.33	-89.38	Dacotah	Upland	8.53	1997	2001	5
24	Site 2	43.33	-89.38	Forestburg	Upland	9.32	1997	2000	4
24	Site 2	43.33	-89.38	Cave-in-Rock	Upland	9.55	1997	1998	2
24	Site 2	43.33	-89.38	Trailblazer	Upland	9.98	1997	1998	2
24	Site 2	43.33	-89.38	Forestburg	Upland	10.00	1997	1999	3
24	Site 2	43.33	-89.38	Shawnee	Upland	10.20	1997	1998	2
24	Site 2	43.33	-89.38	Trailblazer	Upland	10.72	1997	1999	3
24	Site 2	43.33	-89.38	Sunburst	Upland	10.77	1997	1999	3
24	Site 2	43.33	-89.38	Forestburg	Upland	10.95	1997	2001	5
24	Site 2	43.33	-89.38	Trailblazer	Upland	11.16	1997	2000	4
24	Site 2	43.33	-89.38	Sunburst	Upland	11.55	1997	2000	4



- **Herbaceous crop productivity**
  - **Varies geographically**
  - **Baseline yields (dry tons/acre)**
    - **2014 – 3.0 - 9.9**
    - **2030 – 3.6 - 12.0**
  - **Database available**

Woody Crops – Production Costs and Productivity

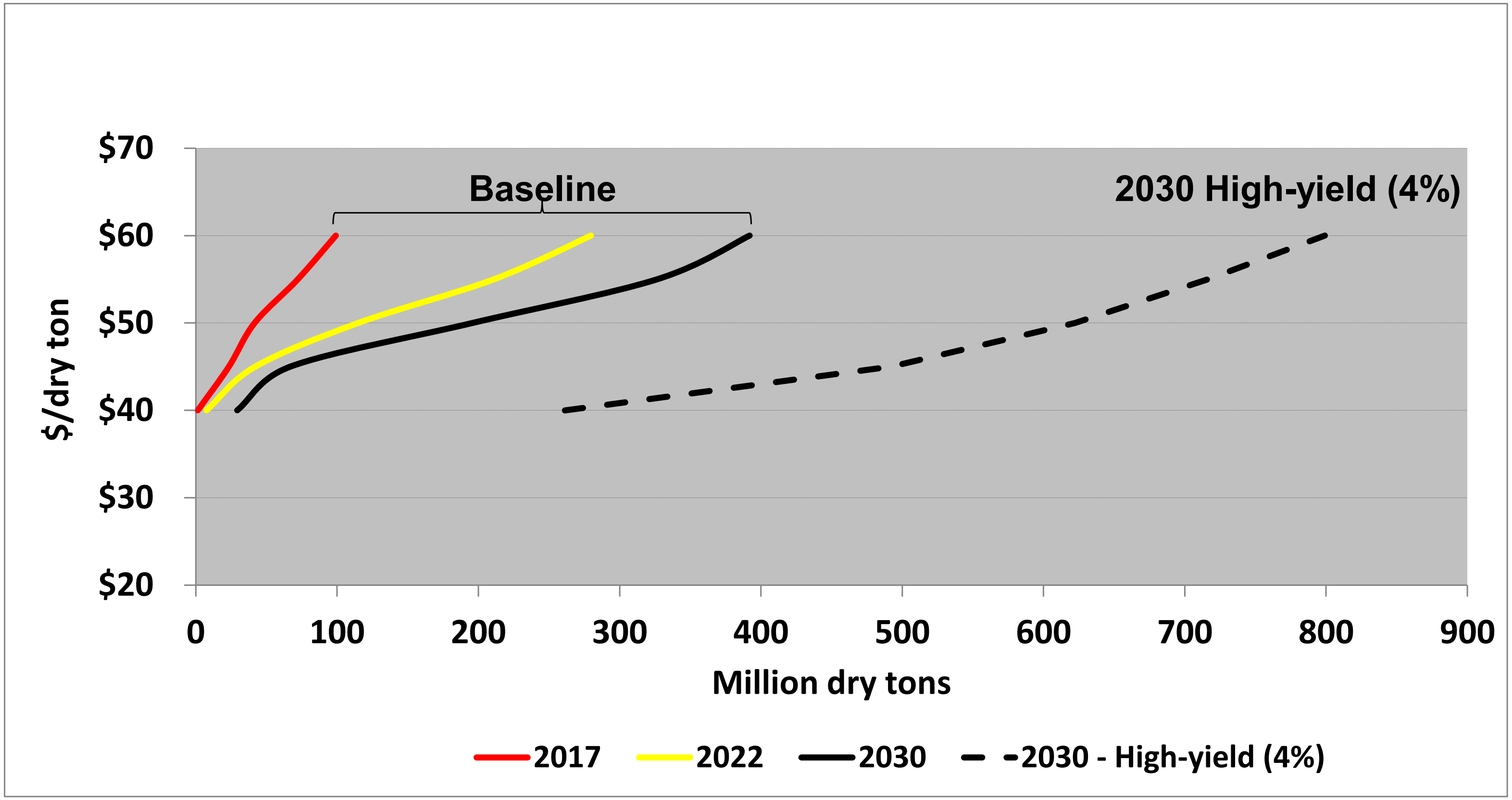
Item	Units	Poplar	Pine	Eucalyptus	Willow (coppiced)
Rotation	Years	8	8	8	4[a] (5 harvests)
Spacing	sq. ft.	60	60	60	7.5
	trees/acre	726	726	726	5800
Productivity	dry tons/acre-year	3.5–6.0	5.0–5.5	6.0	5.1
Growing range	Region	Northeast, Lake States, Northwest, Midwest, Plains	Southeast	Sub-tropics	Northeast and Lake States
Establishment - year 1					
Cuttings	$/tree	$0.10	$0.06	$0.10	$0.12
Planting	$/tree	$0.09	$0.09	$0.09	$0.02
Replants	percent	5	5	5	0
Moldboard plow	-	1-time	1-time	1-time	1-time
Disk	-	1-time	1-time	1-time	1-time
Cultivate	-	2-times	2-times	2-times	2-times
Total kill herbicide	No. applications	1-time	1-time	1-time	1-time
	lbs a.i./acre	1.5	1.5	1.5	1.5
Pre-emergent herbicide	No. applications	1-time	1-time	1-time	1-time
	lbs a.i./acre	1.5	1.5	1.5	1.5
Phosphorous	lbs/acre	0	40	0	0
Establishment costs	$/acre	$310	$280	$310	$1120
Maintenance years					
Cultivate - year 2	-	2-times	2-times	2-times	1-time
Cultivate - year 3		1-time	1-time	1-time	None
Pre-emergent herbicide - year 2	No. applications	1	1	1	1
	lbs a.i./acre	1.5	1.5	1.5	1.5
Lime - year 3	tons/acre	90	90	90	100
	year applied	-	year3	year3	-
Nitrogen - year 4 and 6	lbs/acre	90	90	90	100
	year applied	4 and 6	2,4, and 6	4 and 6	4
	-	-	-	-	-
Phosphorous - year 3	lbs/acre	20	40	15	-
	year applied	3	3	3	-
Potassium - year 3	lbs/acre	35	40	25	-
	year applied	3	3	3	-
Maintenance costs – year 2	$/acre	$60	$100	$100	$30
Maintenance costs – year 3–8	$/acre	$220	$200	$200	$100[b]
Harvest costs	**$/dry ton**	**$20**	**$20**	**$20**	**$15**



- **Woody crop productivity**
  - **Varies geographically**
  - **Baseline yields (dry tons/acre)**
    - **2014 – 3.5 - 6.0**
    - **2030 – 4.2 - 7.2**
  - **Database available**

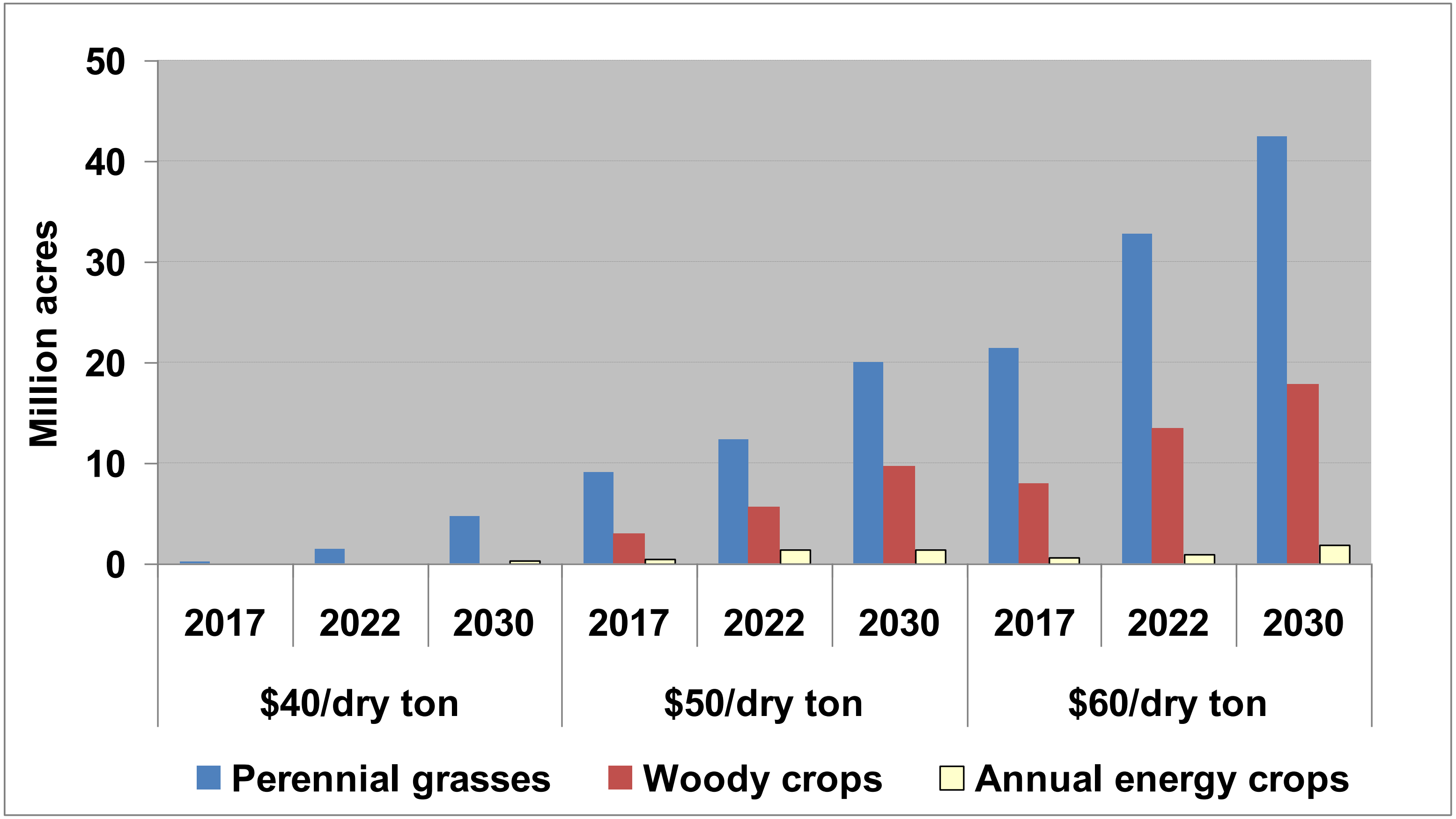
Energy Crop Simulated Supply Curves – Baseline Scenario

- 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



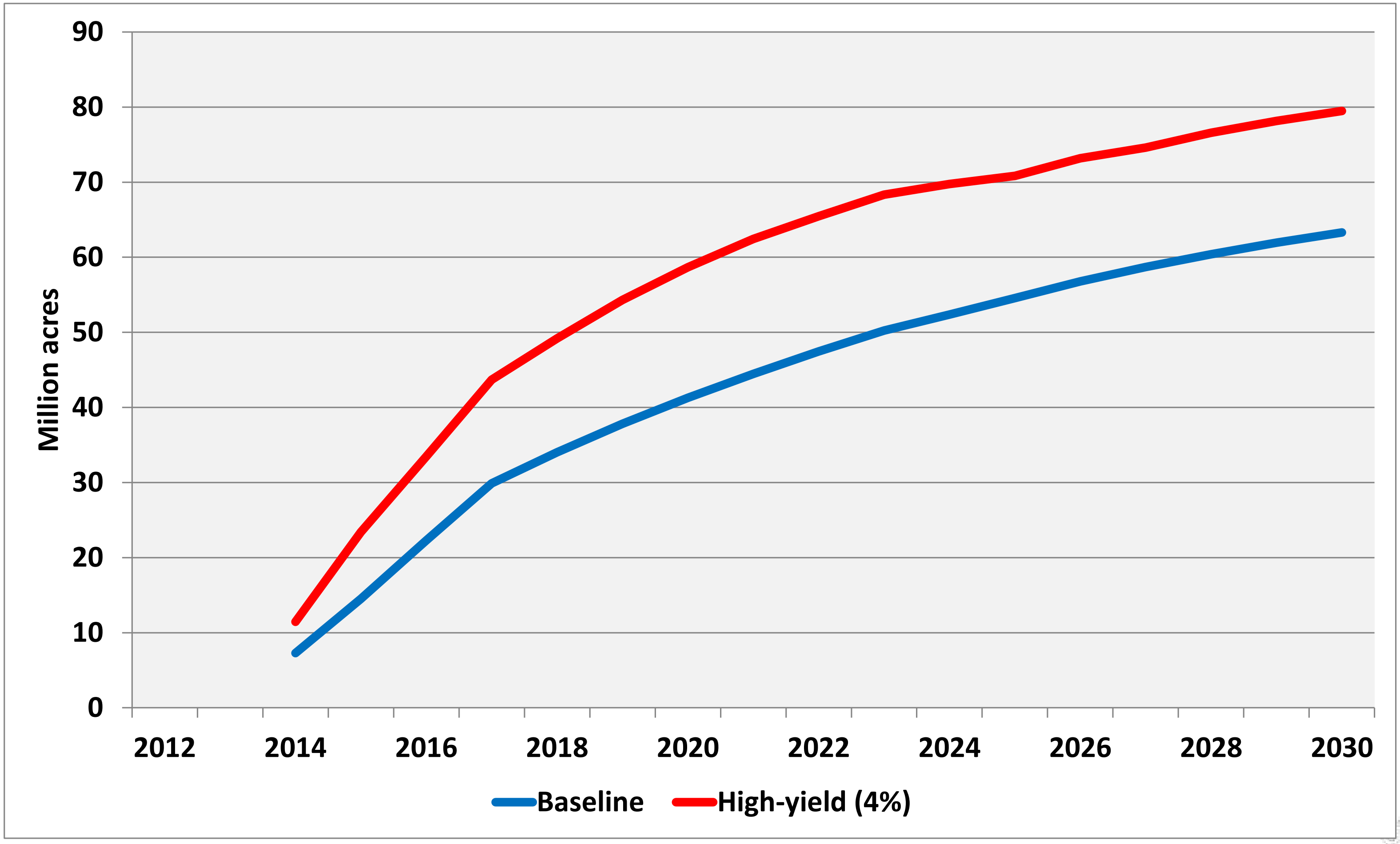
Energy Crop Simulated Land Use Change

- **Land use change at highest simulated prices by 2030**
  - **22 to 30 million acres cropland**
  - **40 to 50 million acres pasture**



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**



Bryce Stokes - CNJV, Washington, DC

Forest Resources

- **Forestland resources in U.S.**
  - **504 million acres of timberland**
  - **91 million acres of other forestland**
- **Forest resource feedstocks**
  - **Composite (combination of logging residues and forest thinnings)**
    - **Logging residues**
    - **Forest thinnings (health treatments on timberlands)**
  - **Thinnings on other forestlands**
  - **Other removal residues**
  - ***Conventional wood***
  - **Fuelwood**
  - **Primary mill residues**
  - **Secondary mill residues**
  - **Pulping liquors**
  - **Urban wood residues**

Forestland – minimal of 1 acre and 10% live tree cover

Timberland – capable of growing 20 ft^3/acre/year
Other Forestland – other than timberland or reserved land

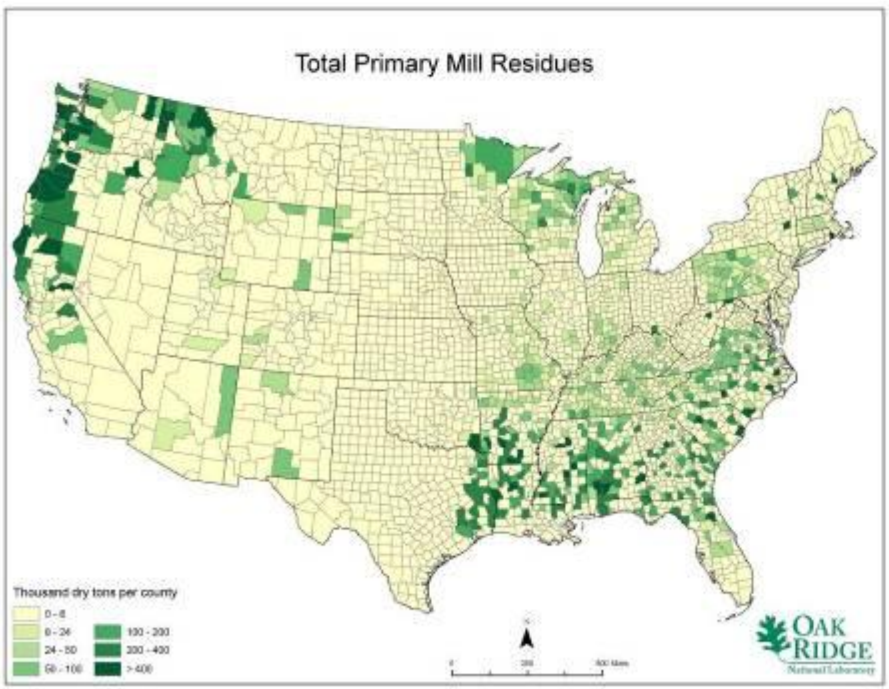
Reserved forestland – administratively removed from production

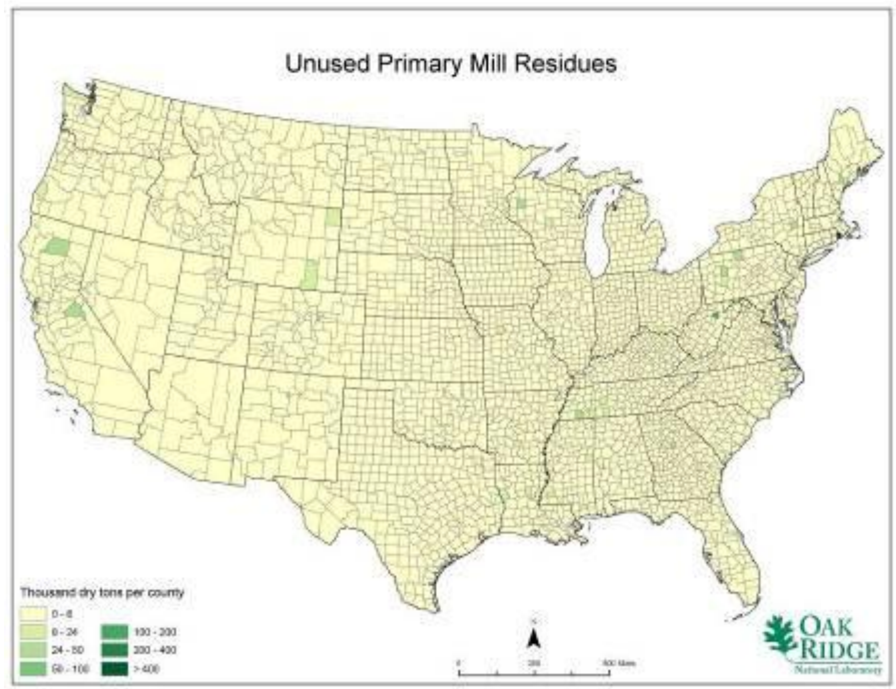
Currently used
- Fuelwood
- Mill residue
- Pulping Liquor
- MSW

Potential
- Composite
- Other removal residue
- Thinnings on other forestlands
- Mill residues
- Urban
- Conventional wood to energy

PRIMARY MILL RESIDUES

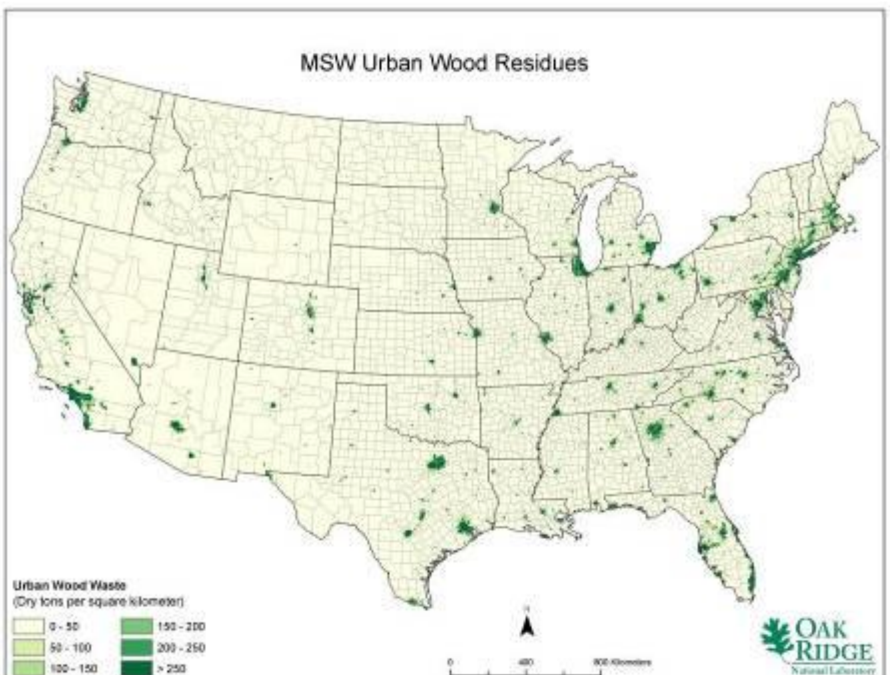
- Very little primary mill residue goes unused
- Potential to divert some lower value uses (e.g., mulch) to bioenergy





URBAN WOOD WASTES

- Urban wood residues are the woody component in MSW and C&D landfills
- Projections based on population growth subject to improvements in reduction, reuse, and recycling



Assumed Integrated Logging to Estimate Logging Residues, Thinnings, and Composite Feedstocks Categories

Logging Residues

(Current) **(Assumed)**

Thinnings

Integrated Logging = Merchantable Materials + Biomass

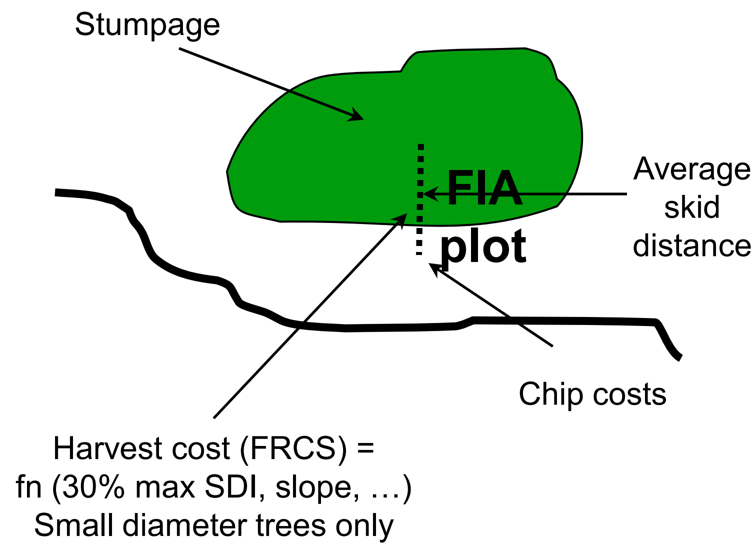
Composite Feedstock Category = Selected Portion of Logging Residues + Selected Portion of Thinnings

Forest Resources Data Sources

- U.S. Forest Service Forest Inventory and Analysis (FIA)
  - Downloaded data from FIA DataMart4 (February/March 2010) - http://199.128.173.17/fiadb4-downloads/datamart.html
  - Used specific data for biomass
    - Small trees (1-5 inch dbh in East and 1-7 inch dbh in West)
    - Non-merchantable tree components of trees great than 5/7 inch dbh
      - Limbs and tops
      - Non-merchantable bole
      - Dead trees
- Includes new method for calculating the non-merchantable volumes of the merchantable trees
  - Component ratio method (CRM)
  - Consistently lower volumes vs. old method
    - 6-8% generally
    - Up to 30% for specific species and stand type
- 2009 RPA (Resource Planning Act) Assessment (Smith et al.)
  - Growth projections
- 2005 RPA Timber Assessment
  - Harvest projections
- RPA Timber Products Output (TPO) database
  - Logging and other removal residue
  - Downloaded (March 2010)
  - http://srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int1.php

Forest Residues Modeling and Sustainability

- **Evaluated biomass removal sustainability (erosion, soil nutrients, biodiversity, soil-organic carbon, and long-term soil productivity)**
- **Sustainability based on biomass retention levels by slope class**
  - **Logging residues - 30% left on-site**
  - **Thinnings**
    - **Slope <40% = 30% left on-site**
    - **Slope >40% to <80% = 40% left on site**
    - **Slope >80% = no removal**
- **Removed steep, wet and roadless sites from consideration**
- **Re-estimated supply curves for logging residues and thinnings on timberland**
- **Estimated supply curves for conventionally sourced wood (i.e., pulpwood) from additional harvests and shift from current uses to bioenergy**



FIA data (~37,000 permanent field plots)

- **Exclude roadless areas and reserved, steep, and wet lands**
- **All fire regime condition classes**
- **Treated if greater then 30% of maximum stand density for forest type/ecoregion**
- **Thin over 30-year period**

Ken Skog – FS, Madison, WI

Forest Feedstock Supply Curve Estimation

- Key forest feedstocks
  - <u>Forest Residues from integrated logging (</u>sawlogs/pulpwood + biomass)
    - Composite estimate sources – logging residue data, forest thinning simulations
  - <u>Conventionally sourced wood (</u>i.e., pulpwood) from 1) additional harvests and 2) shift from current pulpwood uses to bioenergy
- Estimation elements
  - Supply amount by price (= stumpage cost + harvest cost)
  - Limits on amounts of supply
- Only Baseline Scenario for Forest Resources

Forest Residue Supply Curve Estimation

- Composite estimate sources – logging residue data, forest thinning simulations
- Amounts
  - Logging residue – Forest Service Timber Product Output database, removals limited to 70%
    - Increased over time with projected increased harvest
  - Forest thinnings – simulated on Forest Service FIA plots, removals over 30 years
    - Limited so projected sawlog/ pulpwood harvest not exceeded
- Costs
  - Stumpage (forest residues and conventionally-sourced wood)
  - Harvest costs estimated using the Fuel Reduction Cost Simulator

Forest Residue Stumpage Prices

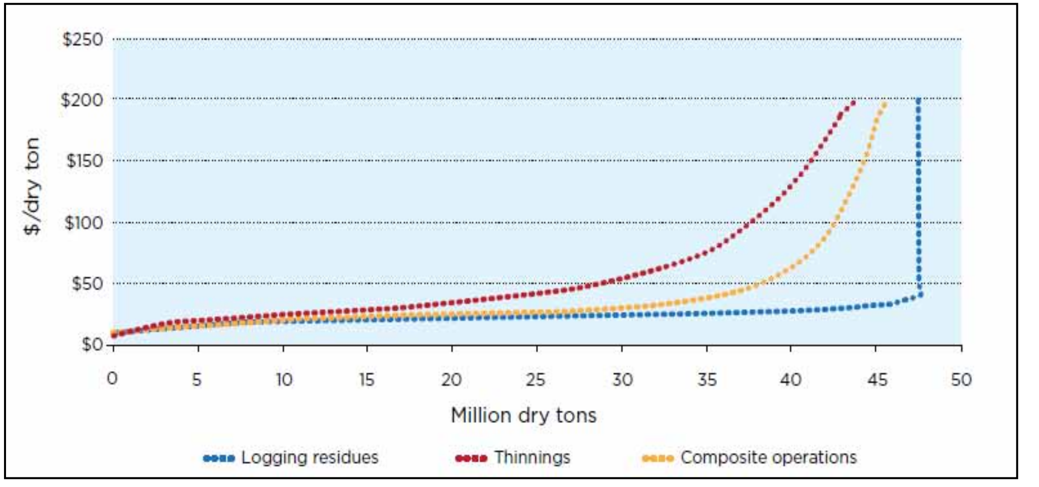
- With low supply - stumpage price of $4/dry ton for tops/branches, increases to 90% of pulpwood stumpage price with high supply

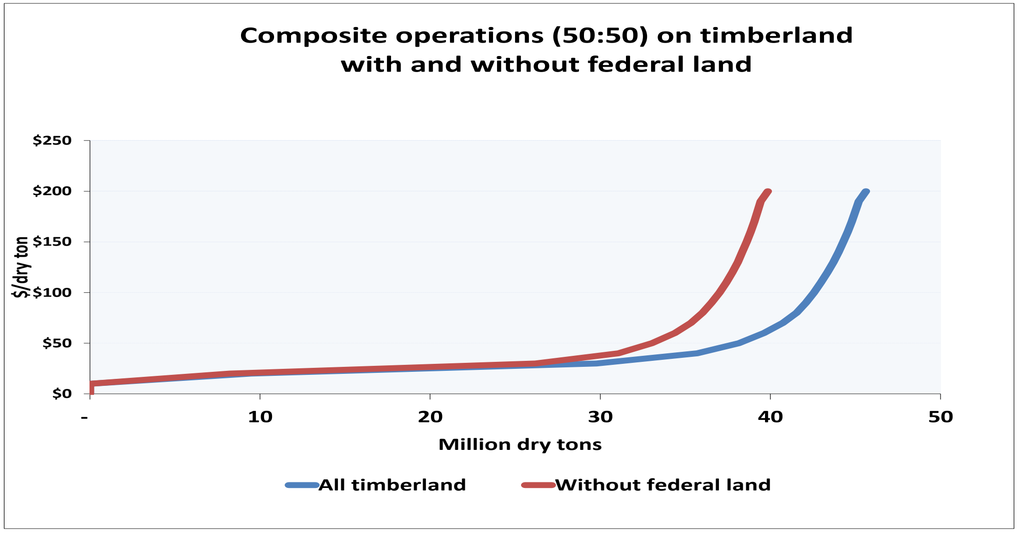
- Use Regional Pulpwood stumpage prices
  - Hardwoods: North $15.40/dry ton; South - $13.30/dry ton
  - Softwoods: North - $20.70/dry ton; South - $15.70/dry ton
  - West - $27.60/dry ton

Forest Residues - Composite Results

- Estimates
  - $20-$200/dry ton
  - Current - 2012
  - Potential – 2017-2030
  - Federal and non-federal (ESIA exclusion)
- Roadside supply curves
  - Includes stumpage & chipping costs
  - Fuel Reduction Cost Simulator model for harvesting
  - Projections based on latest RPA/TPO
  - With & without federal land
  - Based on integrated logging

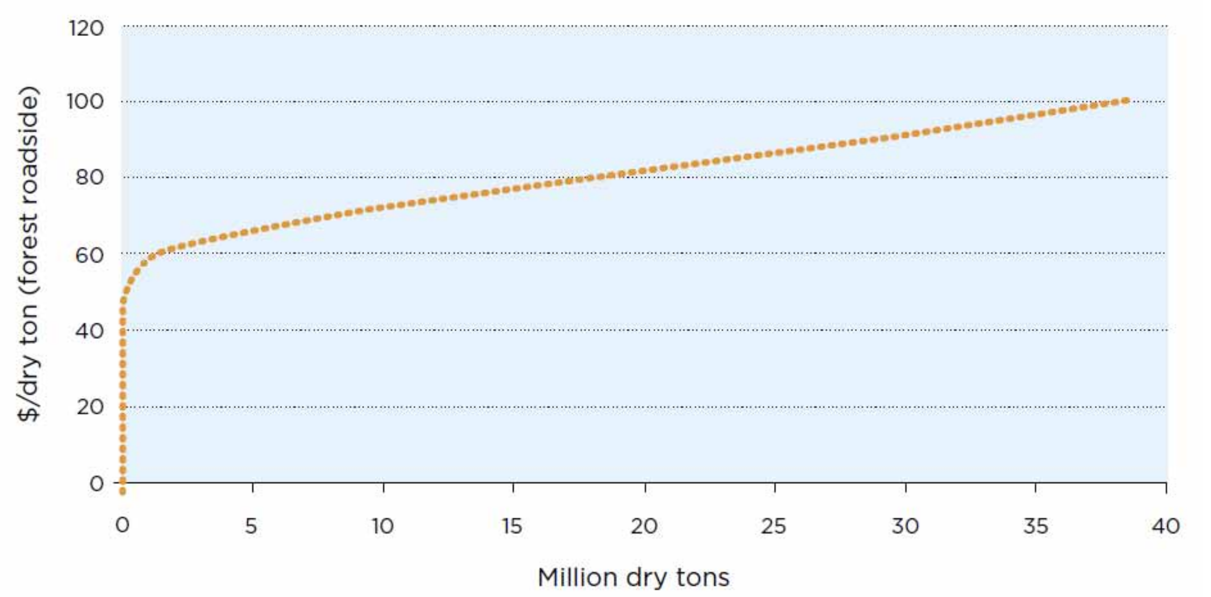
Example Supply Curves





Forest Biomass – Conventionally Sourced Wood (Pulpwood)

- **Sources:**
  - <u>Additional harvest of sites for pulpwood – for biomass only – no sawlogs</u>
  - <u>Shift of pulpwood use from current users to bioenergy use (away from pulp / panel production)</u>
- **Prices – based on recent pulpwood price and elasticities of supply & demand**
- **Limitations:**
  - Additional harvest for biomass cannot exceed current timber growth by state
  - Shift from current use cannot exceed 20% of current use in a state
- **Caveats**
  - Rough estimates
  - Short range
  - Estimates will change with pulpwood market conditions and forest growth



Bob Perlack – ORNL, Oak Ridge, TN

U.S. Billion-Ton Update Summary 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**

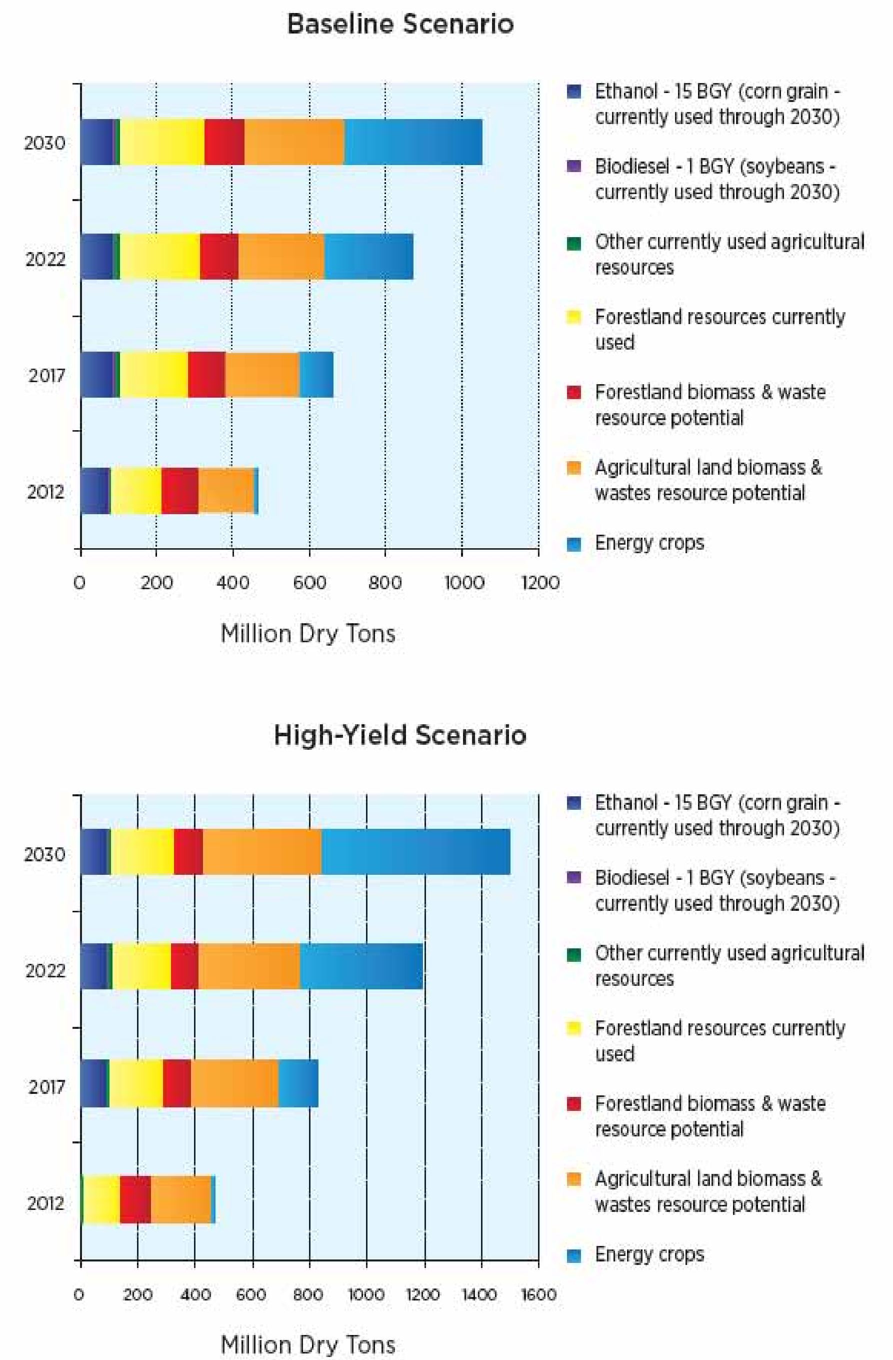


Table ES.1 Summary of Currently Used and Potential Forest and Agriculture Biomass at $60 per Dry Ton or Less under Baseline and High-Yield Assumptions

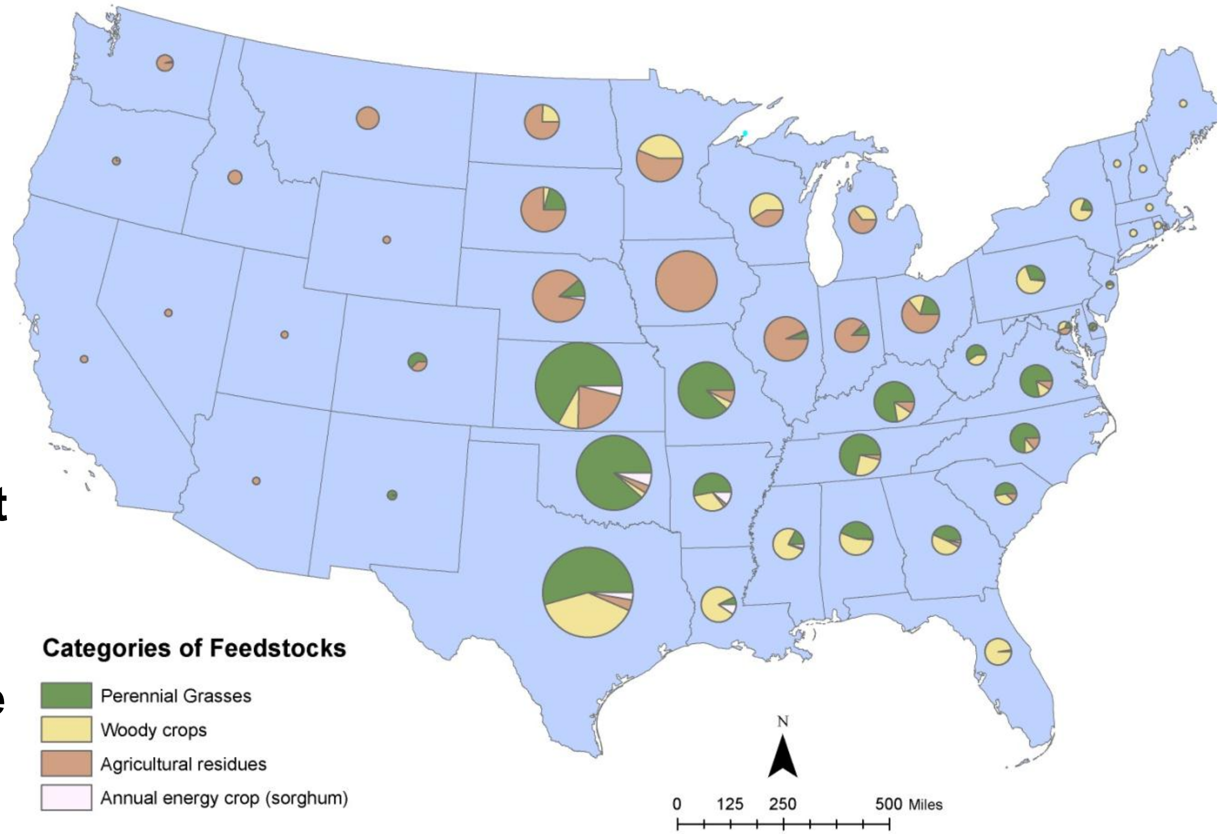
Feedstock	2012	2017	2022	2030
	Million dry tons			
Baseline scenario				
Ethanol - 15 BGY (corn grain)	76	88	88	88
Biodiesel - 1 BGY (fats and oils)	2	4	4	4
Other currently used agricultural resources	7	11	11	11
Forest resources currently used	129	182	210	225
Forest biomass & waste resources	96	99	100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

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

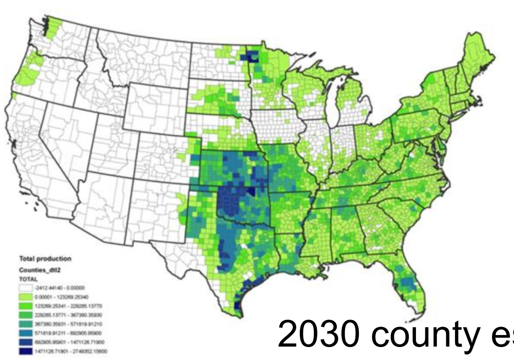
[1] Energy Crops are planted starting in 2014.

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**



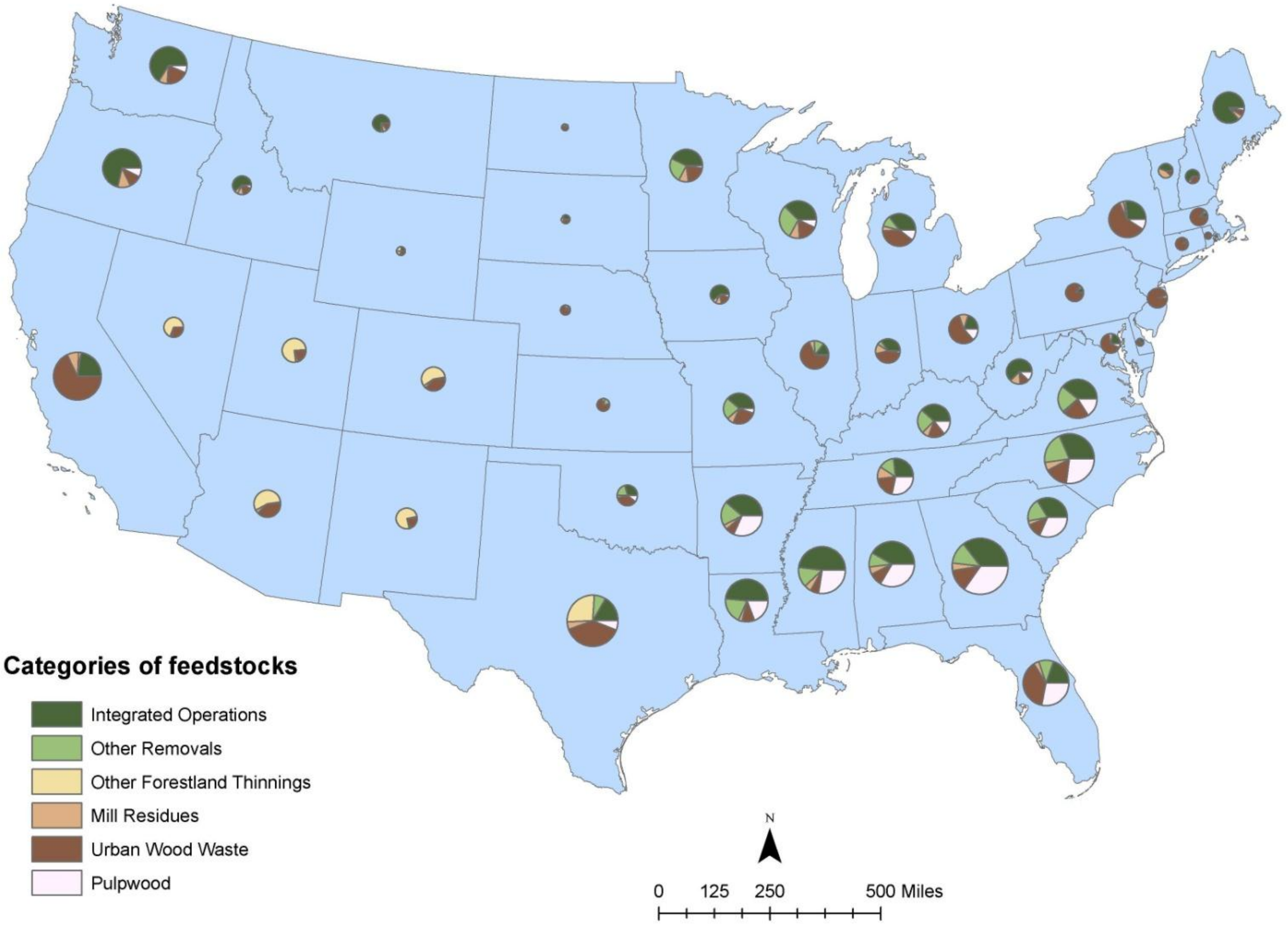
Baseline scenario - $60/dry ton; year 2030



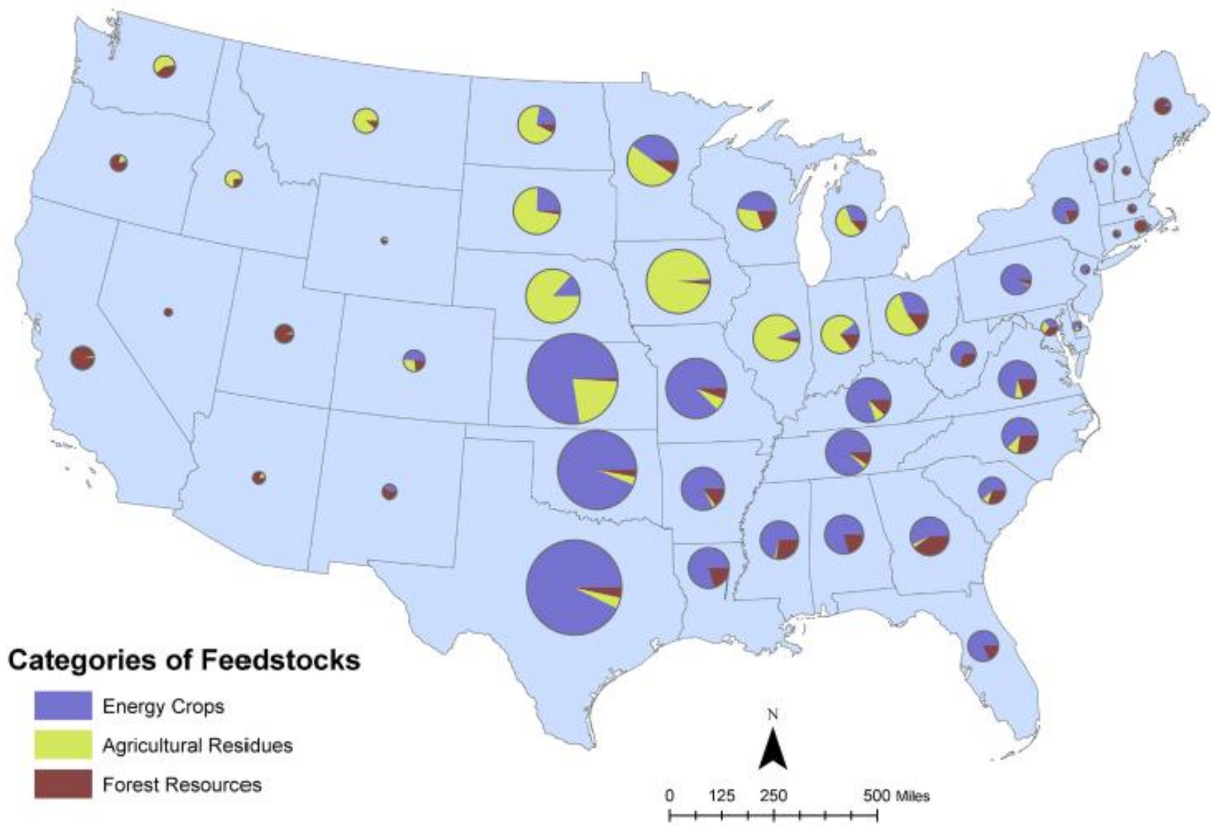
2030 county estimates

Potential to Supply Forest Residues by State

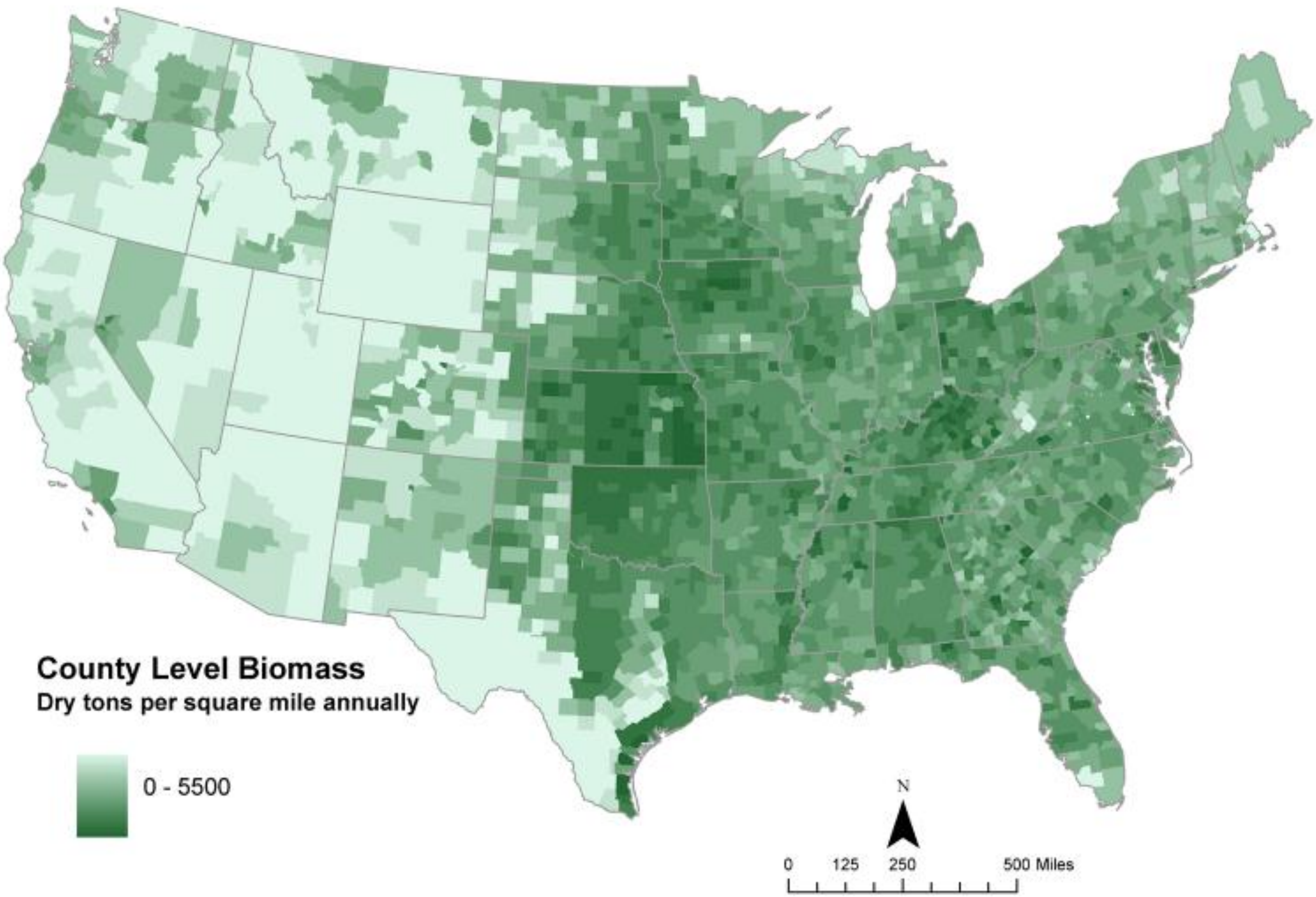
- **Forest residues are widespread in the Southeast, North, and Northwest**



State-level Shares of All Potentially Available Resources at $60 Per Dry Ton or Less in 2030, Under Baseline Assumptions

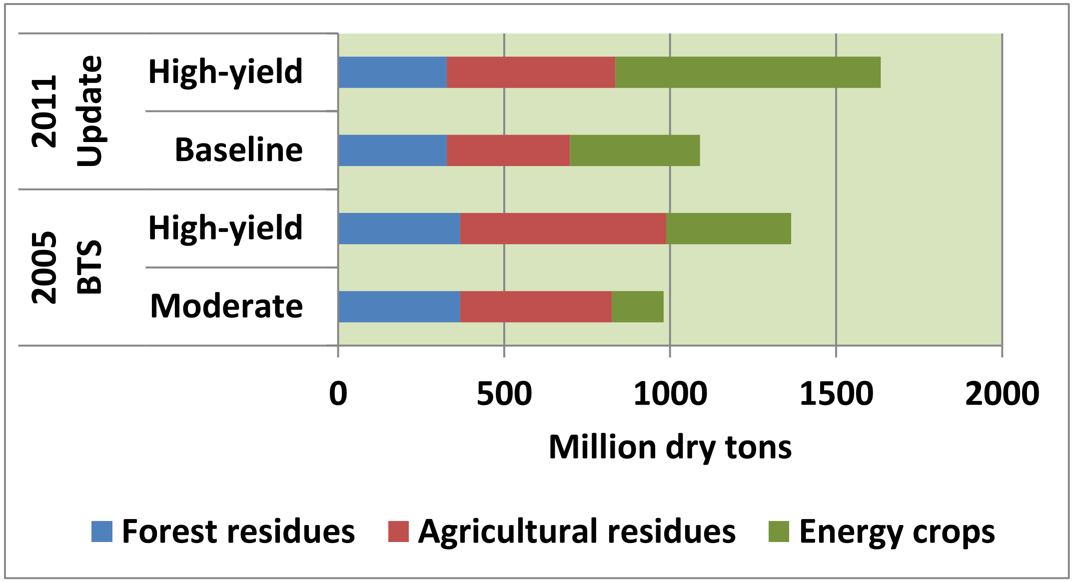


Potential County-level Resources at $60 Per Dry Ton or Less in 2030, Under Baseline Assumptions



Summary

- **Comparison with the 2005 BTS**
  - **Forest residue biomass potential is less – removal of unused resources, 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, POLYSYS modeling**
- **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**
- **Bioenergy KDF provides specific results of the update – feedstock categories, years, prices and quantities, and spatial interest**



2011 BTU - $60/dry ton

