Energy From Agriculture:

New Technologies, Innovative Programs & Success Stories

December 14-15, 2005 *St. Louis, Missouri*

Farm Foundation

USDA's Office of Energy Policy and New Uses

NRCS

Rural Development

Non-Traditional Biomass Resources—Cellulose Feedstocks

Marie E. Walsh

University of Tennessee

December 14, 2005

Definition of Cellulose Biomass

- Available on a regular or recurring basis and includes dedicated energy crops and trees; wood and wood residues; plants; grasses; agricultural residues; fibers; animal wastes and other waste materials; and municipal solid waste (Energy Policy Act of 2005)
- Any organic matter available on a renewable or recurring basis and includes agricultural crops and trees; wood and wood wastes and residues; plants (including aquatic plants); grasses; residues fibers; and animal wastes; municipal wastes, and other waste materials (Biomass R&D Act of 2000)

Cellulose Feedstock Categories

- Forest Residues
  - Logging Residues, Other Removals, Fuel Treatment Removals
- Mill Residues
  - Primary Mills, Secondary Mills
- Urban Wood Wastes
  - Municipal Solid Waste, Yard Trimmings, Residential and Non-Residential Construction, Demolition, and Renovation
- Agricultural Crop Residues
  - Corn Stover, Wheat Straw, Straw from Other Crops
- Dedicated Energy Crops
  - Perennial Grasses (Switchgrass), Short Rotation Woody Crops (Hybrid Poplar, Willow)

Key Issues

- How much?
- At what price?
- Where?

Resource Assessment Status

- Most are inventory studies
  - Quantity only, no price
- Most are geographically limited
  - National, regional, or state quantity
  - County estimates usually limited to a single state or small multi-state region, but not entire U.S. (Forest Service data is the exception)
- Most examine a limited number of feedstocks
  - Crop residues or forest residues, but not both
- Multiple authors using different assumptions and methodologies
  - Issues of comparing apples and oranges

County Level Feedstock Supply Curve Database--ORNL

- Web-based database of the estimated county supplies (quantities available by price) of the five major cellulose feedstock categories (Forest residues, mill residues, urban wood wastes, agricultural crop residues, dedicated energy crops)
- Funding cut-backs lead to the project being discontinued prior to completion
- Walsh has continued the analysis and has a preliminary dataset

Caveats

- Forest, Mill, and Urban Wastes
  - Estimates are preliminary (need to undergo further quality control checks and review)
- Energy Crops
  - Projected based on relative economics (large scale commercial production doesn't exist)
- All Feedstocks
  - Supply estimates based on existing technology, markets, and policy (changes could lead to greater quantities and/or lower prices)
- Costs
  - Producer gate costs—no transportation costs included

Forest Residues

- Logging residues—unused portion of growing stock trees cut by logging and left behind
- Other removals—unutilized wood volume from cut/killed growing stock from cultural operations such as pre-commercial thinnings or timberland clearing

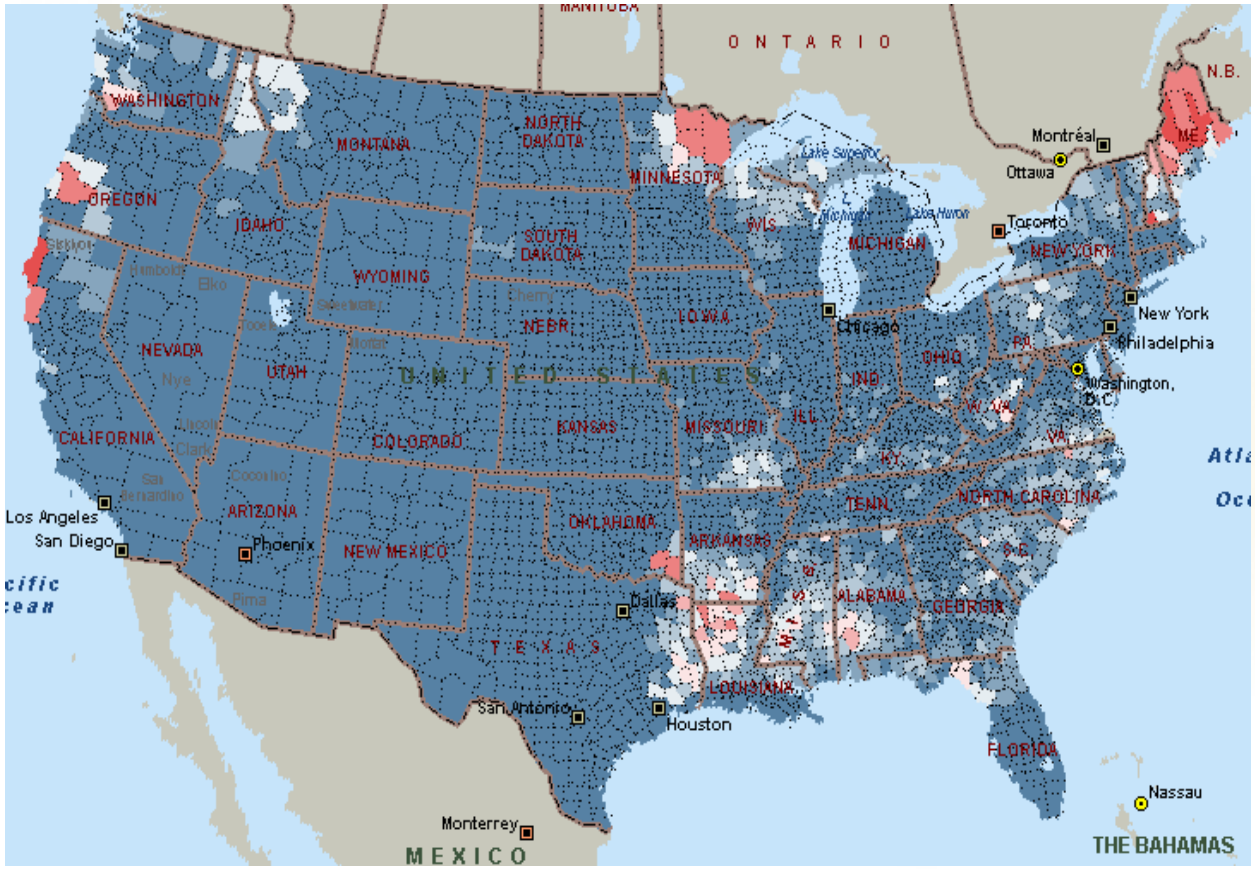
Forest Residues-Methodology

- Quantity and Distribution
  - USDA Forest Service Timber Product Output Database
- Cost
  - Model developed by McQuillan using forest inventory information, logging/chipping costs, site accessibility, equipment limitations

Preliminary Forest Residue Supply Curves (million dry tons)

	$20/dt	$30/dt	$40/dt	$50/dt
Logging Residues	0	12.48	23.15	23.15
Other Removals	0.611	6.49	8.18	8.99
TOTAL	0.611	18.97	31.33	32.14

Distribution of Forest Residues ($40/dt)

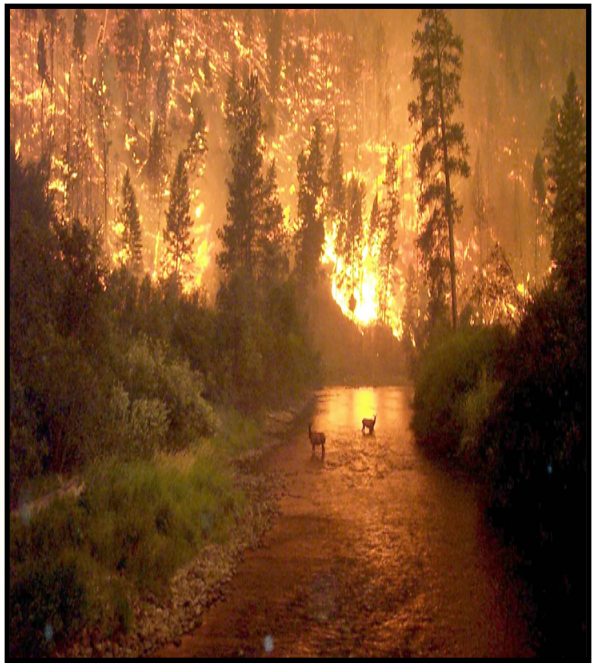


Quantities (dt)

- 200,001 to 300,000
- 100,001 to 200,000
- 75,001 to 100,000
- 60,001 to 75,000
- 45,001 to 60,000
- 30,001 to 45,000
- 15,001 to 30,000
- 0 to 15,000

Fuel Treatment Quantities

- Forest Service is currently developing supply curves
- Preliminary estimates for 15 Western states assuming 60% of treatable timberland in fire class 3 (Rummer et al, 2003)
  - 346 million dry tons could be removed
  - Harvest costs from $35 to $62/dt depending on species, terrain, density, and diameter among other factors



Primary Mill Residues

- Primary Mills convert roundwood products into other products and include lumber, pulp, veneer mills, etc.
  - Wastes generated include bark, fines (sawdust and planar shavings) and coarse
- Secondary Mills generally utilize materials from primary mills to produce consumer products such as cabinets, furniture, etc.
  - Little analysis of secondary mill wastes and indicate quantities are small.

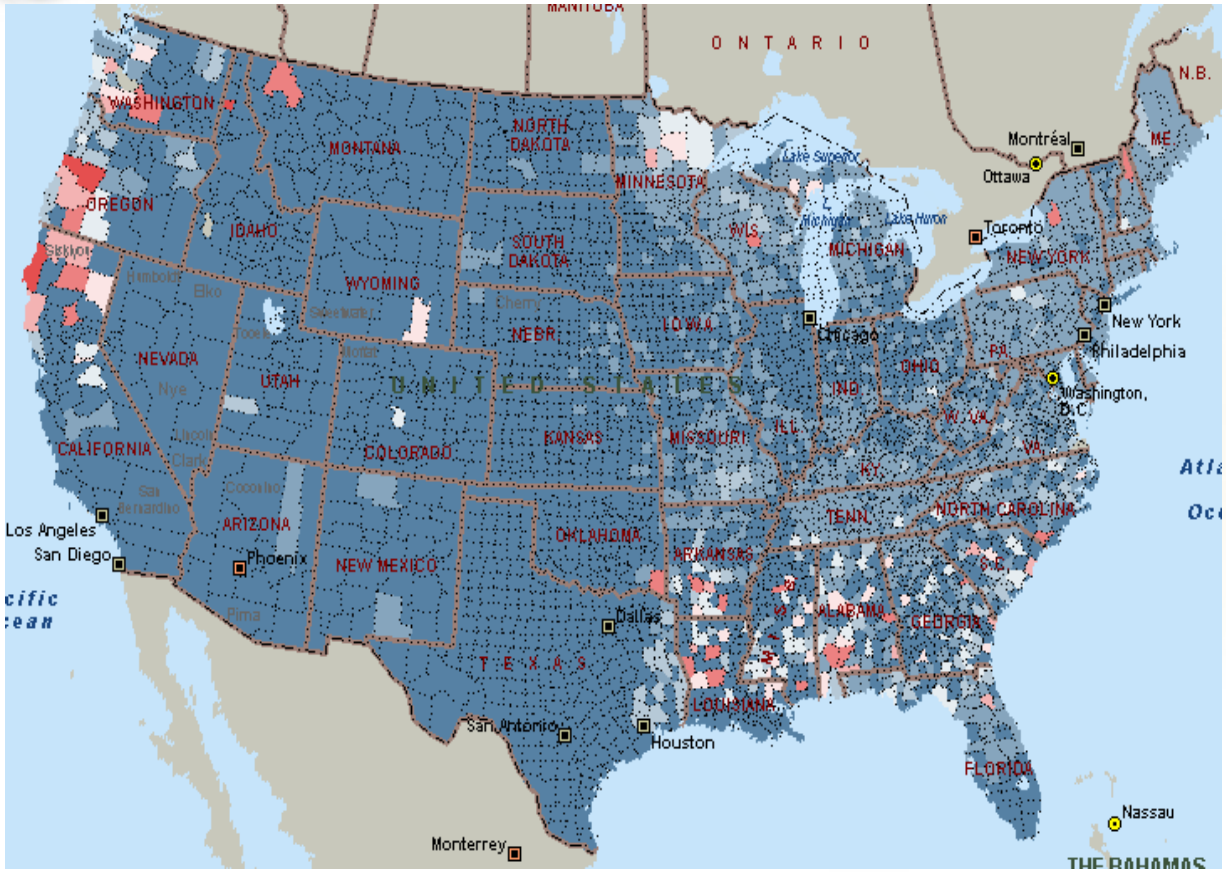
Primary Mill Residue Methodology

- Quantity, location, uses
  - Forest Service Timber Product Output Database
- Costs
  - Size reduction costs, disposal costs and opportunity costs of products (i.e., assumes that residues currently used to produce products could be available for bioenergy and bioproducts if price sufficiently high)

Preliminary Primary Mill Residue Supply Curves (million dry tons)

$15/dt	$20/dt	$30/dt	$40/dt	$50/dt
1.66	33.31	36.34	47.65	53.67

Distribution of Mill Residues ($40/dt)



Quantity (dry tons)

- 500,001 to 750,000
- 250,001 to 500,000
- 200,001 to 250,000
- 150,001 to 200,000
- 100,001 to 150,000
- 50,001 to 100,000
- 0.002 to 50,000
- 0 to 0.001

Urban Wood Wastes

- Municipal Solid Wastes
  - Durables such as furniture and cabinets
  - Packaging such pallets and wood crates
  - Yard trimmings
- Construction Wastes
  - Residential (single and multi-family housing)
  - Non-residential
- Renovation Wastes
  - Residential
- Demolition Wastes
  - Residential
  - Non-residential

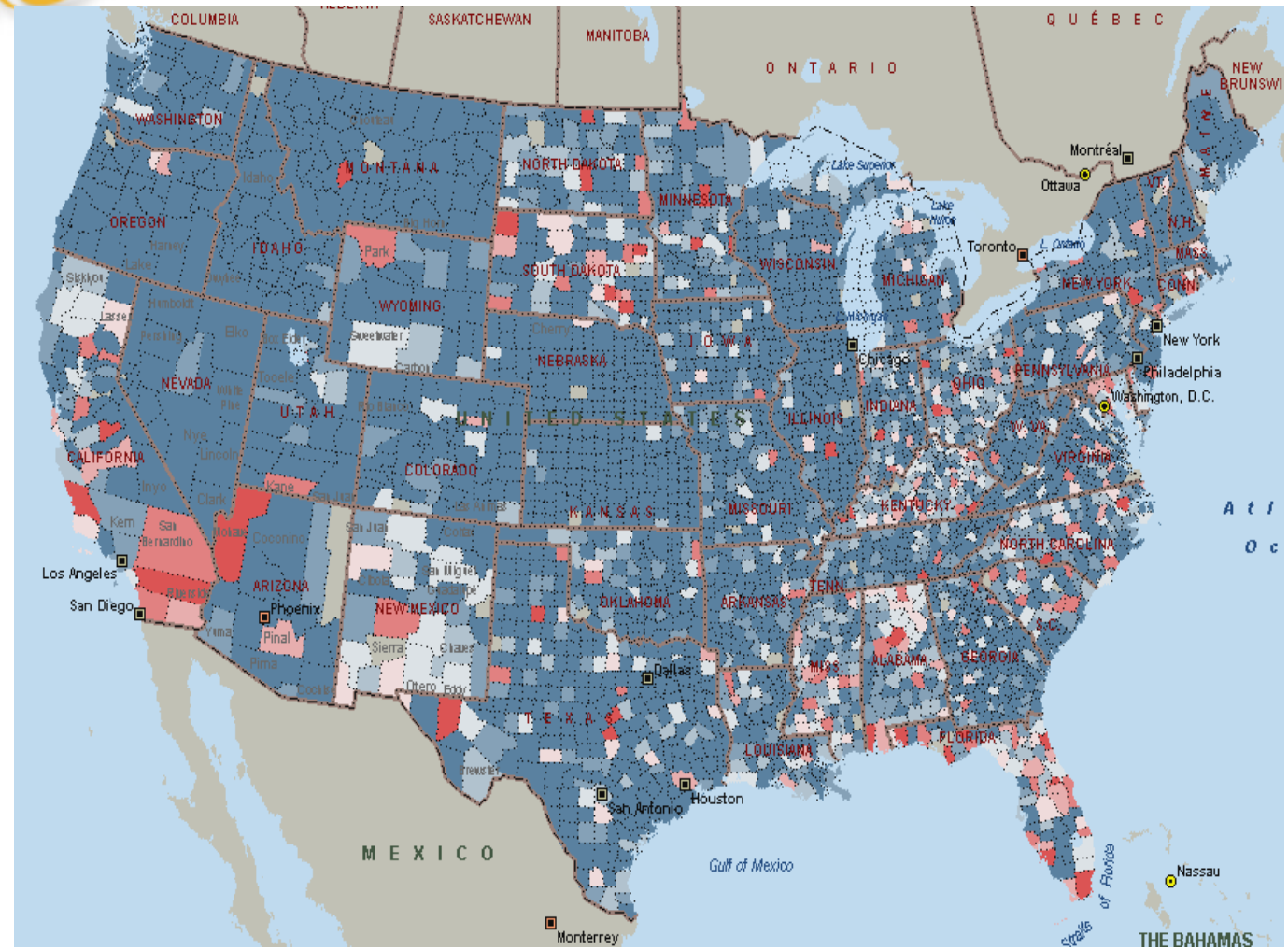
Urban Wood Waste Methodology

- Quantities and location based on a number of surveys (Biocycle, VPI), characterization studies (EPA), and Commerce Department data (housing, population, construction expenditures)
- Costs
  - Sorting costs and size reduction costs
  - Net disposal costs (tipping fees)
  - Value of other products recovered in sorting mixed wastes
  - Opportunity costs of recycled products

Preliminary Urban Wood Waste Supply Curves (million dry tons)

	$15/dt	$20/dt	$30/dt	$40/dt	$50/dt
MSW/Yard Trim	5.9	6.9	8.0	8.8	10.0
Construction & Renovation	1.5	3.1	5.5	9.6	13.4
Demolition	0.3	0.4	4.0	12.2	15.4
Total	7.7	10.4	17.5	30.6	38.8

Urban Wood Waste Distribution ($40/dt)



Quantities (dt)

- 100,001 to 500,000
- 50,001 to 100,000
- 35,001 to 50,000
- 25,001 to 35,000
- 15,001 to 25,000
- 10,001 to 15,000
- 5,001 to 10,000
- 0 to 5,000

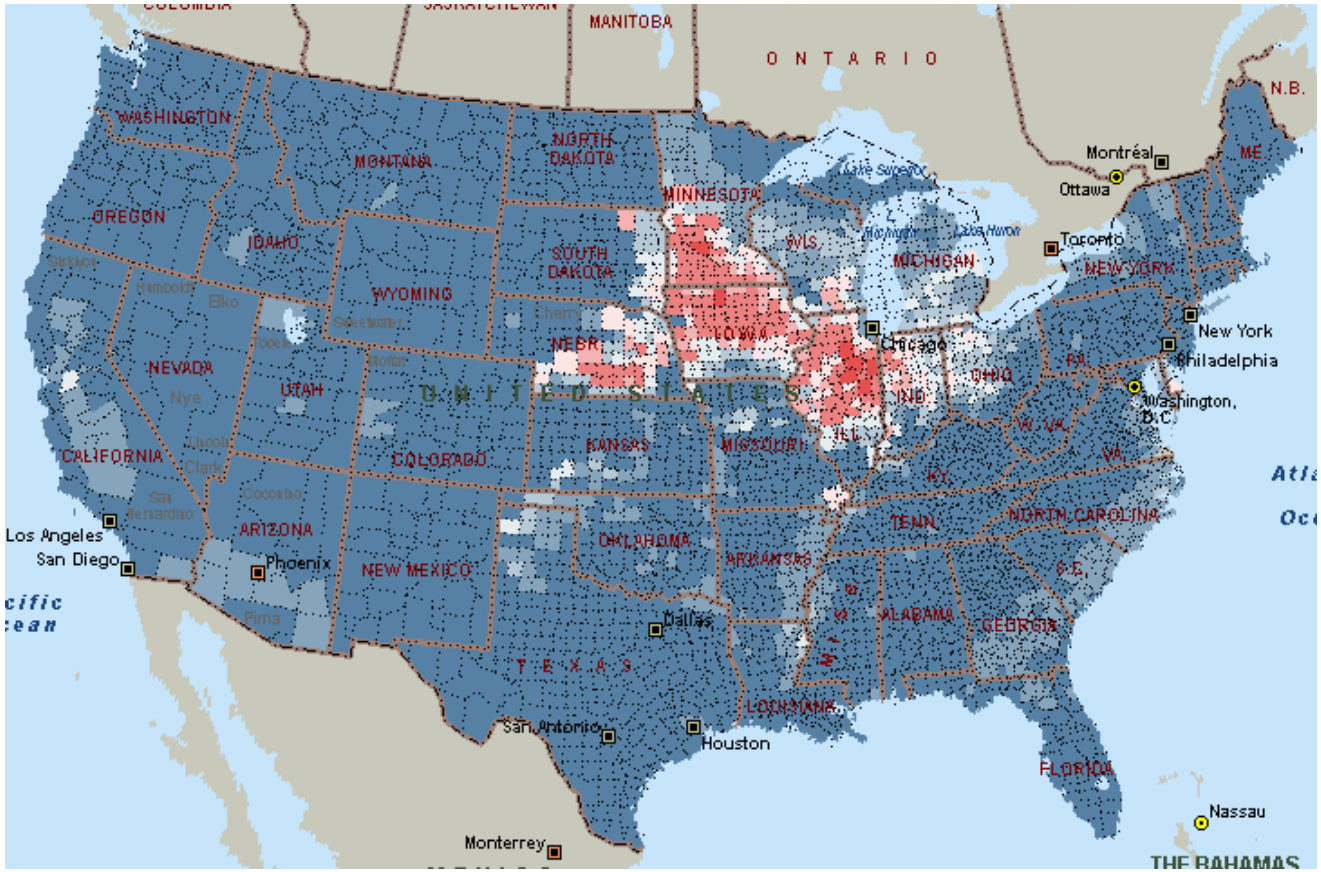
Agricultural Crop Residue Methodology

- Current analysis limited to corn stover and wheat straw
- Controls for erosion (water and wind) at <=T, but not other soil characteristics (organic matter, moisture, etc.)
- Considers soil type, topography, crop rotation and tillage practices (Nelson et al, 2003)
- Costs based on collection as large round bales

Agricultural Crop Residue Supply Curves (million dry tons)

	$30/dt	$40/dt	$50/dt
Corn Stover, Corn-Soybean Rotation, Current Tillage Mix	25.6	42.3	44.4
Corn Stover, Corn-Soybean, All No-Till	95.4	126.8	130.2
Corn Stover, Continuous Corn, Current Tillage Mix	2.3	101.6	110.1
Corn Stover, Continuous Corn, All No-Till	34.3	181.9	192.6
Wheat Straw, Continuous Wheat, Current Tillage Mix	7.1	18.8	21.0
Wheat Straw, Continuous Wheat, All No-Till	14.7	54.6	62.1

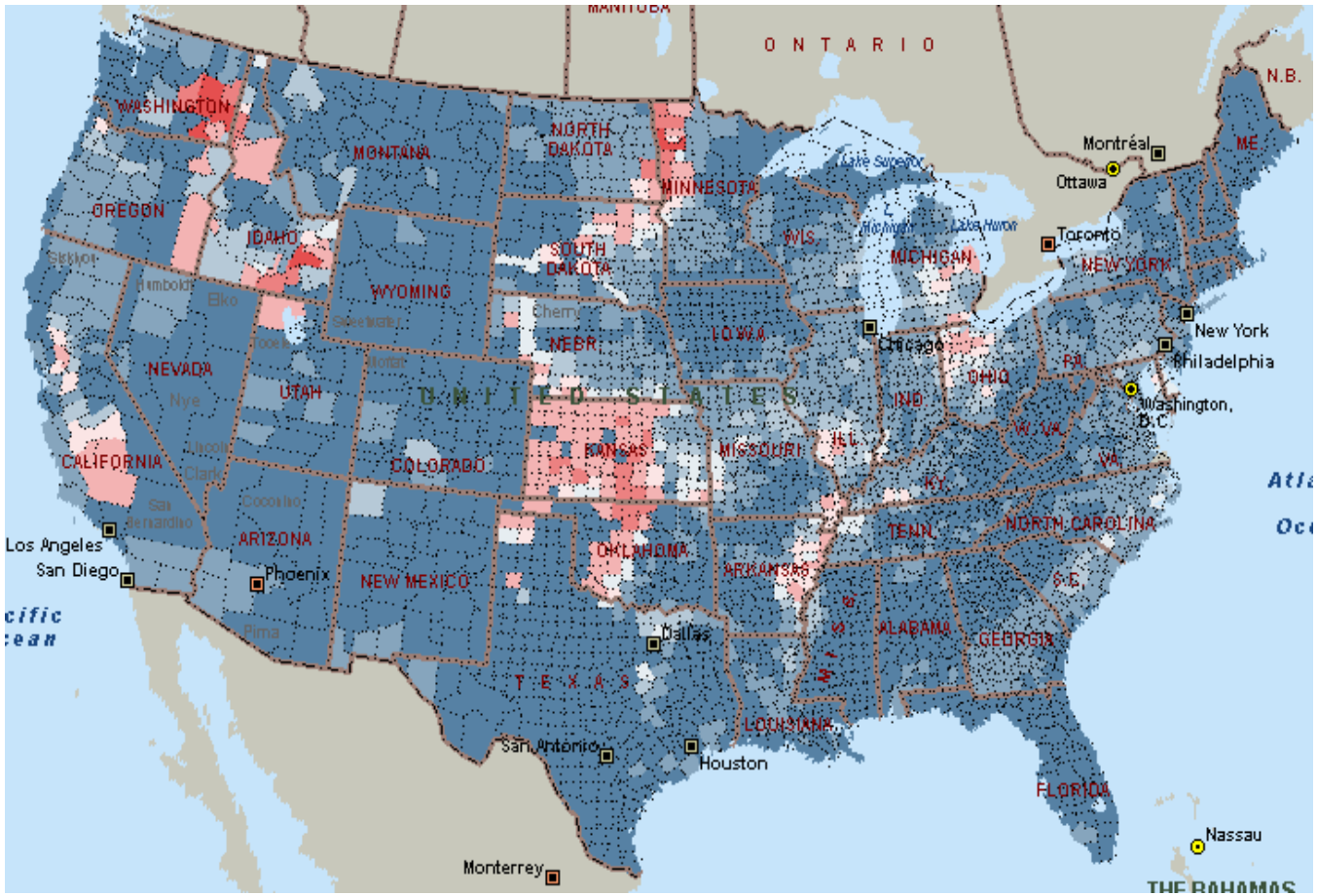
Corn Stover Distribution (Continuous Corn, All No-Till) ($40/dt)



Quantity (dry tons)

- 1,000,001 to 1,500,000
- 500,001 to 1,000,000
- 400,001 to 500,000
- 300,001 to 400,000
- 200,001 to 300,000
- 100,001 to 200,000
- 0.0002 to 100,000
- 0 to 0.0001

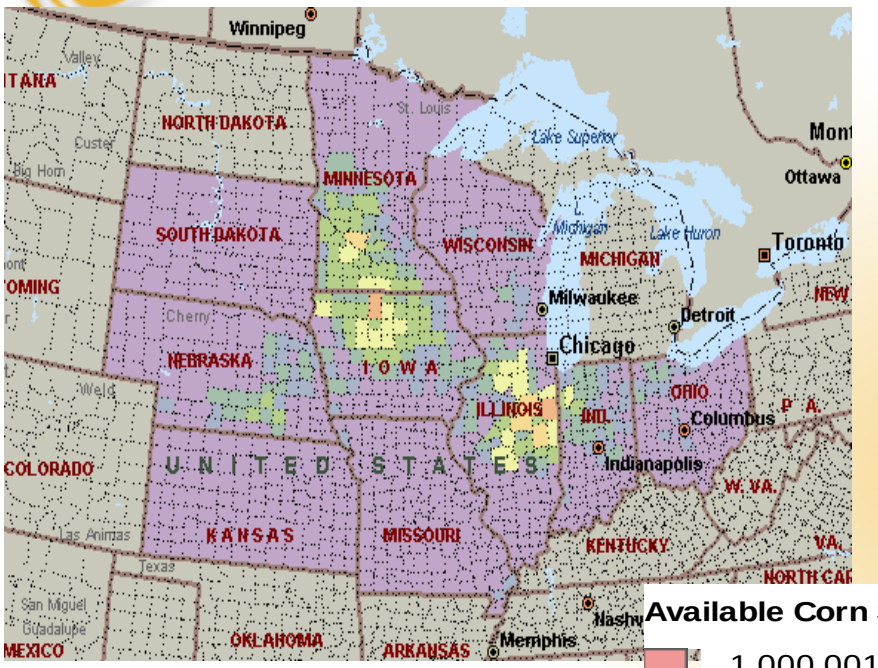
Wheat Straw Distribution (Continuous Wheat, All No-Till) ($40/dt)



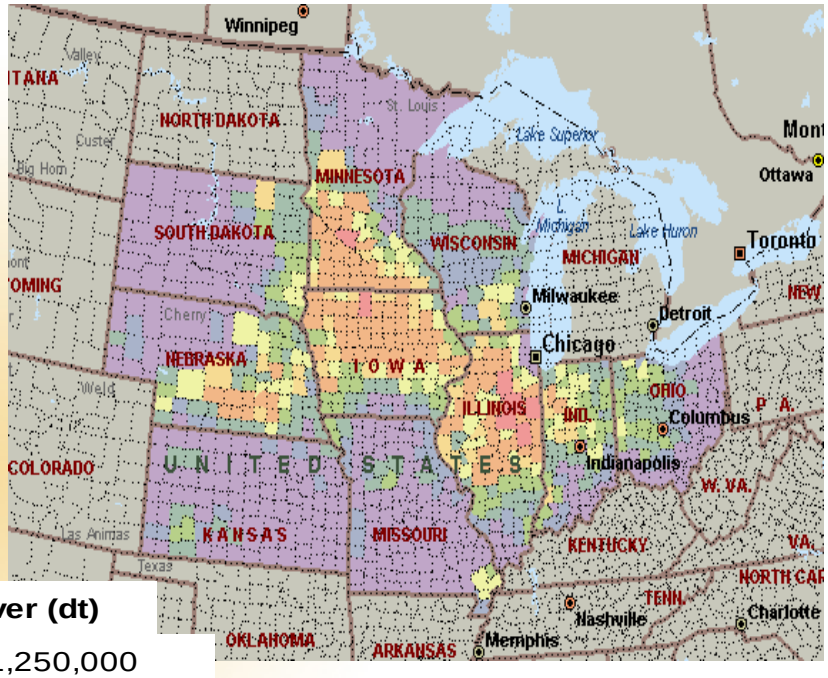
Quantity (dry tons)

- 500,001 to 1,500,000
- 250,001 to 500,000
- 100,001 to 250,000
- 75,001 to 100,000
- 50,001 to 75,000
- 25,001 to 50,000
- 0.0002 to 25,000
- 0 to 0.0001

Corn Stover Distribution (<$50/dt)



Corn-Soybean Rotation,
Current Tillage Practice



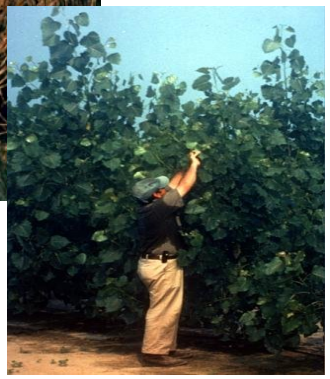
Continuous Corn Rotation,
All No-Till

Available Corn Stover (dt)

- 1,000,001 to 1,250,000
- 500,001 to 1,000,000
- 250,001 to 500,000
- 100,001 to 250,000
- 75,001 to 100,000
- 50,001 to 75,000
- 25,001 to 50,000
- 0 to 25,000

Dedicated Energy Crop Methodology

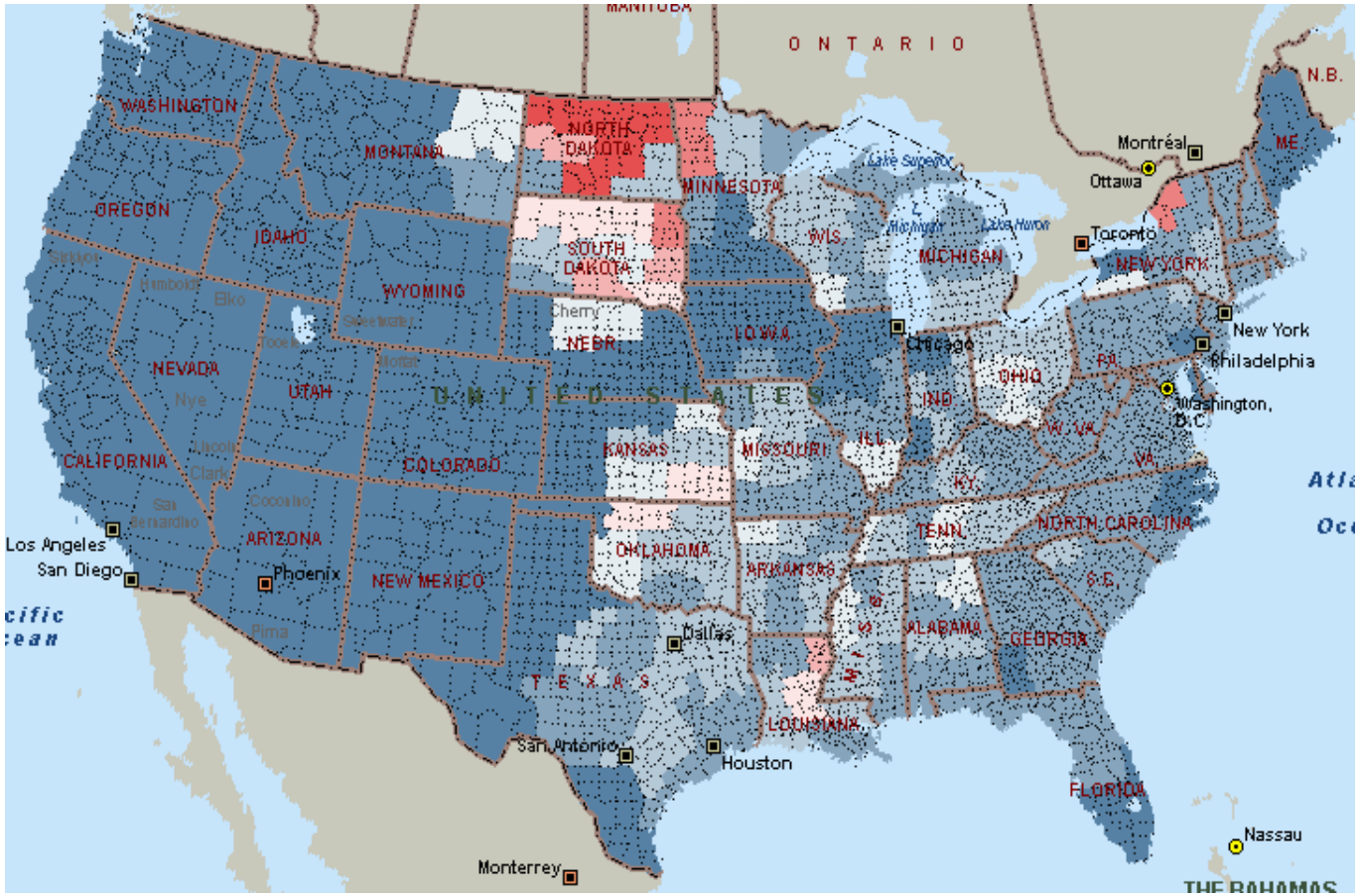
- Use dynamic US agricultural sector model (POLYSYS)
  - Includes major crops; livestock; feed, food, exports and industrial uses; all cropland categories (cropped, idle, pasture, CRP); 305 production regions
- Modified to include switchgrass, hybrid poplar, willow
- Tied to USDA baseline projections
- Land use change based on relative profitability
  - Energy crops compete for land with existing uses and with each other
- See de la Torre Ugarte et al, 2003



Estimated Dedicated Energy Crops: Non-CRP Acres Supply Curves (million dry tons)

	$30/dt	$40/dt	$50/dt
Switchgrass	57.9	131.1	193.3
Hybrid Poplar	0	0.04	0.4
Willow	0	0	0.02
TOTAL	57.9	131.14	193.7

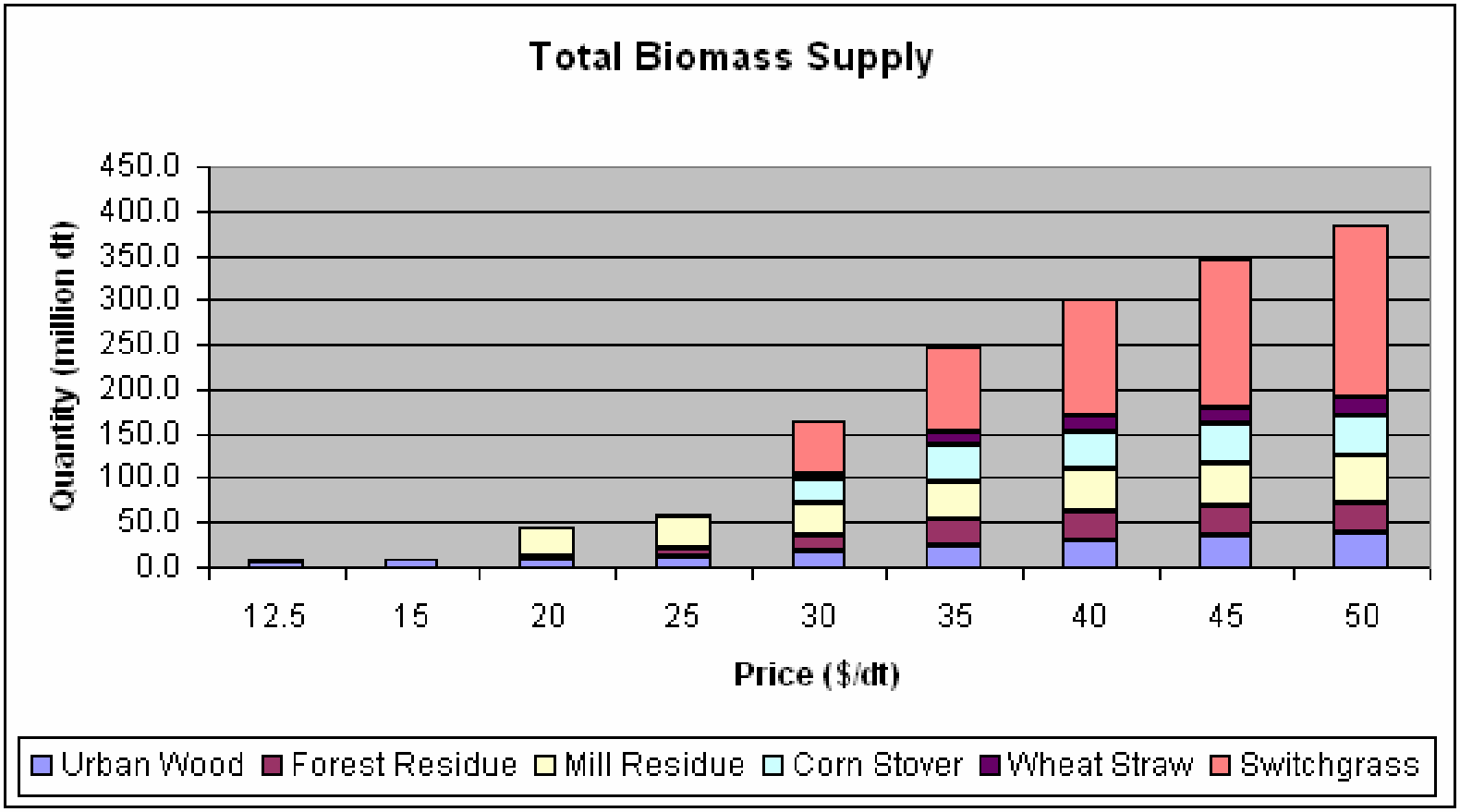
Distribution of Dedicated Energy Crops ($40/dt)



Quantity (dry tons)

- 300,001 to 500,002
- 250,001 to 300,000
- 200,001 to 250,000
- 150,001 to 200,000
- 100,001 to 150,000
- 50,001 to 100,000
- 0.00002 to 50,000
- 0 to 0.00001

Summary—Cellulose Feedstock Supplies (Current Situation)



Future Possibilities

- Technology
  - Yields, collection efficiency, management (shift to no-till production), feedstock composition
- Additional Feedstocks
  - Energy crops, forest fuel treatment biomass, residues from other agricultural crops
- Policy
  - Environmental and regulatory, agricultural, demand, supply
- Match conversion technology to the resource base
  - Understand relation between feedstock location and facility size
  - Apply biorefinery concept of multiple products to the resource base and develop the capability for individual facility to utilize multiple feedstocks

Acknowledgements

- Thanks to all the people who have provided parts of this analysis over time including, but not limited to:
  - Burt English, Daniel de la Torre Ugarte, Richard Nelson, Robert Perlack, Anthony Turhollow, Robin Graham, Sandy McLaughlin, Jerry Tuskan, Denny Becker, Stephen Slinsky, Jamey Menard, Chad Hellwinkel, and Hosein Shapouri and all of the unnamed people who conducted surveys and developed databases used in the analysis