

RESOURCE POTENTIAL: THE BILLION-TON STUDY

**NC Regional Biomass Feedstock Workshop
August 15-17, 2006**

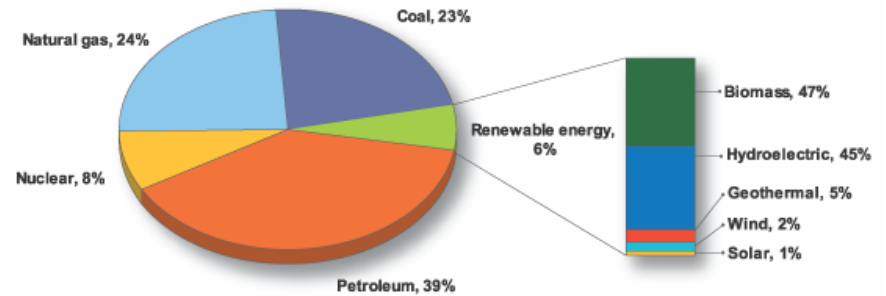
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WHAT WAS THE PURPOSE OF THE STUDY?

- To determine whether the land resources of the U.S. are capable of producing a sustainable supply of biomass sufficient to displace 30% of the country's present petroleum consumption – approximately equivalent to one billion dry tons.
- Goal was set by a joint advisory committee to the DOE and USDA as a vision for making a major contribution to U.S. energy needs
 - 5% of the nation's power
 - 20% of the nation's transportation fuels
 - 25% of the nation's chemicals & materials from biobased products.

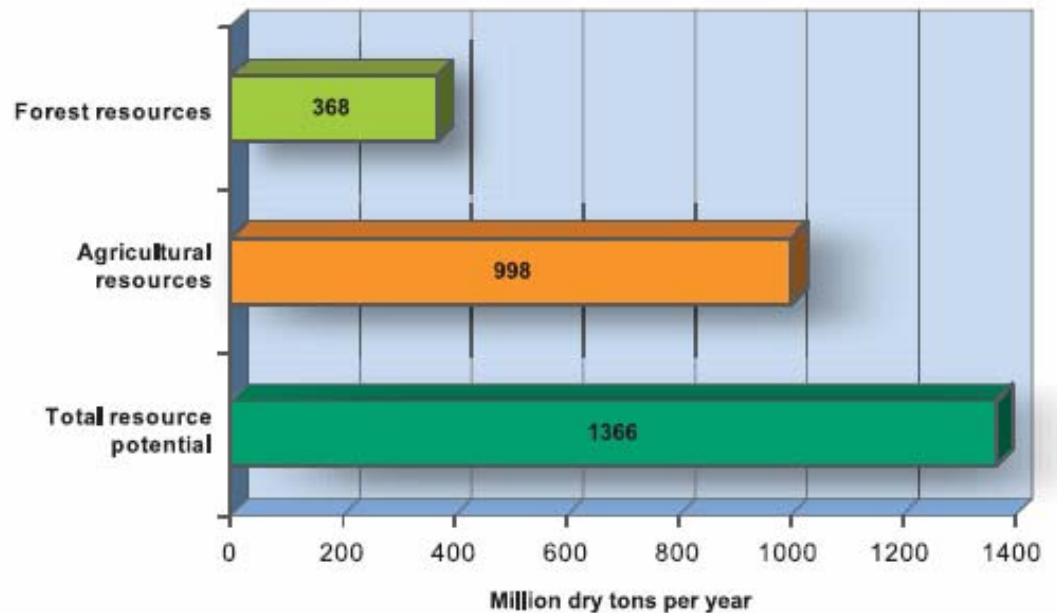
ARE THERE SUFFICIENT BIOMASS RESOURCES TO REPLACE A SIGNIFICANT FRACTION OF THE NATION'S PETROLEUM REQUIREMENTS?

- Yes, land resources can provide a sustainable supply and still meet food, feed, and export demands
- Estimates are reasonable given trends and time for scale-up & deployment
- R&DD, policy change, stakeholder involvement required



Biomass Consumption	Million dry tons/year
Forest products industry	
Wood residues	44
Pulping liquors	52
Urban wood and food & other process residues	35
Fuelwood (residential/commercial & electric utilities)	35
Biofuels	18
Bioproducts	6
Total	190

• Forestlands and agricultural lands contribute 190 million dry tons of biomass - 3% of America's current energy consumption.



THE 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)**
 - Fuelwood
 - Primary wood processing mill residues
 - Secondary wood processing 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

WHAT ANALYSIS APPROACH WAS TAKEN?

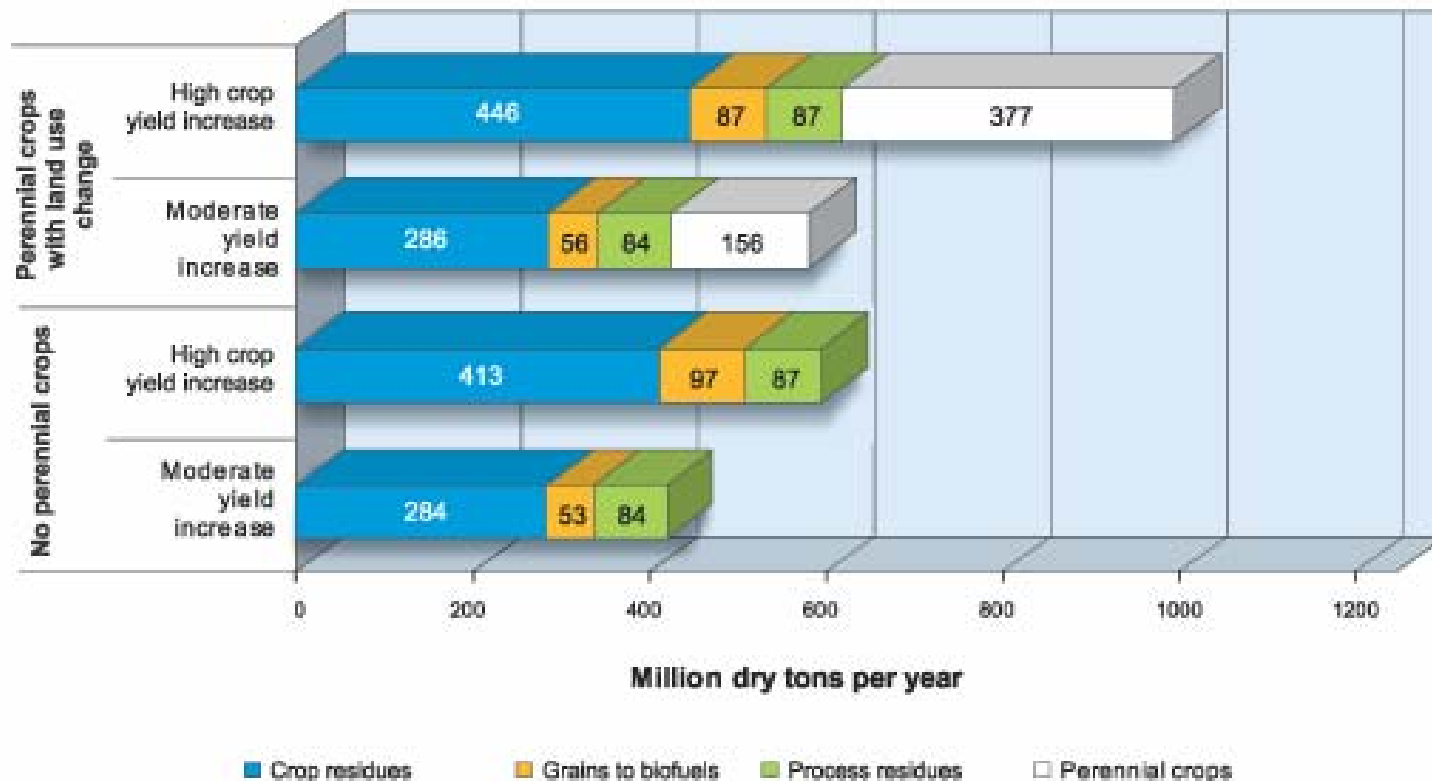
- Agricultural resource estimates based on scenarios extrapolated from current food/feed trends and R&D
 - Active cropland managed intensively on year-to-year basis
 - Includes perennial crops, such as grasses and woody crops
- Forest resource estimates based on analysis of existing resources, uses, and trends in the demand for forest products
 - Managed less intensively than croplands or not suited for intensive management
 - Expected to provide multiple-use benefits (e.g., wildlife habitat, recreation, and ecological and environmental services)

AGRICULTURAL RESOURCE ANALYSIS

- Approach (“what if”) based on available information & expert opinion on potentials (e.g., crop yields, equipment efficiency, etc.)
- Crop yields (annual and perennial crops)
 - 15% to 50% for annual crops
 - 5 to 8 dry tons/acre/year for perennial crops
- Residue to grain ratios
 - Vary by crop; only soybean ratios change in scenarios
- Harvest/collection efficiency
 - 40%, 60%, 75%
- Tillage practices (no-till)
 - Current levels up to 100% no-till
- Allocation of cropland acres
 - Perennial crops accommodated with reductions in active cropland, idle cropland, and cropland pasture
- Used current trends, research directions and previous analysis results such as:
 - 30 yr average corn yield increase at 1.7 bu/ac
 - Research to develop soybeans with higher forage content (higher residue to grain ratio)
 - Research to develop more efficient and one-pass harvesting equipment
 - Increasing levels of no-till management
 - POLYSYS analysis indicating potential acreage available to energy crops under various market conditions.
- Consultation with USDA scientists

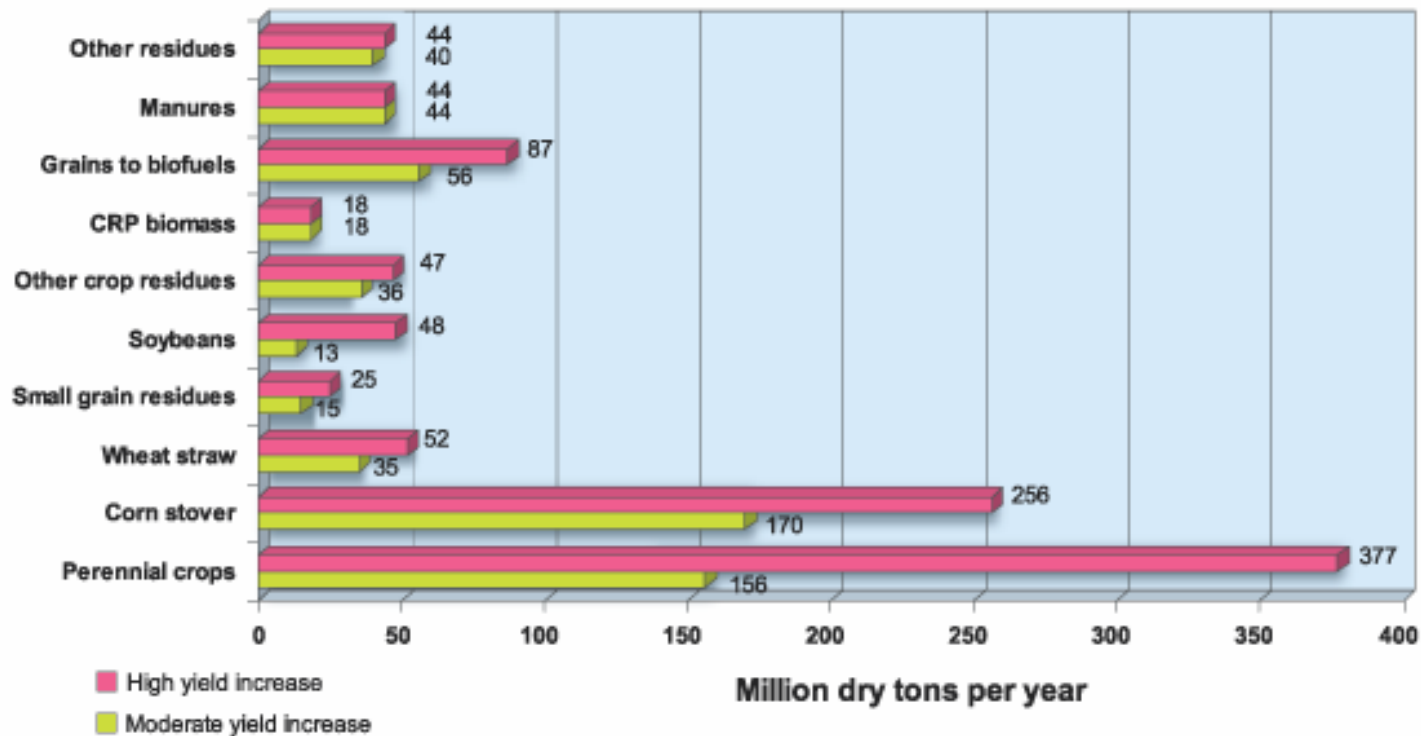
WHAT IS THE CROPLAND POTENTIAL?

- Total resource approaches 1 billion dry tons/year with energy crops
 - Yield increase of 25 - 50% for corn and other small grains, 15 - 30% for other crops
 - Change in tillage practices
 - Residue collection equipment
 - Residues from soybeans
 - The allocation of active cropland, idle cropland, and pasture to perennial crops, yielding 4.7 – 7.4 dry tons/ac; 40 - 60 x10⁶ acres



CROPLAND BIOMASS POTENTIAL WITH ENERGY CROPS

- Primary sources alone are 420 – 800 million dry tons



Notes:

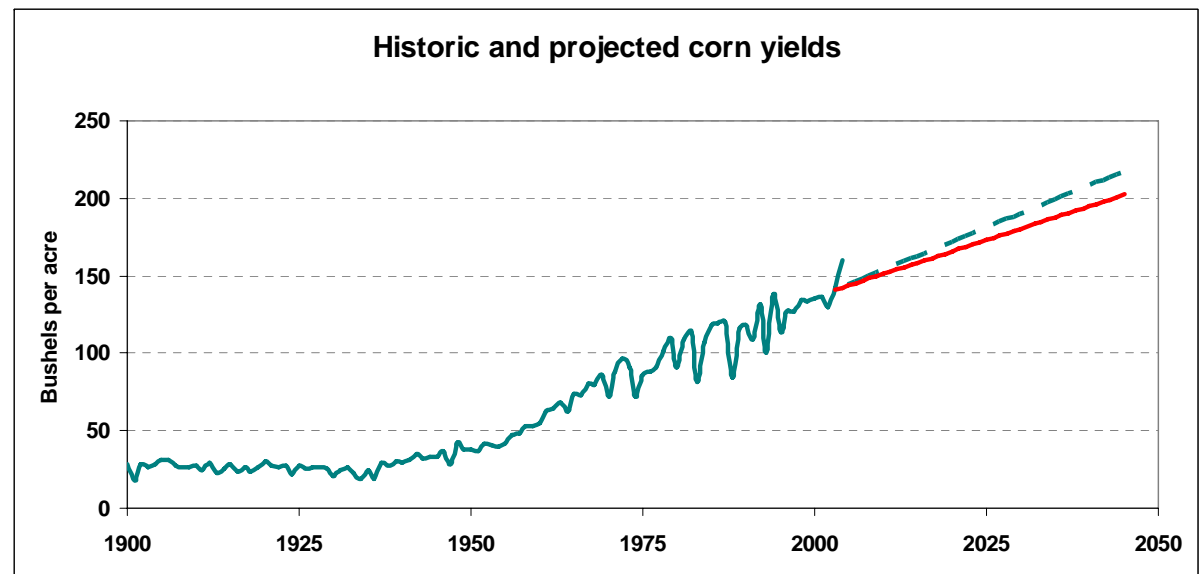
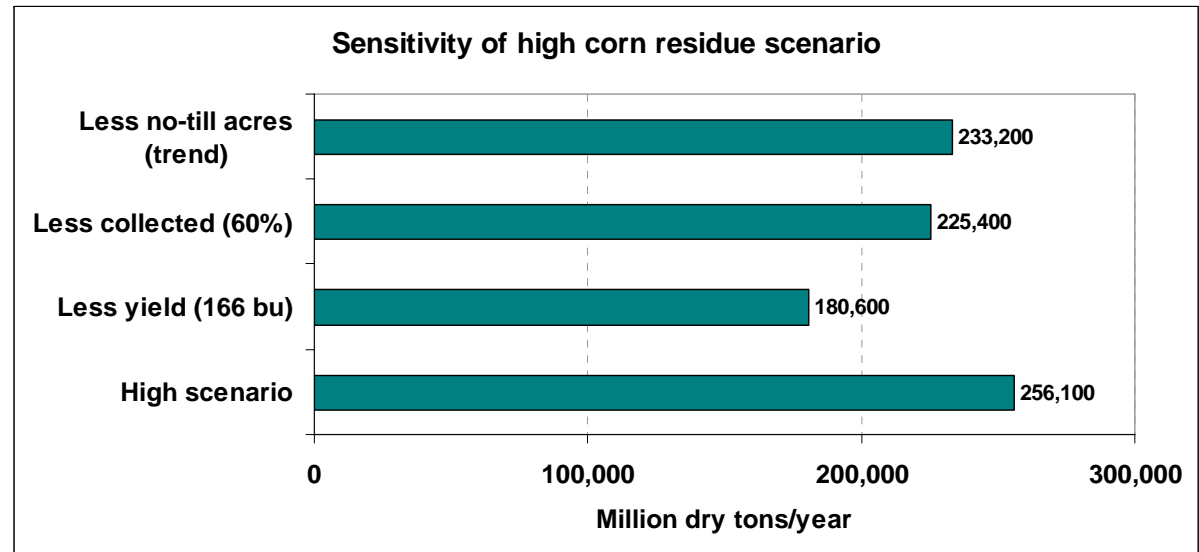
Other crop residues include cotton, oil seeds, sugar crops, double crops, etc.

Other residues include secondary agricultural processing, MSW, and fats/greases.

Small grain residues include sorghum, barley, oats, and rice.

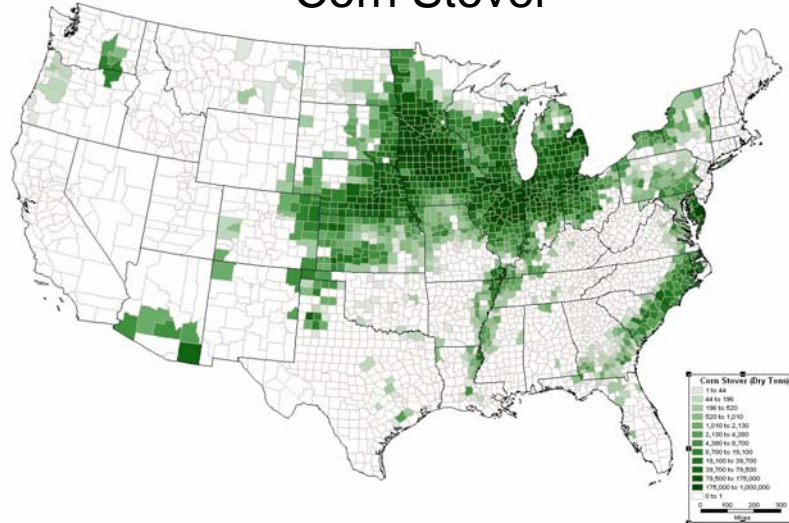
CORN STOVER SUMMARY

- Residue availability dependent on continued yield increase
- Efficiency of collection equipment and shift to no-till less important than yield
- Sustainability requirements accounted for

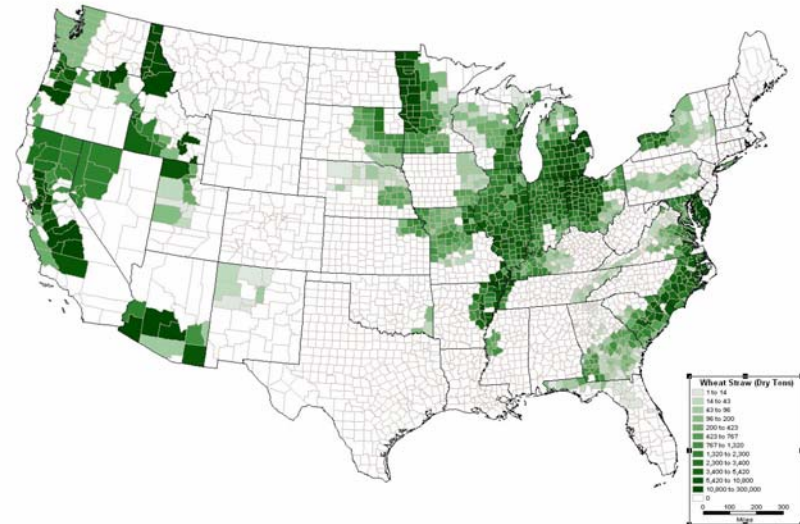


SPATIAL DISTRIBUTION OF CROP RESIDUES

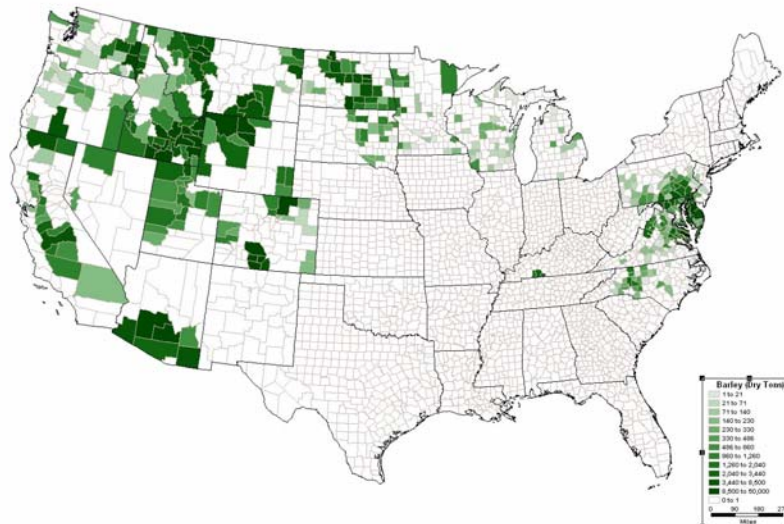
Corn Stover



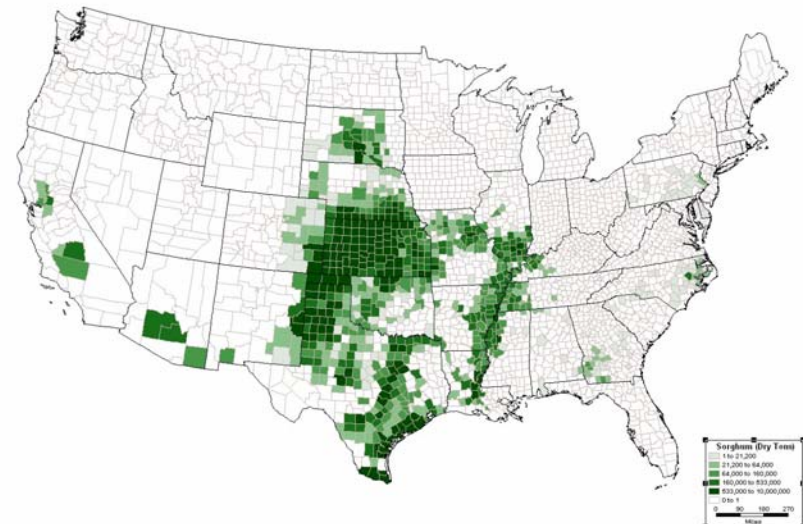
Wheat straw



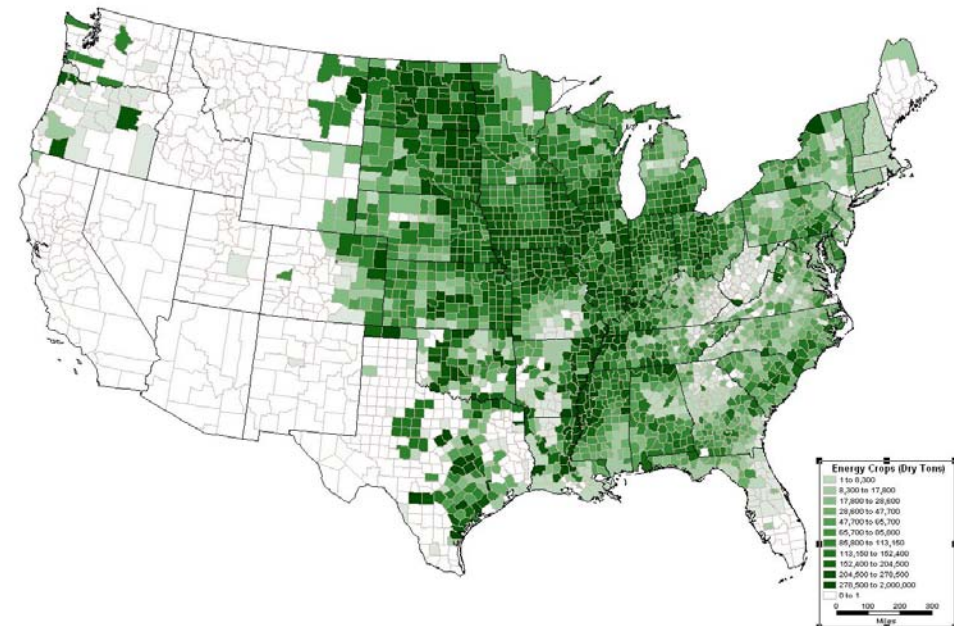
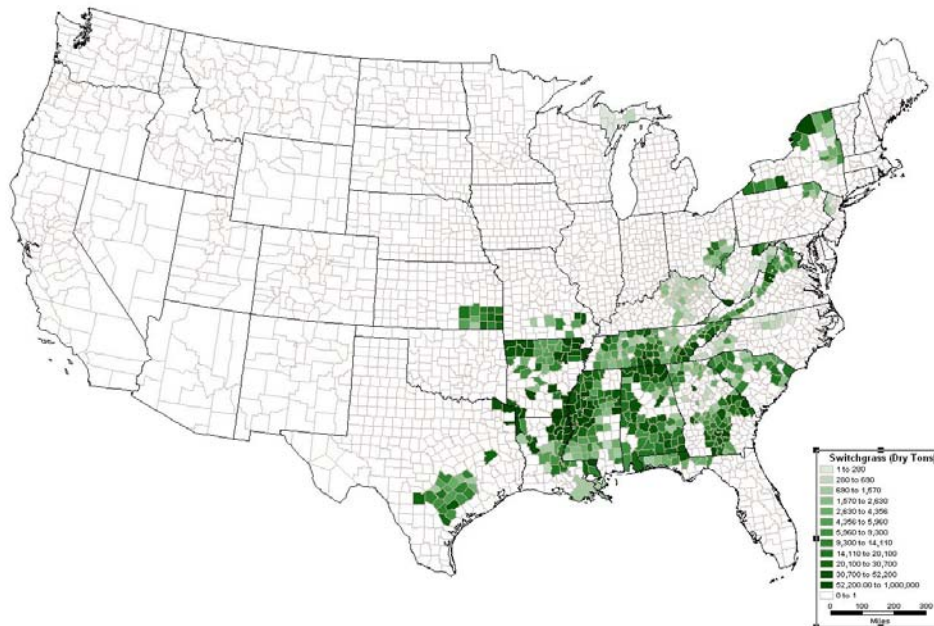
Barley



Sorghum



SPATIAL DISTRIBUTION OF PERENNIAL ENERGY CROPS – 2012 and 2030



SUMMARY OF NC CROPLAND RESOURCES

	Corn stover	Wheat Straw	Switchgrass	Poplar
Illinois	11,563,000	218,000	4,413,000	2,919,000
Indiana	6,207,000	240,000	5,348,000	1,498,000
Iowa	15,116,000	1,000	1,649,000	5,679,000
Minnesota	13,036,000	745,000	1,278,000	1,303,000
Montana	0	734,000	1,044,000	2,000
Nebraska	6,134,000	759,000	466,000	1,867,000
North Dakota	25,000	2,374,000	6,986,000	1,480,000
South Dakota	659,000	825,000	1,979,000	711,000
Wisconsin	1,799,000	54,000	778,000	2,171,000
Wyoming	1,000	0	2,000	18,000
Total	54,541,000	5,950,000	23,941,000	17,649,000
% of U.S.	69%	45%	25%	43%

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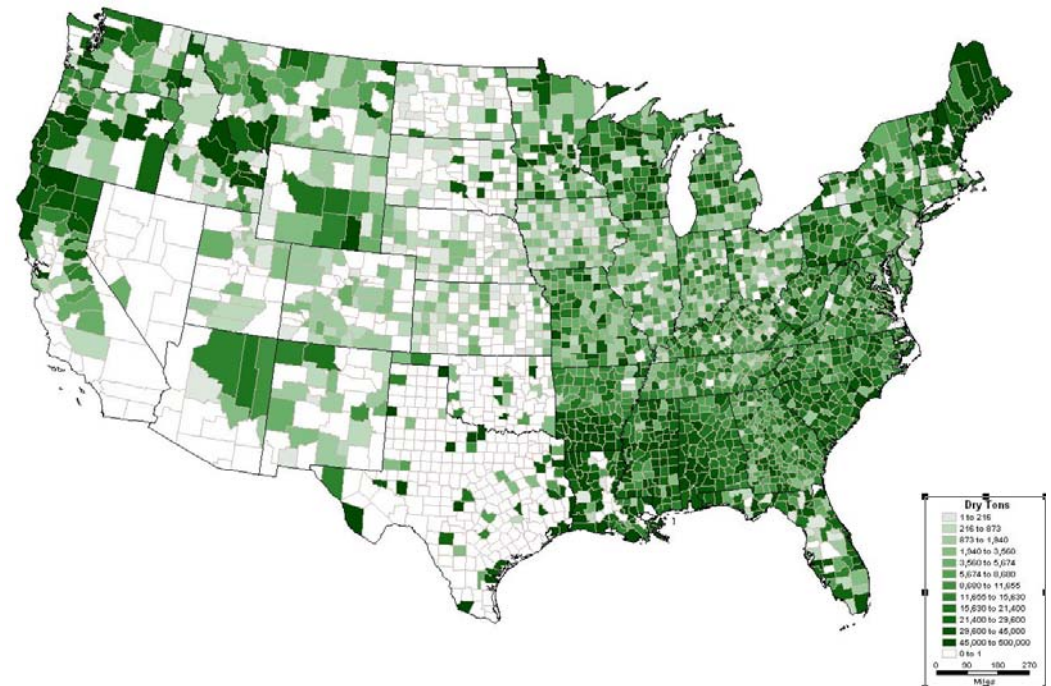
Note: Perennial crop estimates are one of many scenarios

FOREST RESOURCE ANALYSIS

- **Forest resource analysis utilizes USDA/Forest Service databases and expert opinion**
 - Forest Inventory and Analysis database
 - Timber Product Output database
 - Fuel Treatment Evaluator (an assessment tool used to identify and evaluate forest stands with accumulated biomass – Healthy Forest Restoration Act)
 - Resources Planning Act analyses (periodic timber assessment with projections to 2050)
 - Forest Products Laboratory data

RESIDUES – LOGGING, SILVICULTURAL OPERATIONS & CLEARING OF TIMBERLANDS

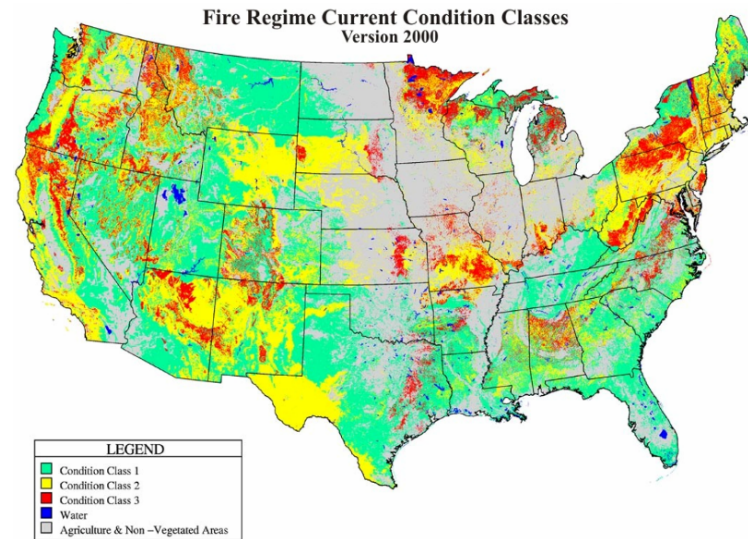
- Timber Product Output database
- 70 million dry tons generated annually
- Collected concurrently with operations
- 50% to 65% of biomass is recoverable (public vs private lands)
- All recovered material (~ 41 million dry tons/year) for biomass uses
- Estimated to increase to ~ 64 million dry tons/year



RESIDUES – FUEL TREATMENT OPERATIONS

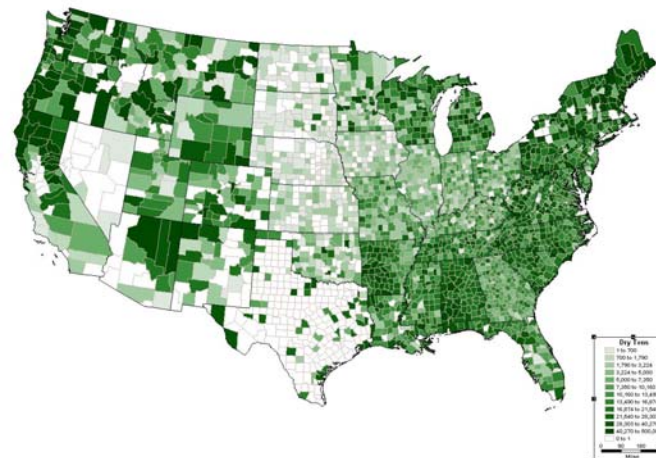
- **Timberlands**

- Fuel Treatment Evaluator
- Recovery of 85% of biomass
- Accessibility – 60% for public lands and 80% for private lands
- **Biomass fraction – 30% (70% conventional forest products)**
- 30 year collection cycle



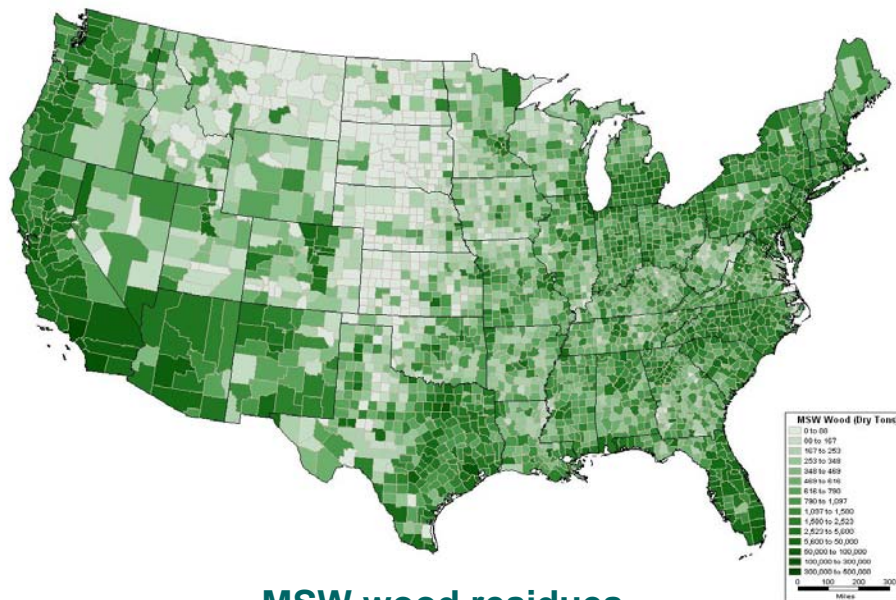
- **Other forestlands**

- Forest Inventory Analysis database used to identify biomass (50% removal)
- Recovery of 85% of the identified biomass
- Accessibility – 60% for public lands and 80% for private lands
- Biomass fraction – 90%
- Collection cycle – 30 years

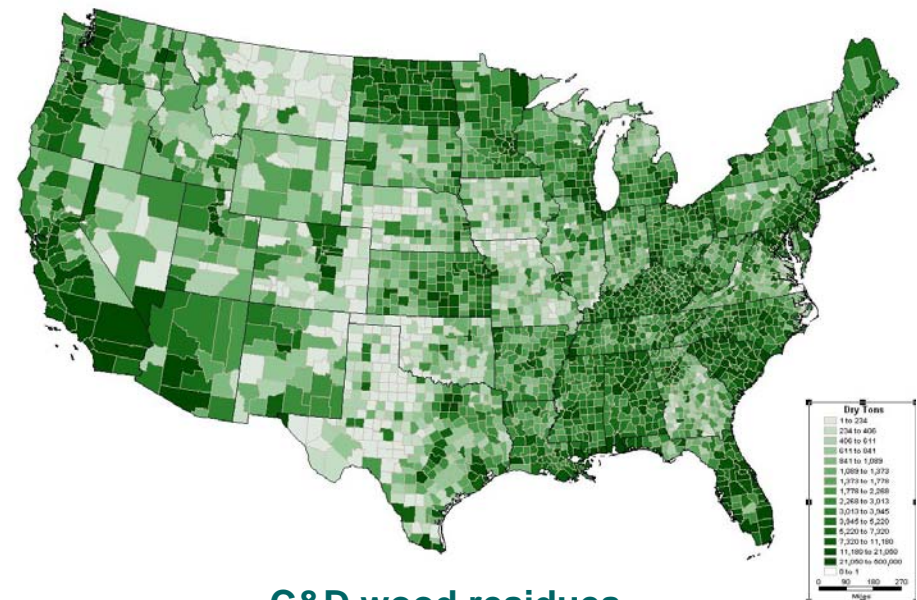


RESIDUES – URBAN WOOD SOURCES

- Wood (finished wood products) and yard & tree trimmings from MSW
 - Landfill survey data, composition sampling, population driven
 - Material destined for MSW landfills
- Construction, remodeling and demolition waste
 - Affected by economic activity (e.g., housing starts)
 - Material destined for C&D landfills
- Contamination/commingling with non-wood products is problematic



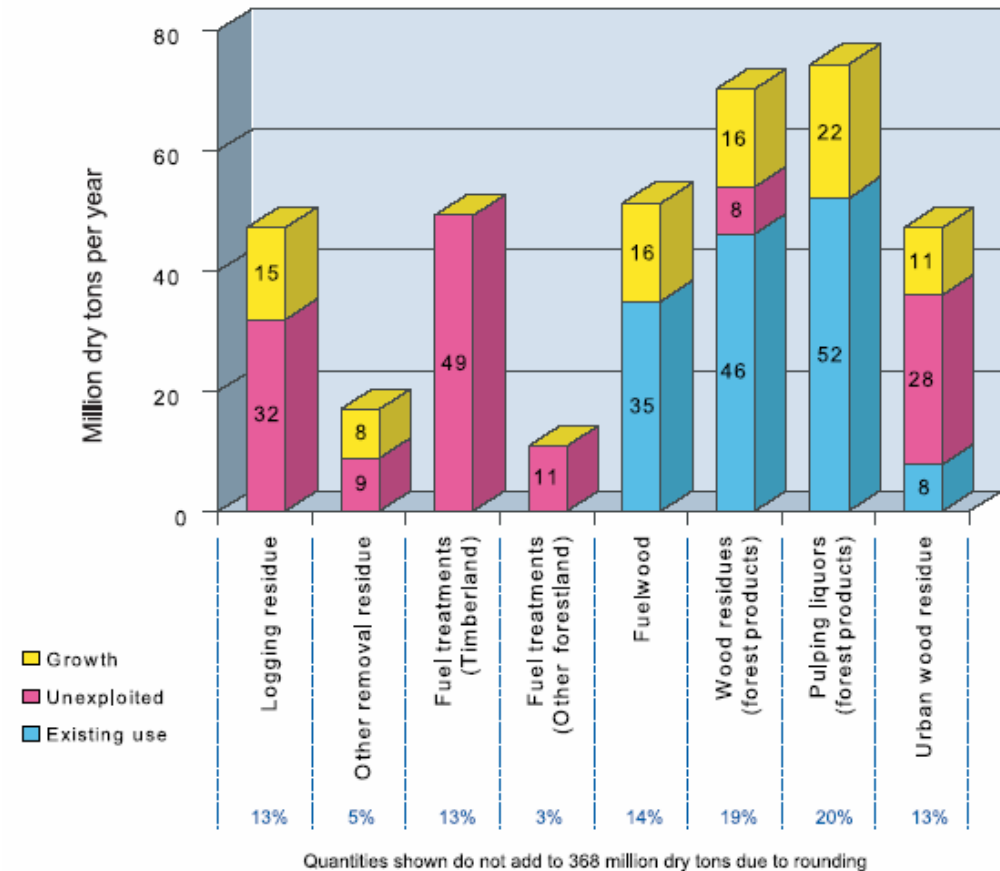
MSW wood residues



C&D wood residues

FOREST RESOURCE SUMMARY

- A considerable fraction of forest residues are already in use by the forest products industry & residential/commercial sectors
- There are over 100 million dry tons of primary forest residue currently available (logging, other removals, & fuel treatment thinnings)
 - Assumes bioenergy does not have a higher-value than conventional forest products
 - Excludes excess pulpwood
 - Changing markets (e.g., low-price wood and/or high-price oil) could make much more available for energy
- Forest growth can contribute additional biomass



SUMMARY OF NC FORESTLAND RESOURCES

	Logging residue	Other Removal residue	Thinnings-timberlands	Thinnings-other forestlands	Primary mill residue
Illinois	307,000	164,000	443,000	0	19,000
Indiana	501,000	123,000	457,000	0	28,000
Iowa	118,000	134,000	170,000	4,000	3,000
Minnesota	1,437,000	250,000	826,000	55,000	75,000
Montana	566,000	4,000	1,089,000	51,000	41,000
Nebraska	33,000	19,000	57,000	4,000	11,000
North Dakota	18,000	28,000	77,000	21,000	0
South Dakota	123,000	34,000	82,000	9,000	6,000
Wisconsin	1,486,000	91,000	1,236,000	5,000	46,000
Wyoming	116,000	10,000	287,000	115,000	60,000
Total	4,705,000	856,000	4,723,000	265,000	290,000
% of U.S.	15%	9%	11%	2%	17%

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