

RESOURCE POTENTIAL: THE BILLION-TON STUDY

**30x30 Workshop
August 1-2, 2006**

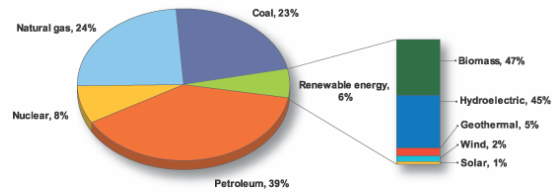
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WHAT WAS THE PURPOSE OF THE STUDY?

- 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.

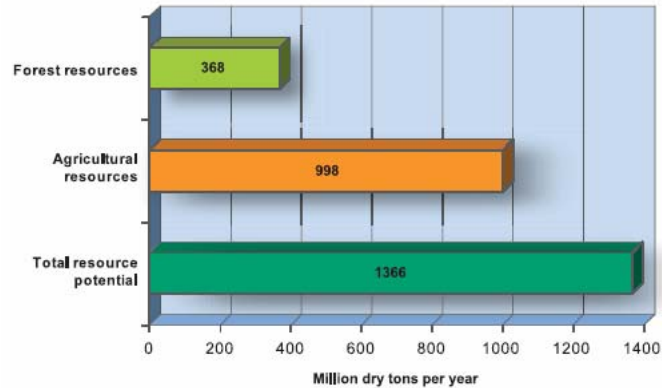
ARE THERE SUFFICIENT BIOMASS RESOURCES TO REPLACE A SIGNIFICANT FRACTION OF THE NATION'S PETROLEUM REQUIREMENTS?

- 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?

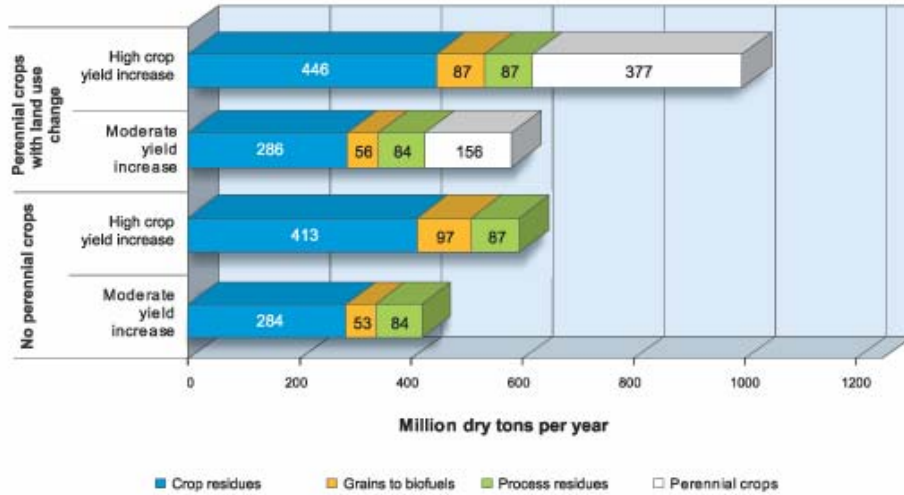
- Forest resource estimates based on analysis of existing resources, uses, and trends in the demand for forest products
 - Managed less intensively than croplands or not suited for intensive management
 - Expected to provide multiple-use benefits (e.g., wildlife habitat, recreation, and ecological and environmental services)
- Agricultural resource 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**

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 tillage with changes 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

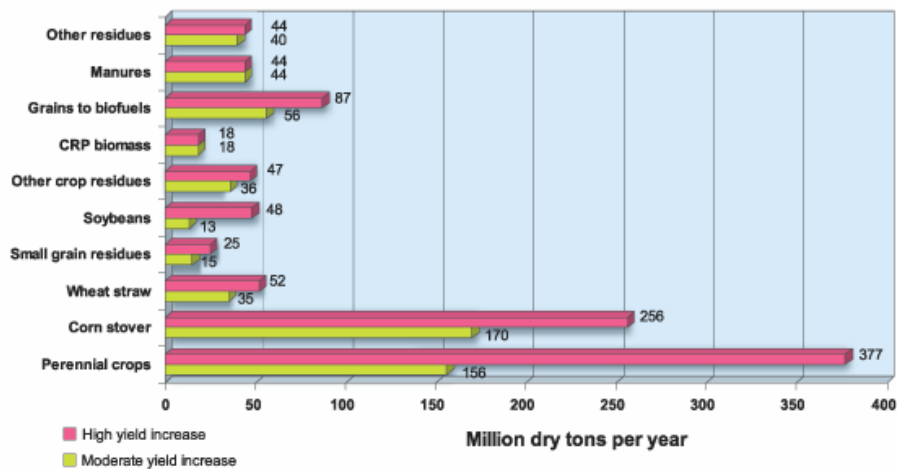
WHAT IS THE CROPLAND POTENTIAL?

- 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 energy crops; 40 - 60 million acres



CROPLAND BIOMASS POTENTIAL WITH ENERGY CROPS

- Primary sources alone are 420 – 800 million dry tons

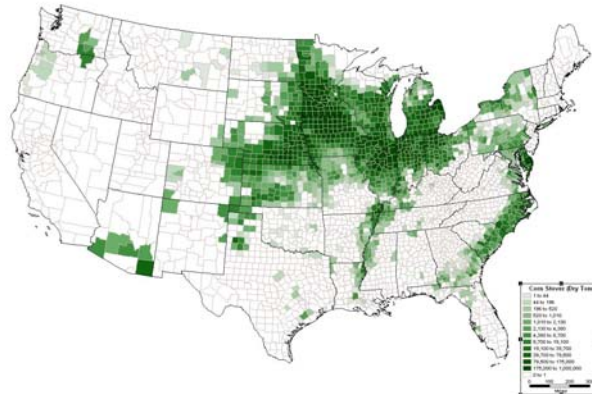
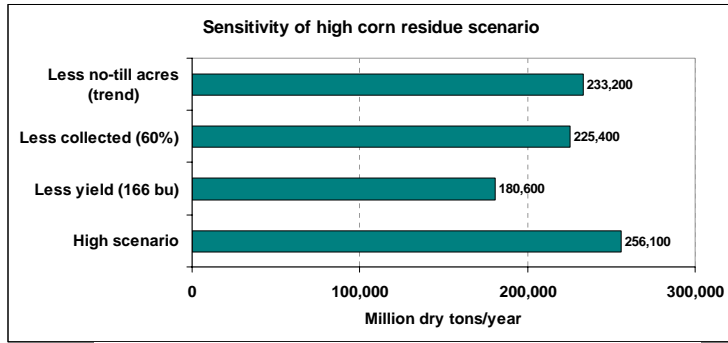


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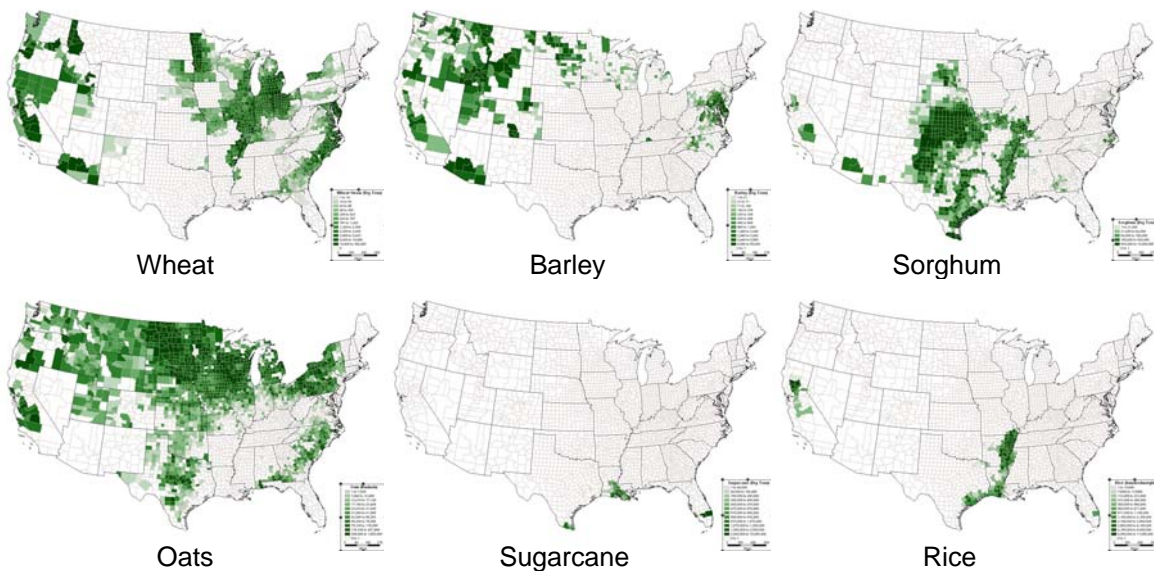
Other crop residues include cotton, oil seeds, sugar crops, double crops, etc.
 Other residues include secondary agricultural processing, MSW, and fats/greases.
 Small grain residues include sorghum, barley, oats, and rice.

CORN STOVER SUMMARY

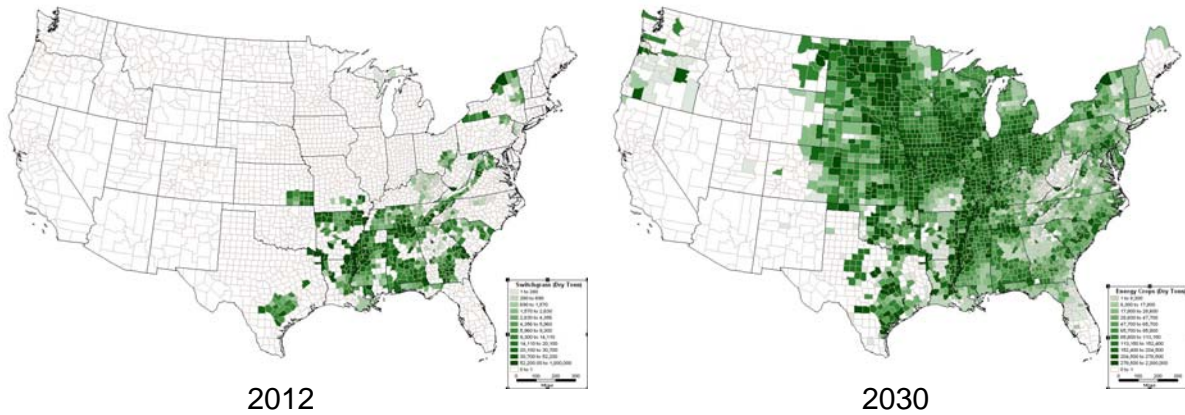
- Residue availability dependent on continued yield increase
- Efficiency of collection equipment and shift to no-till less important than yield
- Sustainability requirements accounted for



SPATIAL DISTRIBUTION OF CROP RESIDUES



SPATIAL DISTRIBUTION OF PERENNIAL ENERGY CROPS – 2012 and 2030

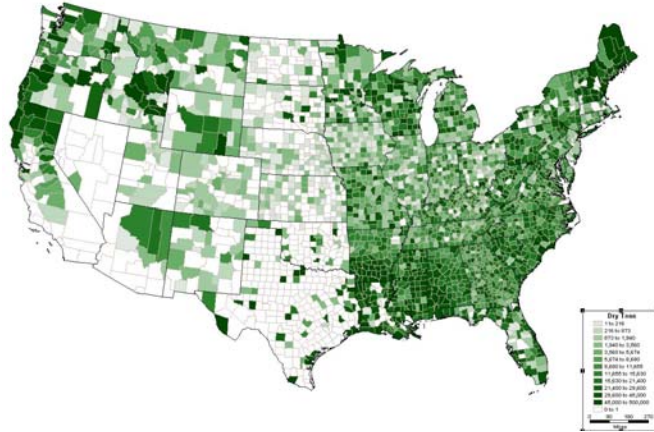


FOREST RESOURCE ANALYSIS

- **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

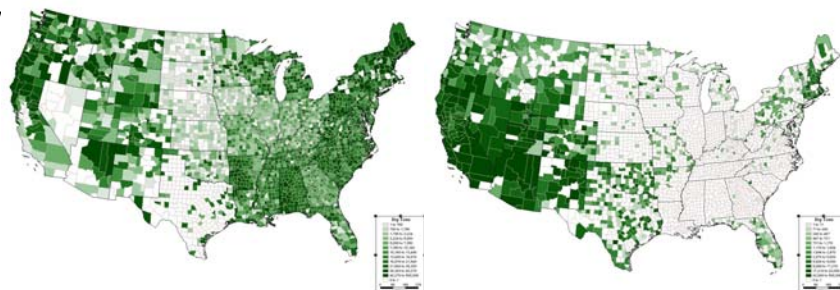
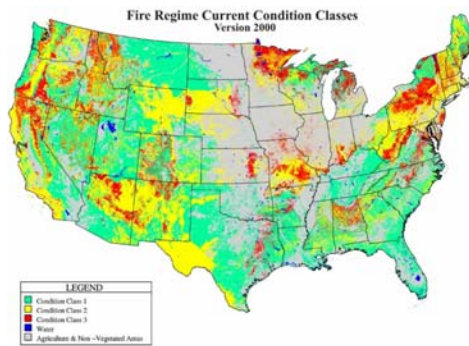
RESIDUES – LOGGING, SILVICULTURAL OPERATIONS & CLEARING OF TIMBERLANDS

- 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

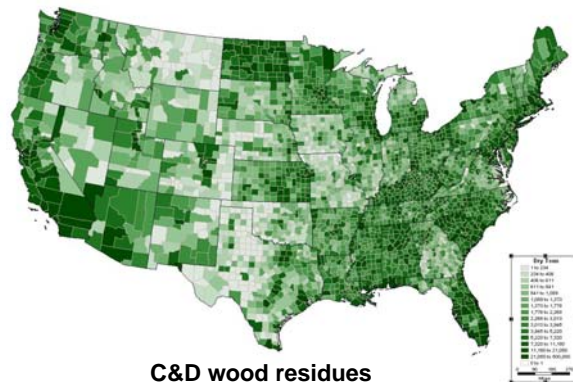
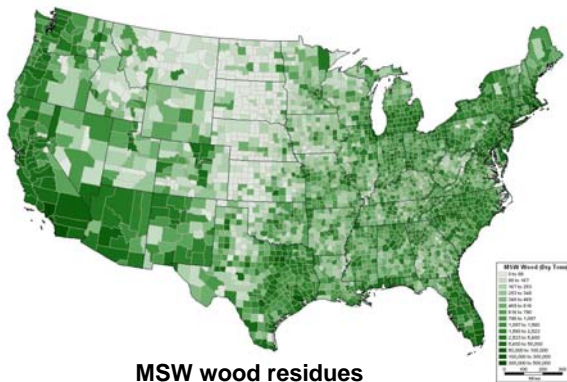


Timberlands

Other forestlands

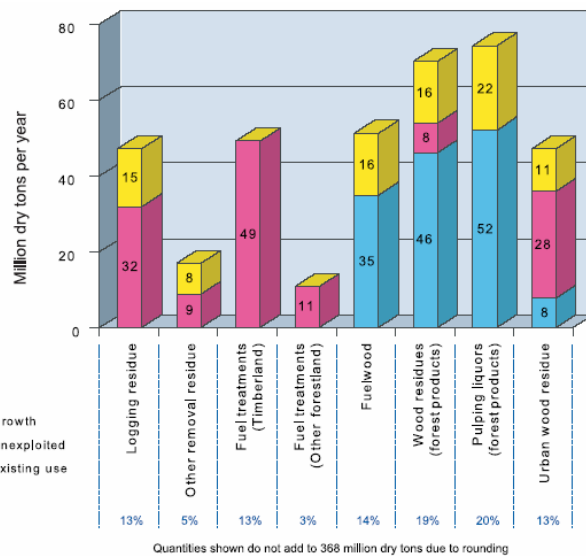
RESIDUES – URBAN WOOD SOURCES

- 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

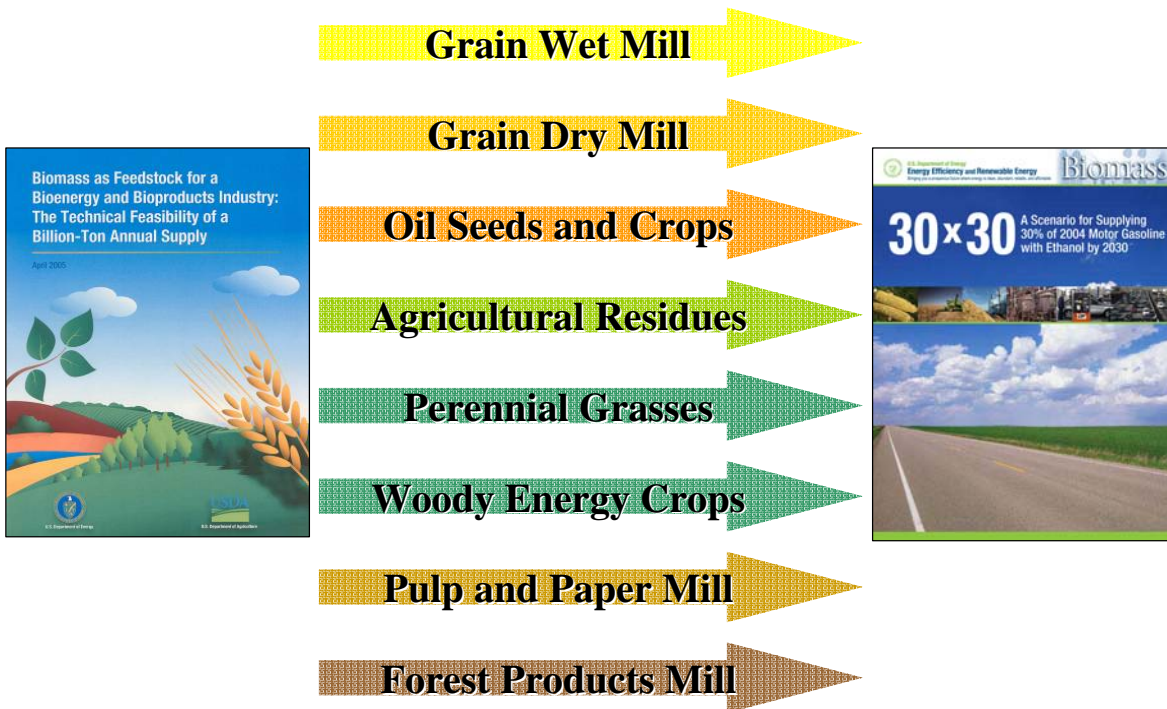


FOREST RESOURCE SUMMARY

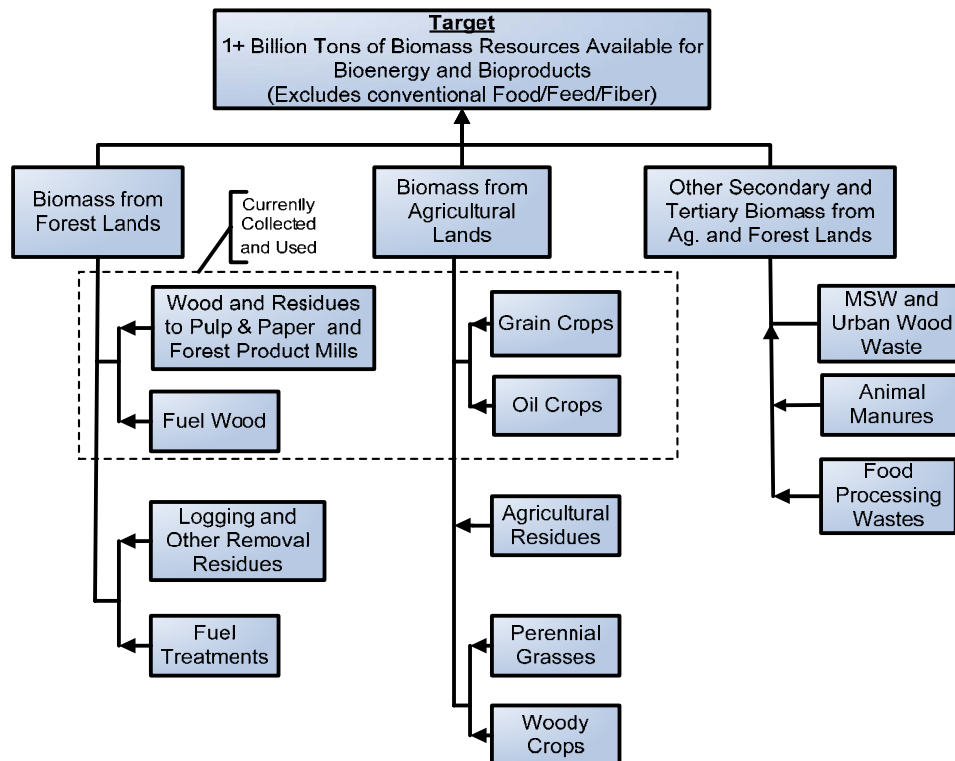
- A considerable fraction of forest residues are already in use by the forest products industry & residential/commercial sectors
- There are over 100 million dry tons of primary forest residue currently available (logging, other removals, & fuel treatment thinnings)
 - Assumes bioenergy does not have 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 bioenergy
- Forest growth can contribute additional biomass



BILLION-TON RESOURCES TO PATHWAYS



Biomass Resource Base Categories



Resources Allocated to Pathways

Pathway Name	Major Primary Feedstocks	Process Intermediates	Other Potential Primary Feedstocks	Other Waste Feedstocks
Wet Mill	Corn	Corn Fiber (Corn Gluten Feed)		
Dry Mill	Corn	DDGS	Sorghum Barley Wheat	
Oil Seed Mills	Soybeans	Glycerol	Other oil seed crops	Fats & Grease
Agricultural Residues Processing	Corn Stover Wheat Straw Rice Straw		Small Grain Straws Soybean Residues Sugarcane Bagasse	
Perennial Crops Processing	Switchgrass (as a model) Hybrid Poplar (as a model)		Other grasses Other trees	
Pulp and Paper Mills		Black Liquor Wood Residue		
Forest Products Mills		Wood Residue		
Forest Residue Processing	Logging Residue Fuel Treatments			Urban Wood Waste Wood Fiber
Pulp and Paper Mill Repurposing	Unutilized Pulpwood	Wood Residue		

Basis for Estimated Biofuel Potential

Underline indicates information in High Case and Pathway Summary Documents

Italics indicates information used in Moderate Case

- Agriculture Feedstocks - Multiple Cases Provided in BTV
 - *Baseline (2001)*
 - No Land Use Change - no energy crops
 - Moderate Yield Increases
 - High Yield Increases
 - Land Use Change – energy crops added
 - *Moderate Yield Increases*
 - High Yield Increases
 - NCGA Projections added for Corn Ethanol
 - High, Medium and *Low* for 2015-2016
 - Manure, MSW, Food Processing waste not used
- Forest Feedstocks – 2 Cases Provided in BTV
 - *Baseline*
 - Future
 - Fuelwood, Urban Wood Waste and wood fiber not used
- Fuel Yield
 - *2012 Target of 90 gal EtOH/ton used for Moderate Case*
 - 2030 Target of 113.5 gal EtOH/ton used for High Case

High Biomass/Biofuels Production Case

Major Assumptions:

- 1) Corn: NCGA High 2015, 2) Ag: High yield increase with land use change, 3) Forest: Future, 4) Fuel Yield: 113.5 gal EtOH/ton

Pathway	Resource Available (Million Dry Tons/year)	% of Total Resource Available	Pathway Potential Fuel* Production (Million gallons/year)	Pathway % of Total Potential Fuel Production
Wet Mill	7	0.6%	900	0.71%
Dry Mill	141	12.8%	17,512	13.74%
Oil Seed Mills	6	0.5%	736	0.58%
Agricultural Residues Processing	428	38.9%	48,983	38.43%
Perennial Crops Processing	386	35.1%	44,186	34.67%
Pulp and Paper Mills	0	0.0%	0	0.00%
Forest Products Mills	9	0.8%	1,009	0.79%
Forest Residue Processing	123	11.2%	14,129	11.09%
Pulp and Paper Mill Repurposing	0	0.0%	0	0.00%
TOTAL	1,100	100.0%	127,455	100.00%

* Oil Seed Mills produce biodiesel, all other values are ethanol

Moderate Biomass/Biofuels Production Case

Major Assumptions:

- 1) Corn: NCGA Low 2015, 2) Ag: Moderate yield increase with land use change, 3) Forest: Baseline, 4) Fuel Yield: 90 gal EtOH/ton

Pathway	Resource Available (Million Dry Tons/year)	% of Total Resource Available	Pathway Potential Fuel Production (million gallons/year)	Pathway % of Total Potential Fuel Production
Wet Mill	7	1.03%	853	1.37%
Dry Mill	101	14.84%	12,254	19.62%
Oil Seed Mills	7	0.97%	766	1.23%
Agricultural Residues Processing	269	39.54%	24,174	38.70%
Perennial Crops Processing	164	24.16%	14,769	23.64%
Pulp and Paper Mills	0	0.00%	0	0.00%
Forest Products Mills	9	1.30%	610	0.98%
Forest Residue Processing	123	18.17%	9,045	14.48%
Pulp and Paper Mill Repurposing	0	0.00%	0	0.00%
TOTAL	679	100.00%	62,471	100.00%

* Oil Seed Mills produce biodiesel, all other values are ethanol

Questions ?