Photo: Robert Grala

Economics of Biomass to Energy

Donald L. Grebner

Mississippi State University, Department of Forestry

Mississippi's Forest Resources

	Mississippi
Total land area (million ac):	**30**
Population (million)	**3**
Total Forest area (million ac):	**18.5**
Forest cover (%):	**62**
Standing Volume (billion ft^3):	**23**

General Introduction

Wood-based bioenergy has several economic, environmental, and energy security benefits

Overall Research Framework

- Feedstock availability estimates
- Logging costs
- Willingness to harvest
- Economic impact assessments



Photos: Katarzyna Grala

Woody biomass feedstock availability

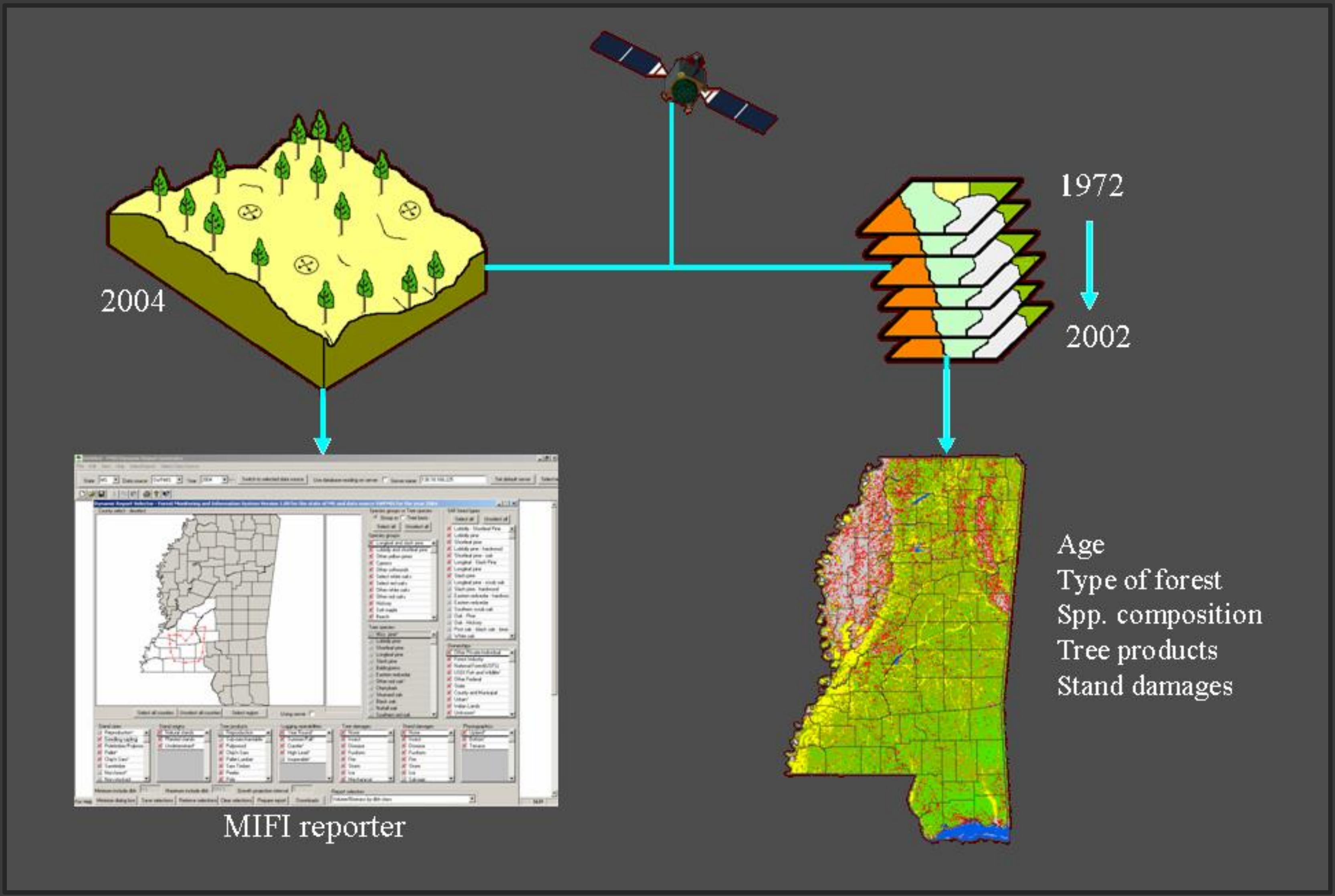
Photo: Katarzyna Grala

Feedstock Availability Estimates

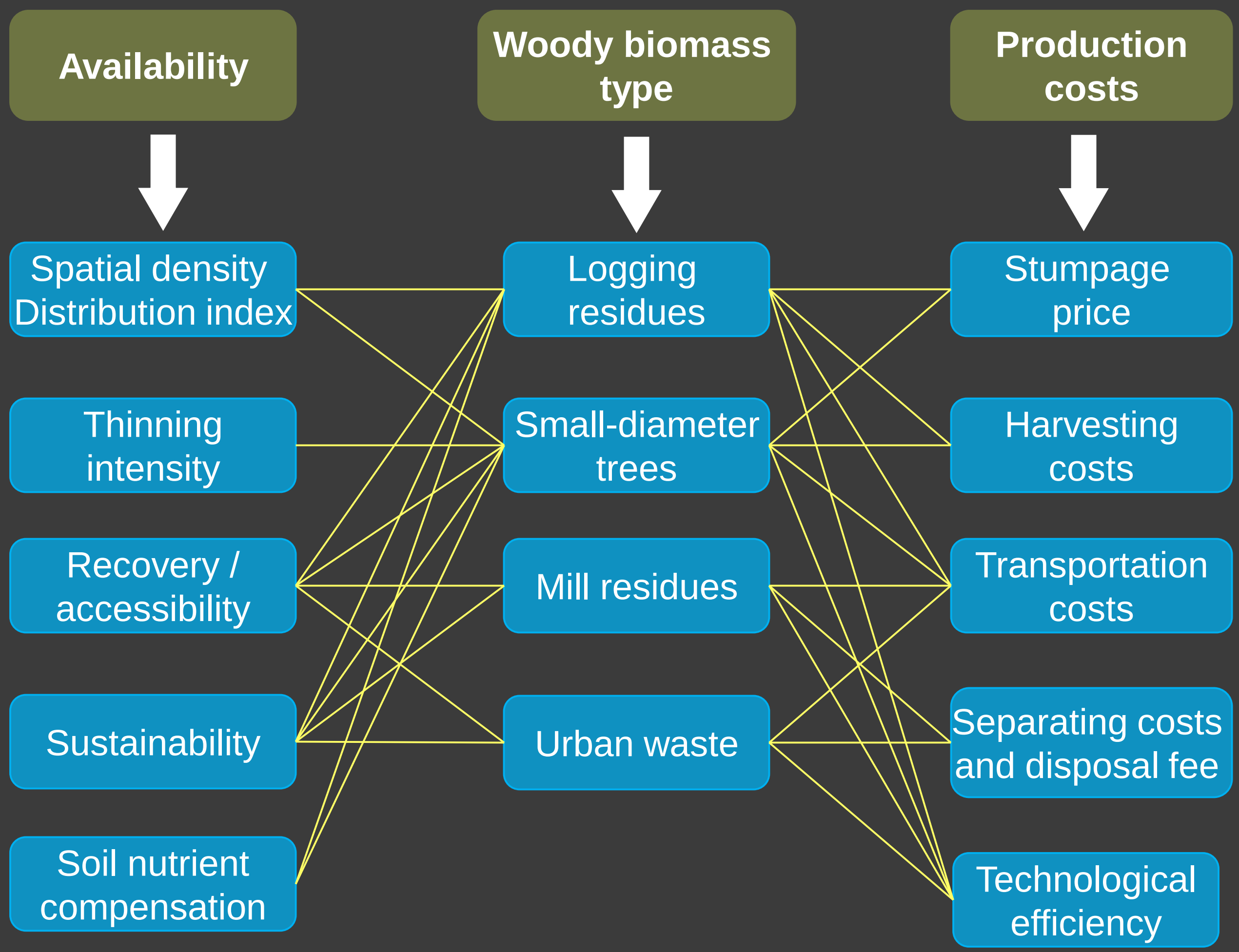
- How much woody biomass feedstock is available?
  - Logging residues
  - Small-diameter trees
  - Mill residue
  - Urban wood waste

Photo: Robert Grala

Feedstock Inventory Analysis



Feedstock Empirical Framework



Sources of information

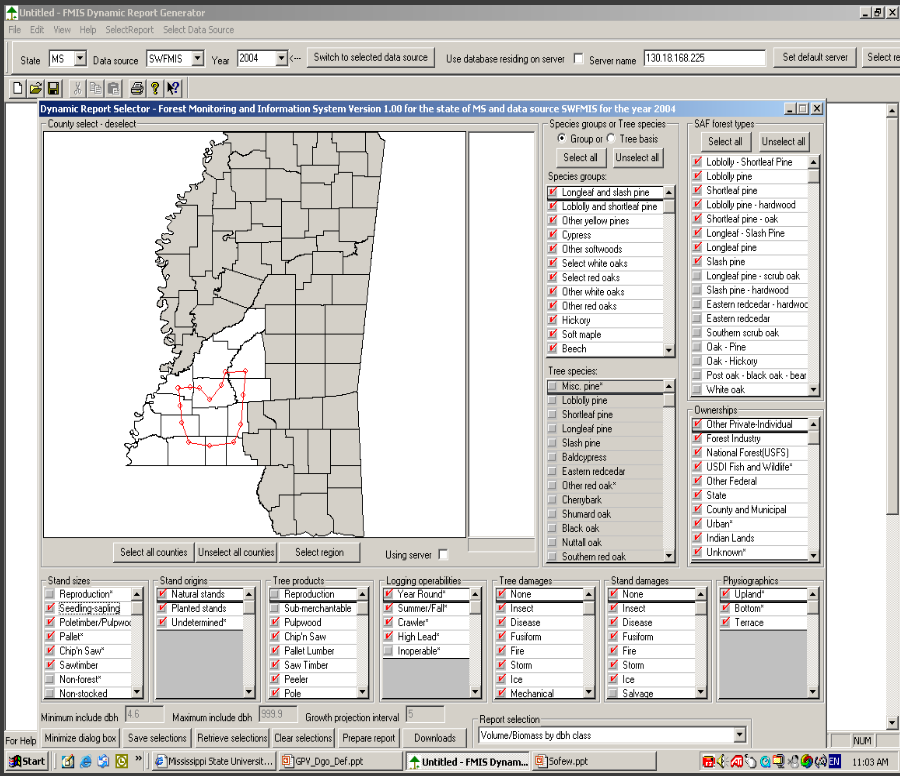
– *Logging residues,* FIA TPO databases (1995, 1997, and 2002)

– *Small-diameter trees*, MIFI, FIA

– *Mill residues,* FIA, state surveys (Garrard and Leightley 2005)

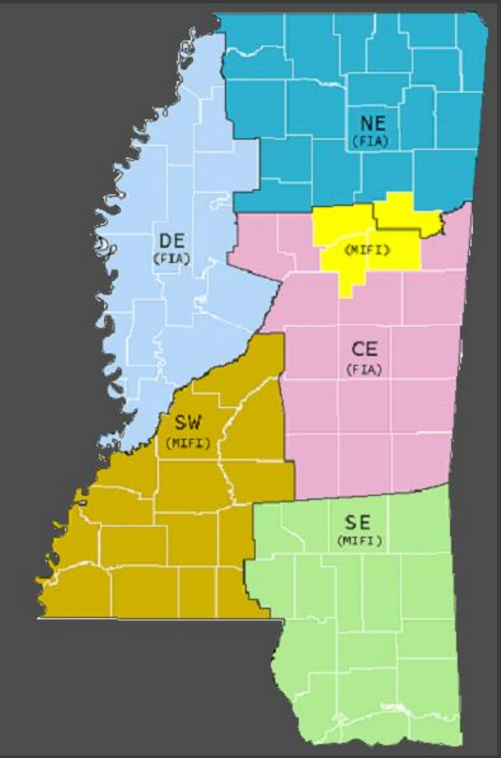
– *Urban waste,* MS DEQ, US census

– *Production costs,* Timber Mart-South, local reports



Available at http://www.mifi.ms.gov/mission.htm

Results


NE
(FIA)
(MIFI)
DE
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CE
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SW
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SE
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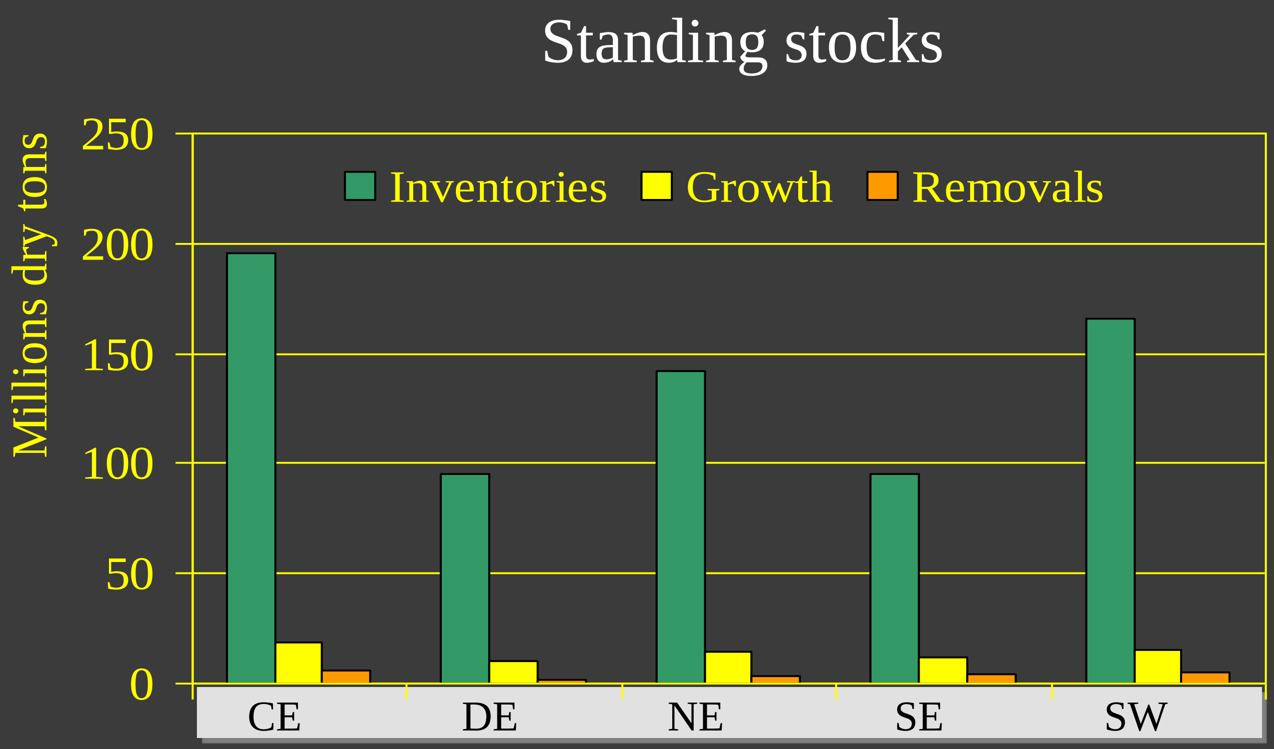
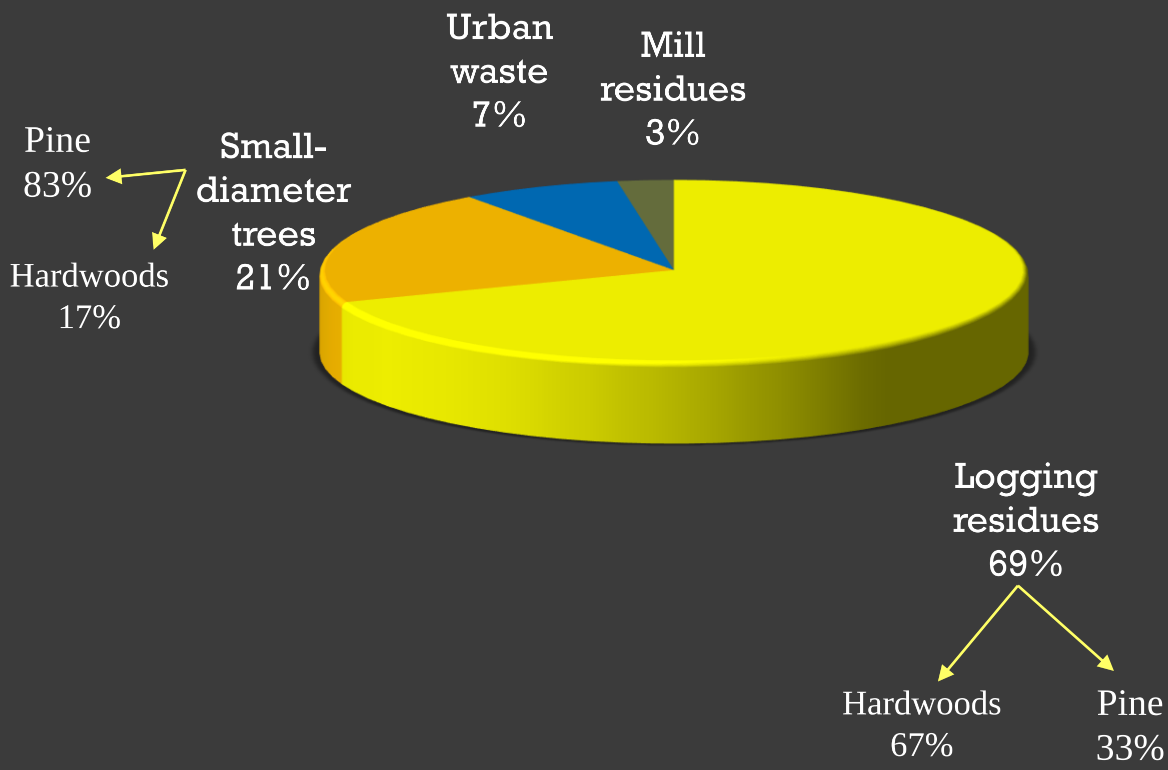
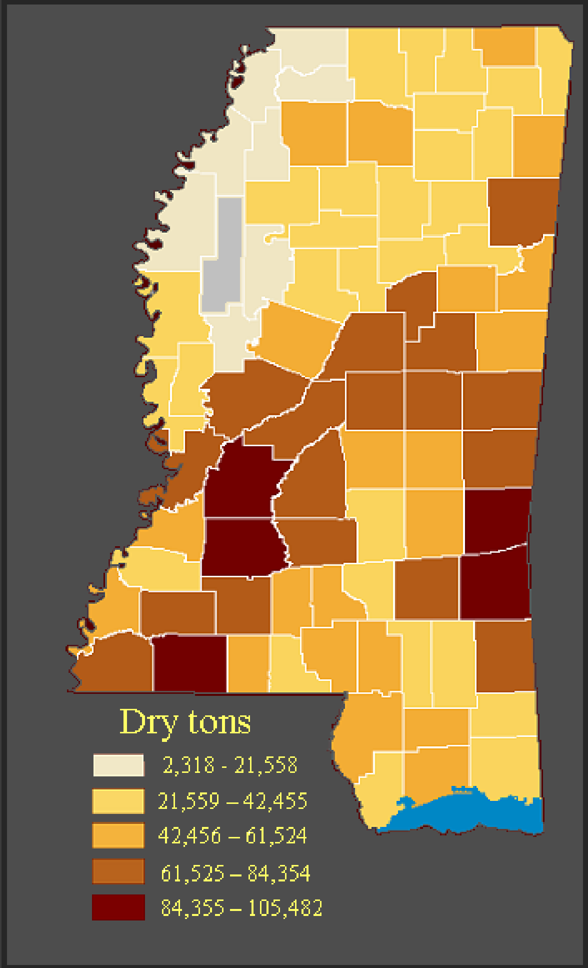

Standing stocks
Millions dry tons
250
200
150
100
50
0
Inventories
Growth
Removals
CE
DE
NE
SE
SW

Feedstock Availability

Available biomass per year: 4 million dry tons





Primary Conclusion

- About 4 million dry tons of woody biomass are available each year in MS
  - It can generate about 1,000 MW of electricity or 320 millions of gallons of biofuel

Photo: Rob

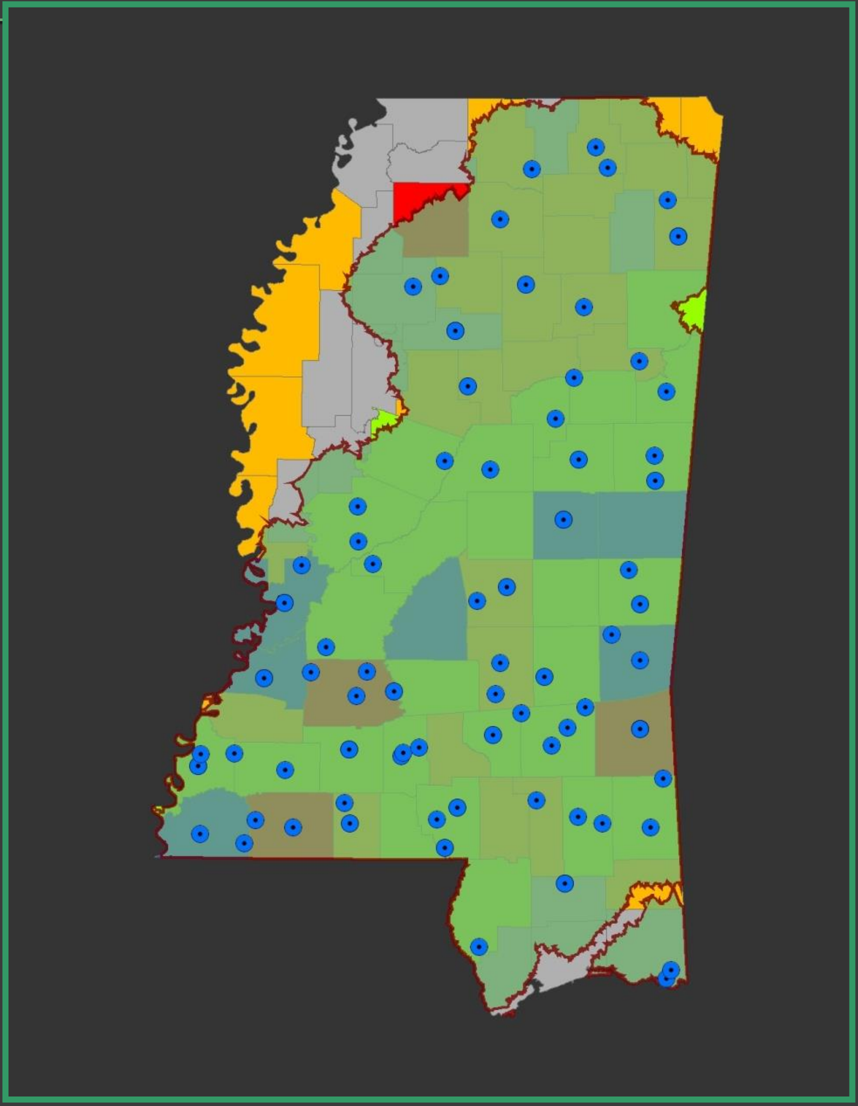
Logging Costs

Logging Costs

- How much does it cost to recover and haul woody biomass to a processing facility?
  - Geographic Information System (GIS)
  - Monte Carlo Simulation

Procurement Zones

- ArcGIS Network
- Analyst
- Mill locations
- Procurement area
  - 30 miles
- County-level volumes

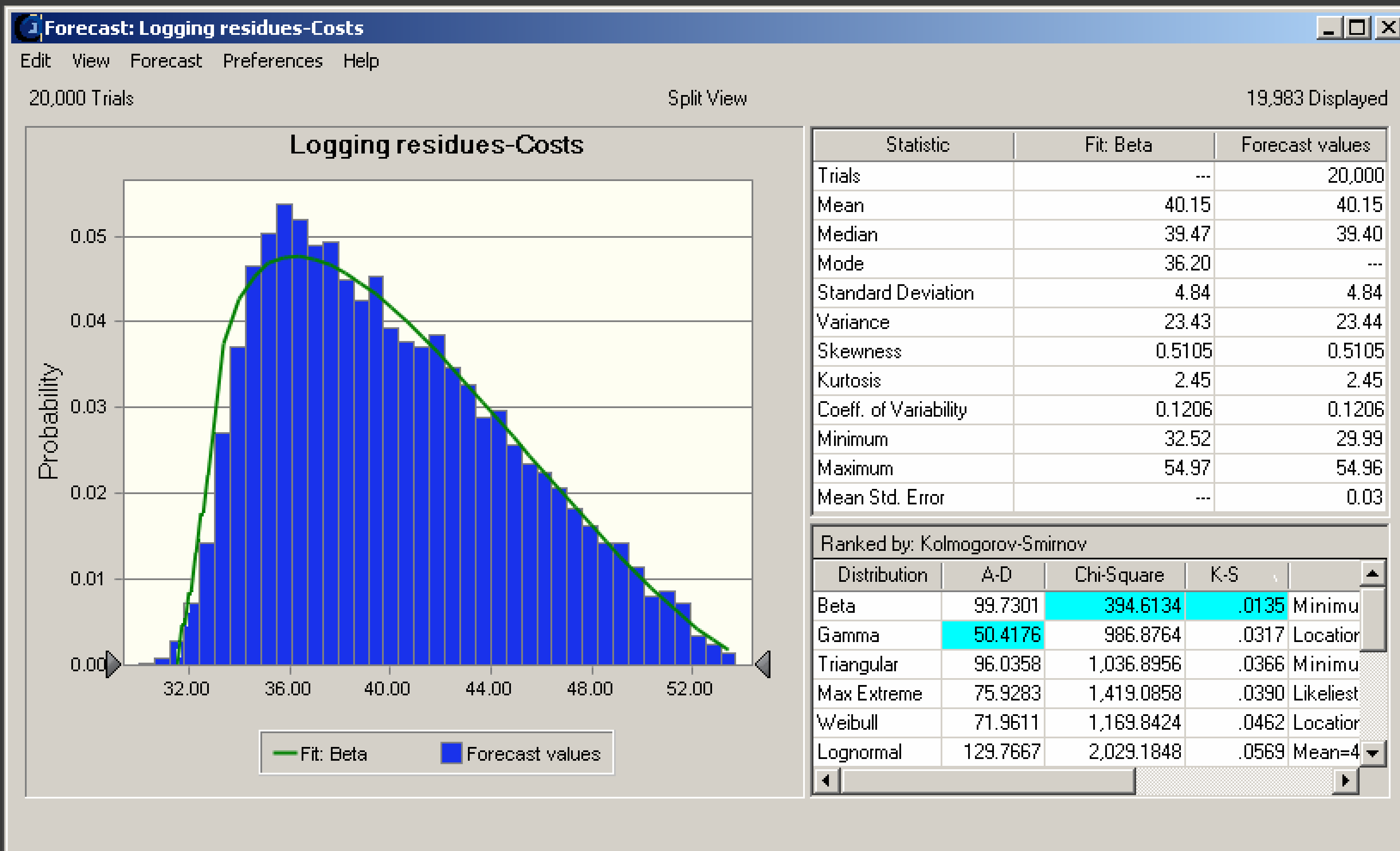


Biomass Production Costs

Costs	Logging residues	Small-diameter trees	Mill residues	Urban waste
Harvest ($/dry ton)	5.82	12.66	0.00	0.00
Transportation				
Fixed ($/dry ton)	6.96	6.96	6.96	6.96
Incremental ($/dry ton/mile)	0.17	0.17	0.17	0.17
Cost (50mile-radius) ($/dry ton)	15.46	15.46	15.46	15.46
Profit to logger ($/dry ton)	3.19	4.22	2.32	2.32
Residual stumpage value ($/dry ton)	4.70	5.99	0.00	0.00
Delivery price ($/dry ton)	29.17	38.33	17.78	17.78
Chipping cost ($/dry ton)	5.06	5.06	0.00	5.06
Selling, disposal / separating ($/dry ton)	0.00	0.00	4.20	5.51
Sum of costs ($/dry ton)	34.23	43.39	21.98	28.35

Source: Timber Mart-South and other sources.

Monte Carlo Simulation



Statistic	Fit: Beta	Forecast values
Trials	---	20,000
Mean	40.15	40.15
Median	39.47	39.40
Mode	36.20	---
Standard Deviation	4.84	4.84
Variance	23.43	23.44
Skewness	0.5105	0.5105
Kurtosis	2.45	2.45
Coeff. of Variability	0.1206	0.1206
Minimum	32.52	29.99
Maximum	54.97	54.96
Mean Std. Error	---	0.03

Distribution	A-D	Chi-Square	K-S	
Beta	99.7301	394.6134	.0135	Minimu
Gamma	50.4176	986.8764	.0317	Locatior
Triangular	96.0358	1,036.8956	.0366	Minimu
Max Extreme	75.9283	1,419.0858	.0390	Likeliest
Weibull	71.9611	1,169.8424	.0462	Locatior
Lognormal	129.7667	2,029.1848	.0569	Mean=4

Expected Logging Costs

(50-mile procurement radius and plant capacity at 52 million gallons of biofuel per year)

Logging residues

$40 / dry ton

Small-diameter trees

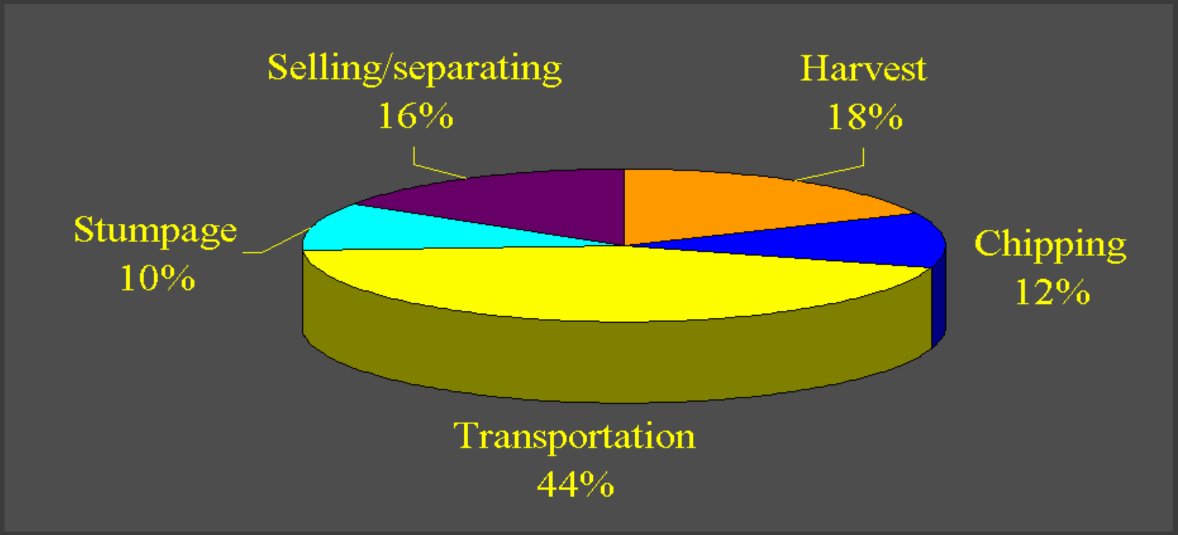
$49 / dry ton

Mill residues

$31 / dry ton

Urban waste

$36 / dry ton



Willingness to harvest

- Are forest landowners willing to harvest woody biomass?
  - Non-industrial private landowners (100 acres and greater)

Woody Biomass Availability

- NIPF Landowners responsible for about 76% of total wood production and own approximately 80% of timber lands (Bentley et al. 2005)

- Will they harvest???

- A mail survey was designed to obtain data on landowner preferences and harvesting decisions

www.tx.nrcs.usda.gov

Methods – Survey Design

Attributes	Scenario 1 (Standard Clearcut)	Scenario 2	Scenario 3	Scenario 4
Biofuel produced	no	yes	yes	yes
Clean harvest site	no	yes	yes	yes
Decrease fire & pest risk	no	yes	yes	yes
Site prep required	intensive	minimal	minimal	minimal
Price received at harvest	$3000/ac	$3000/ac	$3200/ac	$2800/ac

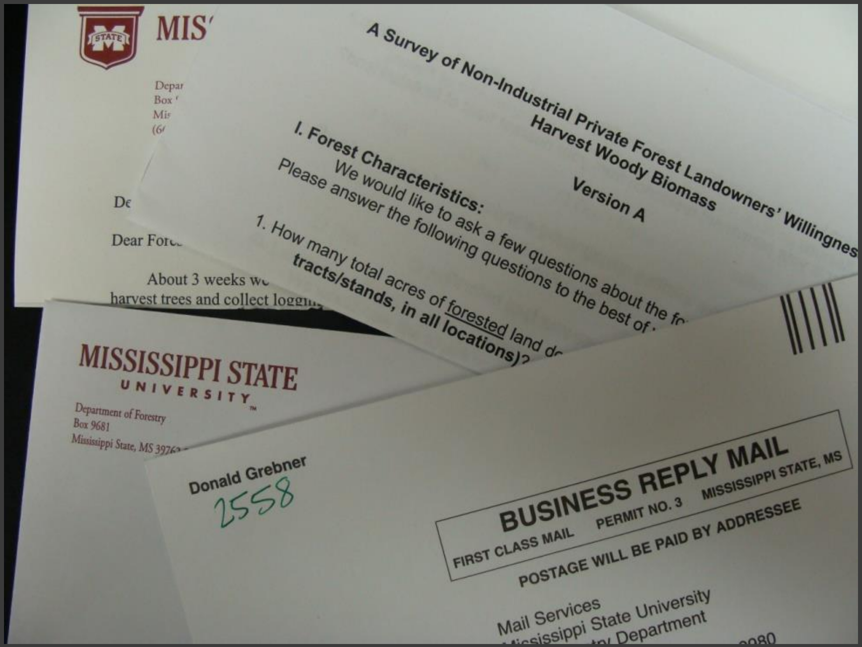
Appropriate sample size was calculated at 2,560 for the approximate 300,000 NIPF landowners in MS.

Hypothetical forest: 100 acres mature loblolly pine to be clearcut

Results – Survey Response

- Total response rate
  – 703 (28.8%)

- Usable response
  – 511 (20.96%)



Results – Model Comparison

- Comparison of predicted and observed frequencies of landowner decisions from the 3 ordered multinomial logit models

	MODEL 1 (V2V1) (Bioenergy (no price change) vs. Traditional)		**MODEL 2 (V3V1) (Bioenergy (with price change) vs. Traditional)**		**MODEL 3 (V4V1) (Bioenergy (with revenue loss) vs. Traditional)**	
	% Predicted	**% Observed**	**% Predicted**	**% Observed**	**% Predicted**	**% Observed**
0 (Less likely)	2.32	2.74	2.41	2.94	24.55	25.44
1 (Equally likely)	35.97	36.4	25.46	26.61	44.37	42.47
2 (More likely)	61.71	60.86	72.13	70.45	31.09	32.09
*511 observations						

Results – Summary

- Older landowners with larger landholdings were less likely to prefer the bioenergy scenarios
- Higher-educated landowners who were financially motivated, considered habitat management an important goal, and thought global climate change was an important issue, were more likely to prefer the bioenergy utilization scenario over the standard clearcut

Methods: Choice Experiment Survey Design

Sample size: 2,438 landowners
Number of returned questionnaires: 703
Adjusted response rate: 28.8%
Non-response bias analysis

Harvest Attributes	Harvest Plan A	Harvest Plan B	Harvest Plan C
Woody biomass utilization	**95%**	**0%**	**-**
Environmental quality effect	**Substantial decrease**	**Slight decrease**	**-**
Site preparation/cleanliness of site	**No site prep required**	**Intensive site prep required**	**-**
Price received per acre	**$3000/ac**	**$3000/ac**	**-**
	A	**B**	**No harvest**
Choosing to harvest means clear-cutting 100 acres of planted pine forestland			

Results: Nested Logit Models

Returned questionnaires: 703 (28.8%)
Usable questionnaires: 520 (21.3%)
85.7% of landowners chose to harvest timber

Attributes	Association	Implied WTA
Woody biomass Utilization:		
95%	Positive**	-141.70
70%	Positive	-14.99
Environmental quality effect:		
SUBSTANTIAL	Negative**	116.16
SLIGHT	Positive**	-59.71
Site prep required:		
INTENSIVE	Negative**	150.08
MINIMAL	Positive**	-51.18
PRICE	Positive**	
AGE	Positive**	
AGE2	Negative**	
EDUCATION	Negative*	
INCOME	Negative**	

Results

- Harvesting plan intend to utilize 95% woody biomass was preferred over those having no utilization (0%)
- Timber harvesting plan leading to substantial environmental quality loss was not preferred over base category
- Landowners preferred harvesting plan that resulted only in slight environmental quality loss
- While landowners did not prefer plans that required intensive site preparation, a modest site preparation requirement was acceptable

Concluding Remarks

- Nevertheless, as more than 85% of landowners were willing to supply woody biomass, Mississippi has great potential for wood-based bioenergy.

Mill Residuals

- How much mill residual exists and what is available for bioenergy use?

Photo: planetgreen.discovery.com

Results of Mill Survey

Population Size: 458 mills
Number of returned questionnaires: 99
Adjusted response rate of survey: 21.6%
Non-response bias analysis was conducted

- 54% were primary mills, 28% were secondary, and 18% had both facilities
- Monthly woody residue volume was 208,490 tons; 92% was contributed by primary mills
- 69% of mill residues was internally used, 30% was sold, and 1% was given away

Concluding Remarks

- As most of the available woody residues in the state is sold, entrepreneurs might need to pay a competitive feedstock price to operate wood-based bioenergy facility in Mississippi

- Appropriate location of wood-based bioenergy industry should be an important consideration to ensure low cost wood-based bioenergy production

- Earlier estimates were low

Urban Wood Waste

- How much urban wood waste exists and how much is recoverable?
  - Class I & II rubbish sites
  - Industrial sites
  - Municipal sites
  - Composting sites

Results

Population Size: 208
Number of survey respondents: 62
Adjusted response rate: 29.8%
Non-response bias analysis

Surveyed facilities included:

- Class I rubbish sites: 43%
- Class II rubbish sites: 26%
- Other (industrial, municipal, transfer, composting): 31%
- Total wood waste was 392,864 tons annually
- Total wood waste recoverable was 48%

Concluding Remarks

- Most material is not used
- Several issues evolve around what is recoverable and what is not
- No existing markets

Photo: Katarzyna Grala

Economic Impact Assessment

Methods

- The Impact Analysis for Planning (IMPLAN) model was used for economic impact analysis of wood pellet, bio-oil, and methanol industries
- IMPLAN reported direct, indirect and induced economic impacts
- Direct Impacts explain the immediate changes in the production of an economic activity
- Indirect impacts report on the cumulated impacts attributed to inter-industry spending
- Induced impacts are the ripple impacts in different sectors of an economy due to changes in household spending patterns

Impact Analysis

Economic Impacts of Wood Pellet Industry (75,000 dry tonne/yr)

Activities	Direct	Indirect	Induced	Total	Type SAM
Construction					
Employment	15	5	27	47	3.09
Output (MM$)	2.34	0.65	2.75	5.75	2.45
Operation					
Employment	19	20	43	82	4.32
Output (MM$)	6.64	1.27	4.46	12.37	1.86

Impact Analysis

	Economic Impacts of bio-oil facility (66,255 dry tonne/yr)				
Activities	Direct	Indirect	Induced	Total	Type SAM
Construction					
Employment	67	26	30	122	1.82
Output (MM$)	9.71	2.73	3.06	15.50	1.60
Operation					
Employment	53	24	35	112	2.11
Output (MM$)	7.92	1.72	3.64	13.20	1.68

Impact Analysis

Activities	Direct	Indirect	Induced	Total	Type SAM
	Economic Impacts of Methanol Industry (730,000 dry tonne/yr)				
Construction					
Employment	886	243	393	1,522	1.72
Output (MM$)	129.68	28.53	40.36	198.57	1.53
Operation					
Employment	243	205	346	795	3.27
Output (MM$)	47.48	13.44	35.48	96.40	2.03

Impact Analysis

Economic Impacts of all three industries on Mississippi economy based on per tonne of biomass

Industry	Total ($MM)	Per Unit ($)
Wood Pellet	12.37	164.93
Bio-oil	13.27	200.38
Methanol	96.4	132.03

Discussion and Conclusion

- While methanol based gasoline industry had the highest impacts, its economic impact per ton biomass use was least among all three industries
- Wood pellet industry has the highest employment multiplier indicating that it would most contribute to the local economy
- Wood pellet industry relies on the biomass from primary wood processing facilities and it would be less likely to compete with other facilities for biomass

Overall Concluding Remarks

- Mississippi has great potential for bioenergy due to availability of mill residues and landowner willingness to harvest biomass
- Landowners and mill owners are in need of information related to bioenergy
- Wood-based bioenergy industry would likely contribute state economy by generating employment and new economic opportunities

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