



Modeling economic, social, and environmental issues surrounding woody biomass

Biomass Site Assessment Tool



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Xia Huang
University of Tennessee
Center for Renewable Carbon

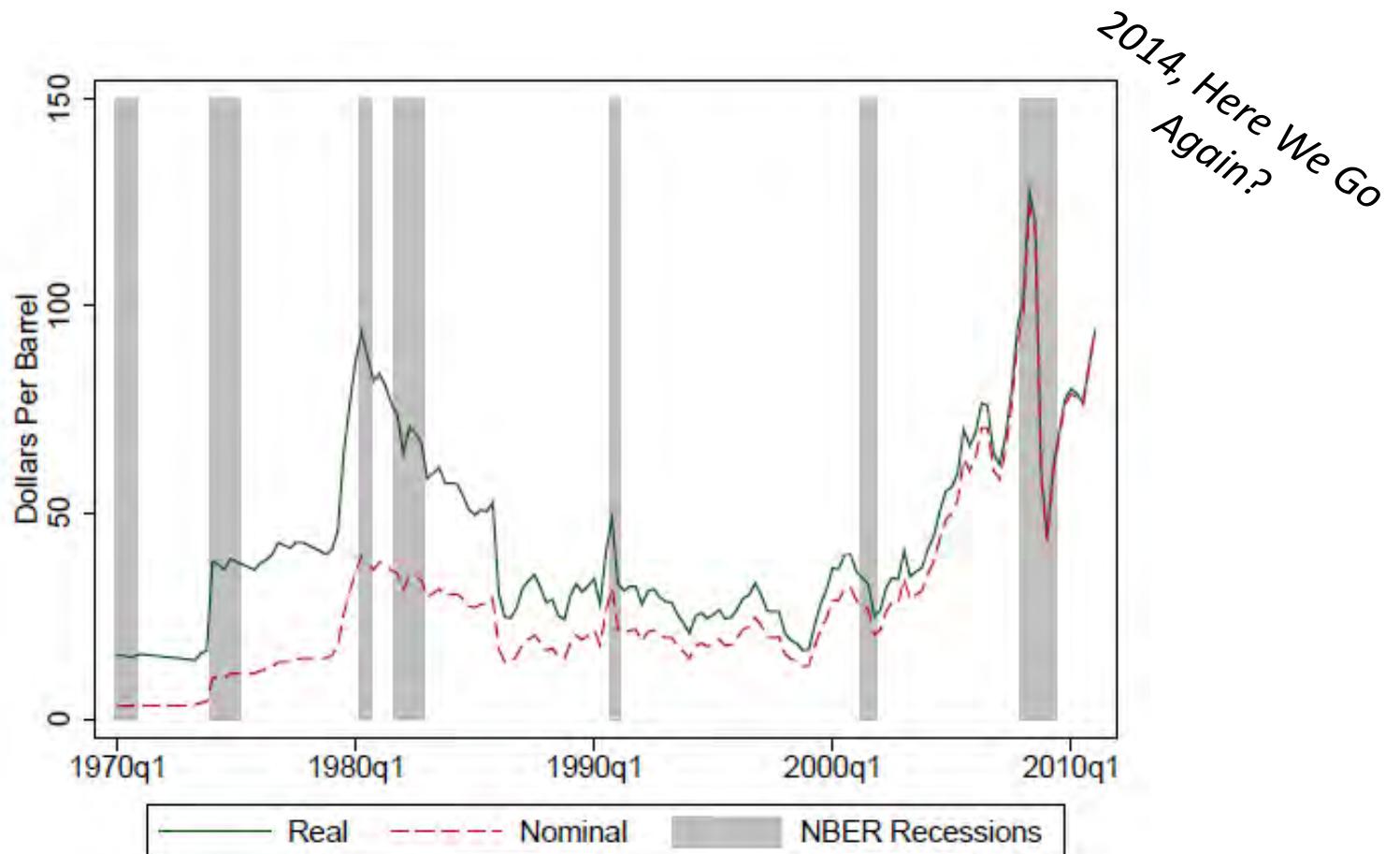
James H. Perdue

U.S. Forest Service
Southern Research Station



NORTHWEST WOOD-BASED
BIOFUELS + CO-PRODUCTS
CONFERENCE

Why are we Here?



Foote, C.L. and J.S. Little. 2011. *Oil and the Macroeconomy in a Changing World: A Conference Summary*. Federal Reserve Bank.



Problem Definition

Develop a web-based, economic decision tool with periodic data updates to assist business planners in the development of facilities that require cellulosic feedstocks, *e.g., biorefineries, biopower, traditional biomass, etc.*



BioSAT

Phases

Phase I: woody residues, agricultural residues, and roundwood with geo-referenced aggregate supply curves; also develop web-site - www.BioSAT.net

Phase II: stochastic-based site selection, constraint criteria's (*e.g., competition, elasticity's, state policies, some sustainability criteria*)

Phase III: integration with larger KDF



BioSAT

Phase I Objectives

1. Develop SQL database of resource data ✓
 - Forest (roundwood) – USFS FIA
 - Mill Residues – USFS FIA
 - Logging Residues – SRTS
 - Ag Residues - NASS
2. Develop wood resource costs ✓
 - Timber Mart South/Timber Mart North
 - Northern State Price Reporting Services
3. Develop truck transportation model ✓
4. Develop harvesting cost models ✓
 - FRCS for logging residues (Dennis Dykstra)
 - AHA for roundwood (Bob Rummer/Dale Greene)



BioSAT

Phase I Objectives

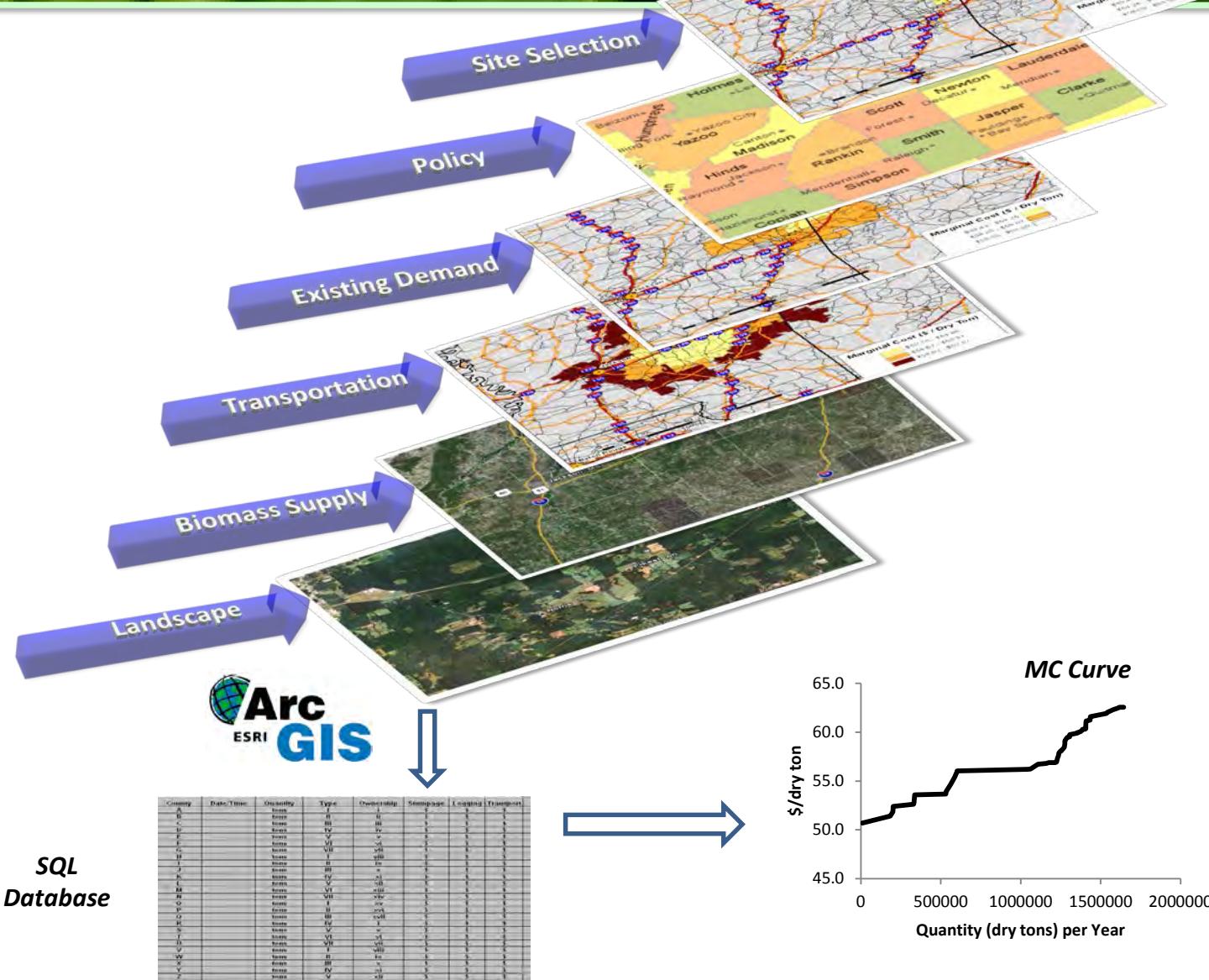
5. Develop web-based system in the public domain
www.BioSAT.net ✓
6. Develop a web-based system with periodic update capabilities, e.g., ✓
 - Diesel prices (US DOE EIA)
 - Resource costs (TMS, State Reports)
 - Road network (MapPoint 2009)
 - Resource data (USFS FIA, USDA NASS, SRTS)

Scope: 33 Eastern United States

Resolution: 25,044 Zip Code Tabulation Areas (ZCTA)

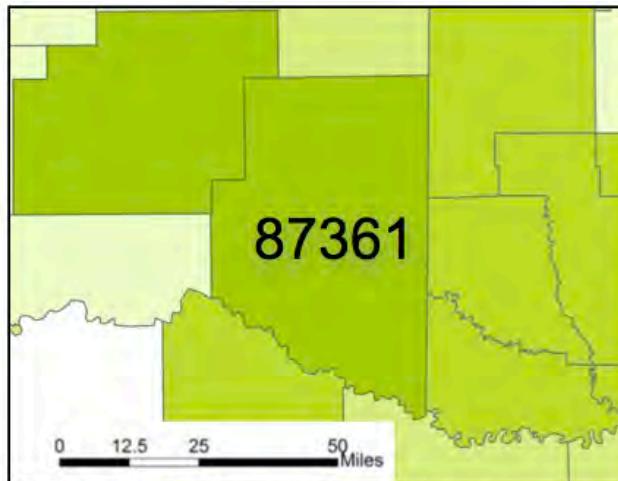


BioSAT

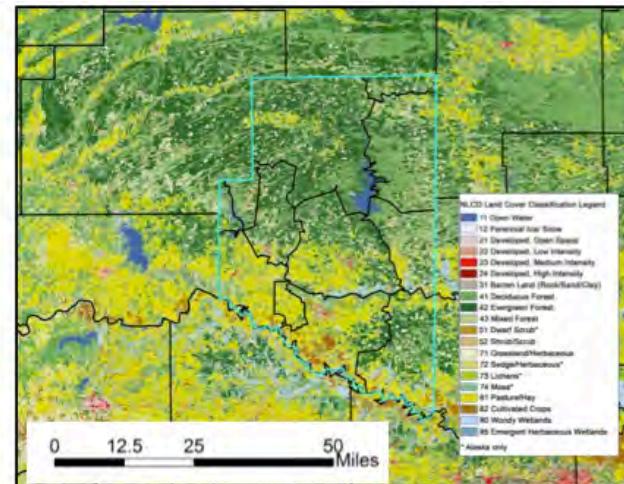


BioSAT

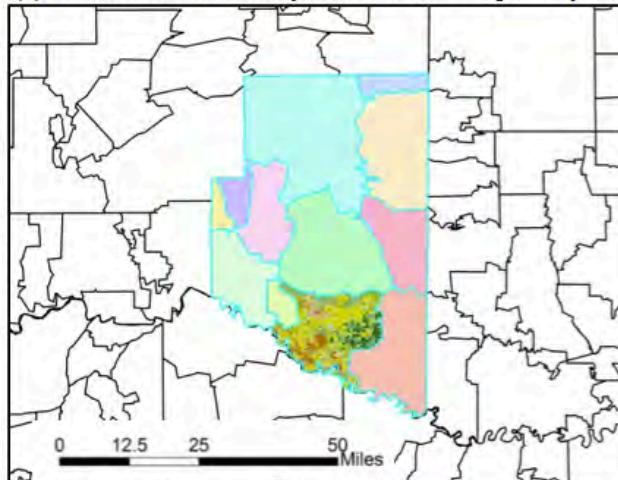
Use Land Cover Data to Proportionally Allocate the biomass by ZCTA



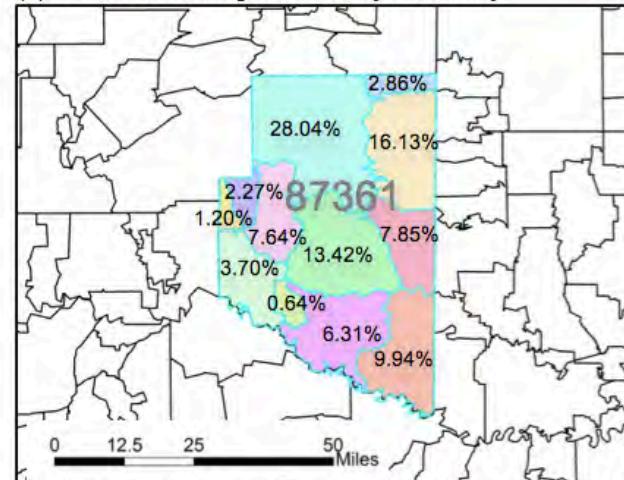
(a). Illustration of county forest biomass quantity



(b). Land cover map and county boundary



(c). Land cover for 5-digit ZCTA boundary



(d). Forest biomass allocation by 5-digit ZCTA

BioSAT Model

Feedstocks



Woody Residues & Merchantable Wood

- Logging Residues
 - Softwood/Hardwood
 - At the landing/In the woods
- Mill Residues
 - Softwood/Hardwood
 - Clean/Unclean
- Roundwood “Pulpwood”
 - Softwood/Hardwood
- Roundwood “Sawtimber”
 - Softwood/Hardwood

Ag Residues

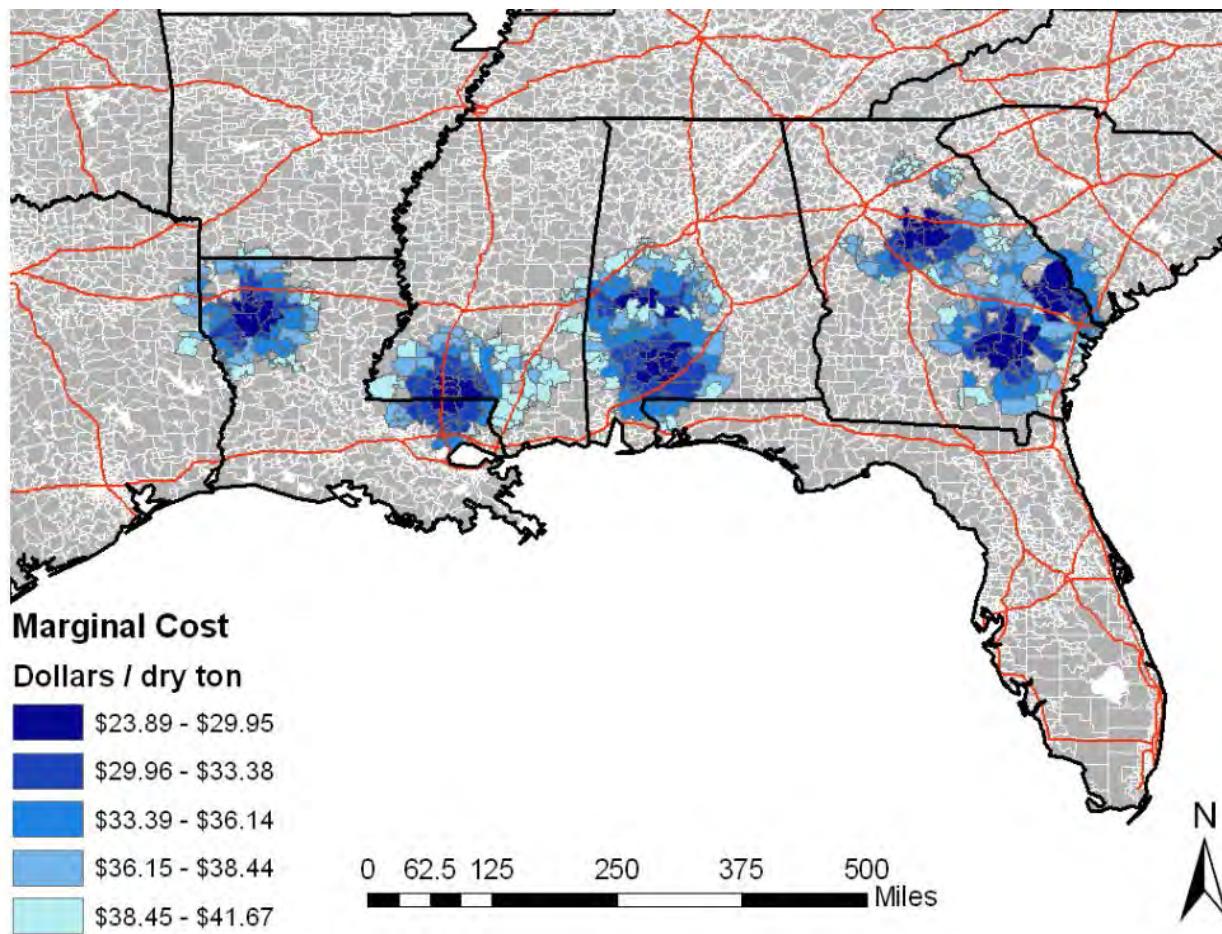
- Barley Straw
- Corn Stover
- Oat Straw
- Sorghum Straw
- Wheat Straw (Winter)
- Wheat Straw (All)



Model Results

Mill Residue Example

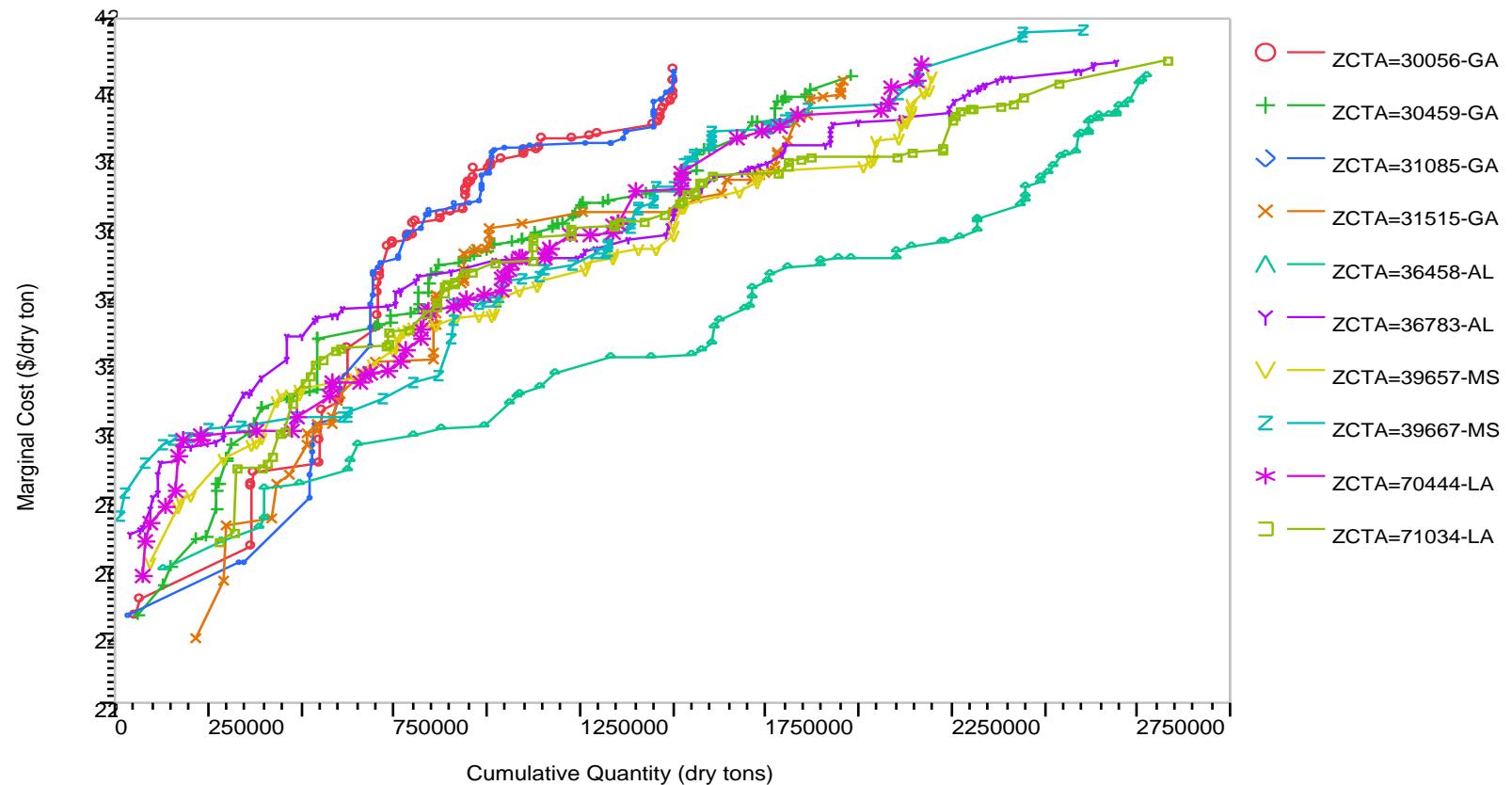
Low cost “biobasins” in southeast



Model Results

Mill Residue Example

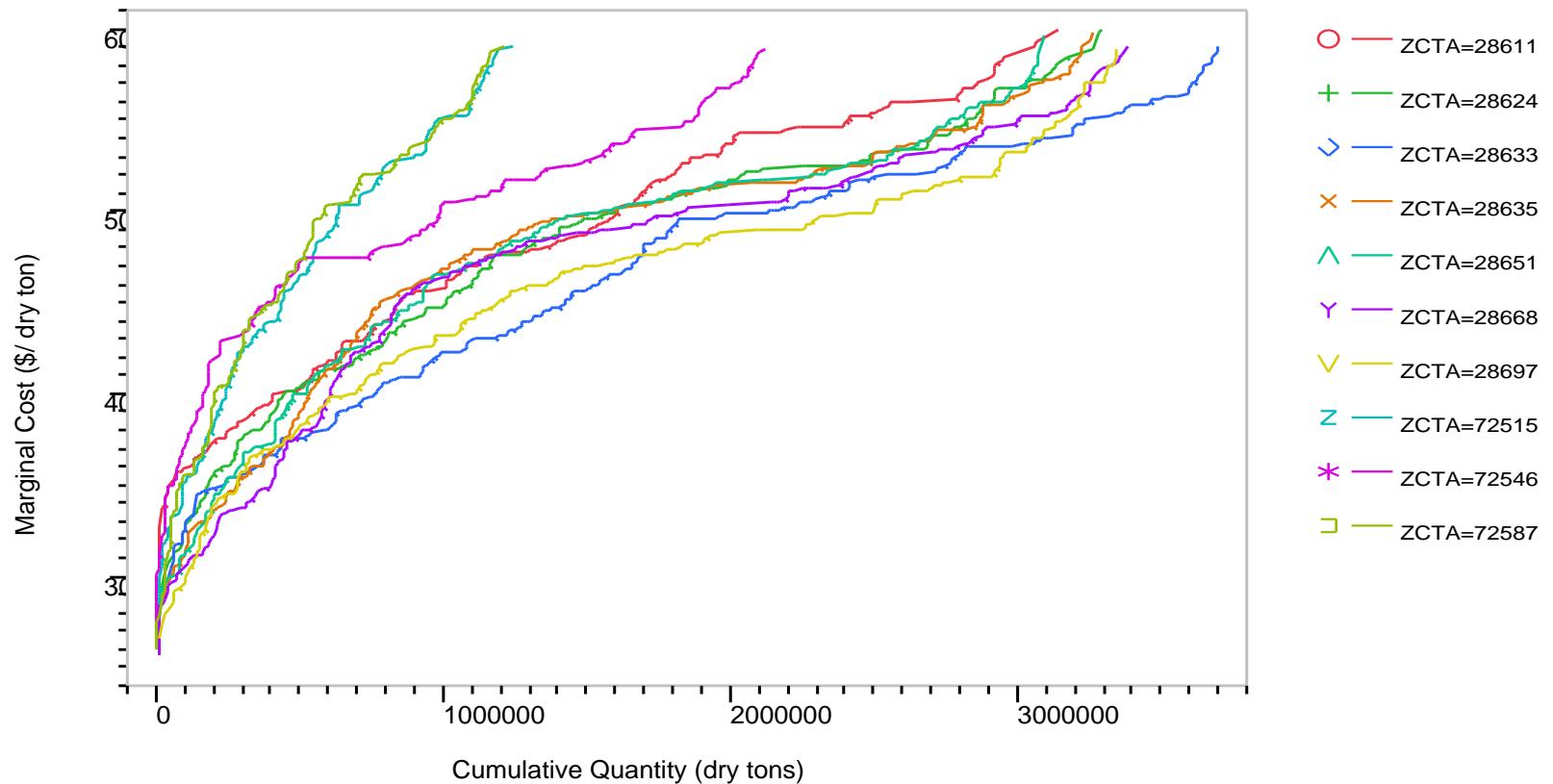
Corresponding Marginal Cost Curves



Model Results

Mill Residue Example

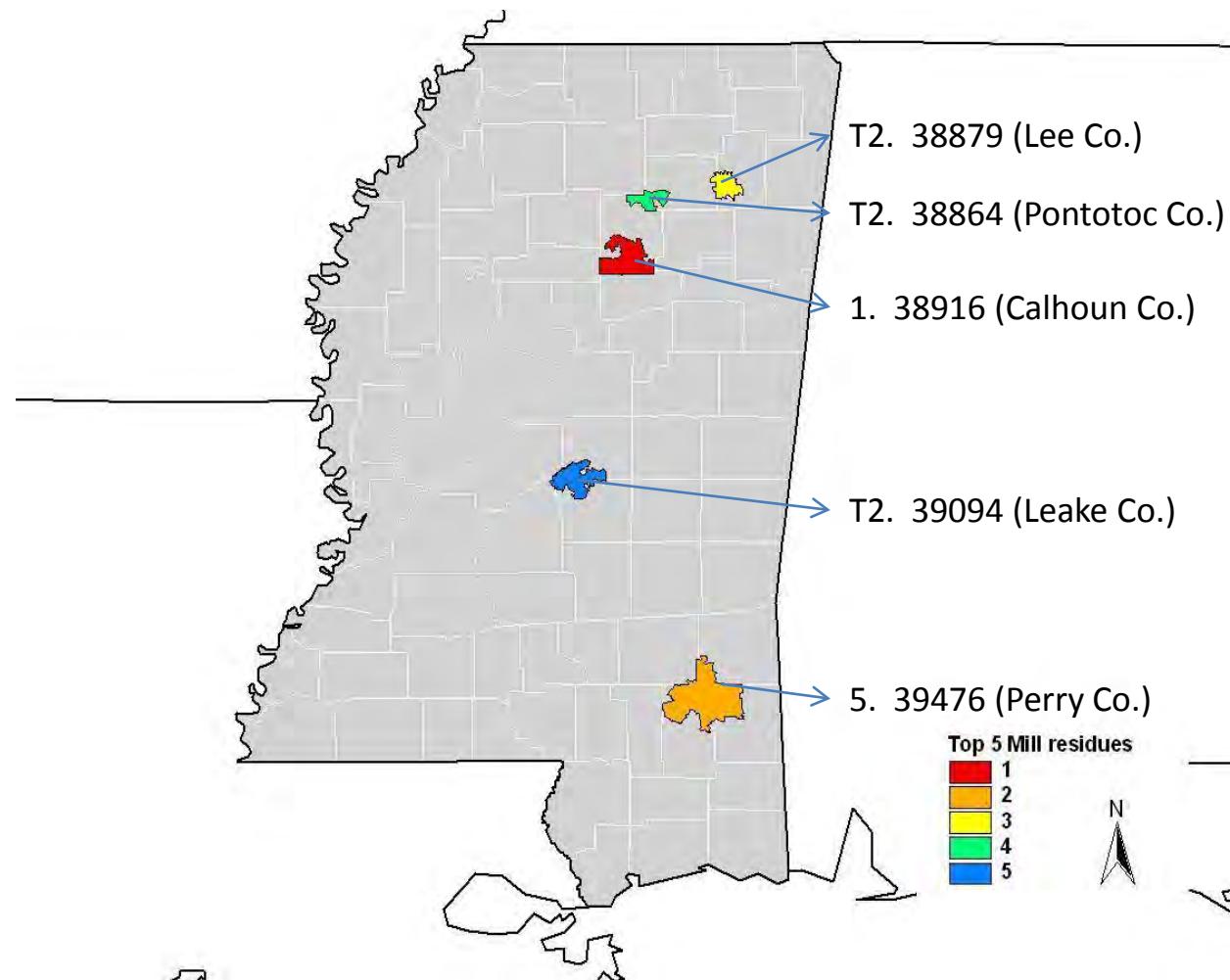
“Highest Cost” Biobasin Marginal Cost Curves



Model Results

Mill Residue Example – Top Five Locations within MS

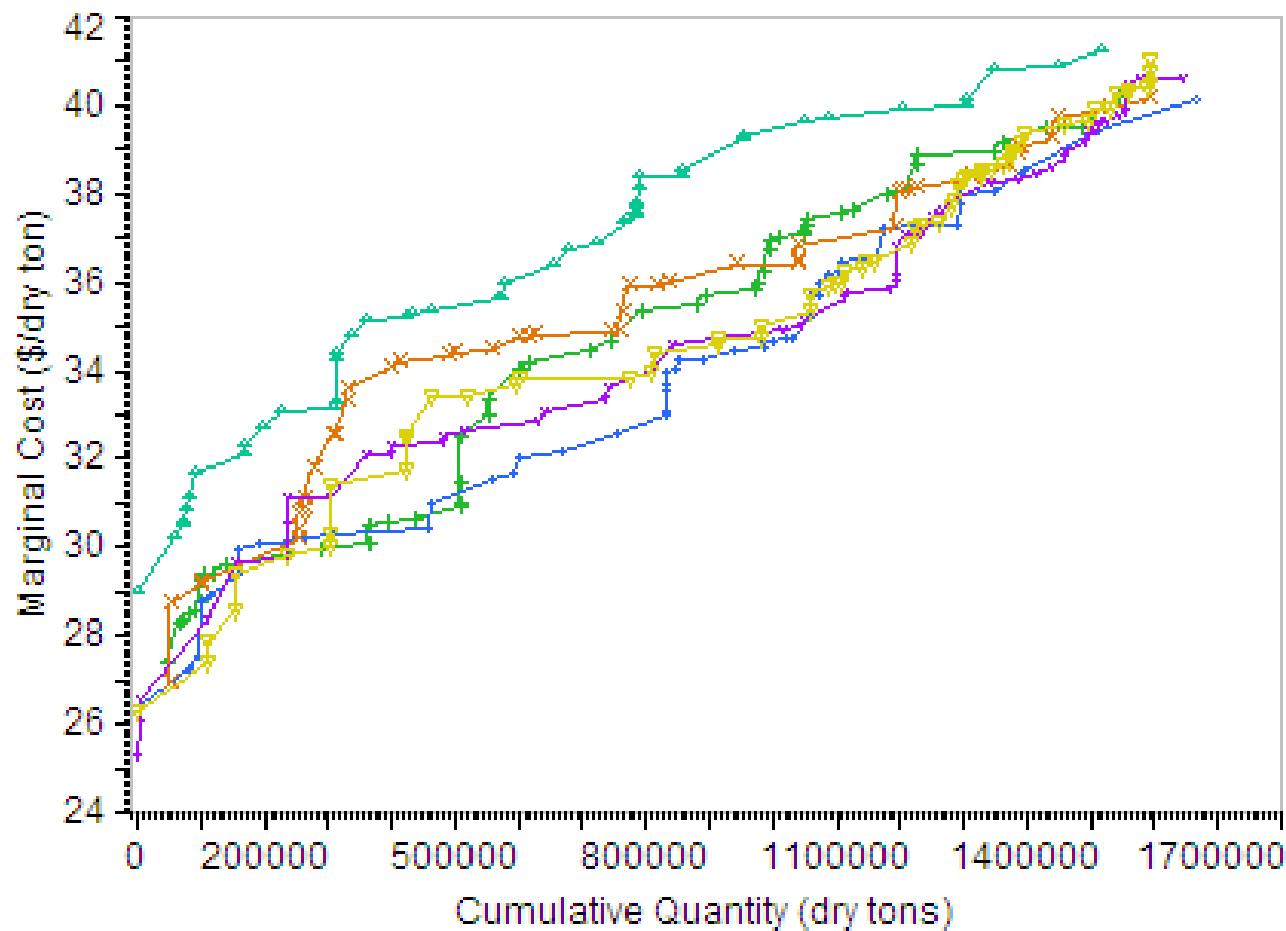
Annual Capacity \leq 1.5 M Dry Tons/Year



Model Results

Mill Residue Example – Top Five Locations within MS

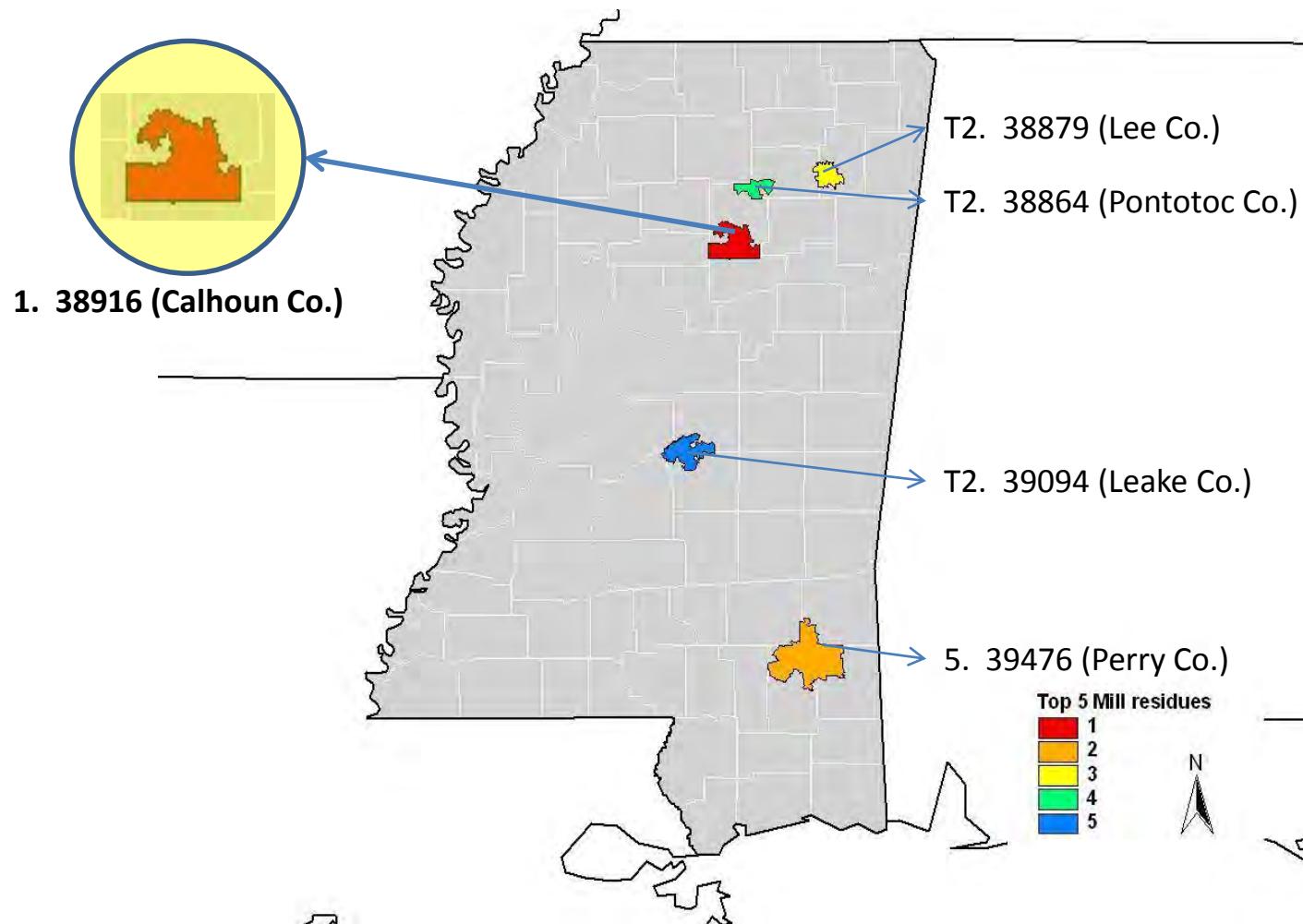
Corresponding Marginal Cost Curves



Model Results

Mill Residue Example – Top Five Locations within MS

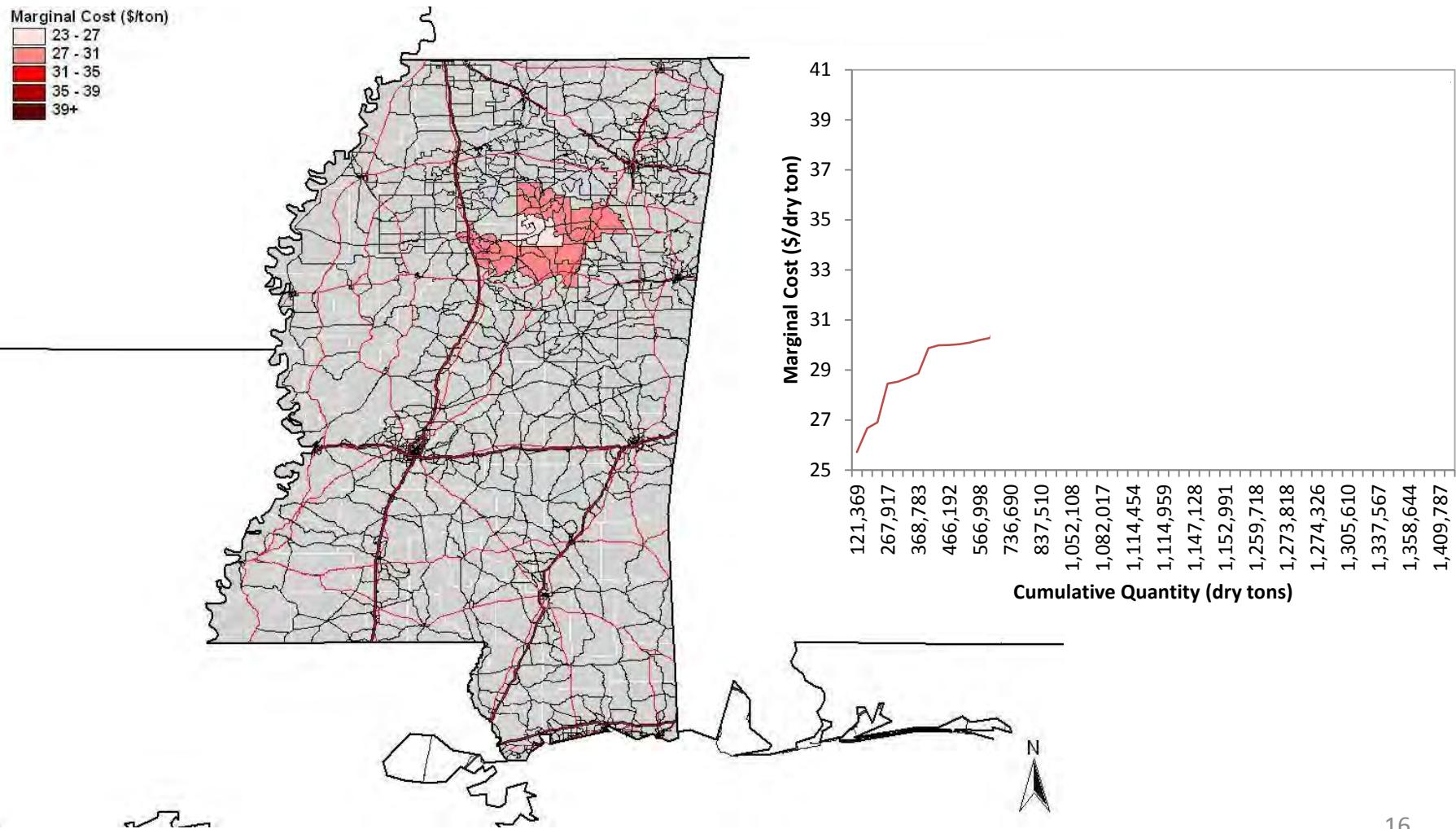
Annual Capacity \leq 1.5 M Dry Tons/Year



Model Results

Mill Residues – ZCTA 38916 (Calhoun County)

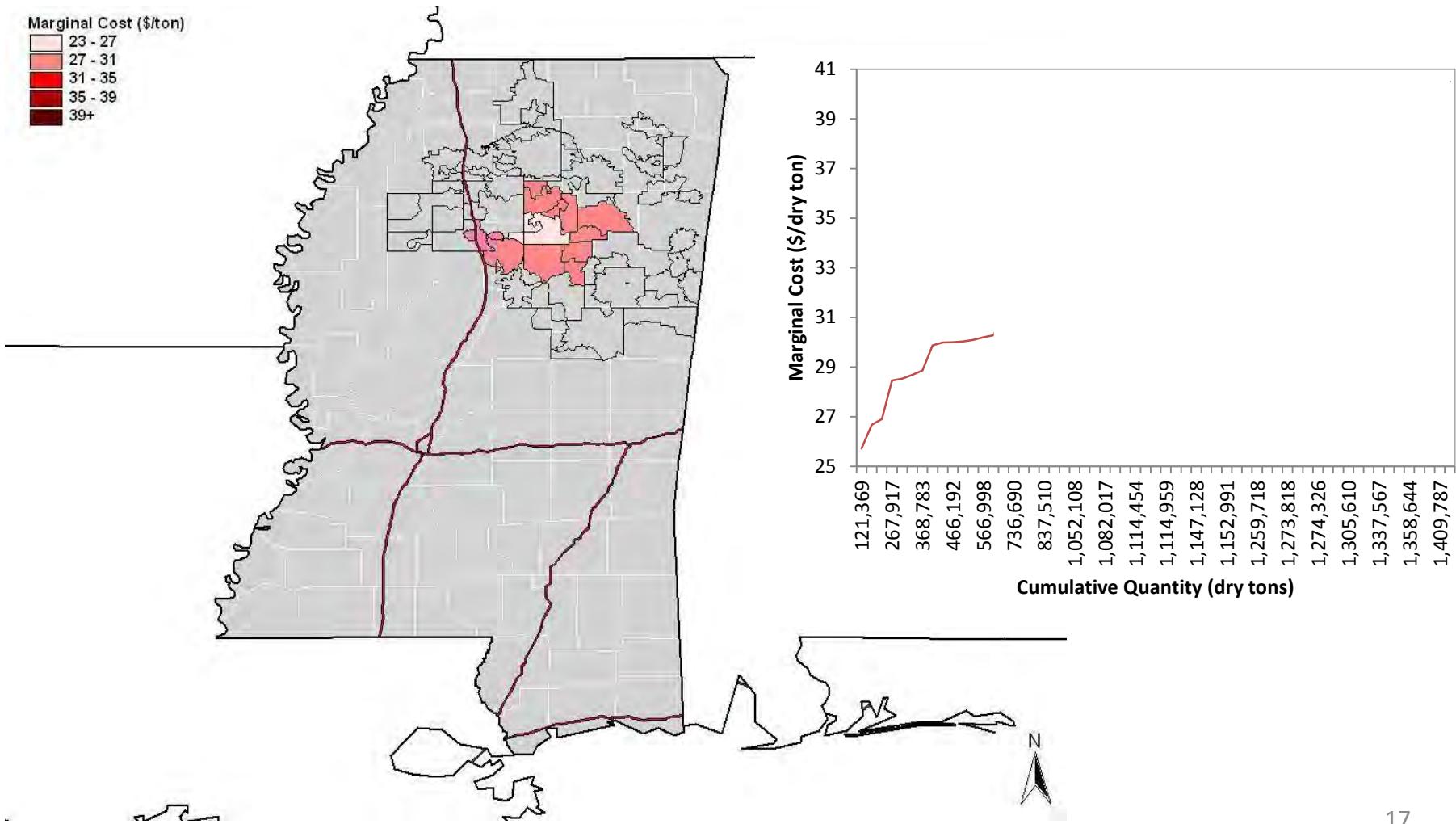
Marginal Cost Curve Development



Model Results

Mill Residues – ZCTA 38916 (Calhoun County)

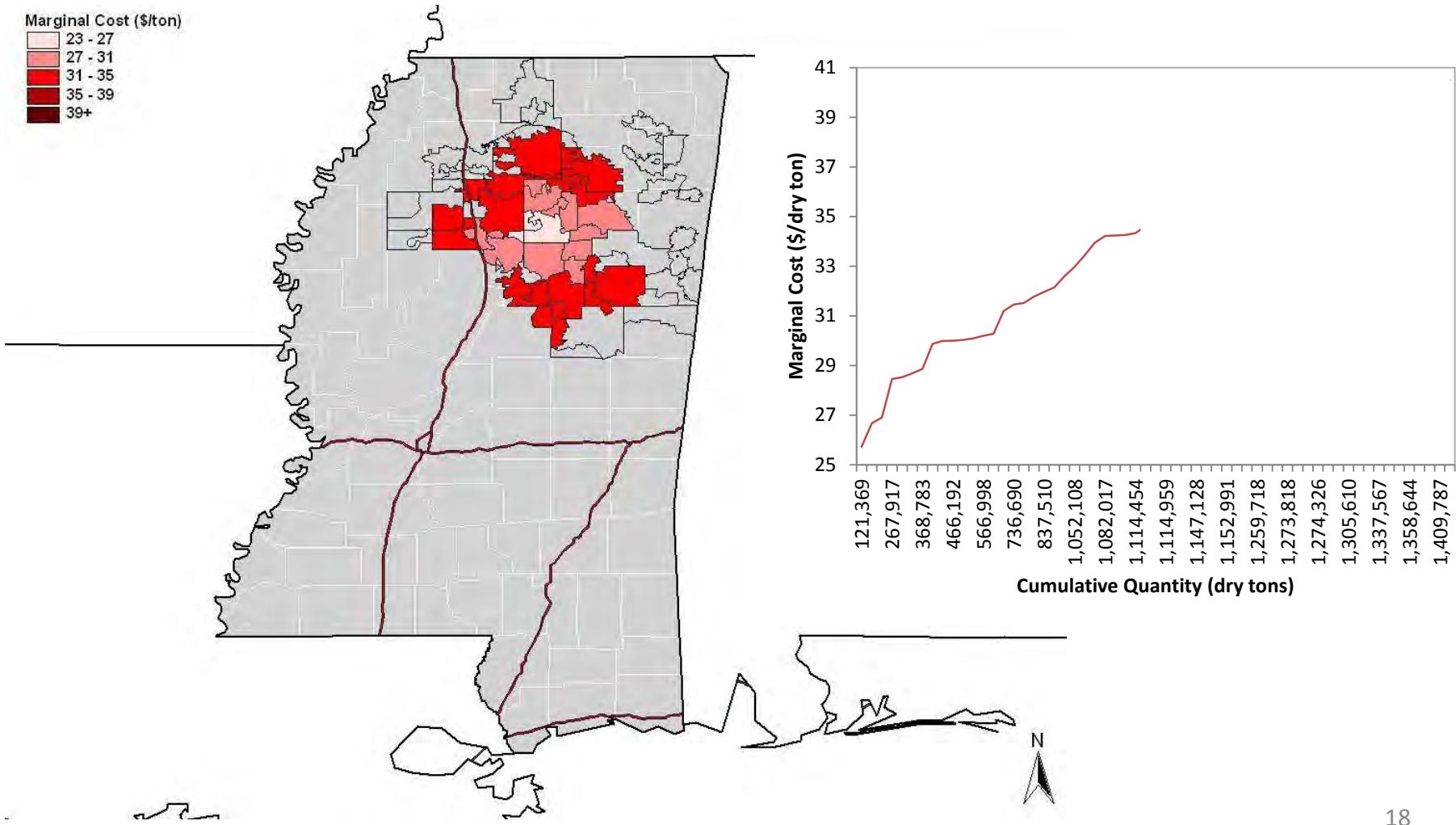
Marginal Cost Curve Development



Model Results

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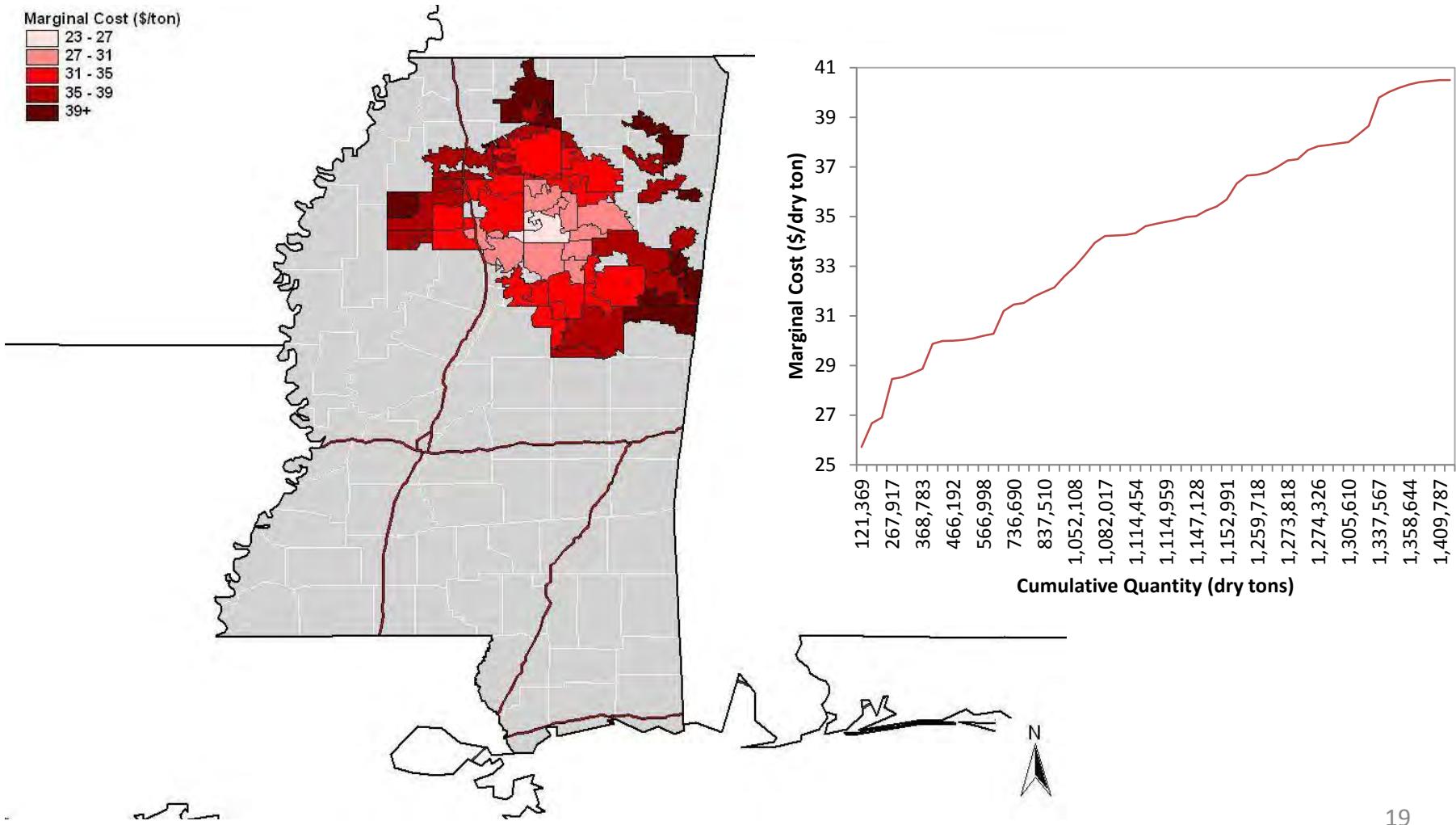
Marginal Cost Curve Development



Model Results

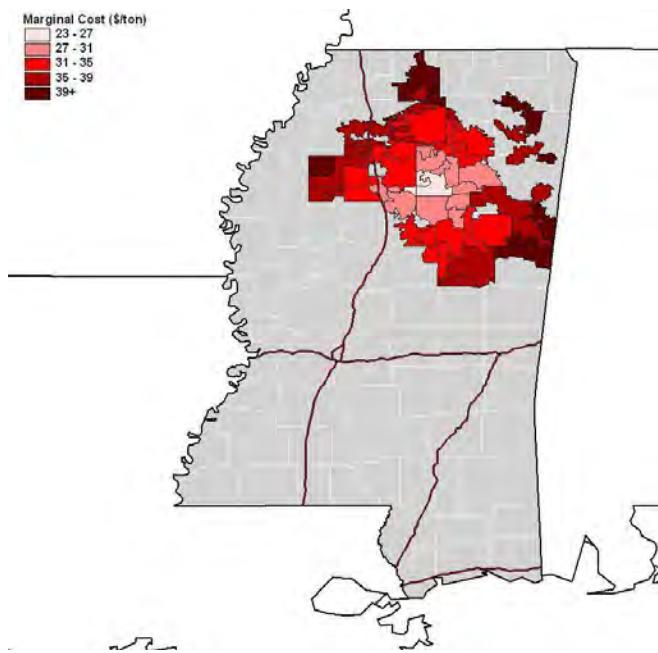
Mill Residues – ZCTA 38916 (Calhoun County)

Marginal Cost Curve Development

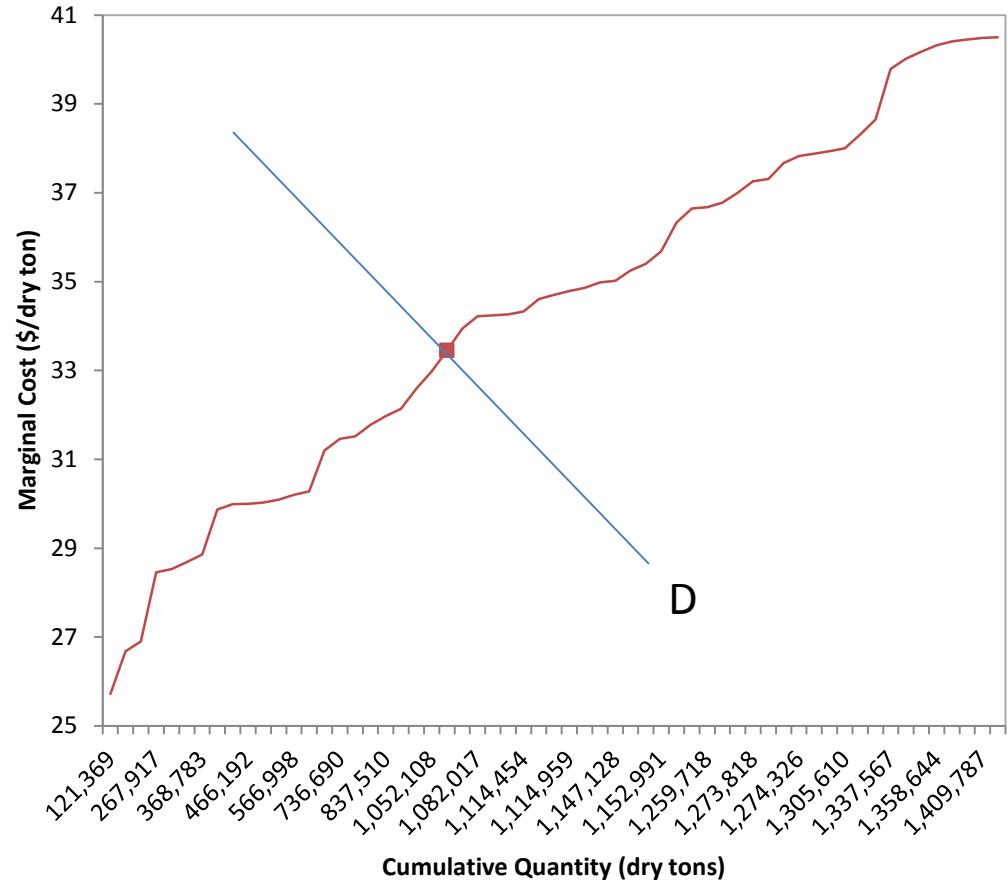


Model Results

Mill Residues – Competition

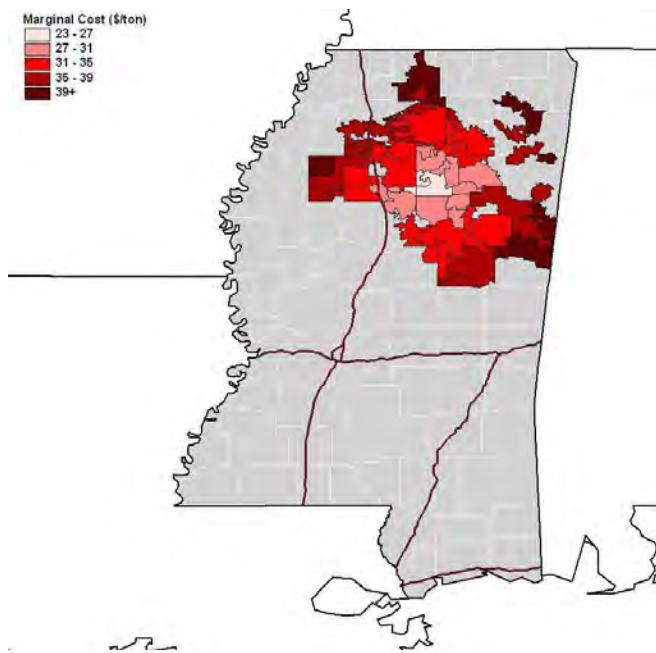


Competition (*User Must Estimate Elasticity*)

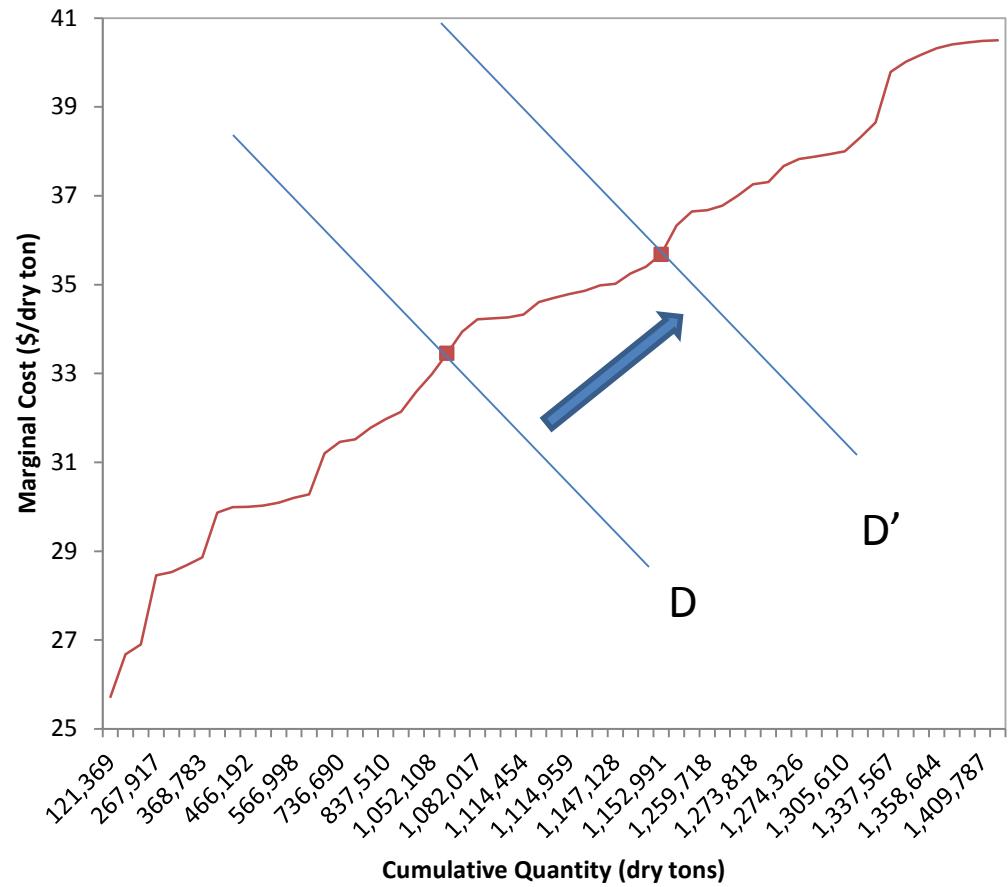


Model Results

Mill Residues – Competition

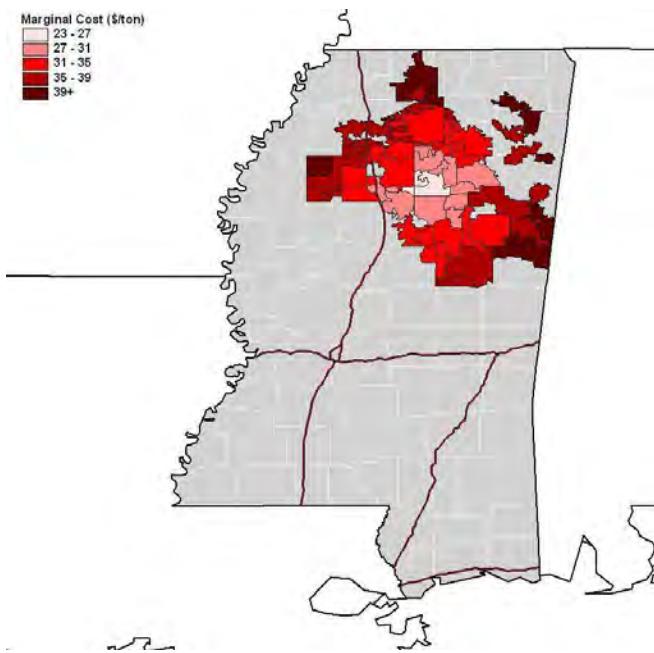


Competition (*User Must Estimate Elasticity*)

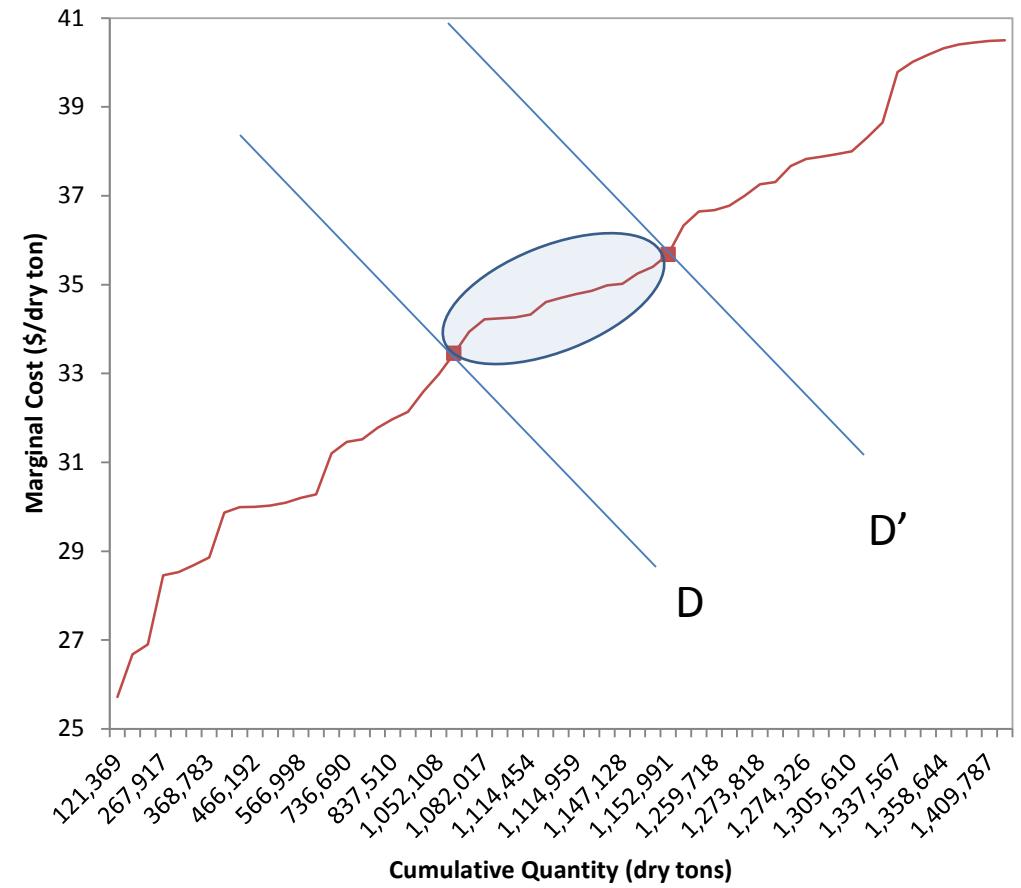


Model Results

Mill Residues – Competition



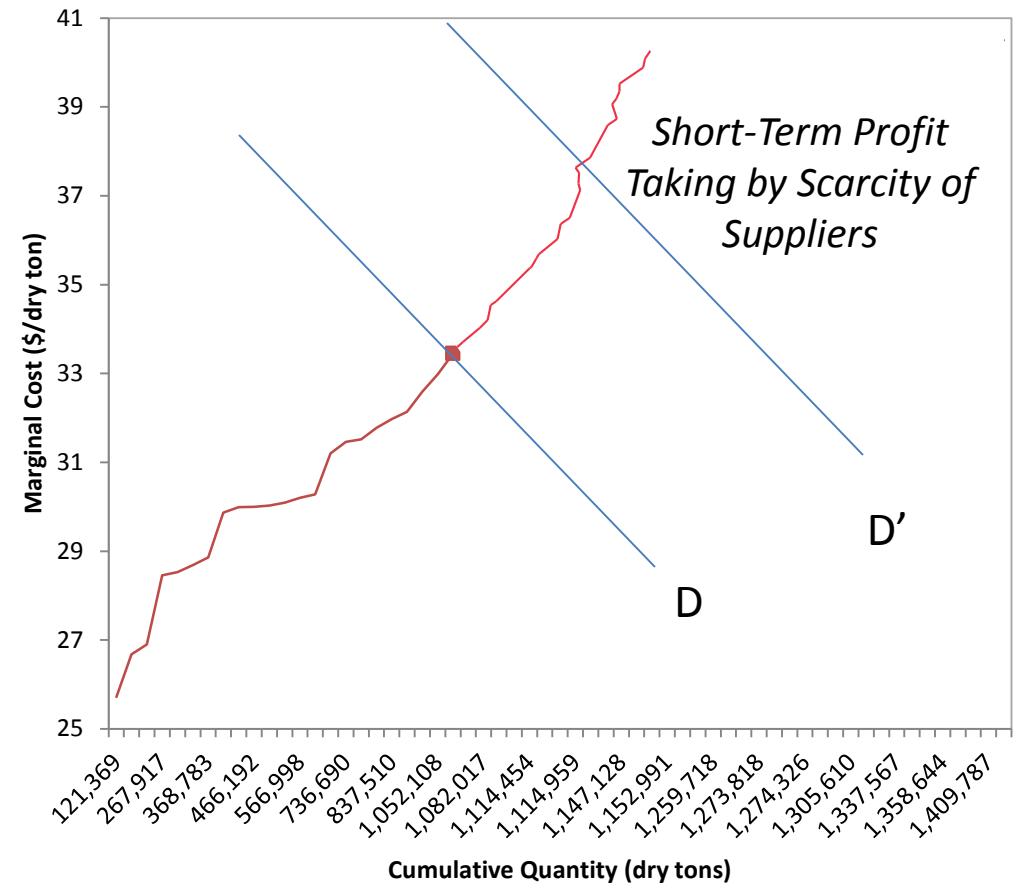
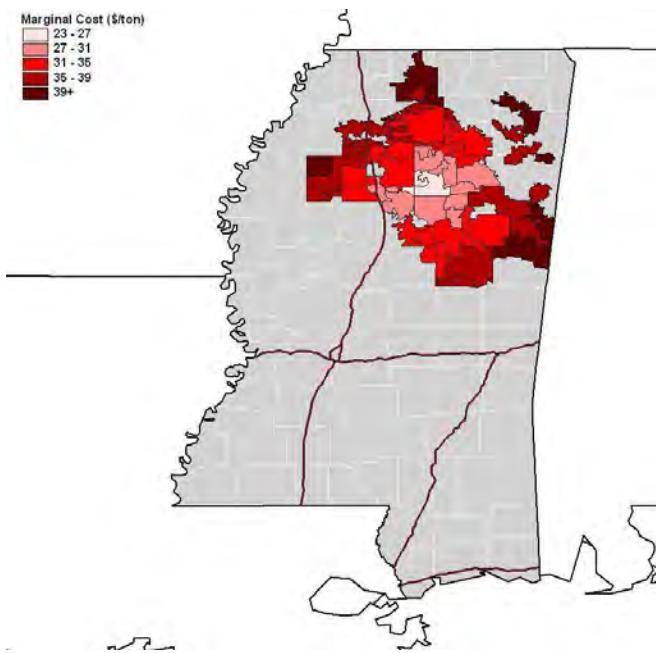
Competition (*Phase I – User Must Estimate Elasticity*)



Model Results

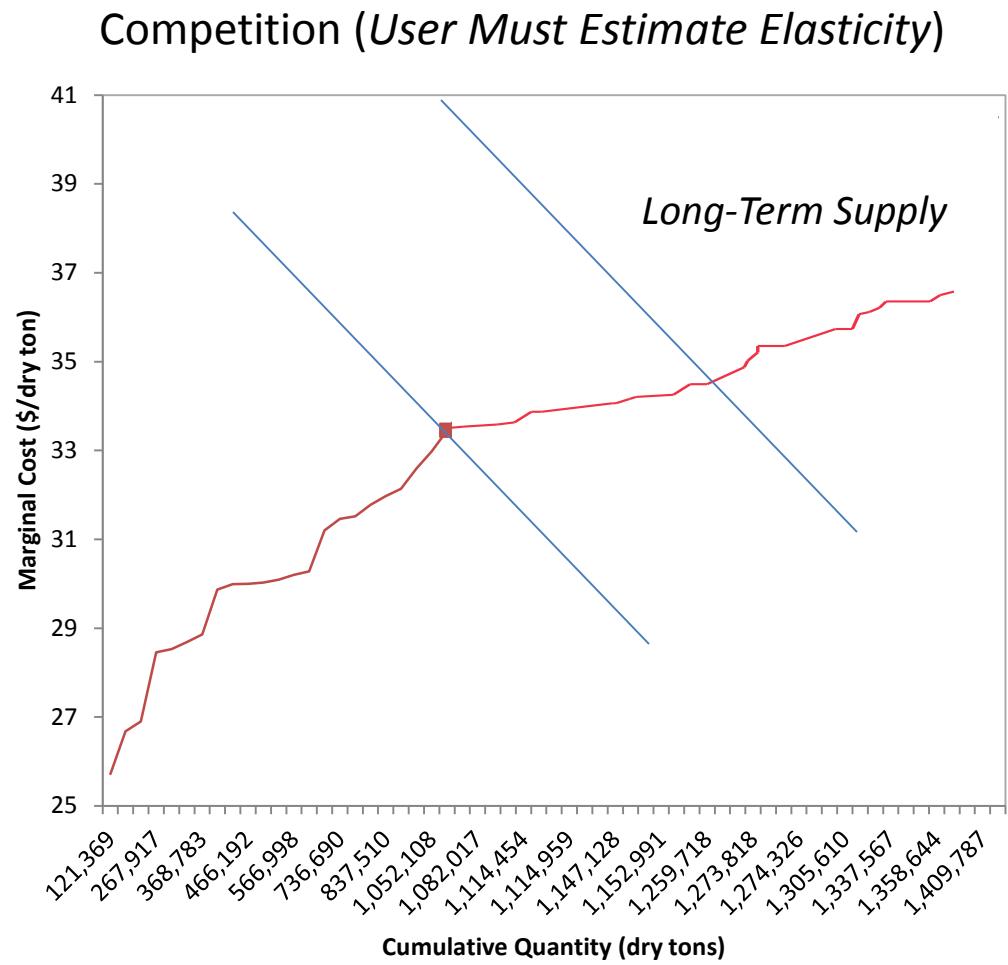
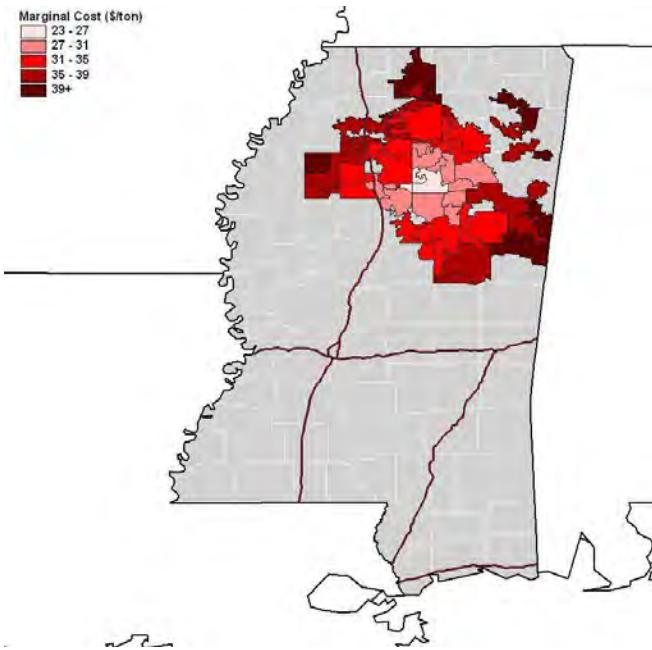
Mill Residues – Competition

Competition (*User Must Estimate Elasticity*)



Model Results

Mill Residues – Competition



Model Results

Logging Residue Example

Low cost logging residues for “*chipping at landing or hog fuel*”

Rank	ZCTA	County	State	City	Annual Quantity Available (dry tons)	Total Cost	Average Total Cost (\$/dry ton)	Median MC (\$/dry ton)
1	27412	Guilford	NC	Greensboro	502,198	\$13,599,152	\$26.93	\$27.99
2	38501	Putnam	TN	Cookeville	511,366	\$13,719,978	\$26.94	\$27.21
3	27403	Guilford	NC	Greensboro	502,663	\$13,656,959	\$26.99	\$28.02
4	30604	Clarke	GA	Athens	501,664	\$13,734,656	\$27.27	\$28.33
5	30602	Clarke	GA	Athens	501,809	\$13,780,111	\$27.34	\$28.92
6	27498	Guilford	NC	Greensboro	506,446	\$13,716,390	\$27.41	\$27.66
7	27419	Guilford	NC	Greensboro	500,535	\$13,755,368	\$27.45	\$27.95
		Clarke	GA	Athens	500,382	\$13,782,215	\$27.52	\$28.41
			New Johnsonville		500,063	\$13,774,854	\$27.54	\$29.18
			Reevesville		507,943	\$13,800,431	\$27.59	\$28.65



Model Results

Logging Residue Example

Low cost logging residues for “*in-woods small tree harvesting & and logging residue collection*”

Rank	ZCTA	County	State	City	Annual Quantity Available (dry tons)	Total Cost	Average Total Cost (\$/dry ton)	Median MC (\$/dry ton)
1	31636	Lowndes	GA	Lake Park	1,508,464	\$257,769,437	\$169.47	\$168.27
2	31648	Echols	GA	Statenville	1,503,001	\$256,495,423	\$170.22	\$170.97
3	31525	Glynn	GA	Brunswick	1,511,098	\$260,849,639	\$173.35	\$169.54
4	31631	Echols	GA	Fargo	1,543,578	\$262,612,006	\$174.22	\$168.89
5	31778	Thomas	GA	Pavo	1,504,400	\$263,082,933	\$174.96	\$170.26
			GA	White Oak	1,540,318	\$270,216,219	\$175.02	\$170.29
			GA	Townsend	1,519,054	\$264,079,498	\$176.04	\$175.27
			GA	Darien	1,540,998	\$267,272,628	\$177.74	\$171.77
			GA	Folkston	1,572,056	\$268,987,024	\$179.31	\$169.36
			GA	Savannah	1,527,829	\$270,658,985	\$179.79	\$183.39



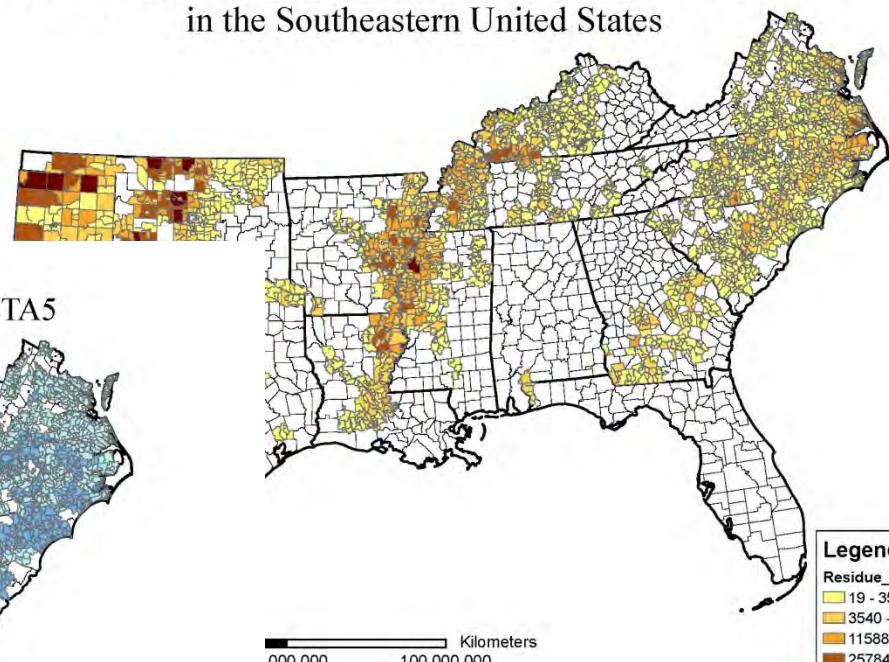
Model Results

Agricultural Residue Example

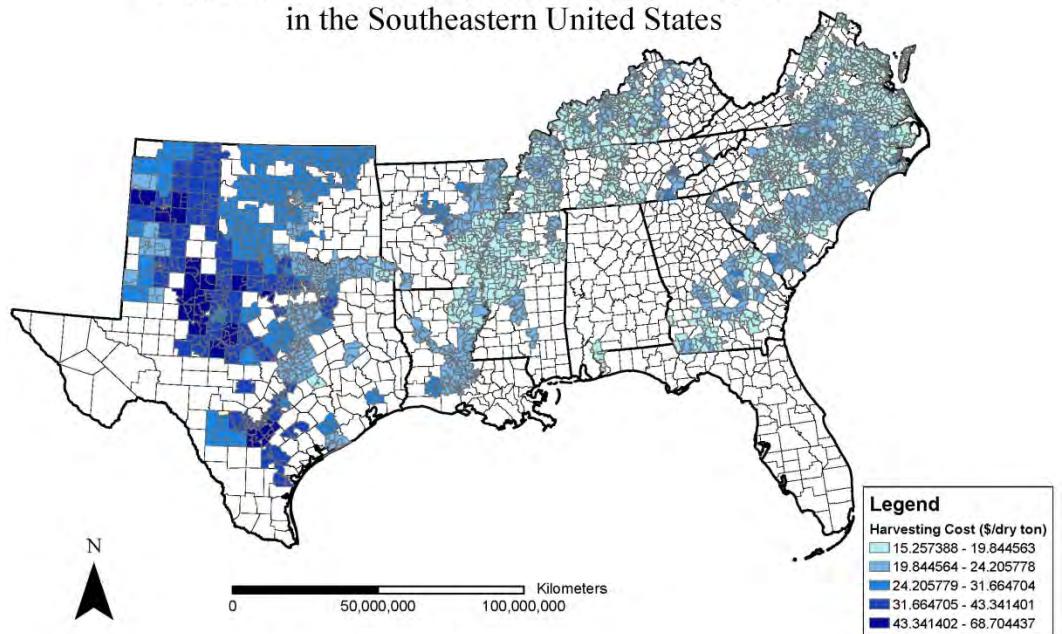
Key Assumptions:

- 60% Recovery
- Yield/County = Tons Harvested/Acreage

Wheat Straw (Wheat All) Residue Quantity By ZCTA5
in the Southeastern United States



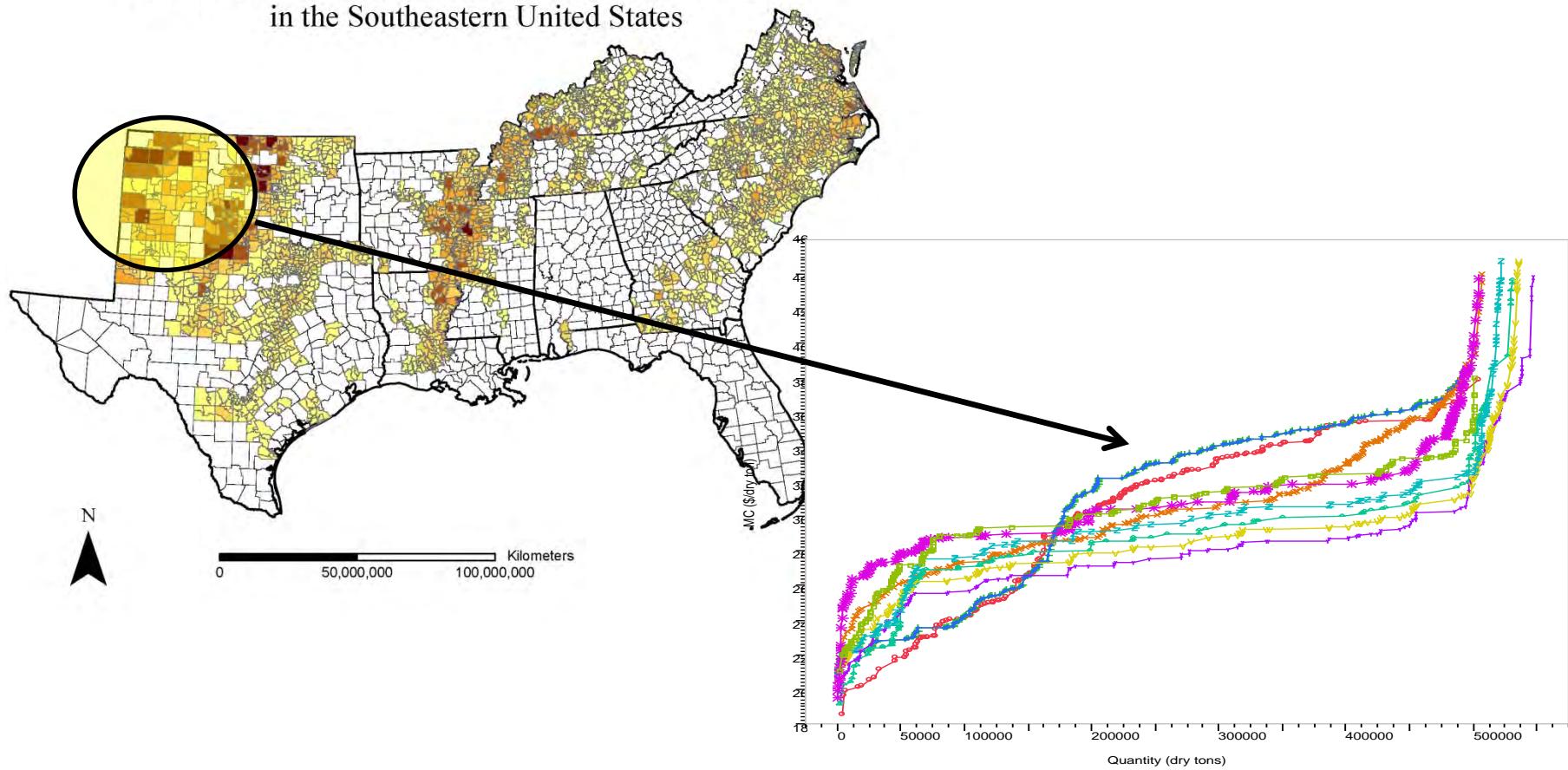
Wheat Straw (Wheat All) Harvesting Cost By ZCTA5
in the Southeastern United States



Model Results

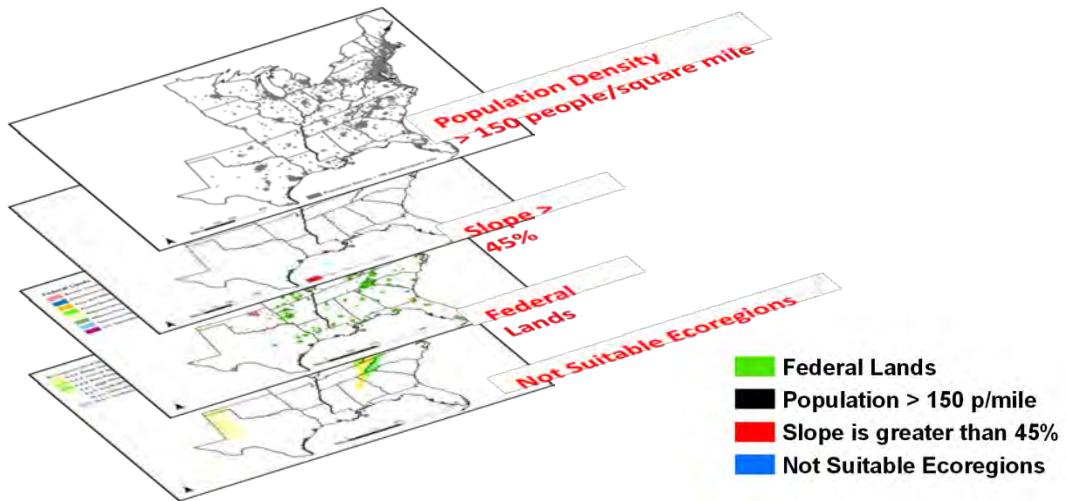
Agricultural Residue Example

Wheat Straw (Wheat All) Residue Quantity By ZCTA5
in the Southeastern United States

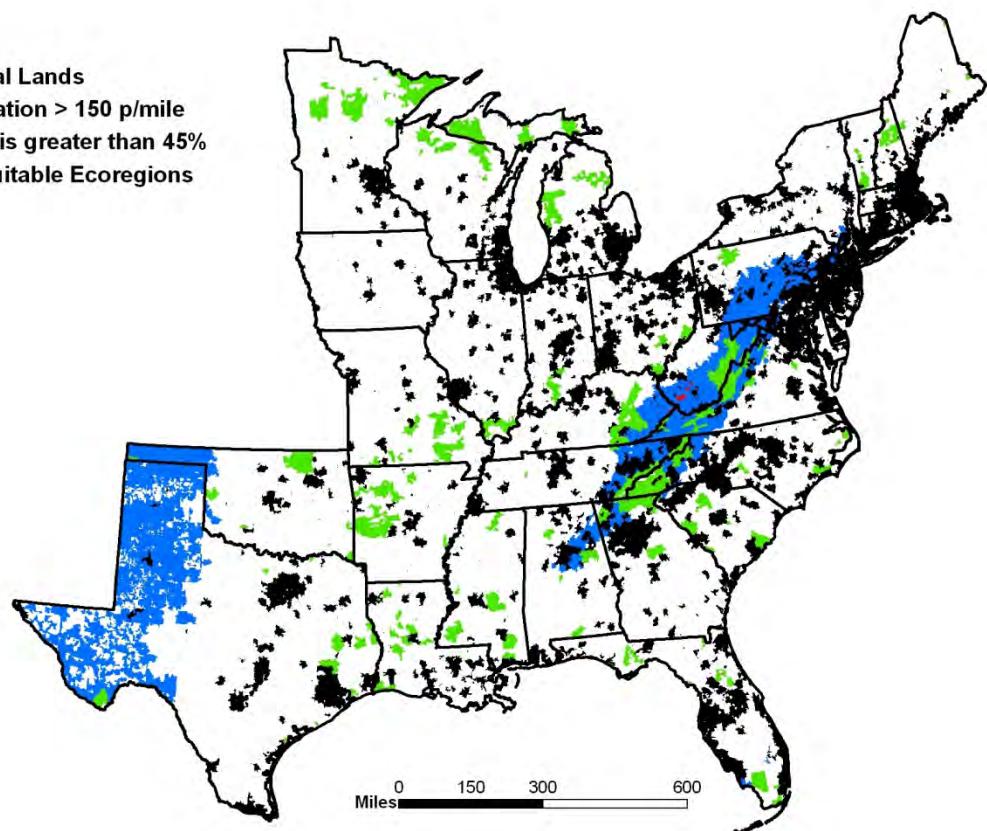


Phase II - GIS Spatial Overlays

“Opportunity Zones”



Total 5-digit ZCTAs excluded: 13,051
($13,051/25,307=51.6\%$)



Exclusion Factors

Factor 1: Federal Land

Factor 2: Population Density

Factor 3: Slope

Factor 4: Ecoregions

Phase II - GIS Spatial Overlays

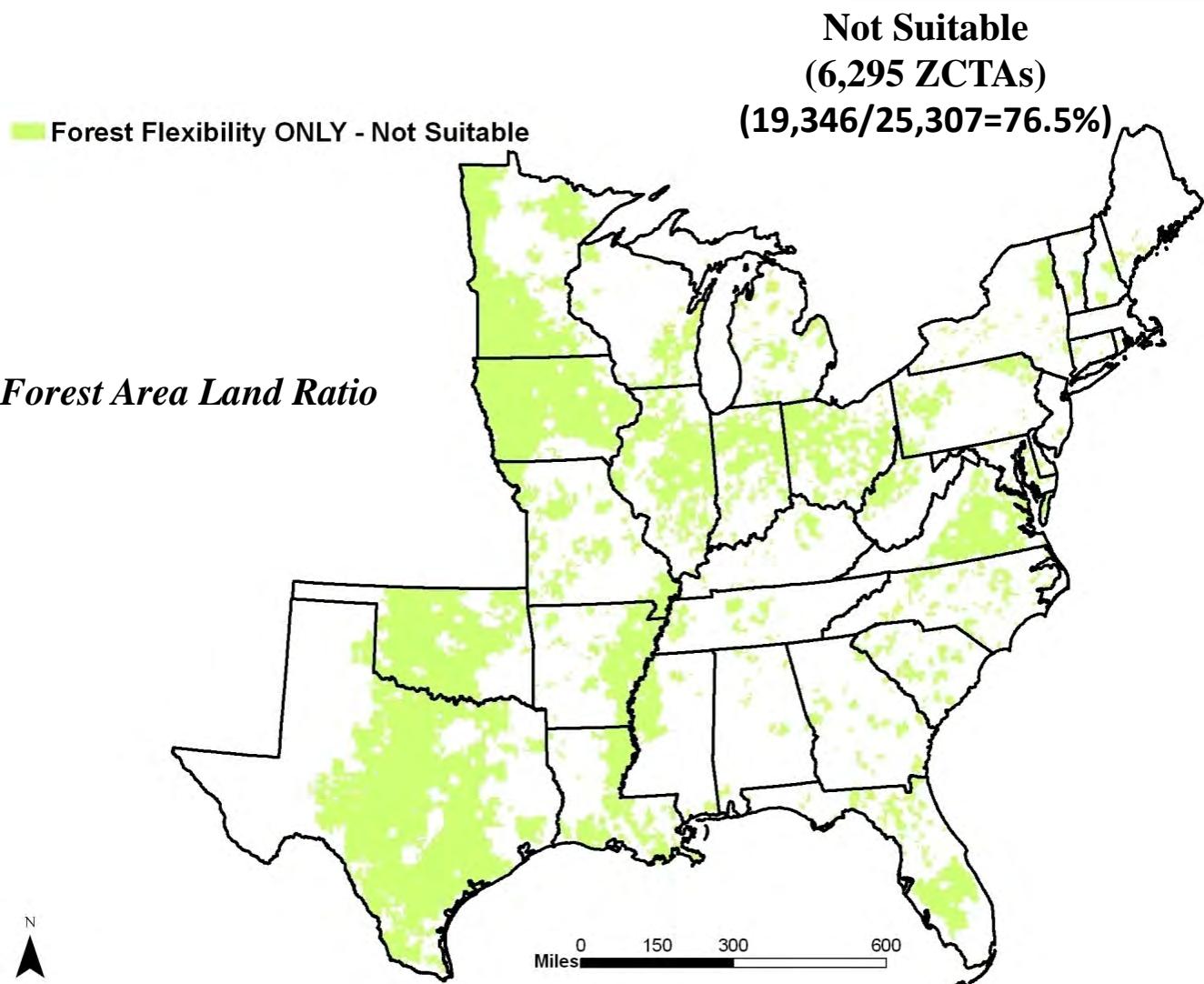
“Opportunity Zones”

Factor 1: Income

Factor 2: G/R Ratio + Forest Area Land Ratio

Factor 3: Ecoregions

Factor 4: Road Density

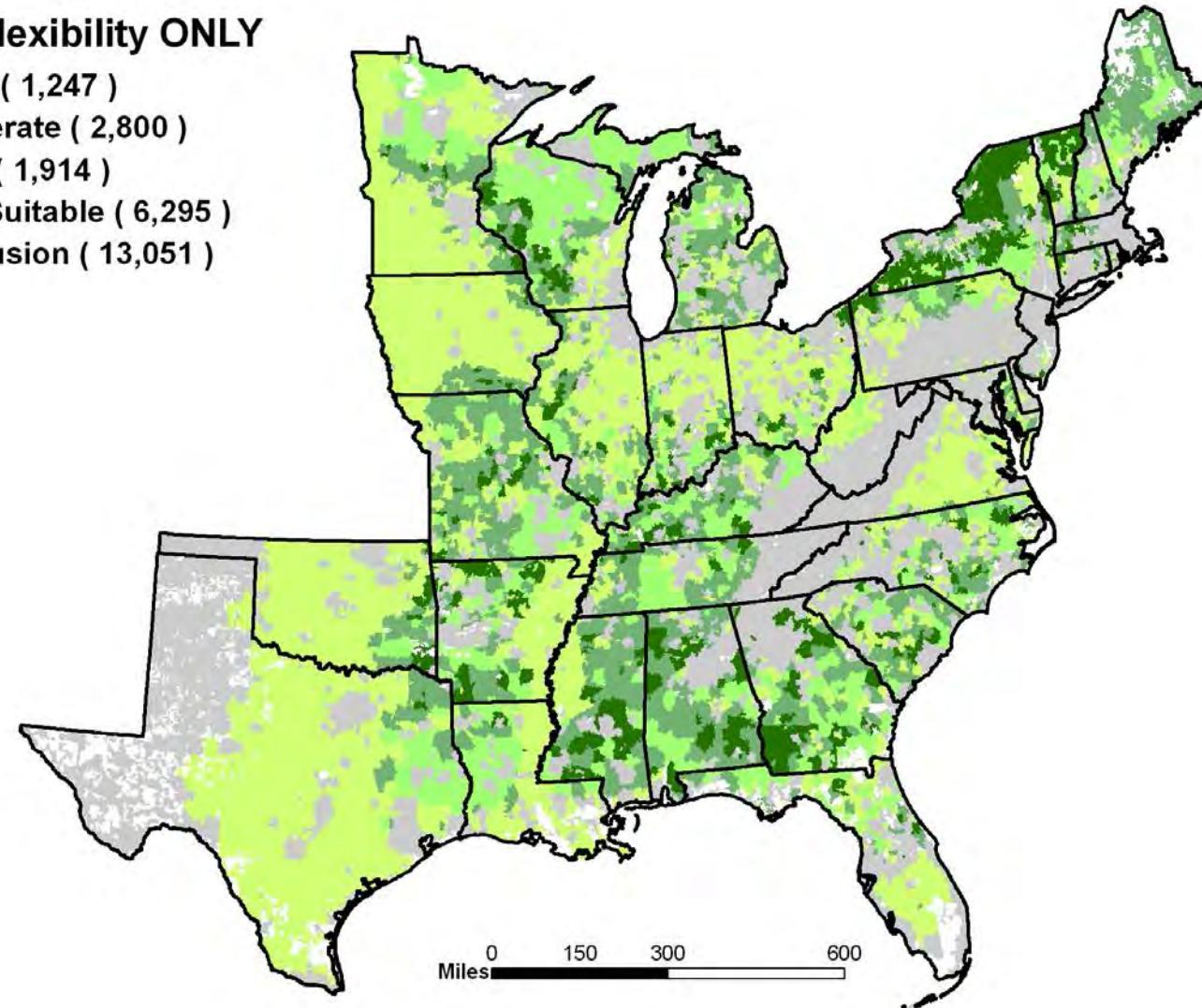


Phase II- GIS Spatial Overlays

“Opportunity Zones”

Forest Flexibility ONLY

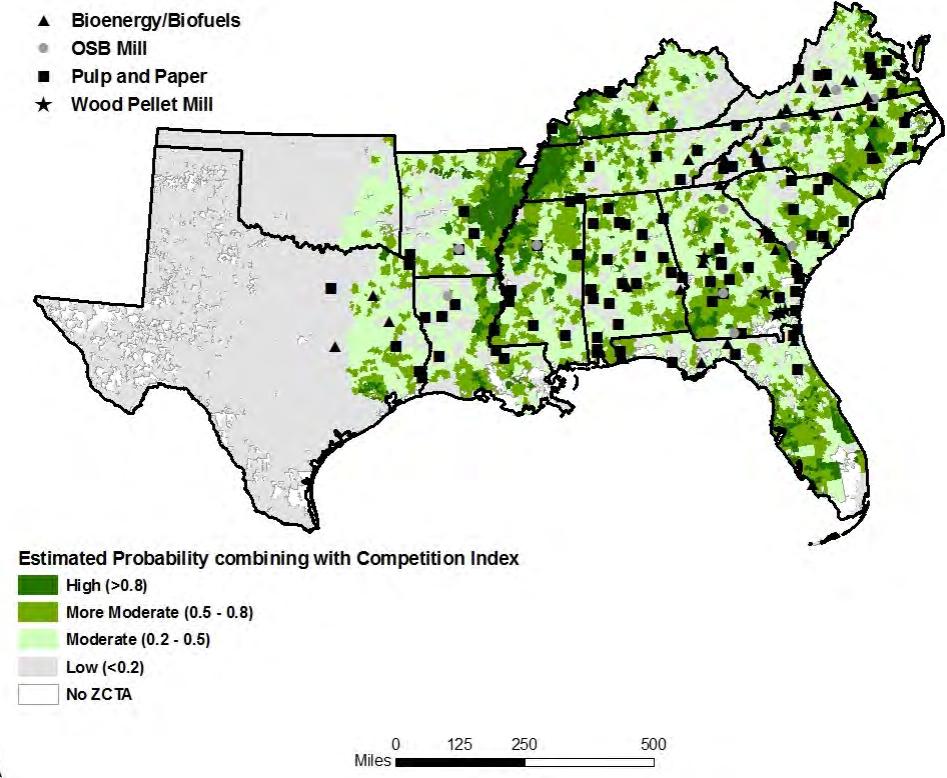
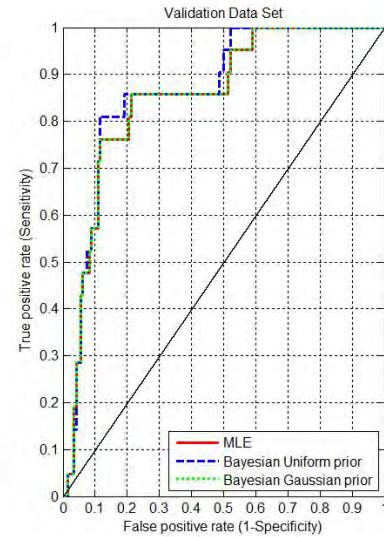
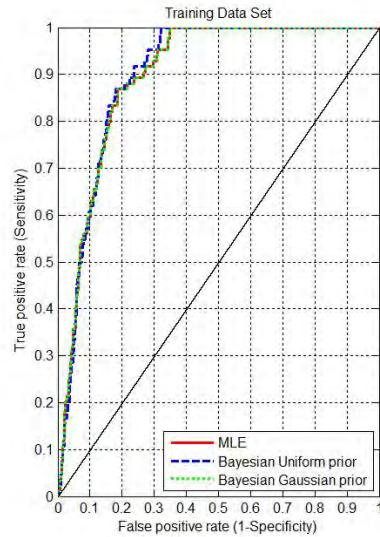
- High (1,247)
- Moderate (2,800)
- Low (1,914)
- Not Suitable (6,295)
- Exclusion (13,051)



Phase II- Influence of Uncertainty

Bayesian Logistic Regression

Parameter Estimation Method		Validation Data Set ($y = \text{Prediction Value} \text{Actual Value}$)					
		$y=0 0$	$y=1 0$	$y=0 1$	$y=1 1$	Specificity	Sensitivity
Maximum Likelihood Estimation (MLE)		117	29	4	17	80.14%	80.95%
Bayesian Inference	Uniform	117	29	2	19	80.14%	90.48%
	Gaussian	117	29	4	17	80.14%	90.48%





BioSAT
Making Innovation Work

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Fact Sheets
Publications
Presentations
General Toolsets
Research Links
Glossary
Result Maps
Our Progress
Collaborators
Advanced Users

The BioSAT Project

[BioSAT "Terms of Use Agreement"](#)

Update Notice: BioSAT is a **research project in progress**. The system has update capabilities combined with additional research targeted to continuously adding innovation and utility. **From time to time you will see updates and new features. For example:** All features of the regional analyses (by state) for merchantable trees are not fully functional; however they will be available in the near future.

BioSAT stands for Biomass Site Assessment Tools.

BioSAT fuses layers of spatial and economic data together to create a relational database for geographic-based economic cost assessment for woody and agricultural residue biomass collection or processing demand centers.

The resolution of the BioSAT model is by five-digit zip-code tabulation area (ZCTA) for the 33

The image shows a screenshot of the BioSAT website. At the top, there is a banner with a speedometer graphic and the text "www.BioSAT.net". Below the banner, the BioSAT logo is displayed with the tagline "Making Innovation Work". A navigation bar contains links for "BioSAT Home", "BioSAT Fundamentals", "Biomass Sources", "Harvesting & Logistics", "BioSAT Guide", "Guided Assessment" (which is highlighted with a blue oval), and "Contact Us". On the left, a sidebar lists links for "Fact Sheets", "Publications", "Presentations", "General Toolsets", "Research Links", "Glossary", "Result Maps", "Our Progress", "Collaborators", and "Advanced Users". The main content area features a section titled "Guided Assessment" with the question "What type of biomass are you interested in?". It includes two options: "Forest" (selected) and "Agricultural". To the right, a yellow box labeled "Your Progress" contains the heading "Biomass Type". Below the "Forest" option is a photo of a forest, and below the "Agricultural" option is a photo of a harvested field.

BioSAT
Making Innovation Work

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Fact Sheets
Publications
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General Toolsets
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Glossary
Result Maps
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Advanced Users

Guided Assessment

What type of biomass are you interested in?

Forest

Agricultural

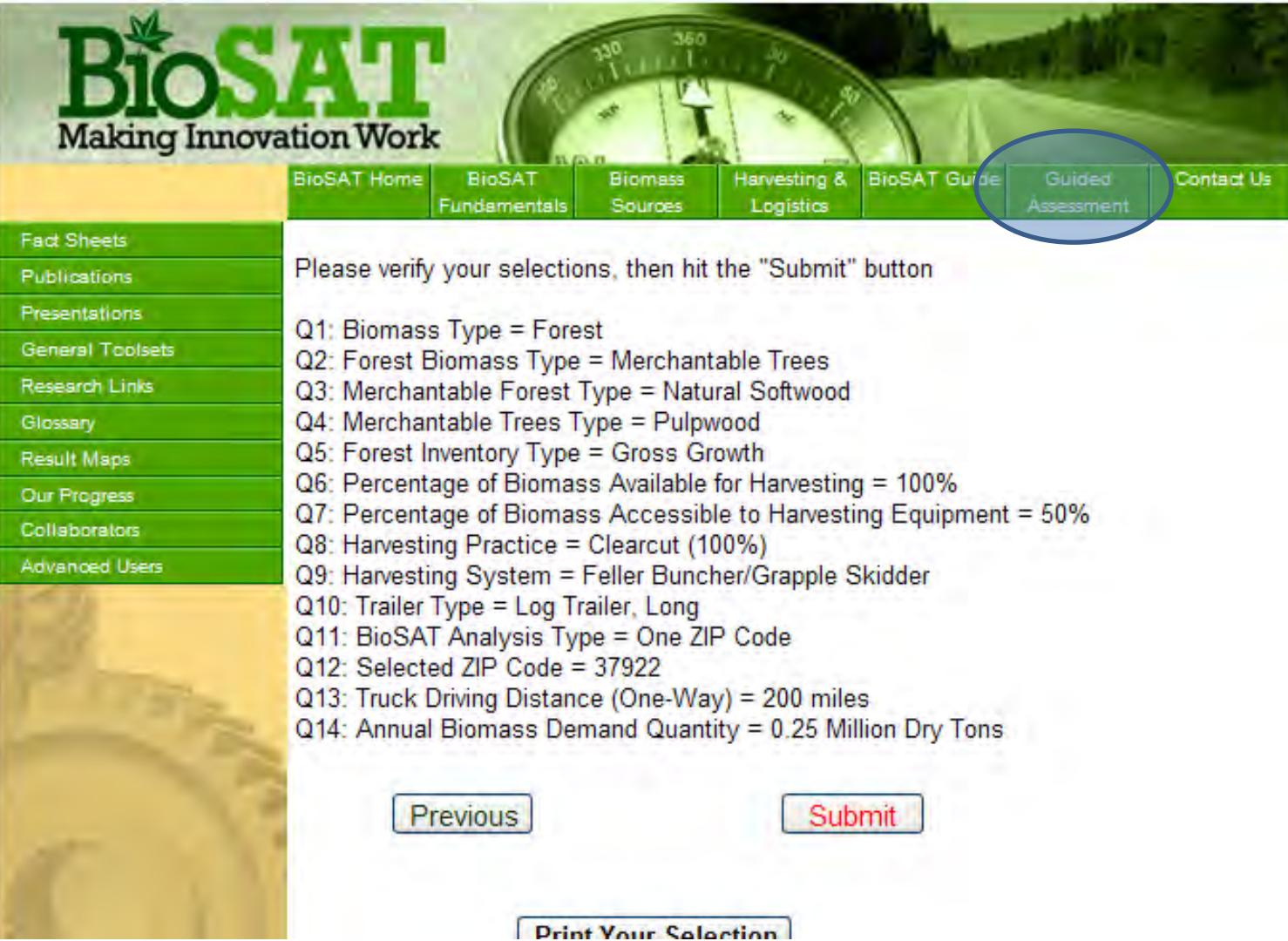
Your Progress

Biomass Type





Making Innovation Work



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Please verify your selections, then hit the "Submit" button

Q1: Biomass Type = Forest
Q2: Forest Biomass Type = Merchantable Trees
Q3: Merchantable Forest Type = Natural Softwood
Q4: Merchantable Trees Type = Pulpwood
Q5: Forest Inventory Type = Gross Growth
Q6: Percentage of Biomass Available for Harvesting = 100%
Q7: Percentage of Biomass Accessible to Harvesting Equipment = 50%
Q8: Harvesting Practice = Clearcut (100%)
Q9: Harvesting System = Feller Buncher/Grapple Skidder
Q10: Trailer Type = Log Trailer, Long
Q11: BioSAT Analysis Type = One ZIP Code
Q12: Selected ZIP Code = 37922
Q13: Truck Driving Distance (One-Way) = 200 miles
Q14: Annual Biomass Demand Quantity = 0.25 Million Dry Tons

[Previous](#) [Submit](#)

[Print Your Selection](#)

Marginal Cost Analysis for one Zip Code Tabulation Area (ZCTA) Merchantable Trees

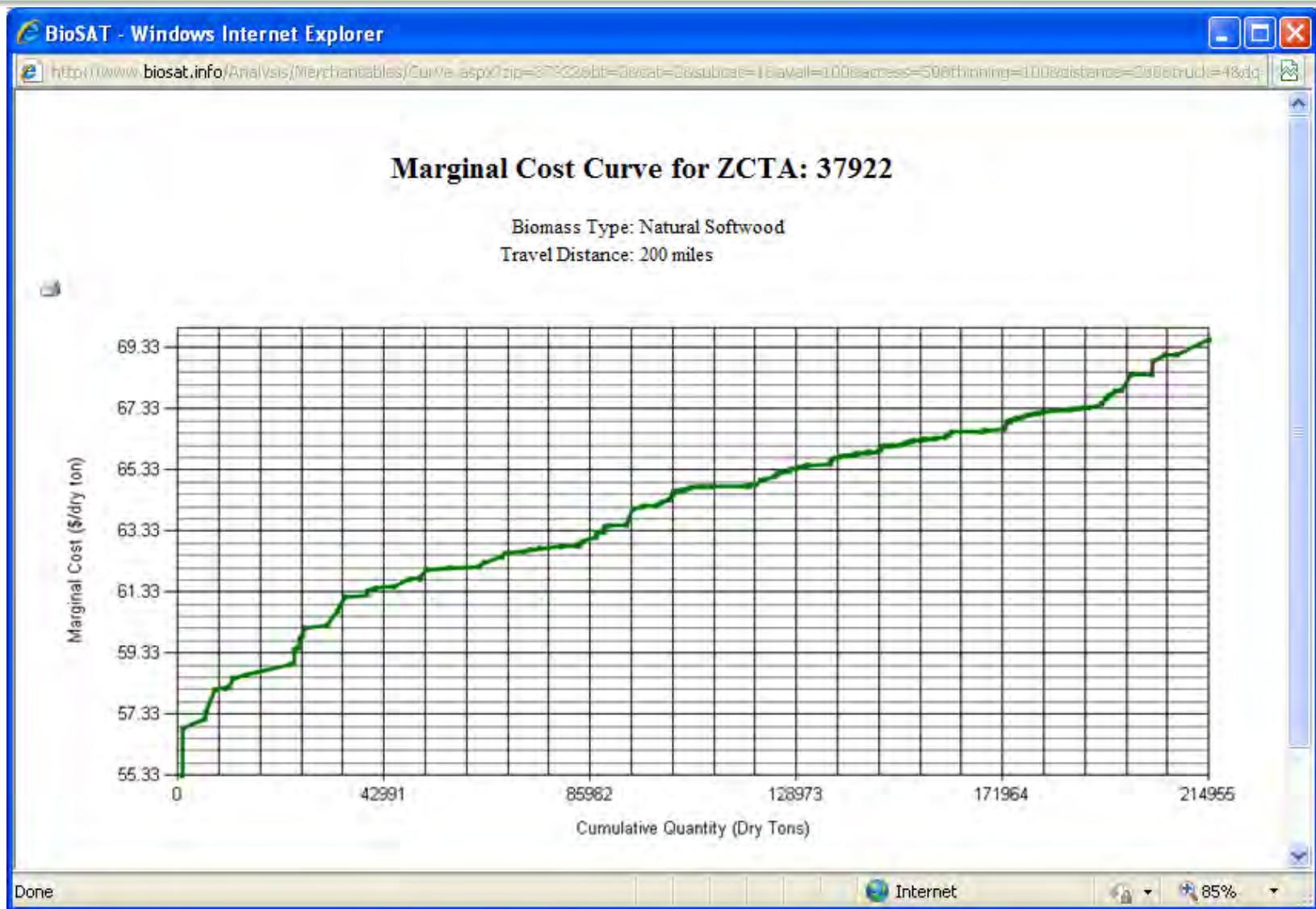
◀ ▶ 1 of 4 Select a format Export

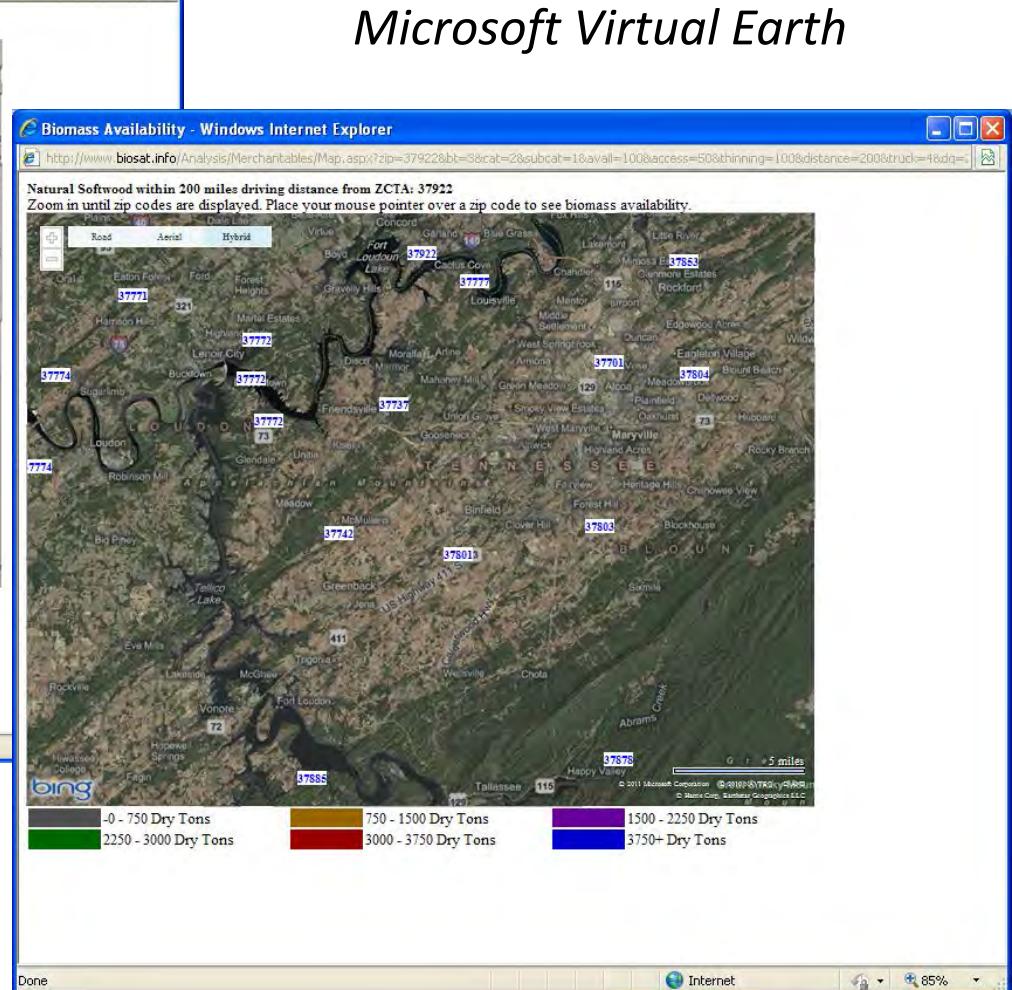
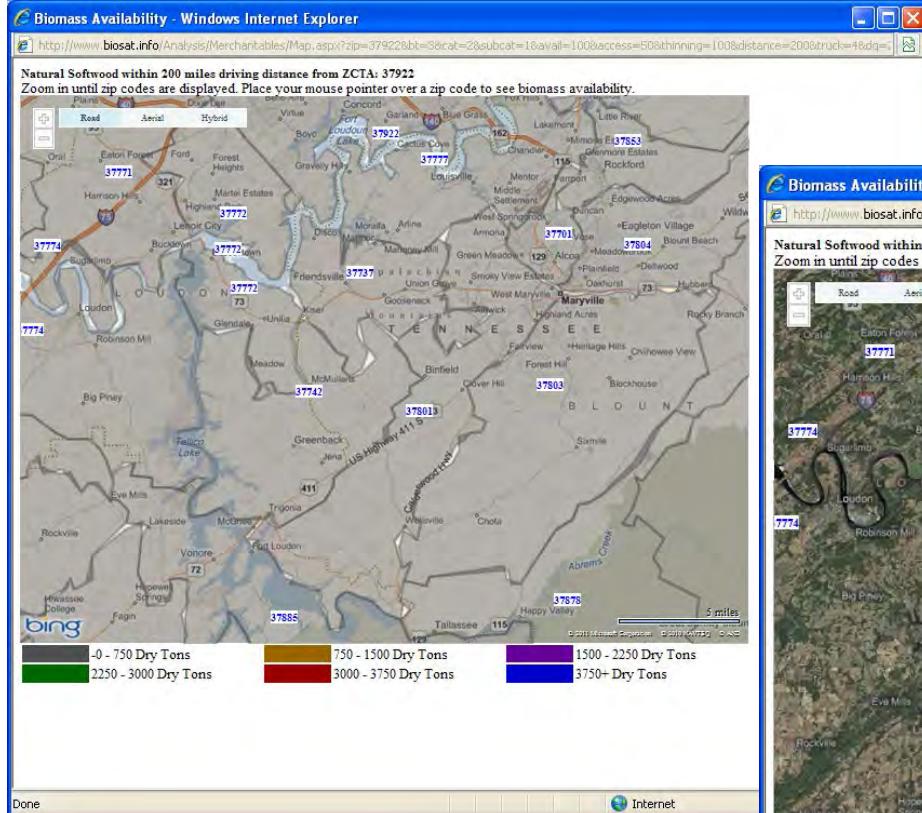
[Bioshed Map](#) [Marginal Cost Curve](#)

Demand Quantity is not met. Showing Infeasible Quantity Table.

* 'Distance' below shows Round Trip Distance.

ZCTA	Quantity (Dry Tons)	Distance (Miles)	Resource Cost (\$/dry ton)	Trucking Cost (\$/dry ton)	Harvesting Cost (\$/dry ton)	Total Cost (\$)	Cumulative Qty (Dry Tons)	Marginal Cost (\$/dry ton)
30711	918.6	191.680	17.16	12.51	25.66	50826.14	918.6	55.33
30755	164.5	224.760	17.16	14.04	25.66	9353.47	1083.0	56.86
30705	4580.8	224.880	17.16	14.36	25.66	261930.14	5663.8	57.18
30739	272.9	231.780	17.16	14.59	25.66	15667.19	5936.7	57.41
30707	1893.2	241.580	17.16	15.31	25.66	110051.72	7829.9	58.13
30721	2111.4	246.500	17.16	15.36	25.66	122841.25	9941.3	58.18
30740	699.0	243.680	17.16	15.39	25.66	40688.79	10640.2	58.21
30720	855.0	253.080	17.16	15.69	25.66	50026.05	11495.2	58.51
30728	2580.8	251.760	17.16	15.79	25.66	151260.69	14076.0	58.61
30738	9460.3	260.080	17.16	16.14	25.66	557779.29	23536.2	58.96
30734	657.7	255.380	17.16	16.16	25.66	38791.15	24193.9	58.98
30746	50.6	268.420	17.16	16.62	25.66	3007.66	24244.5	59.44
30753	884.5	260.000	17.16	16.88	25.66	52440.25	25125.0	59.50





BioSAT
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Fact Sheets
Publications
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Result Maps (highlighted with a blue oval)
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Logging Residues At Landing Marginal Cost Alabama

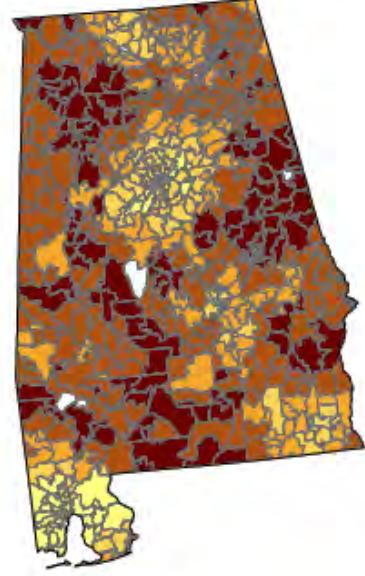
HWAL = HardWood At Landing HWIW = HardWood In Woods
SWAL = SoftWood At Landing SWIW = SoftWood In Woods

	HWAL	HWIW
Alabama	Show	Show
Arkansas	Show	Show
Connecticut	Show	Show
Delaware	Show	Show
Florida	Show	Show

Marginal Cost (\$/dry ton)

24.54 - 26.54
26.54 - 27.54
27.54 - 28.58
28.58 - 29.20
29.20 - 30.79

0 15 30 60 90 120 Miles



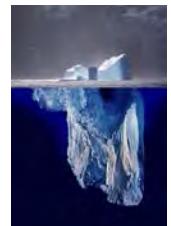
Summary

- *BioSAT model provides decision tool for siting woody and ag-residue biomass using facilities*
- *Completed Peer Review (always on-going)*
- www.BioSAT.net version 1.0 available
- www.BioSAT.net version 2.0 in development



On-going and Future Research

- Competition Indices✓
- “Opportunity Zones”✓
- Bayesian Logistic Regression Models for Probabilistic-based Site Selection✓
- Dedicated Energy Crops - SRWC Siting

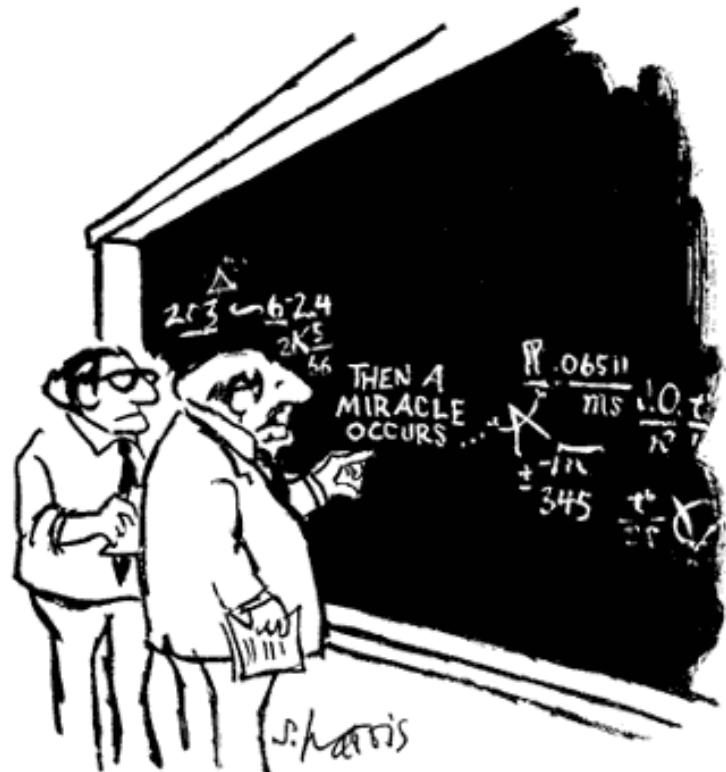


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Thank You!



"I think you should be more explicit here in step two."

"All Models are Wrong, Some are Useful"

George Box (U of Wisconsin)