

# A Web-based BIOmass Site Assessment Tool



version 1.0

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Forest Products Center



U.S. Forest Service

Southern Research Station



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# Motivation

Bioenergy and biofuels are emerging industries that require an economic-based decision-making framework and easily accessible tools to assist in plant site location



# Problem Definition



Develop a web-based economic decision-making model for cellulose resources that exists in the public domain with quasi real-time data update capabilities

Phase I:      woody and ag cellulose, geo-referenced aggregate supply curves, develop web-site - [www.BioSAT.net](http://www.BioSAT.net)

Phase II:      stochastic-based site selection, market constraints (price elasticities, policy influence, some sustainability criteria)

Phase III:      integration with larger KDF

# Phase I Objectives

1. Develop SQL database of resource data
  - Forest – USFS FIA
  - Mill Residues – USFS FIA
  - Logging Residues – SRTS
  - Urban Waste – BT<sup>2</sup>
  - Ag Residues - NASS
2. Develop wood resource costs
  - Timber Mart South
  - State reports
3. Develop truck transportation models
4. Develop harvesting cost models
  - FRCS for logging residues (Dennis Dykstra)
  - AHA for merchantable wood (Bob Rummer/Dale Greene)

# Phase I Objectives

5. Develop web-based system in the public domain ([www.BioSAT.net](http://www.BioSAT.net))
6. Develop a web-based system with quasi real-time data update capabilities, e.g.,
  - Diesel prices (US DOE EIA)
  - Resource costs (TMS, State Reports)
  - Road network (MapPoint 2006)
  - Resource data (USFS FIA, SRTS, BT<sup>2</sup>)
  - etc.

Scope: 33 Eastern United States

Resolution: 24,975 Zip Code Tabulation Areas (ZCTA)



# Database Development

## Fusion of Phase I data layers

Forest Cover Data

Economic Data

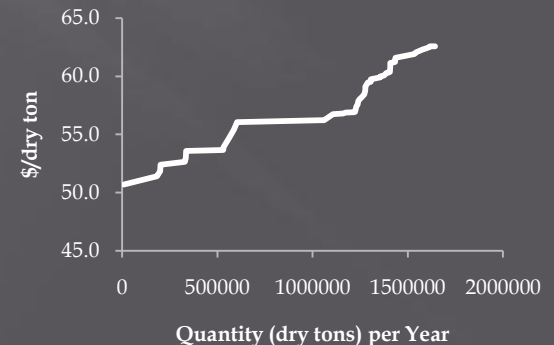
Polygon Boundaries

Siting Solution

Phase I Supply Curves

SQL Relational Database

County	Date/Time	Quantity	Type	Ownership	Storage	Logging	Transport
A		1000	I	I	S	S	S
B		1000	II	II	S	S	S
C		1000	III	III	S	S	S
D		1000	IV	IV	S	S	S
E		1000	V	V	S	S	S
F		1000	VI	VI	S	S	S
G		1000	VII	VII	S	S	S
H		1000	III	VIII	S	S	S
I		1000	II	IX	S	S	S
J		1000	III	X	S	S	S
K		1000	IV	XI	S	S	S
L		1000	V	XII	S	S	S
M		1000	VI	XIII	S	S	S
N		1000	VII	XIV	S	S	S
O		1000	I	XV	S	S	S
P		1000	II	XVI	S	S	S
Q		1000	III	XVII	S	S	S
R		1000	IV	I	S	S	S
S		1000	V	II	S	S	S
T		1000	VI	III	S	S	S
U		1000	VII	IV	S	S	S
V		1000	VIII	V	S	S	S
W		1000	IX	VI	S	S	S
X		1000	X	VII	S	S	S
Y		1000	XI	VIII	S	S	S
Z		1000	XII	IX	S	S	S



# METHODS

## Biomass Quantity



### Physical Biomass:

- Logging Residues (hardwood, softwood)  
(at landing, in-woods)
- Mill Residues (clean, unclean)
- Urban Waste
- Thinnings
- Merchantable (pulpwood and sawtimber)

Initially, for any demand ZCTA the “physical biomass” available is the sum of “physical biomass” in **nearest neighbor** ZCTAs for up to a 40, 80, 120, or 160 mile one-way haul distances

# METHODS

## Nearest Neighbor ZCTAs

For any demand ZCTA, nearest neighbor supply ZCTAs are computed from the change in longitudes and latitudes:

$$D = \sqrt{(M \times \Delta\tau)^2 + (N \times \cos \tau \times \Delta\lambda)^2}$$

where  $\tau$  - mean latitude

$\Delta\tau$  - difference in latitude

$\Delta\lambda$  - difference in longitude (in radians)

$M$  - Earth's radius of curvature in the (north-south) meridian at  $\tau$

$N$  - radius of curvature in the prime normal to  $M$  at  $\tau$

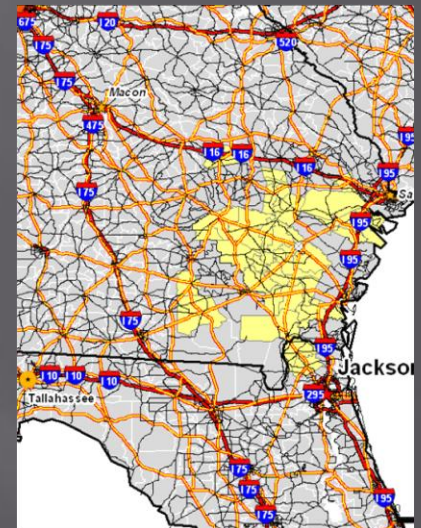


# METHODS

## Final Selection of Neighboring ZCTAs (“Bioshed”)

For each potential neighboring supply ZCTA, the driving time and distance are calculated from Microsoft MapPoint 2006

- Geographic Data Technology, Inc. (GDT) data are used for rural areas and small to medium size cities
- Navteq data are used for major metropolitan areas.



Next, ZCTAs beyond **5-hour** one-way haul are eliminated (assume day-cab trucks with legal driving maximum of **11 hours**)

# METHODS

## Resource Costs

South (Timber Mart South [www.tmart-south.com](http://www.tmart-south.com))

- Mill Residues
  - Clean/Unclean
- Pulpwood
  - Softwood/Hardwood
- Sawtimber
  - Softwood/Hardwood
- Biomass



North (State Reporting Services)

- Connecticut (pulpwood, sawtimber, biomass)  
<http://forest.fnr.umass.edu/snespsr/reports/all%20reports.htm>
- Maine (pulpwood, sawtimber, biomass)  
<http://www.state.me.us/doc/mfs/pubs/annpubs.htm#stump>
- etc.

# METHODS

## Trucking Cost Model

Enhancement of Berwack et al. 2003

(dry van, live bottom van, longwood log trailer, shortwood log trailer)

$$\text{Total Cost (a, d, t)} = \text{Variable Cost (d, t)} + \text{Fixed Cost (a, d, t)}$$

where,

a = annual miles

d = travel distance (miles)

t = travel time (hours)



Validation assuming a contract fleet: three trucking companies and one forest products company (4 mills):  $\pm 2\%$

# METHODS

## Trucking Cost Model

Fixed Cost =  $\Sigma$  (Equipment Cost, State Tax, State License Fee, Overhead Cost, Insurance Premium)/a x d

Variable Cost = Fuel Cost (c, d, g, j, k) + Labor Cost (i, w) + Tire Cost (c, m, n, r) + Maintenance and Repair Cost (b, c, v)

where, b = repair cost per mile

g = diesel price per gallon

j = loaded truck miles/gallon

m = miles/tire

r = tire cost

w = wage rate

c = time loaded (%)

i = labor time (hours)

k = empty truck miles/gallon

n = number of tires

v = gross vehicle weight

User can use model default values or enter their own inputs



# METHODS

## Harvesting Cost Models

Fuel Reduction Cost Simulator  
(FRCS) – BT<sup>2</sup>  
Dennis Dykstra



- Logging Residue Costs  
(at-landing, in-woods)

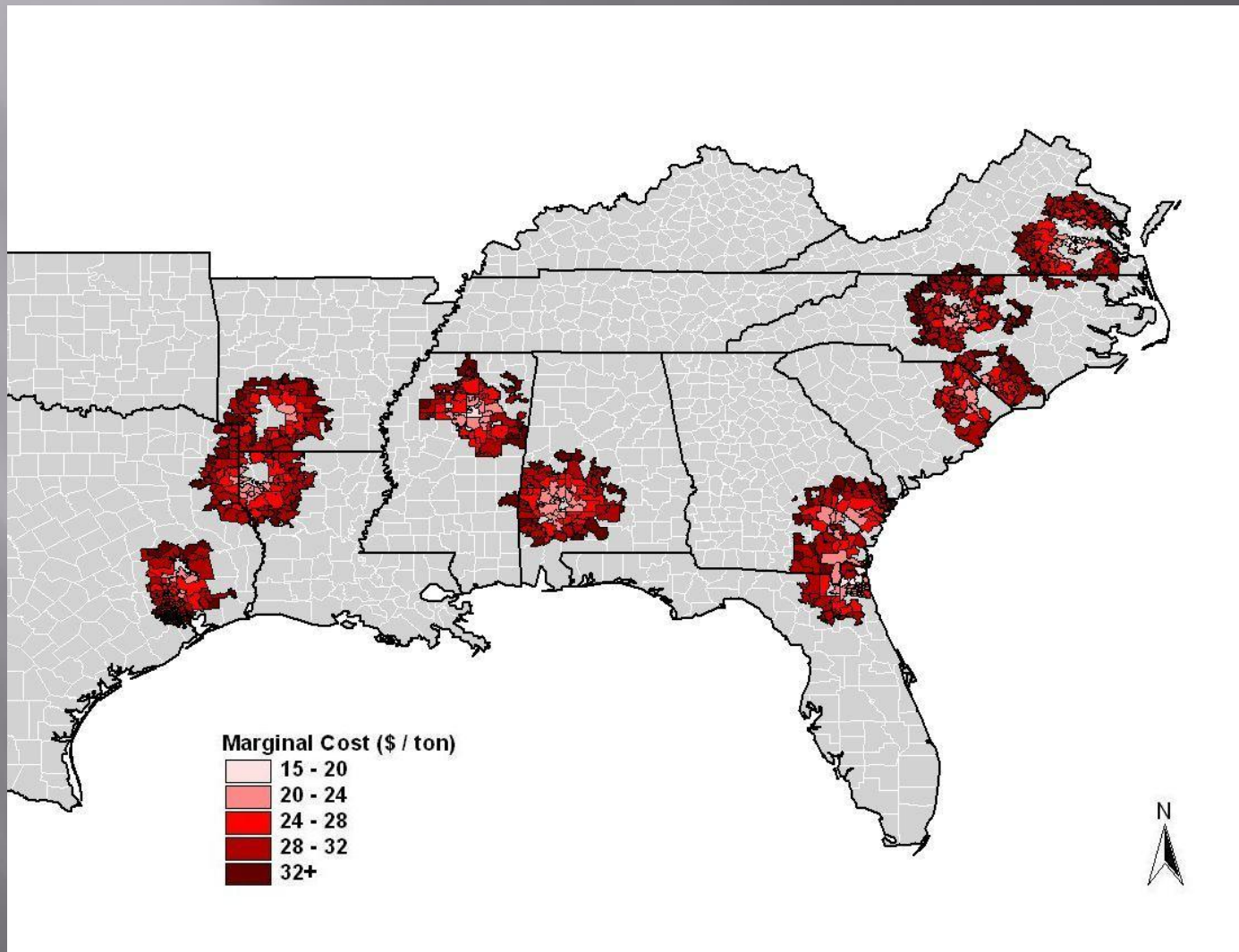
Auburn Harvest Analyzer (AHA)  
Bob Rummer and Dale Greene

- Pulpwood Costs
- Sawtimber Costs
- Thinning Costs



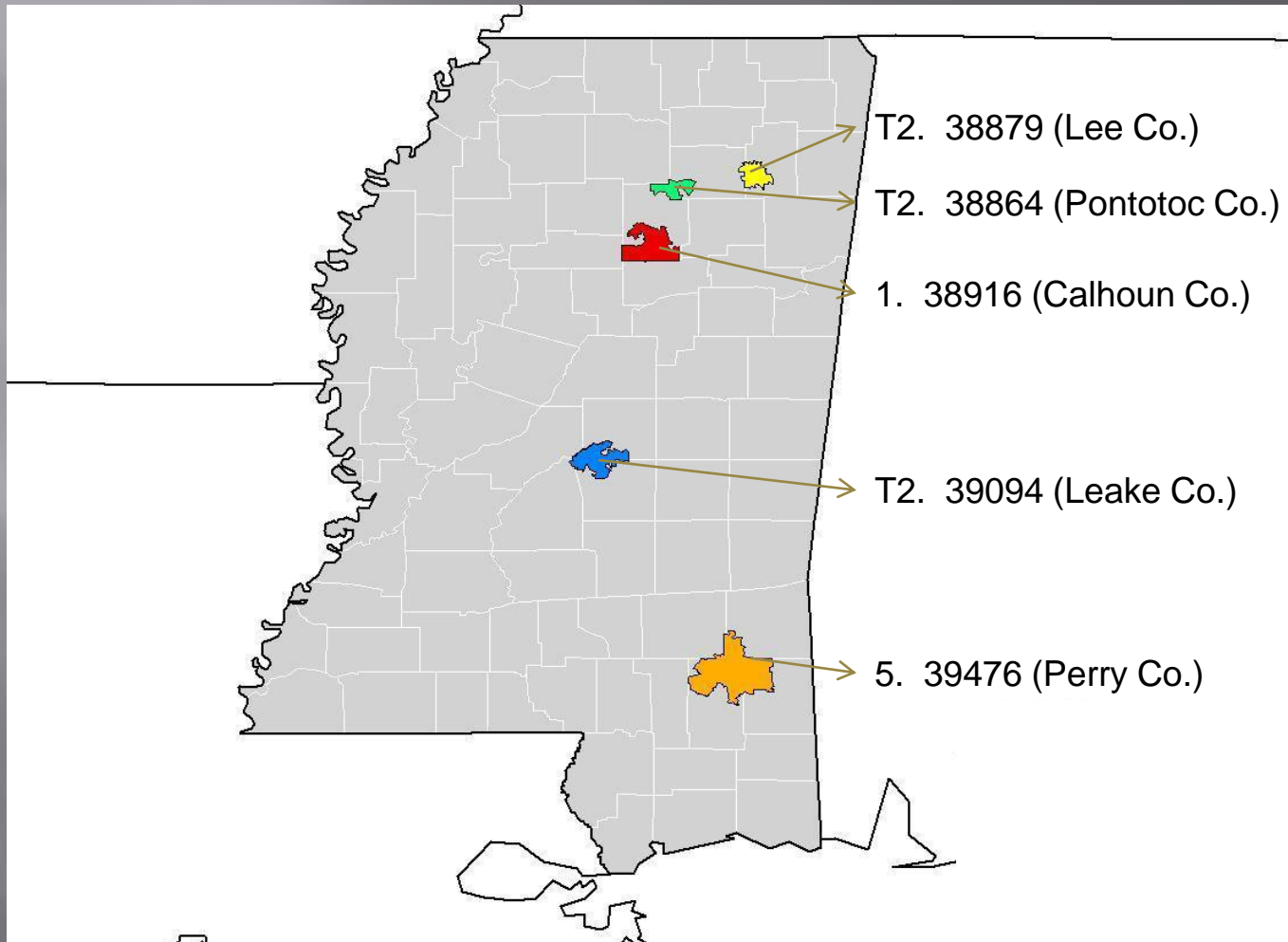
# RESULTS

LOW COST BIOSHEDS FOR 11 SOUTHERN STATE  
(MILL RESIDUES  $\leq 1.5$  M DRY TONS / YEAR)



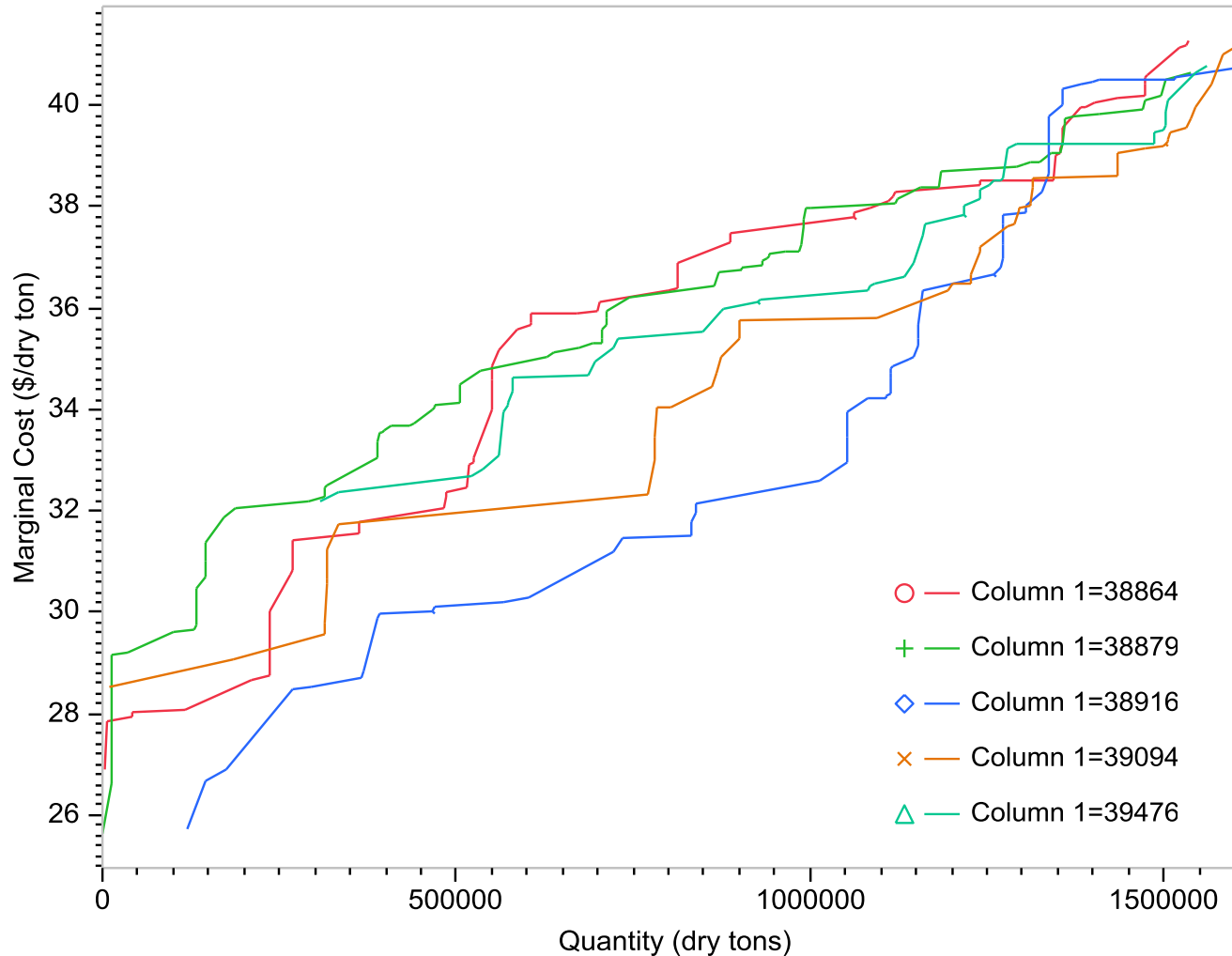
# RESULTS

MS – Top Five Demand ZCTAs for Mill Residues  
( $\leq 1.5$  M Dry Tons per Year)



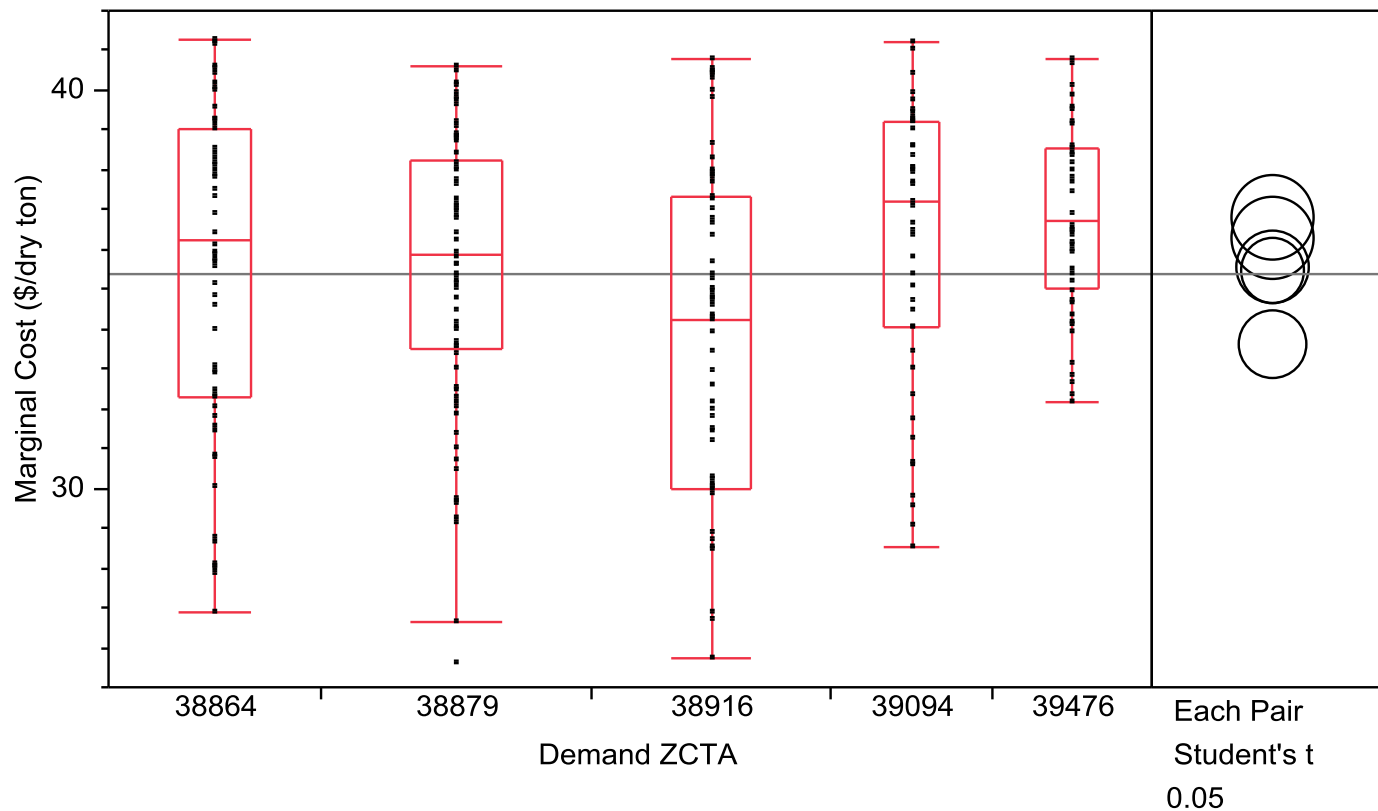
# RESULTS

## MS – Top Five Demand ZCTAs MC Curves ( $\leq 1.5$ M Dry Tons per Year)



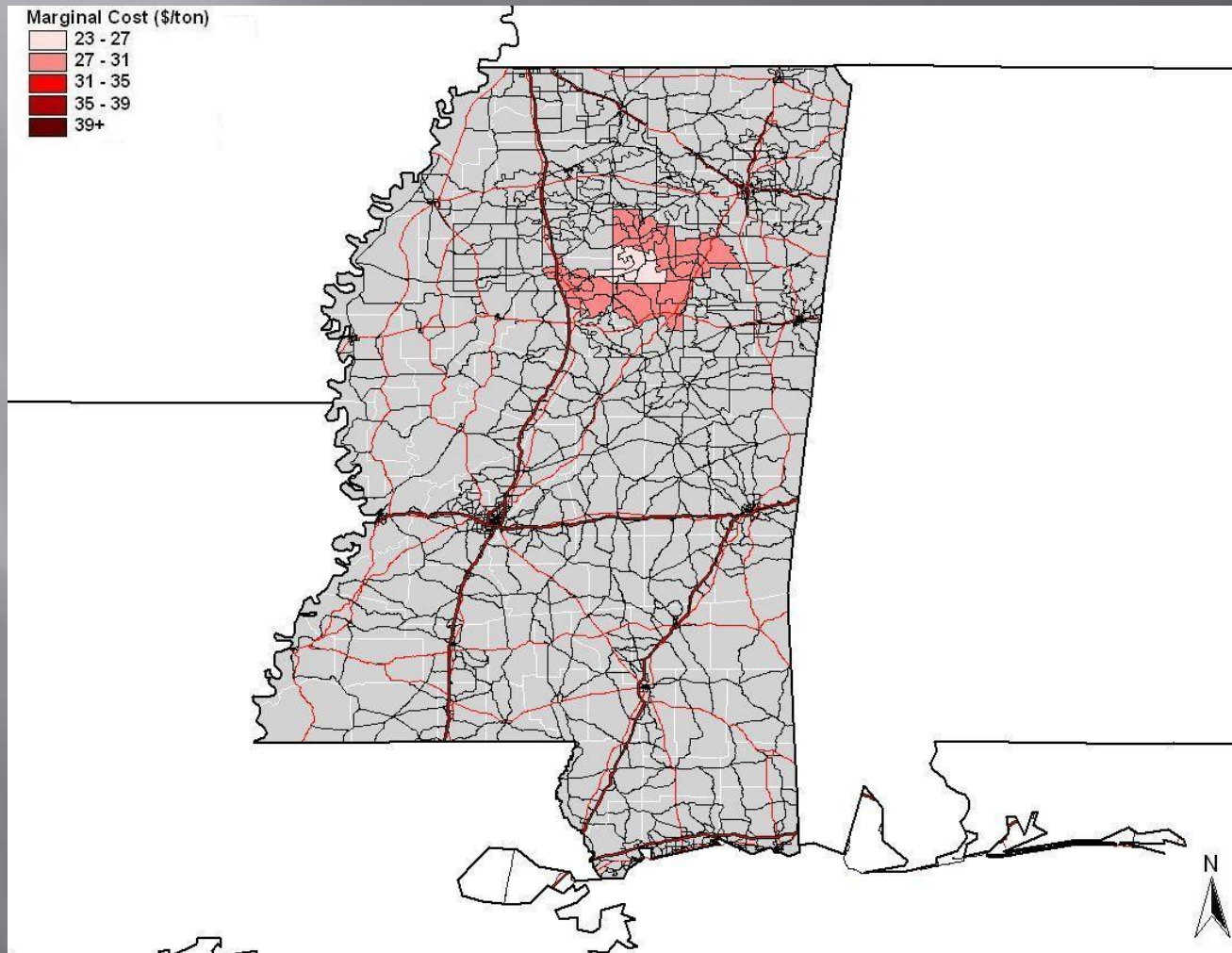
# RESULTS

## MS – Top Five Demand ZCTAs MC Curves ( $\leq 1.5$ M Dry Tons per Year)



# RESULTS

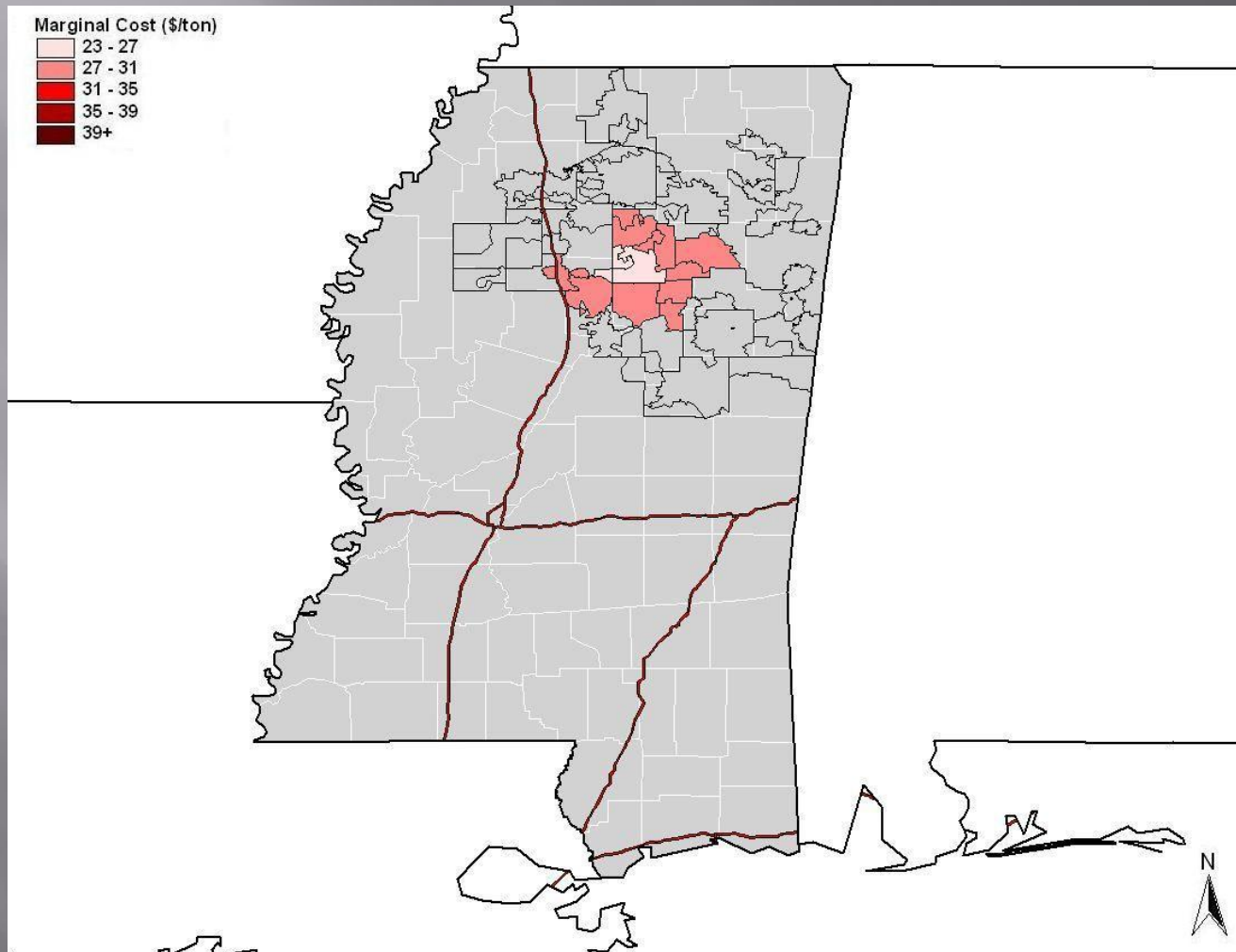
## DEMAND ZCTA 38916 (CALHOUN CO.)





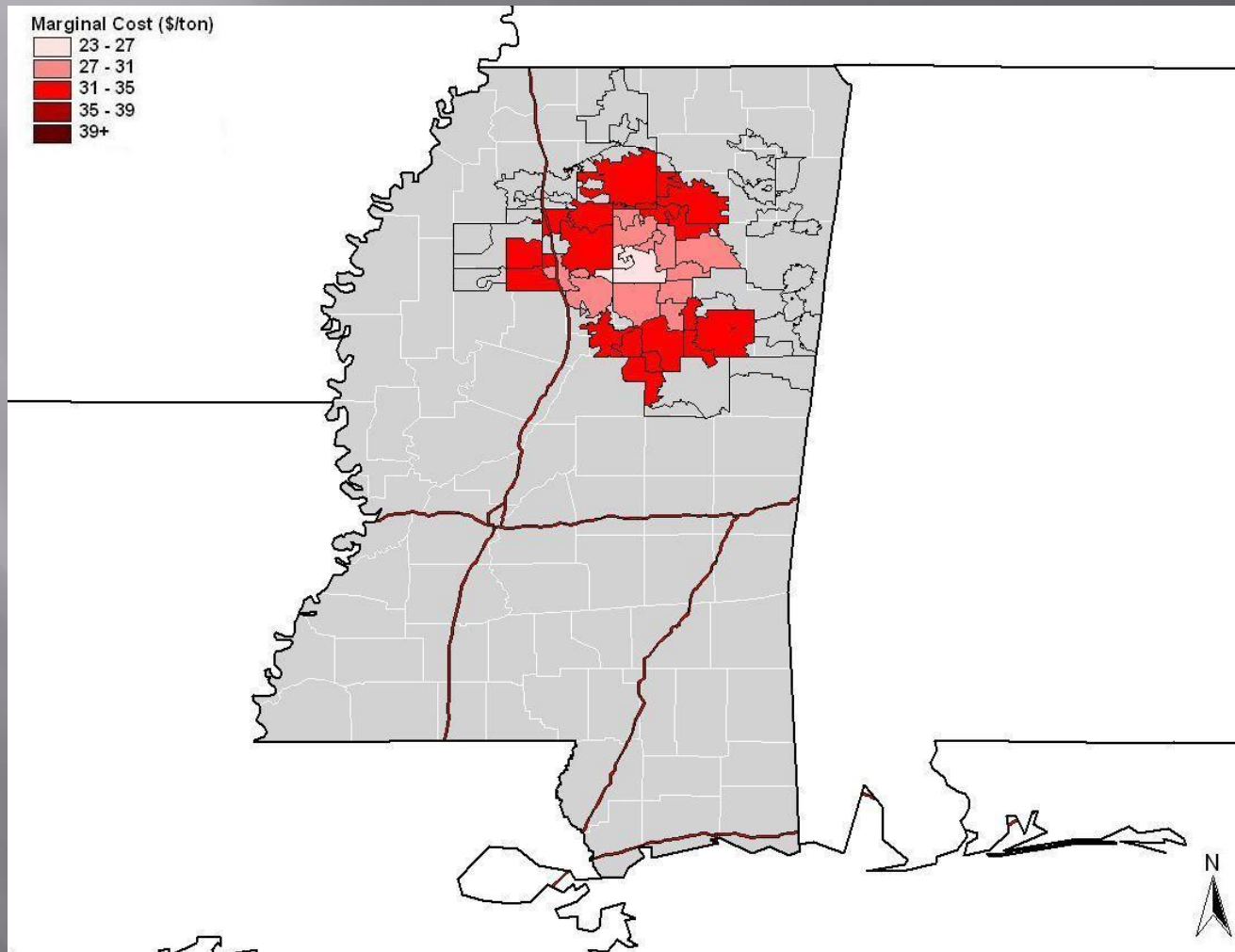
# RESULTS

DEMAND ZCTA 38916 (CALHOUN CO.)



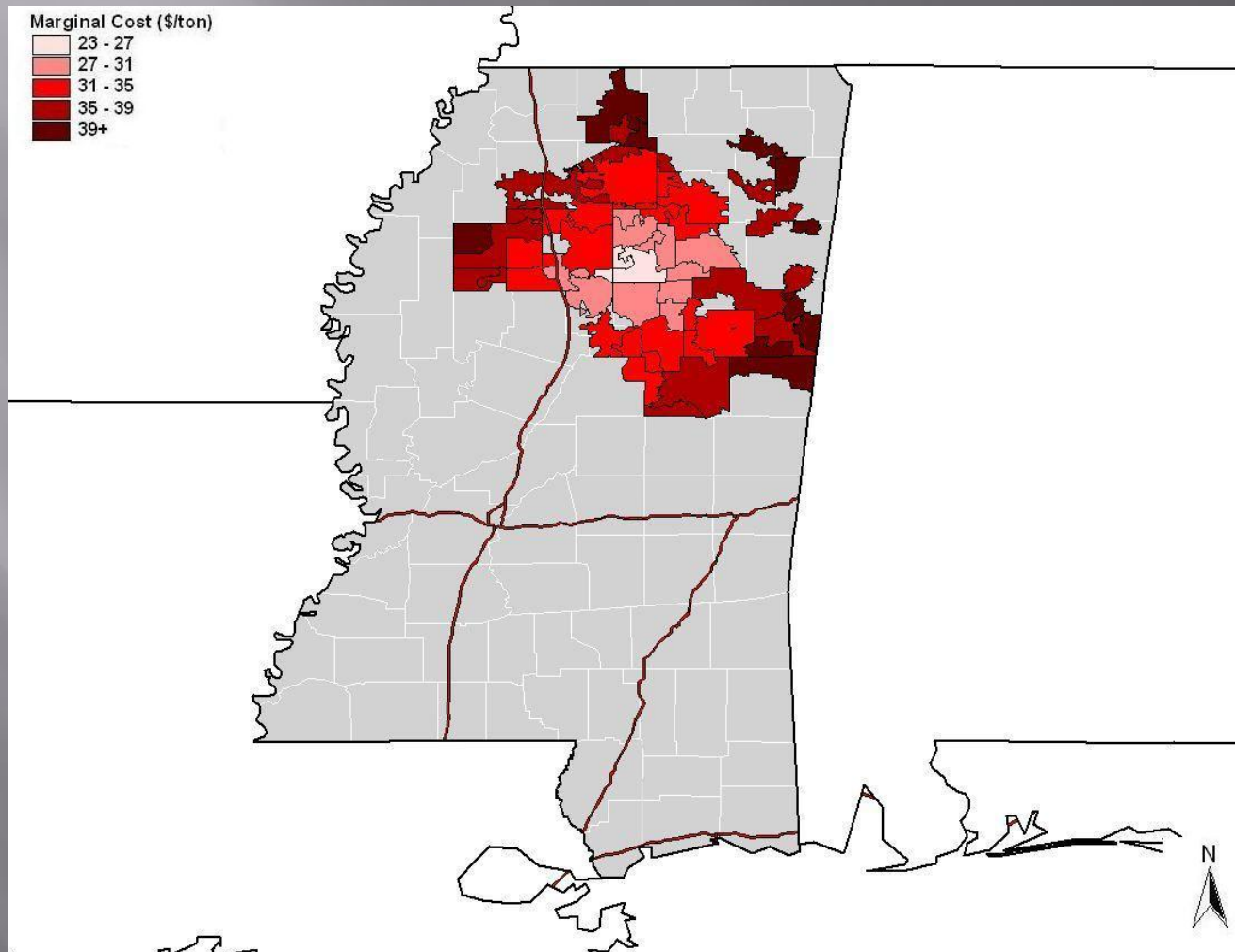
# RESULTS

DEMAND ZCTA 38916 (CALHOUN CO.)



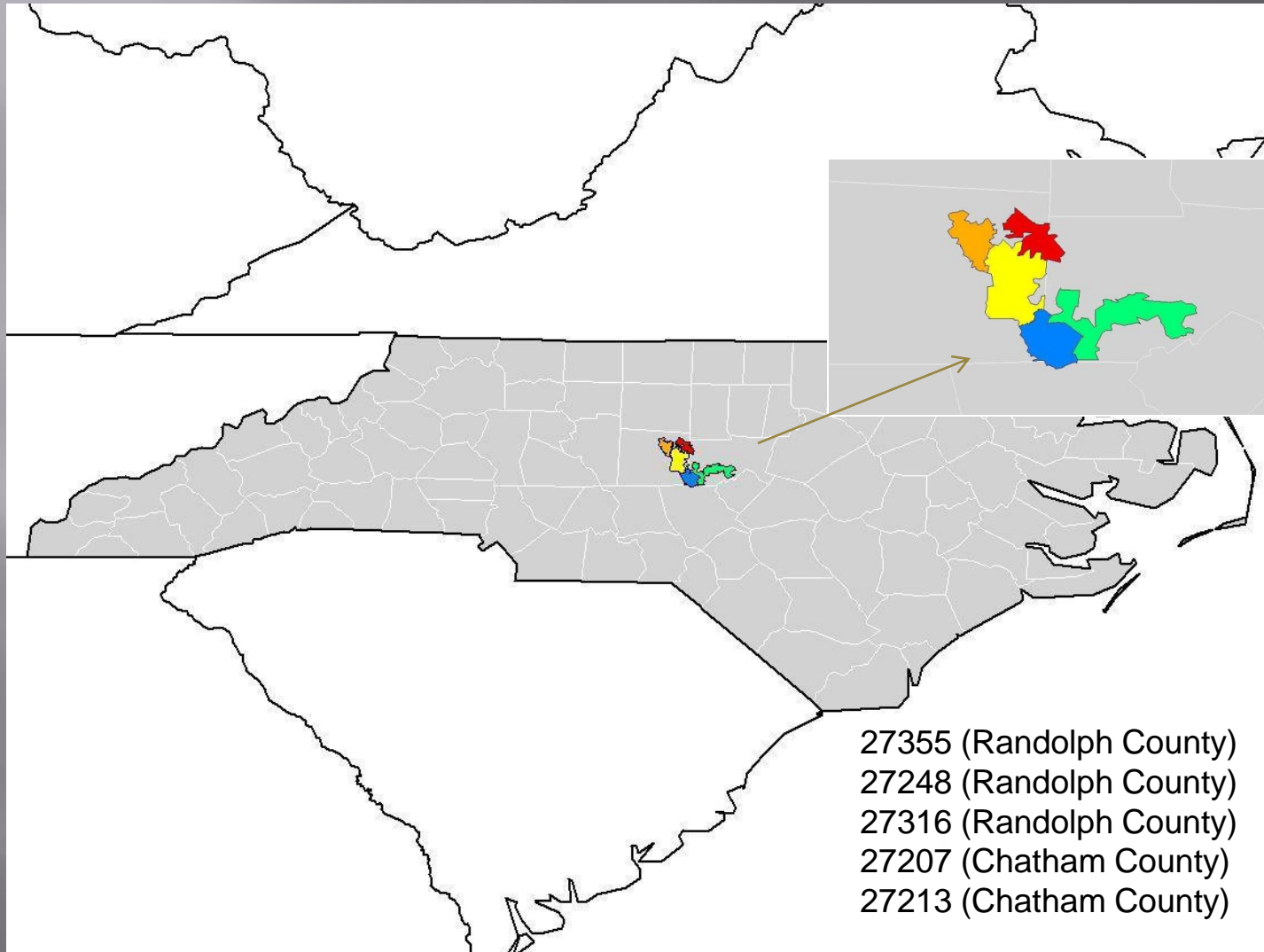
# RESULTS

DEMAND ZCTA 38916 (CALHOUN CO.)



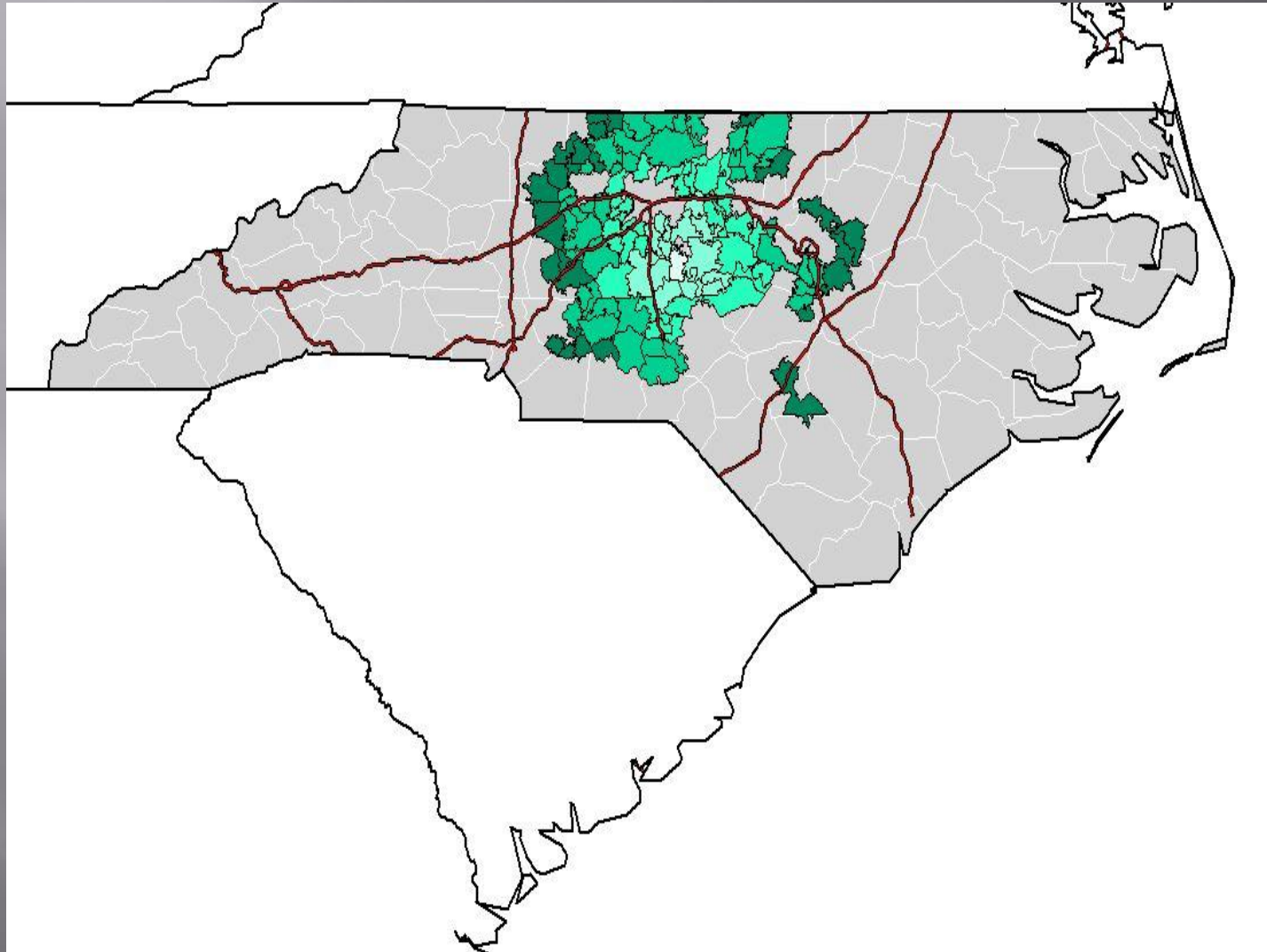
# RESULTS

NC - TOP FIVE DEMAND ZCTAS FOR MILL RESIDUES  
( $\leq 1.5$  M DRY TONS PER YEAR)



# RESULTS

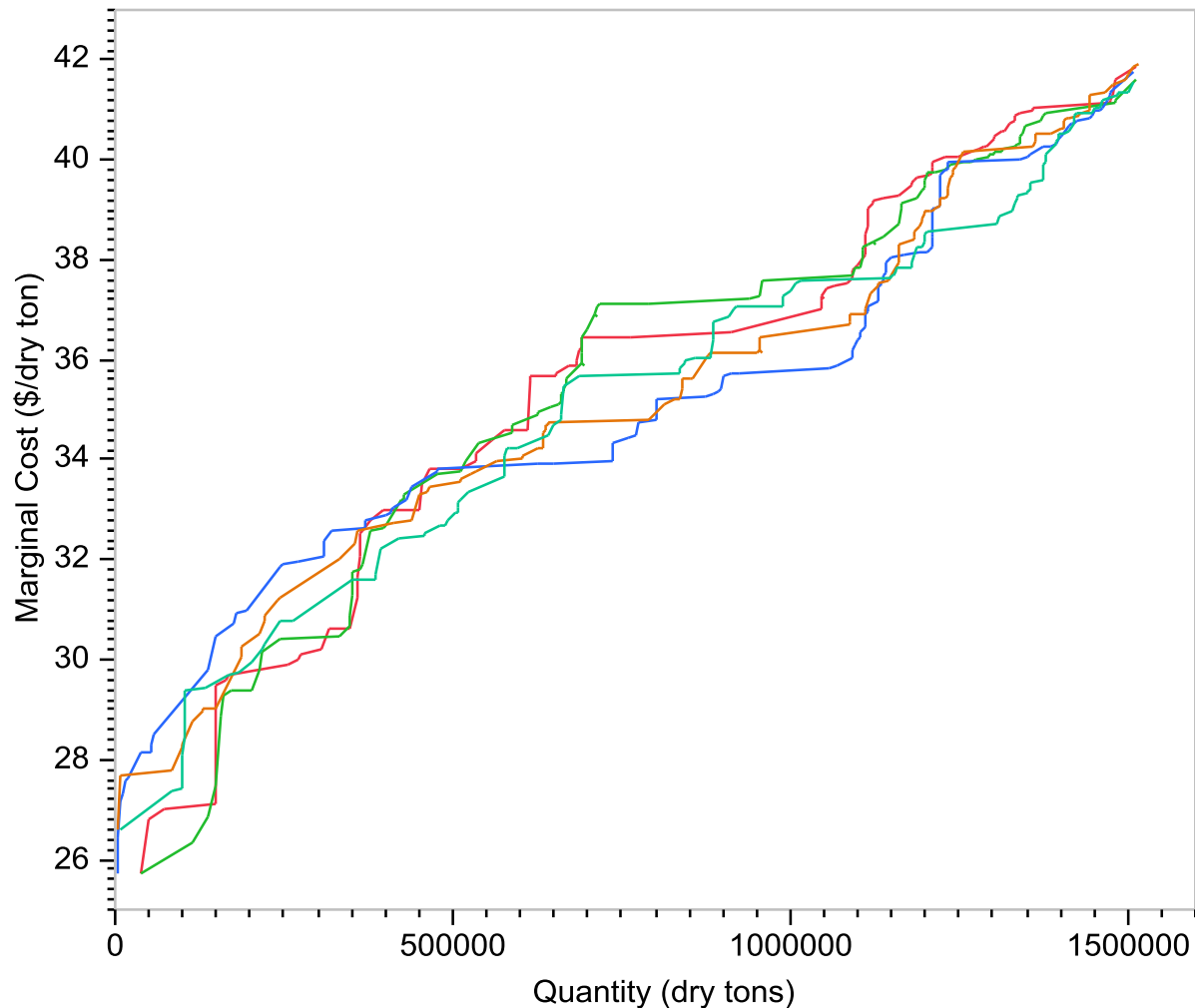
NC - TOP FIVE DEMAND ZCTAS FOR MILL RESIDUES  
( $\leq 1.5$  M DRY TONS PER YEAR)





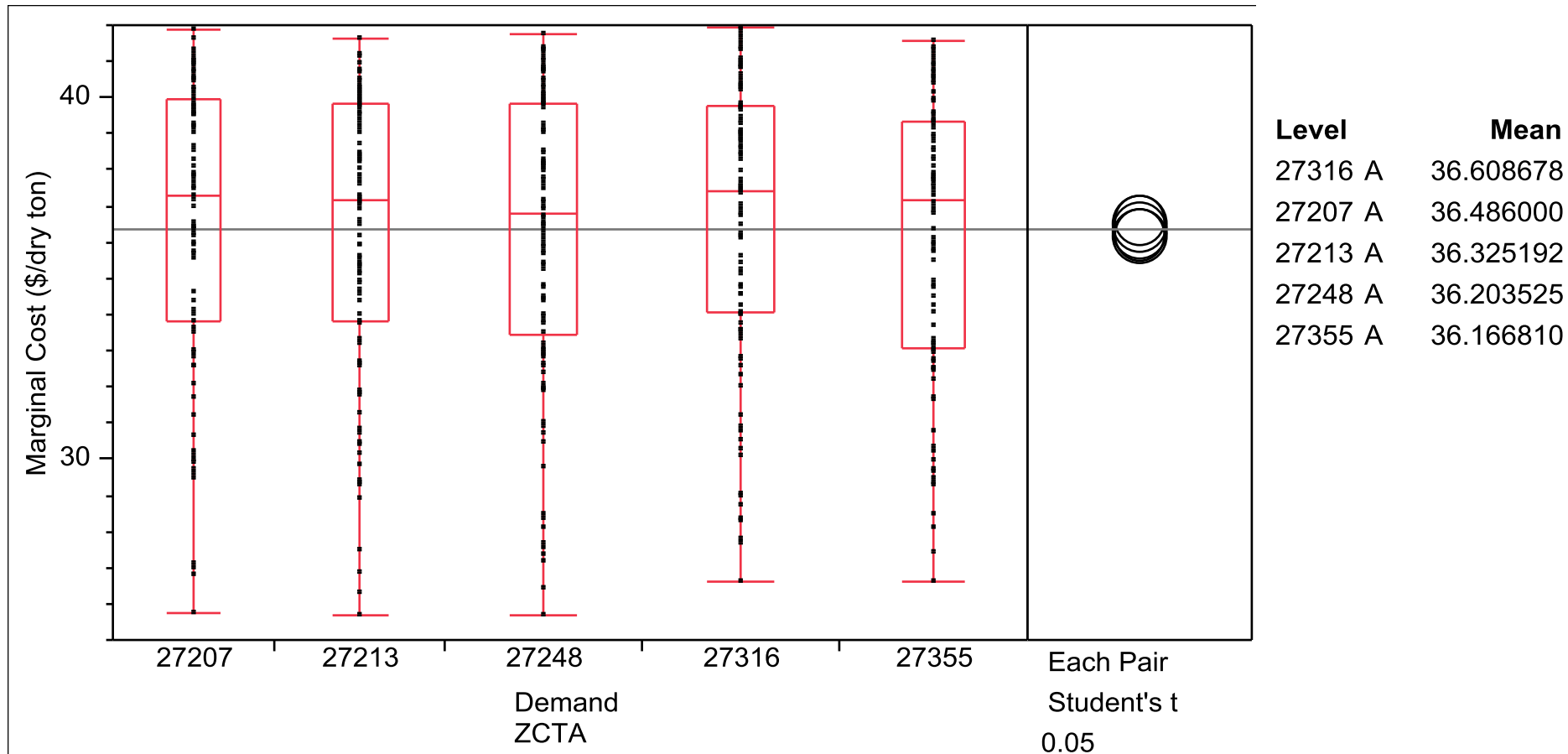
# RESULTS

NC – Top Five Demand ZCTAs MC Curves  
( $\leq 1.5$  M Dry Tons per Year)



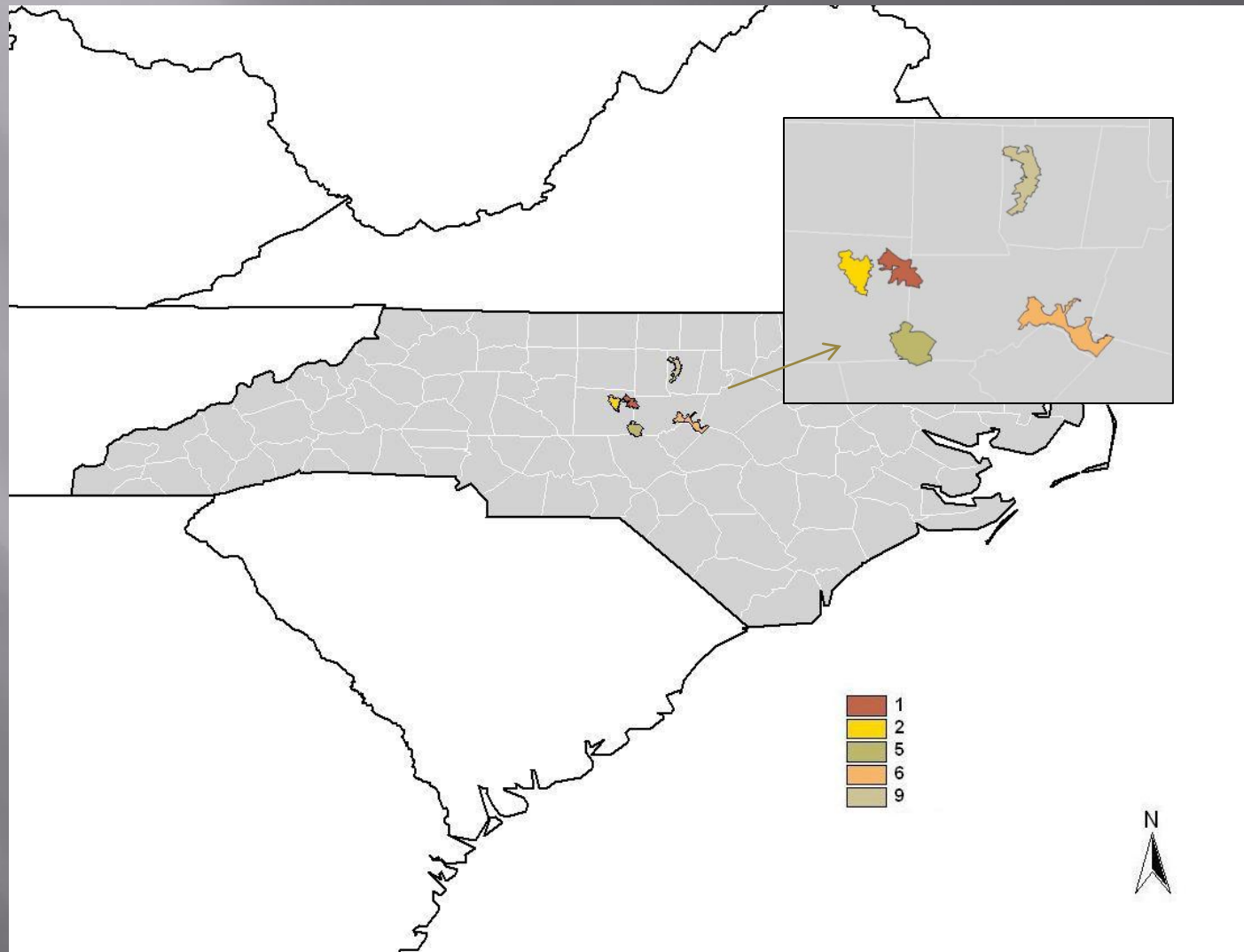
# RESULTS

NC – Top Five Demand ZCTAs MC Curves  
( $\leq 1.5$  M Dry Tons per Year)



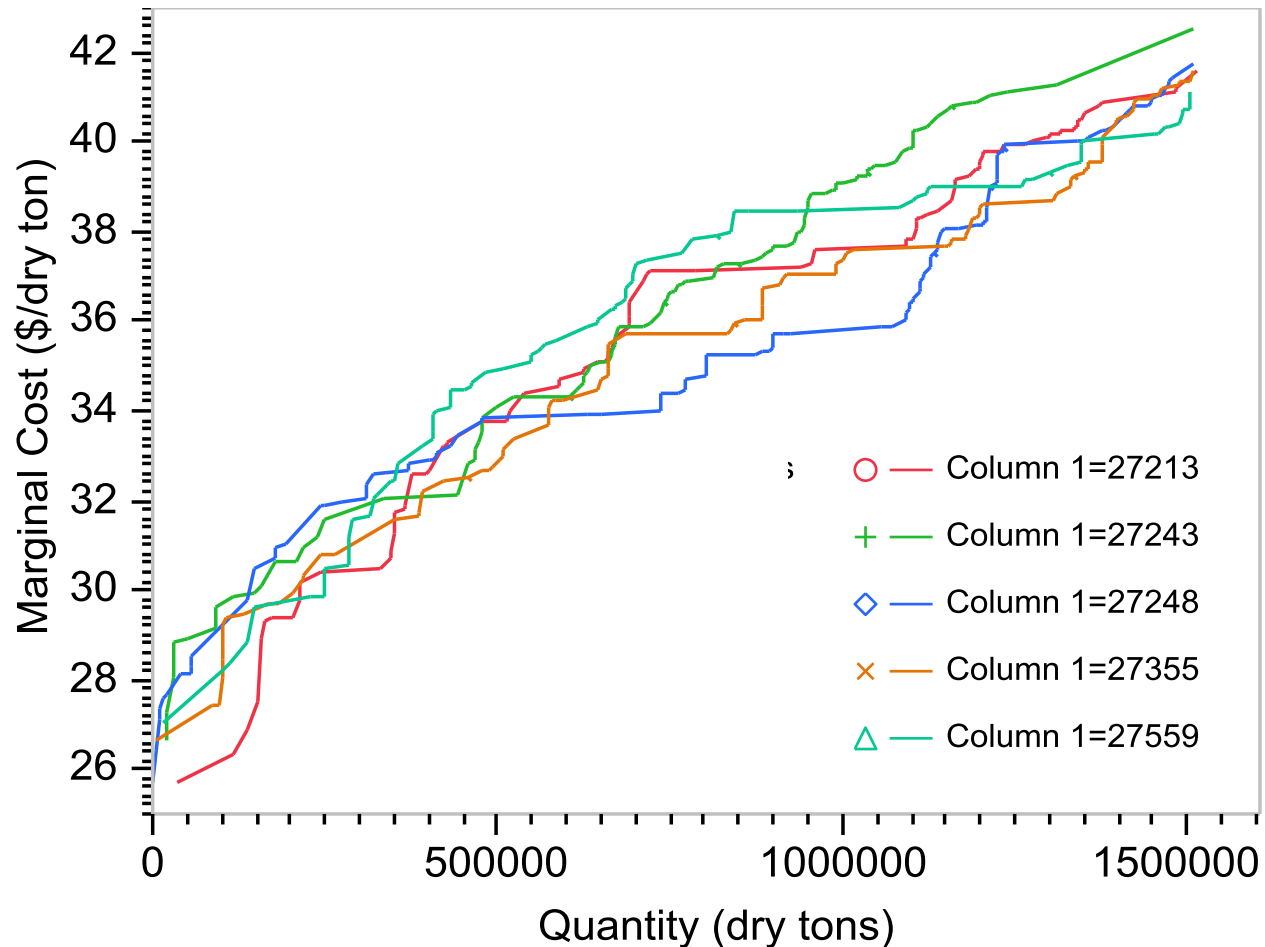
# RESULTS

NC - TOP FIVE DEMAND ZCTAS FOR MILL RESIDUES  
( $\leq 1.5$  M DRY TONS PER YEAR)



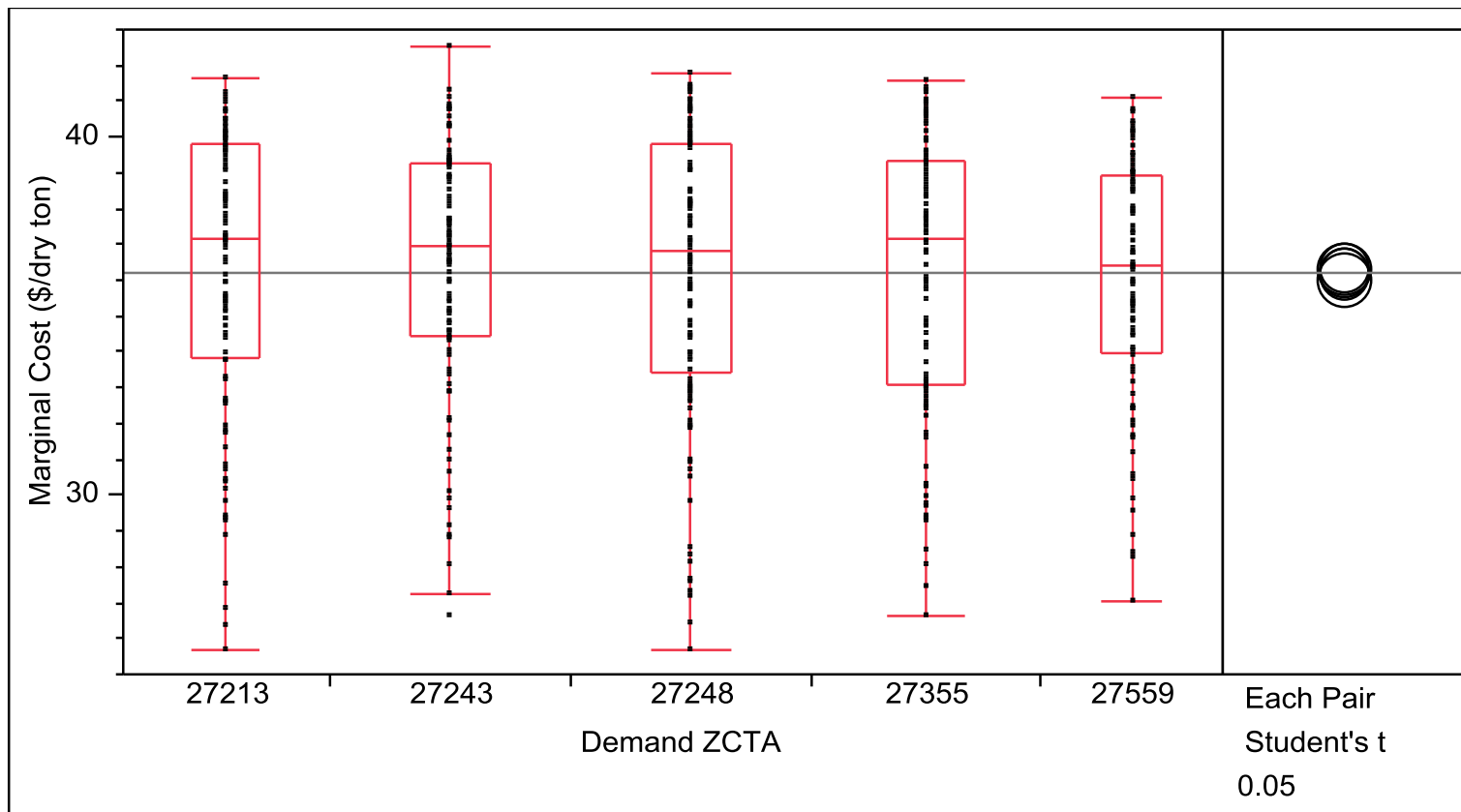
# RESULTS

NC – “De-clustered” ZCTAs MC Curves  
( $\leq 1.5$  M Dry Tons per Year)



# RESULTS

NC – “De-clustered” ZCTAs MC Curves  
( $\leq 1.5$  M Dry Tons per Year)

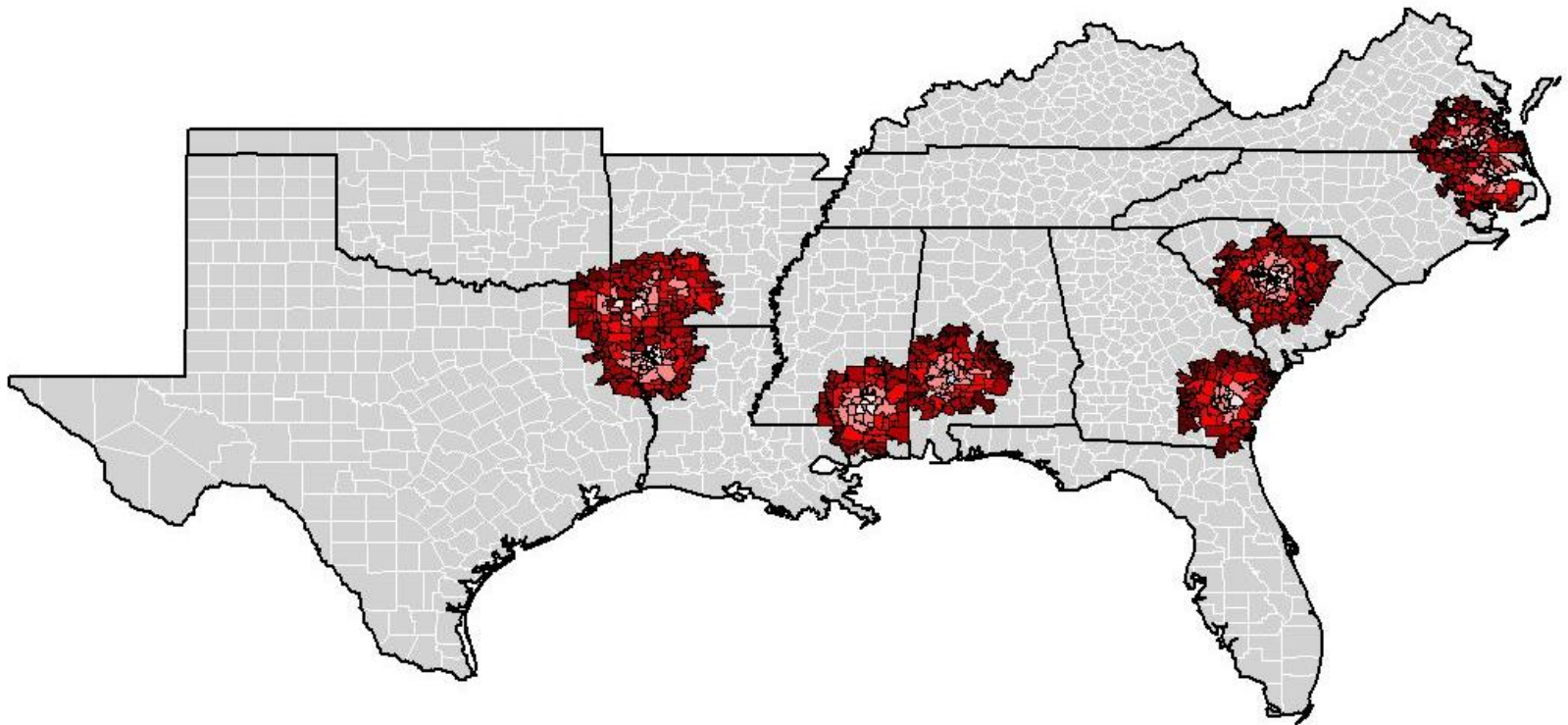


Level	Mean
27243 A	36.363115
27213 A	36.325192
27248 A	36.203525
27355 A	36.166810
27559 A	36.000000



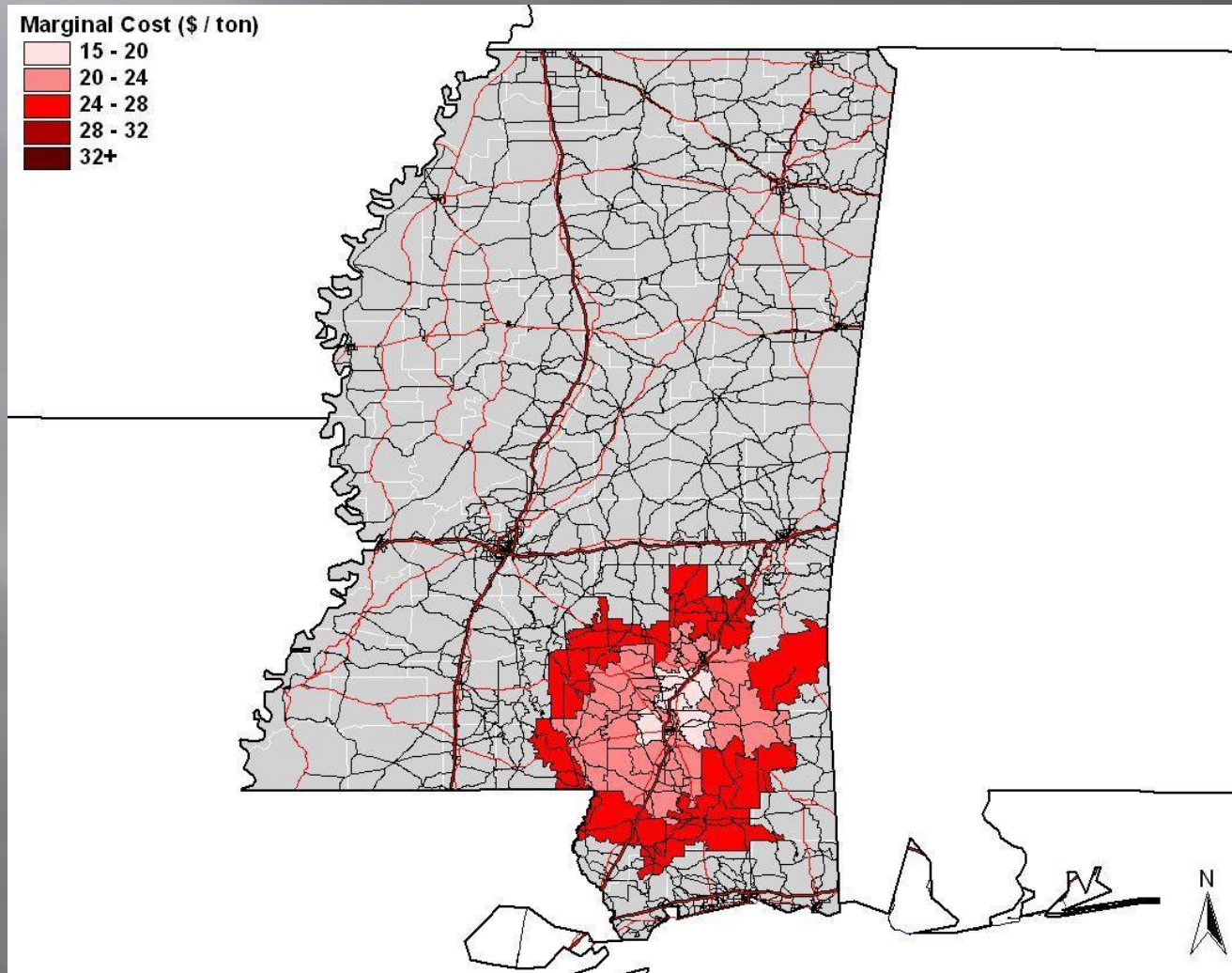
# RESULTS

Low cost biosheds for 9 southern state  
(Logging residues “at-landing”  $\leq 1.5$  M Dry tons / year)



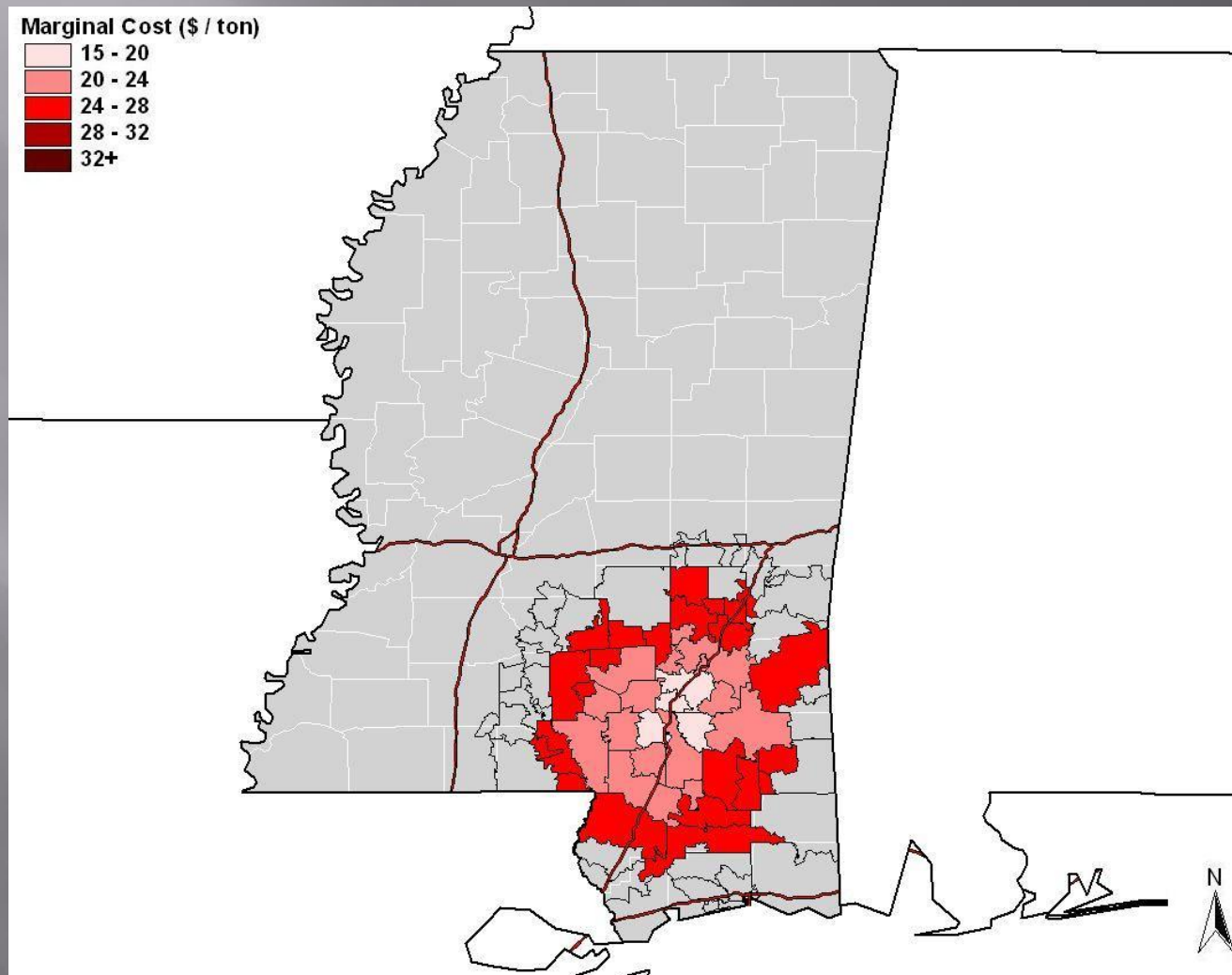
# RESULTS

MS - Least Cost Logging Residue (“at-landing”) Bioshed  
( $\leq 1.5$  M Dry Tons per Year)



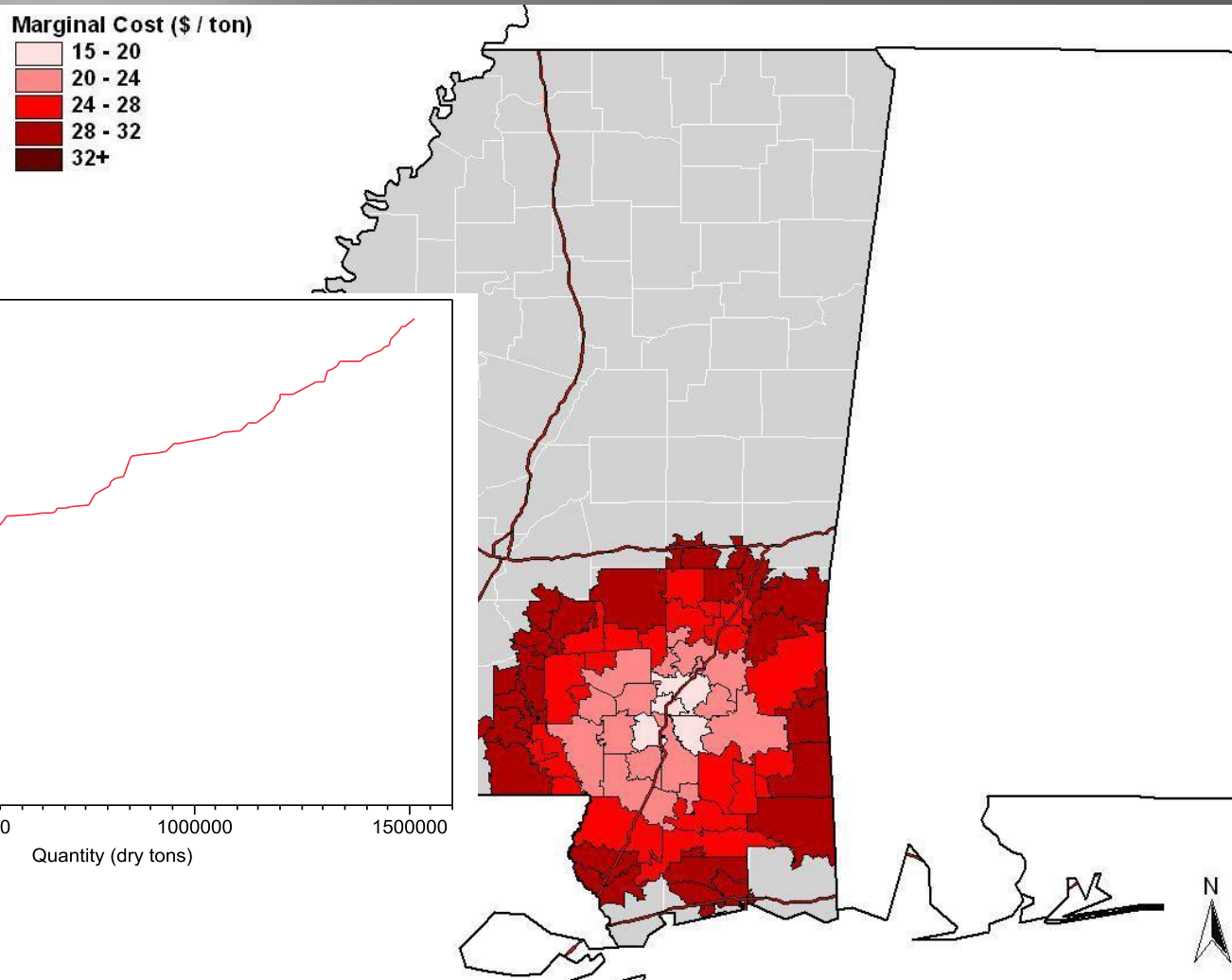
# RESULTS

MS - Least Cost Logging Residue (“at-landing”) Bioshed  
( $\leq 1.5$  M Dry Tons per Year)



# RESULTS

MS - Least Cost Logging Residue (“at-landing”) Bioshed  
( $\leq 1.5$  M Dry Tons per Year)





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the region's governors, legislators, business and academic

For more information:  
James H. Perdue  
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## Marginal Cost Analysis for one Zip Code Tabulation Area (ZCTA)

Zip Code:

Biomass Type: Logging Residues (At Landing, Hardwood) ▼

Travel Distance: 40 Miles ▼ (one way)

Bioshed Map Marginal Cost Data Marginal Cost Curve

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**Marginal Cost Analysis for**

**ion Area (ZCTA)**

Zip Code:

Biomass Type: Total Mill Residues

Travel Distance: 80 Miles (one way)

Bioshed Map Marginal Cost Data Marginal Cost Curve

Logging Residues (At Landing, Hardwood)  
Logging Residues (At Landing, Softwood)  
Logging Residues (At Landing, Total)  
Logging Residues (In Woods, Hardwood)  
Logging Residues (In Woods, Softwood)  
Logging Residues (In Woods, Total)  
Other Removals (Hardwood)  
Other Removals (Softwood)  
Other Removals (Total)  
Thinning 40  
Thinning 80  
Thinning 120  
Thinning 160  
Thinning 200  
Total Mill Residues  
Unused Mill Residues  
Urban Waste  
Mill Residues (Clean, Softwood)  
Mill Residues (Unclean, Softwood)  
Mill Residues (Clean, Total)  
Mill Residues (Clean, Hardwood)  
Mill Residues (Unclean, Hardwood)  
Mill Residues (Unclean, Total)  
Total Logging Residues

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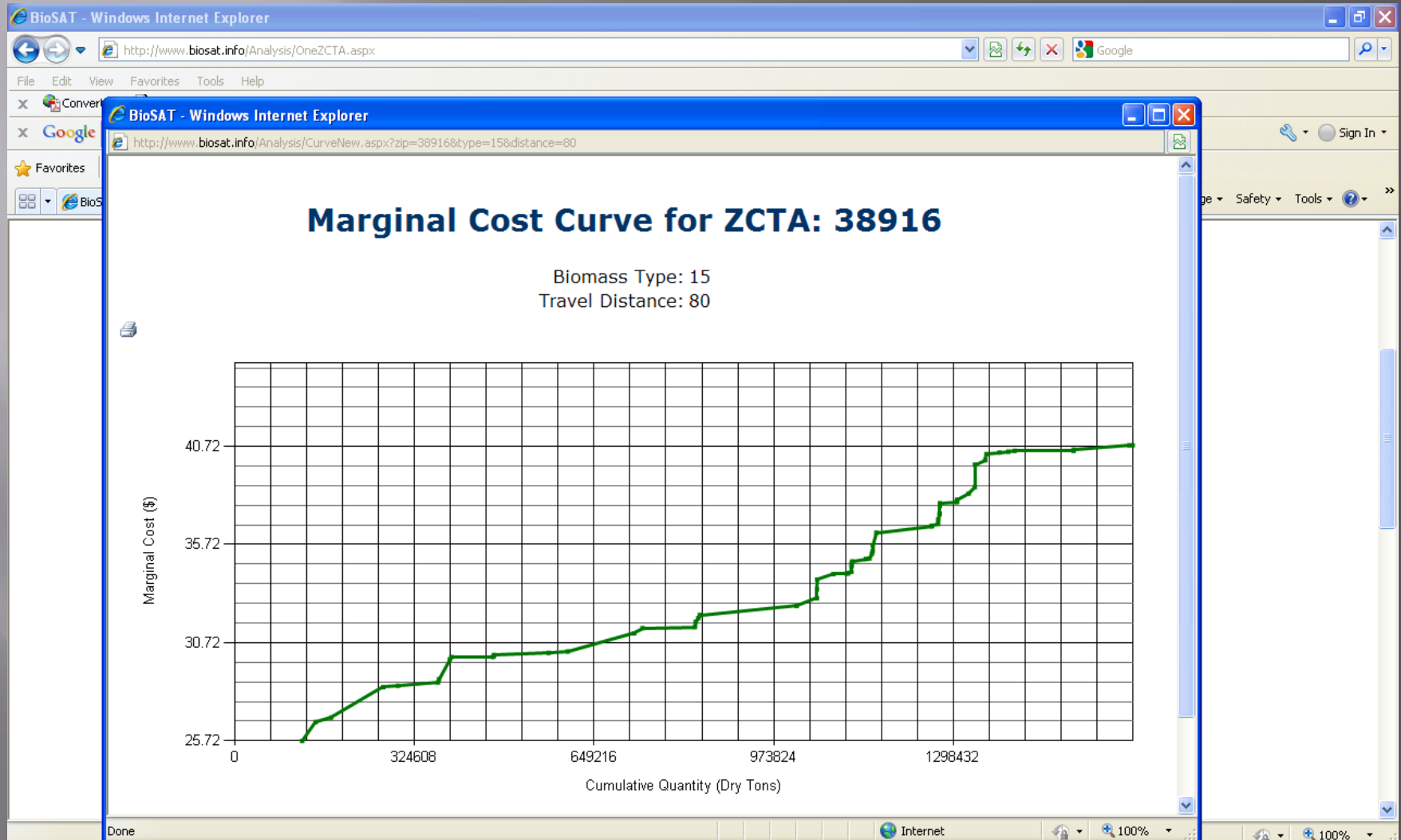
Distance below shows Round Trip Distance.

ZCTA	Quantity	Distance	Resource Cost	Trucking Cost	Harvesting Cost	Total Cost	Cumulative Qty	Marginal Cost
38916	121369.40	15.640	21.10	4.62	0.00	3121620.97	121369.40	25.72
38929	24570.50	23.660	21.10	5.58	0.00	655540.94	145939.90	26.68
38914	27583.40	23.340	21.10	5.80	0.00	741993.46	173523.30	26.90
38915	94393.50	39.900	21.10	7.36	0.00	2686439.01	267916.80	28.46
38951	26620.70	40.480	21.10	7.43	0.00	759488.57	294537.50	28.53
38878	72508.80	42.060	21.10	7.59	0.00	2080277.47	367046.30	28.69
39744	1736.90	40.940	21.10	7.76	0.00	50126.93	368783.20	28.86
39752	19622.40	51.040	21.10	8.77	0.00	586121.09	388405.60	29.87
39776	2585.50	53.980	21.10	8.89	0.00	77539.15	390991.10	29.99
38925	75200.50	50.920	21.10	8.90	0.00	2256015.00	466191.60	30.00
38851	1498.50	53.660	21.10	8.93	0.00	44999.96	467690.10	30.03
39751	446.90	54.240	21.10	8.99	0.00	13447.22	468137.00	30.09
38901	98860.70	55.920	21.10	9.10	0.00	2985593.14	566997.70	30.20
38913	34572.20	56.500	21.10	9.18	0.00	1046846.22	601569.90	30.28
39735	119850.90	65.260	21.10	10.10	0.00	3739348.08	721420.80	31.20
38864	15268.70	67.000	21.10	10.36	0.00	480353.30	736689.50	31.46
38922	94633.60	66.480	21.10	10.42	0.00	2982851.07	831323.10	31.52
39750	1356.80	68.740	21.10	10.68	0.00	43119.10	832679.90	31.78
38949	4829.90	70.320	21.10	10.87	0.00	154411.90	837509.80	31.97
38850	2795.80	74.760	21.10	11.04	0.00	89857.01	840305.60	32.14
38940	174953.20	77.700	21.10	11.49	0.00	5701724.79	1015258.80	32.59

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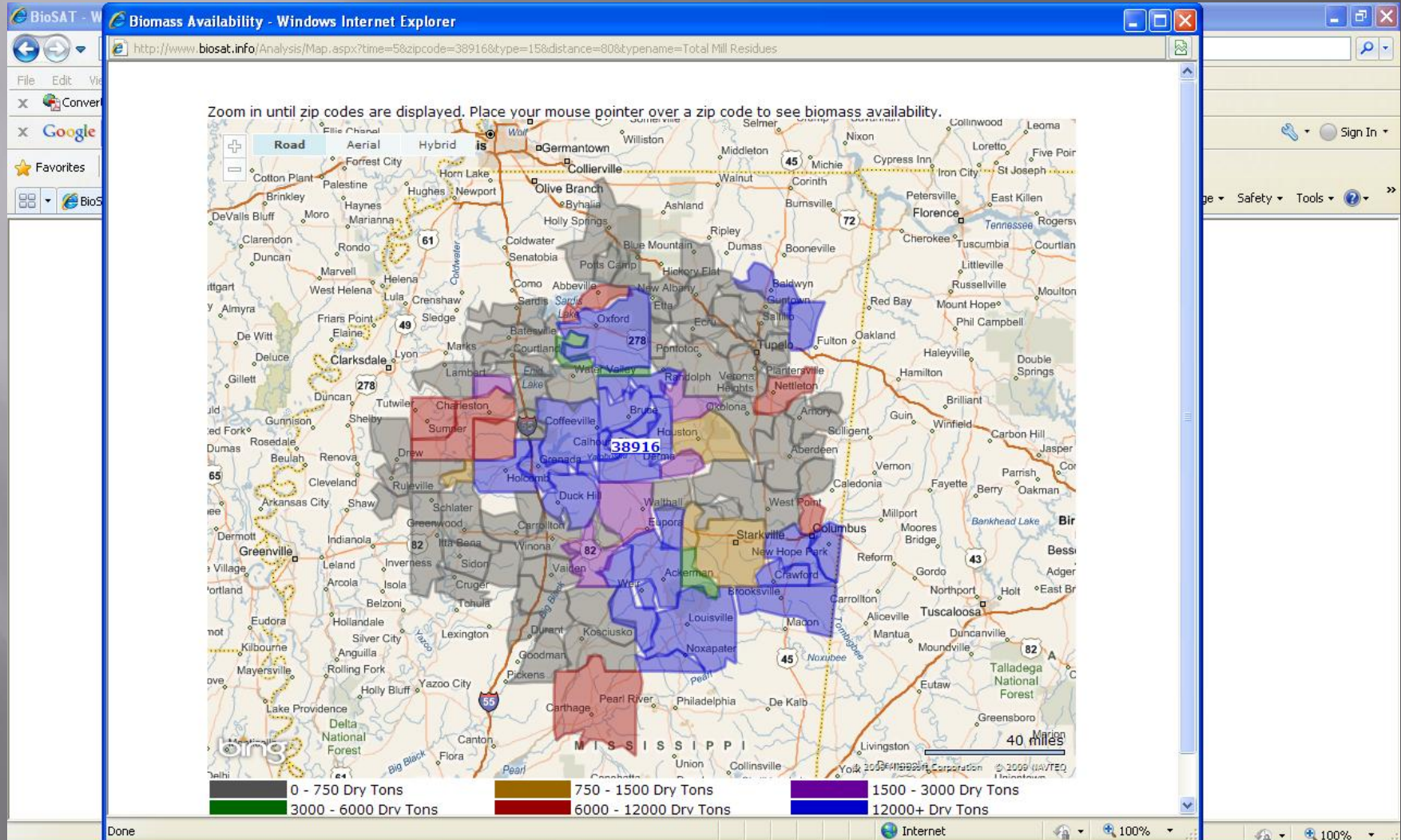
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**Biomass Type**  
Total Mill Residues

**Travel Distance**  
40 Miles

**Transportation**  
Truck - Dry Van

**Biomass Supply Quantity**  
1.5 Million Ton/Year

**States**

<input type="checkbox"/> Alabama	<input type="checkbox"/> Maine	<input type="checkbox"/> Ohio
<input type="checkbox"/> Arkansas	<input type="checkbox"/> Maryland	<input type="checkbox"/> Oklahoma
<input type="checkbox"/> Connecticut	<input type="checkbox"/> Massachusetts	<input type="checkbox"/> Pennsylvania
<input type="checkbox"/> Delaware	<input type="checkbox"/> Michigan	<input type="checkbox"/> Rhode Island
<input type="checkbox"/> Florida	<input type="checkbox"/> Minnesota	<input type="checkbox"/> South Carolina
<input type="checkbox"/> Georgia	<input checked="" type="checkbox"/> Mississippi	<input type="checkbox"/> Tennessee
<input type="checkbox"/> Illinois	<input type="checkbox"/> Missouri	<input type="checkbox"/> Texas
<input type="checkbox"/> Indiana	<input type="checkbox"/> New Hampshire	<input type="checkbox"/> Vermont
<input type="checkbox"/> Iowa	<input type="checkbox"/> New Jersey	<input type="checkbox"/> Virginia
<input type="checkbox"/> Kentucky	<input type="checkbox"/> New York	<input type="checkbox"/> West Virginia
<input type="checkbox"/> Louisiana	<input type="checkbox"/> North Carolina	<input type="checkbox"/> Wisconsin

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**Biomass Type**

Total Mill Residues

Total Mill Residues

Total Logging Residues

Logging Residues (At Landing, Hardwood)

Logging Residues (At Landing, Softwood)

Logging Residues (In Woods, Hardwood)

Logging Residues (In Woods, Softwood)

Urban Waste

Mill Residues (Clean, Softwood)

Mill Residues (Unclean, Softwood)

Mill Residues (Clean, Hardwood)

Mill Residues (Unclean, Hardwood)

**Travel Distance**

80 Miles

**Transportation**

Truck - Dry Van

**Biomass Supply Quantity**

1.5 Million Ton/Year

☐ Maine ☐ Ohio

☐ Maryland ☐ Oklahoma

☐ Massachusetts ☐ Pennsylvania

☐ Michigan ☐ Rhode Island

☐ Minnesota ☐ South Carolina

☒ Mississippi ☐ Tennessee

☐ Missouri ☐ Texas

☐ New Hampshire ☐ Vermont

☐ New Jersey ☐ Virginia

☐ New York ☐ West Virginia

☐ North Carolina ☐ Wisconsin

Run Reset

Select a format Export

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[www.BioSAT.net](http://www.BioSAT.net)

# RESULTS

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http://www.biosat.info/Analysis/SouthernStatesNew.aspx

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**Biomass Type**  
Total Mill Residues

**Travel Distance**  
80 Miles  
40 Miles  
80 Miles  
120 Miles  
180 Miles

**Transportation**  
Truck - Dry Van

**Biomass Supply Quantity**  
1.5 Million Ton/Year

**States**

<input type="checkbox"/> Alabama	<input type="checkbox"/> Maryland	<input type="checkbox"/> Ohio
<input type="checkbox"/> Arkansas	<input type="checkbox"/> Massachusetts	<input type="checkbox"/> Oklahoma
<input type="checkbox"/> Connecticut	<input type="checkbox"/> Michigan	<input type="checkbox"/> Pennsylvania
<input type="checkbox"/> Delaware	<input type="checkbox"/> Minnesota	<input type="checkbox"/> Rhode Island
<input type="checkbox"/> Florida	<input checked="" type="checkbox"/> Mississippi	<input type="checkbox"/> South Carolina
<input type="checkbox"/> Georgia	<input type="checkbox"/> Missouri	<input type="checkbox"/> Tennessee
<input type="checkbox"/> Illinois	<input type="checkbox"/> New Hampshire	<input type="checkbox"/> Texas
<input type="checkbox"/> Indiana	<input type="checkbox"/> New Jersey	<input type="checkbox"/> Vermont
<input type="checkbox"/> Iowa	<input type="checkbox"/> New York	<input type="checkbox"/> Virginia
<input type="checkbox"/> Kentucky	<input type="checkbox"/> North Carolina	<input type="checkbox"/> West Virginia
<input type="checkbox"/> Louisiana		<input type="checkbox"/> Wisconsin

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**Biomass Type**  
Total Mill Residues

**Travel Distance**  
80 Miles

**Transportation**  
Truck - Dry Van

**Biomass Supply Quantity**  
1.5 Million Ton/Year  
1.5 Million Ton/Year  
1.0 Million Ton/Year  
0.5 Million Ton/Year

**States**

<input type="checkbox"/> Alabama	<input type="checkbox"/> Maine	<input type="checkbox"/> Ohio
<input type="checkbox"/> Arkansas	<input type="checkbox"/> Maryland	<input type="checkbox"/> Oklahoma
<input type="checkbox"/> Connecticut	<input type="checkbox"/> Massachusetts	<input type="checkbox"/> Pennsylvania
<input type="checkbox"/> Delaware	<input type="checkbox"/> Michigan	<input type="checkbox"/> Rhode Island
<input type="checkbox"/> Florida	<input type="checkbox"/> Minnesota	<input type="checkbox"/> South Carolina
<input type="checkbox"/> Georgia	<input checked="" type="checkbox"/> Mississippi	<input type="checkbox"/> Tennessee
<input type="checkbox"/> Illinois	<input type="checkbox"/> Missouri	<input type="checkbox"/> Texas
<input type="checkbox"/> Indiana	<input type="checkbox"/> New Hampshire	<input type="checkbox"/> Vermont
<input type="checkbox"/> Iowa	<input type="checkbox"/> New Jersey	<input type="checkbox"/> Virginia
<input type="checkbox"/> Kentucky	<input type="checkbox"/> New York	<input type="checkbox"/> West Virginia
<input type="checkbox"/> Louisiana	<input type="checkbox"/> North Carolina	<input type="checkbox"/> Wisconsin

Run Reset

Select a format Export

Internet 100%

# RESULTS

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Select a format

- XML file with report data
- CSV (comma delimited)
- TIFF file
- Acrobat (PDF) file
- Web archive
- Excel

Report Formats	Total Cost	Marginal Total Cost	State	County	
7	35.2444	40.5000	MS	Calhoun	
2	36.4564	39.5000	MS	Perry	
36079	54352904.55	36.5502	40.5000	MS	Lee
38864	54977527.55	35.5652	41.1200	MS	Pontotoc
39094	55166272.54	36.7523	39.1900	MS	Leake
39457	55408137.18	36.7130	39.9800	MS	Pearl River
39072	55711034.16	36.6337	39.7000	MS	Madison
39056	55835501.88	36.6541	39.5400	MS	Hinds
39451	56243756.66	36.1159	41.1400	MS	Greene
38839	56263286.35	36.7428	40.1900	MS	Calhoun
39152	57258650.76	35.9284	39.6300	MS	Scott
39350	57347098.06	37.9213	39.3600	MS	Neshoba
38870	57655921.10	38.2630	40.4400	MS	Monroe
39057	57853615.34	37.7709	39.6300	MS	Newton
39120	57917779.60	35.9432	40.7500	MS	Adams
38801	57995309.01	37.9227	40.1300	MS	Lee
38878	59153219.06	35.6914	40.5800	MS	Calhoun
39470	59287248.97	38.0989	39.5400	MS	Pearl River
20085	59518876.08	36.0210	40.1500	MS	Carroll

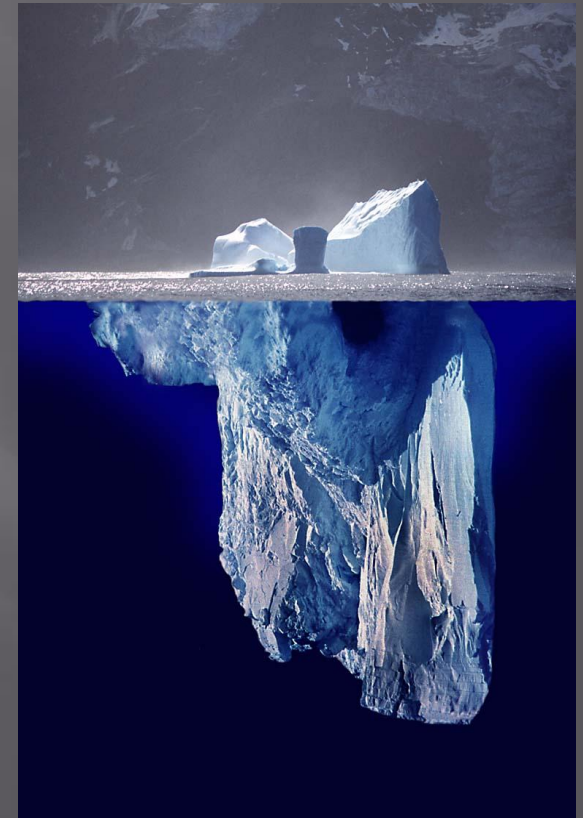
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# Summary

- [www.BioSAT.net](http://www.BioSAT.net) version 1.0 provides an economic decision-making framework and tool for identifying least cost woody and ag cellulose demand sites for 33 eastern states
  - mill residues, logging residues, and ag residues
  - resource costs, transportation costs, harvesting costs
- Validation is on-going
- Web-site nears beta-ready (August 4-5, 2009 Woody Biomass Utilization Mtg. – Starkville, MS)

# Future Research

- Merchantable wood costing
- Ag cellulose resource database
- Ag cellulose costing
  - Resource, harvest, transport
- Railroad networks and intra-modal transfer points
- Water availability
- Wood using facilities (competition)
- Stochastic-model site selection
- Policy influence
- Sustainability criteria
  - Population data, climatology data, fragmentation, etc.





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- University of Tennessee Agricultural Experiment Station
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  - Christy Pritchard, Research Associate
  - Xu (Nancy) Liu, GRA
  - Yingjin Wang, former GRA
- University of Tennessee College of Business (Frank Guess)
- North Carolina State University (Bob Abt)
- University of Georgia (Dale Greene)

# QUESTIONS

