A Web-based BIOmass Site Assessment Tool

BioSAT Making Innovation Work version 1.0

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FUTURE Forest Products Center SunGrant INITIATIVE

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

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^2
   - 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)

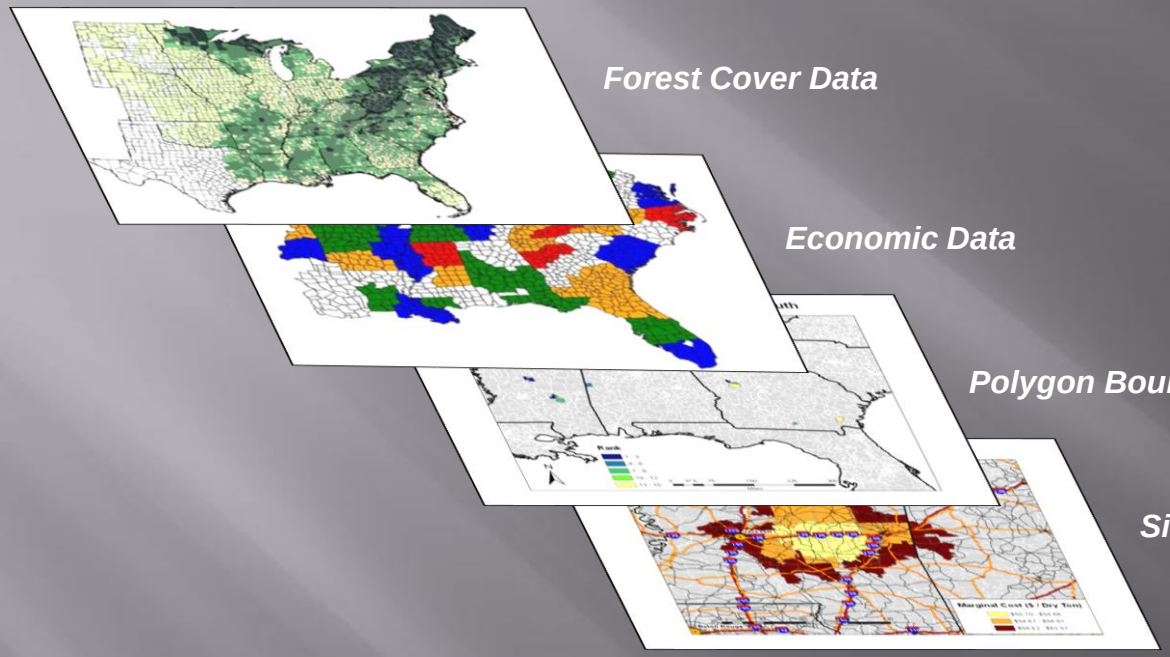
Phase I Objectives

5. Develop web-based system in the public domain (www.BioSAT.net)
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^2)
   - 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

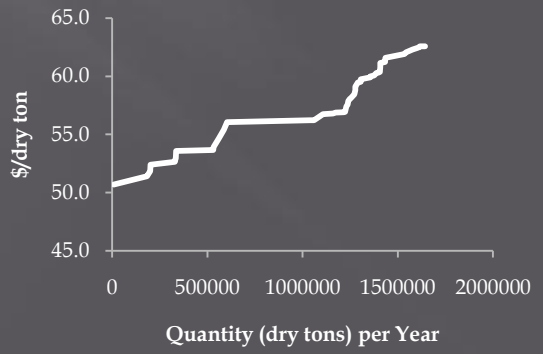
Polygon Boundaries

Siting Solution

SQL Relational Database

County	Date/Time	Quantity	Type	Ownership	Stumpage	Logging	Transport
A		tons	I	i	$	$	$
B		tons	II	ii	$	$	$
C		tons	III	iii	$	$	$
D		tons	IV	iv	$	$	$
E		tons	V	v	$	$	$
F		tons	VI	vi	$	$	$
G		tons	VII	vii	$	$	$
H		tons	I	viii	$	$	$
I		tons	II	ix	$	$	$
J		tons	III	x	$	$	$
K		tons	IV	xi	$	$	$
L		tons	V	xii	$	$	$
M		tons	VI	xiii	$	$	$
N		tons	VII	xiv	$	$	$
O		tons	I	xv	$	$	$
P		tons	II	xvi	$	$	$
Q		tons	III	xvii	$	$	$
R		tons	IV	i	$	$	$
S		tons	V	v	$	$	$
T		tons	VI	vi	$	$	$
U		tons	VII	vii	$	$	$
V		tons	I	viii	$	$	$
W		tons	II	ix	$	$	$
X		tons	III	x	$	$	$
Y		tons	IV	xi	$	$	$
Z		tons	V	xii	$	$	$

Phase I Supply Curves



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 τ - 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 τ

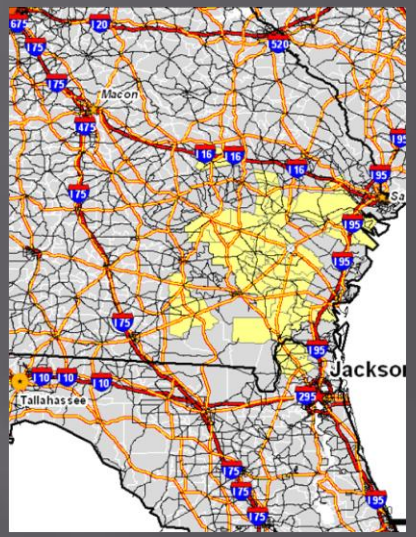
N - radius of curvature in the prime normal to ***M*** at τ

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.

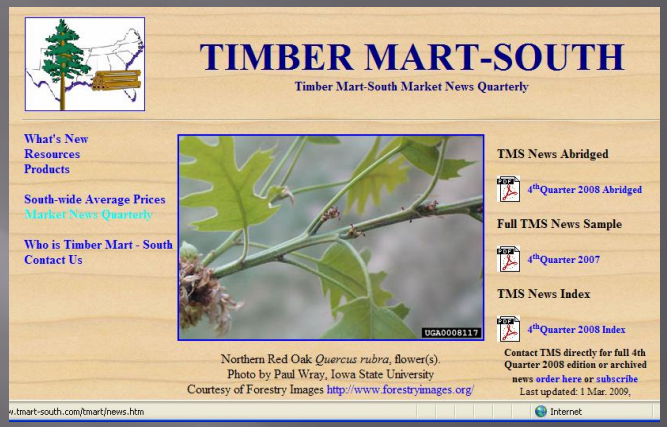


Next, ZCTAs beyond 5-hour one-way haul are eliminated (assume day-cab trucks with legal driving maximum of 11 hours)

METHODS
Resource Costs

South (Timber Mart South www.tmart-south.com)

- 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)

Total Cost (a, d, t) = Variable Cost (d, t) + 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): ± 2%

METHODS
Trucking Cost Model

Fixed Cost = Σ (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^2

Dennis Dykstra

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

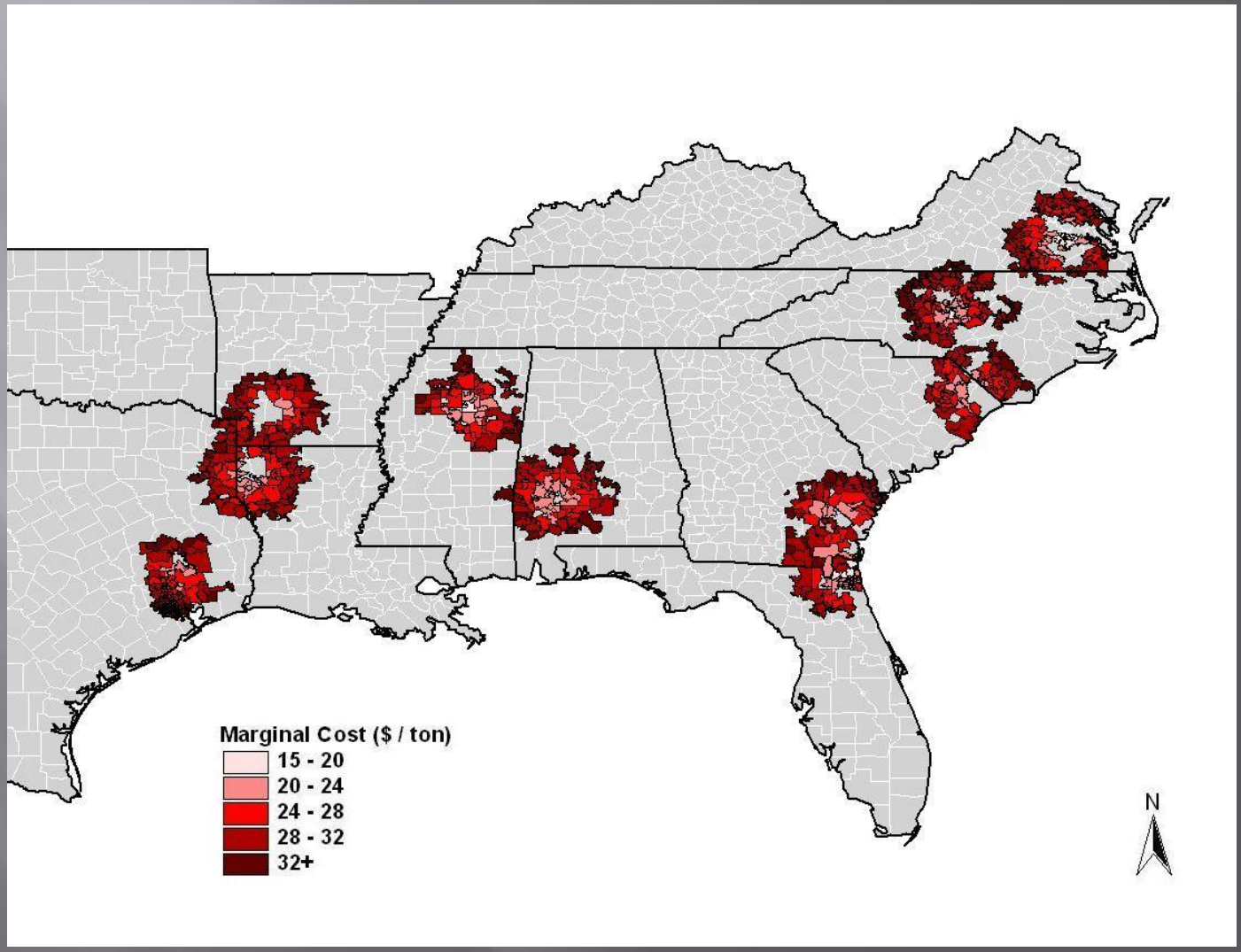
Auburn Harvest Analyzer (AHA)

Bob Rummer and Dale Greene

- Pulpwood Costs
- Sawtimber Costs
- Thinning Costs

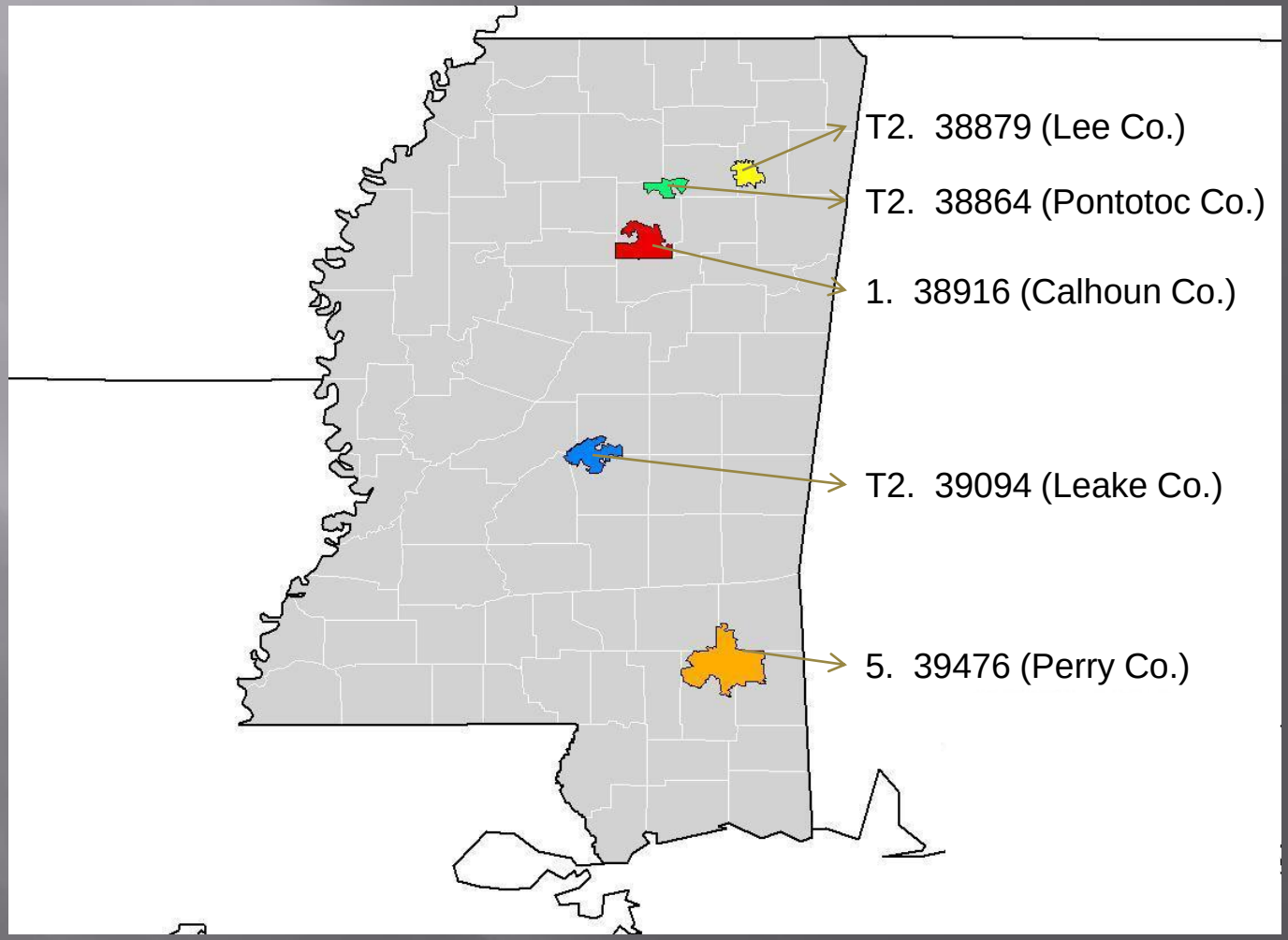
RESULTS

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



RESULTS

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



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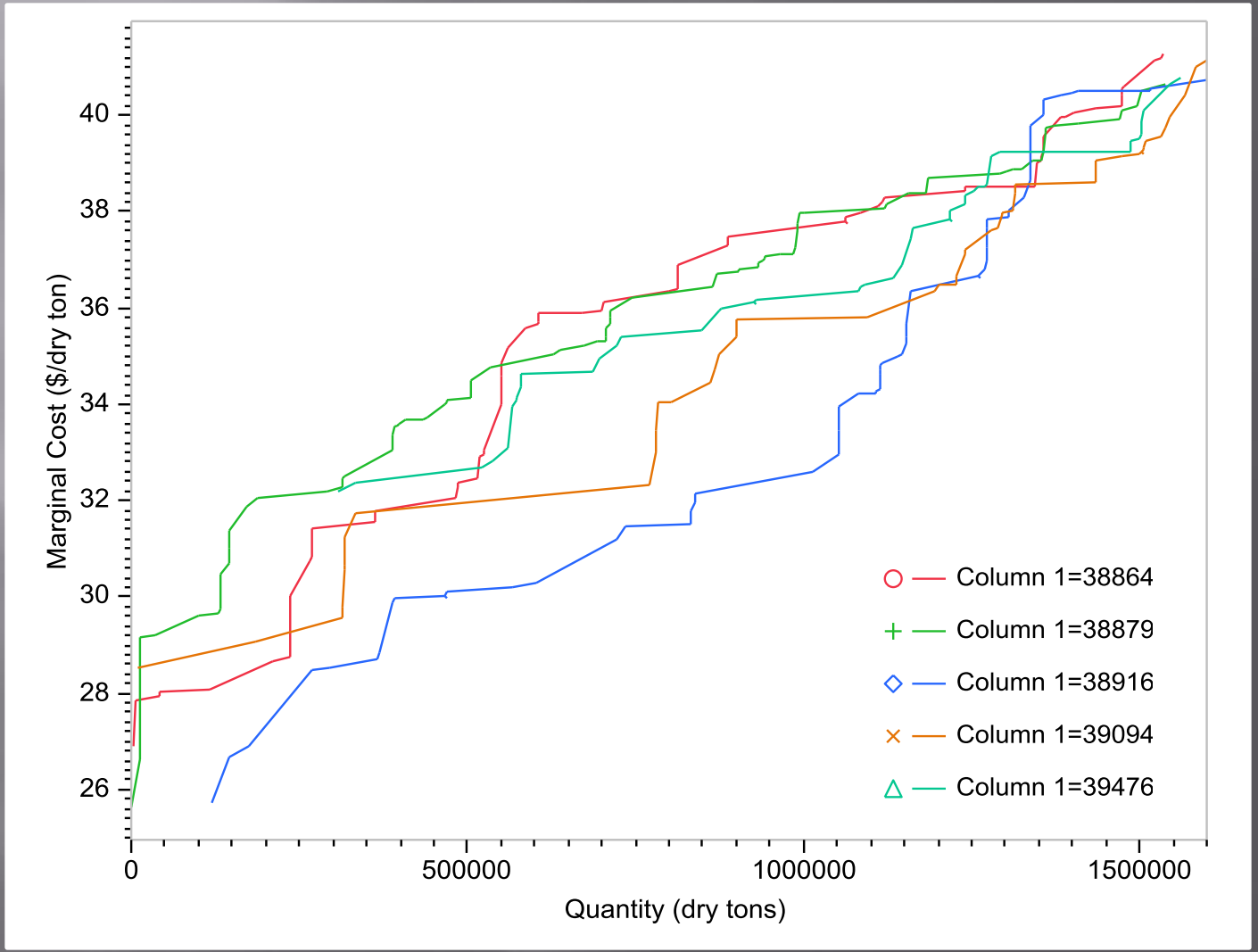
MS – Top Five Demand ZCTAs MC Curves (≤ 1.5 M Dry Tons per Year)



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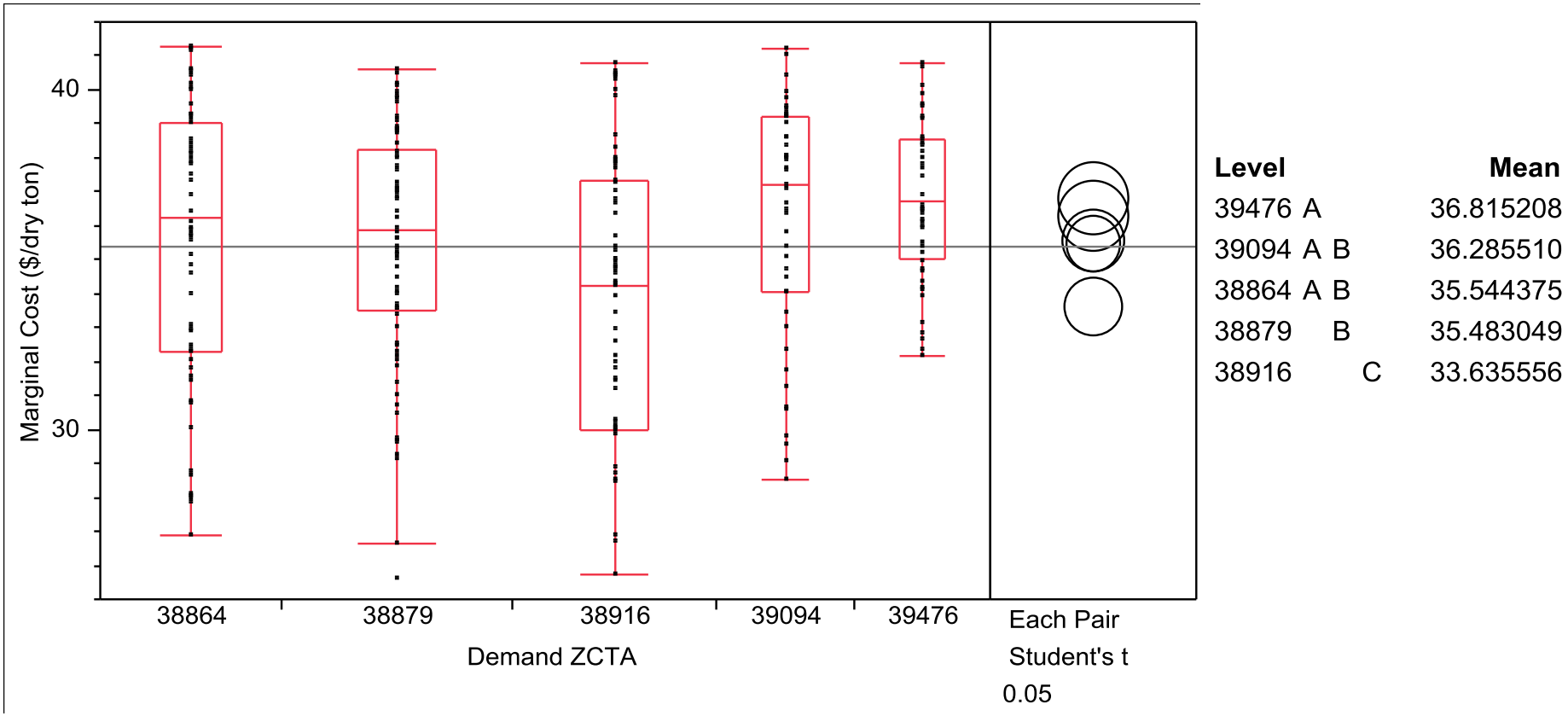
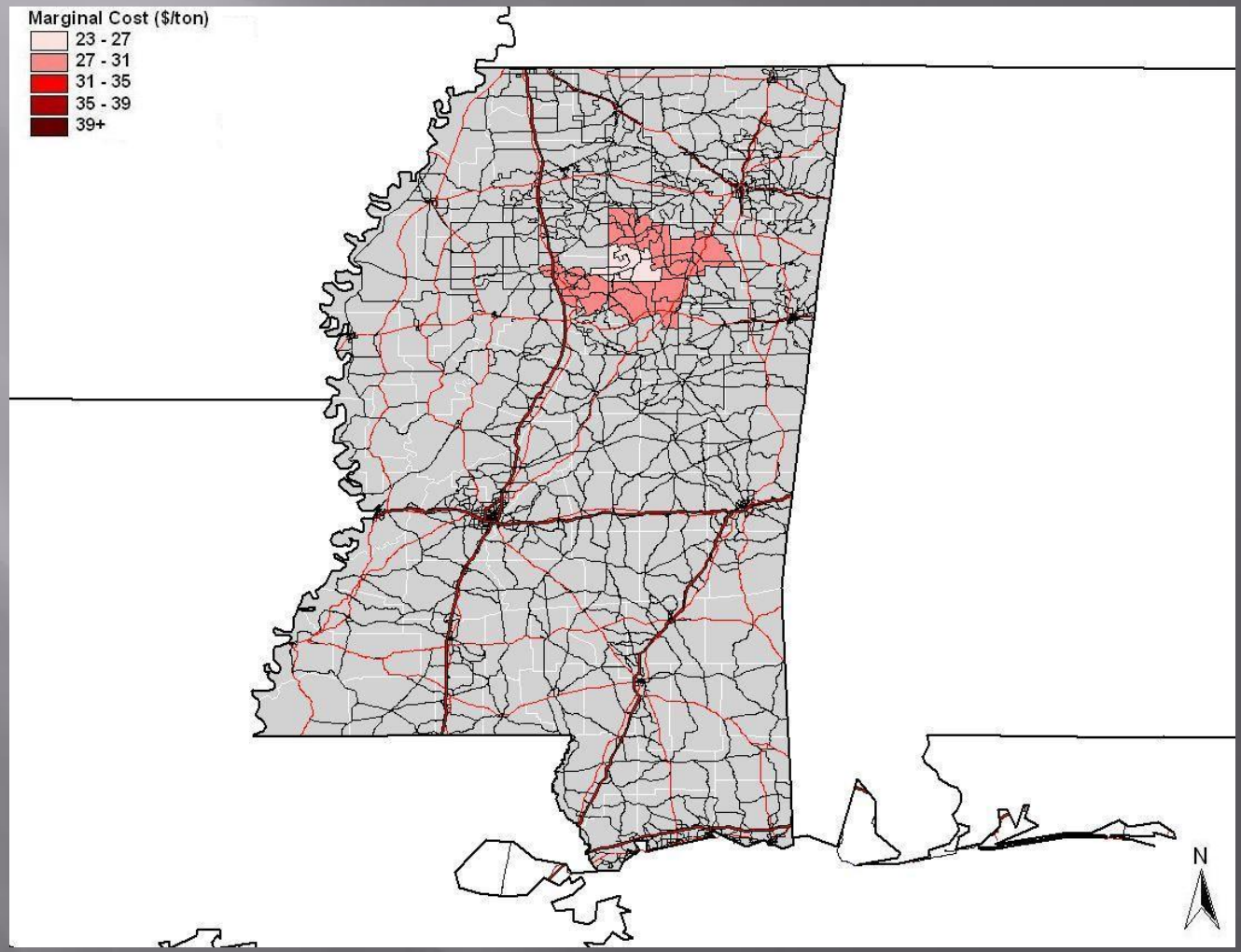


RESULTS

DEMAND ZCTA 38916 (CALHOUN CO.)



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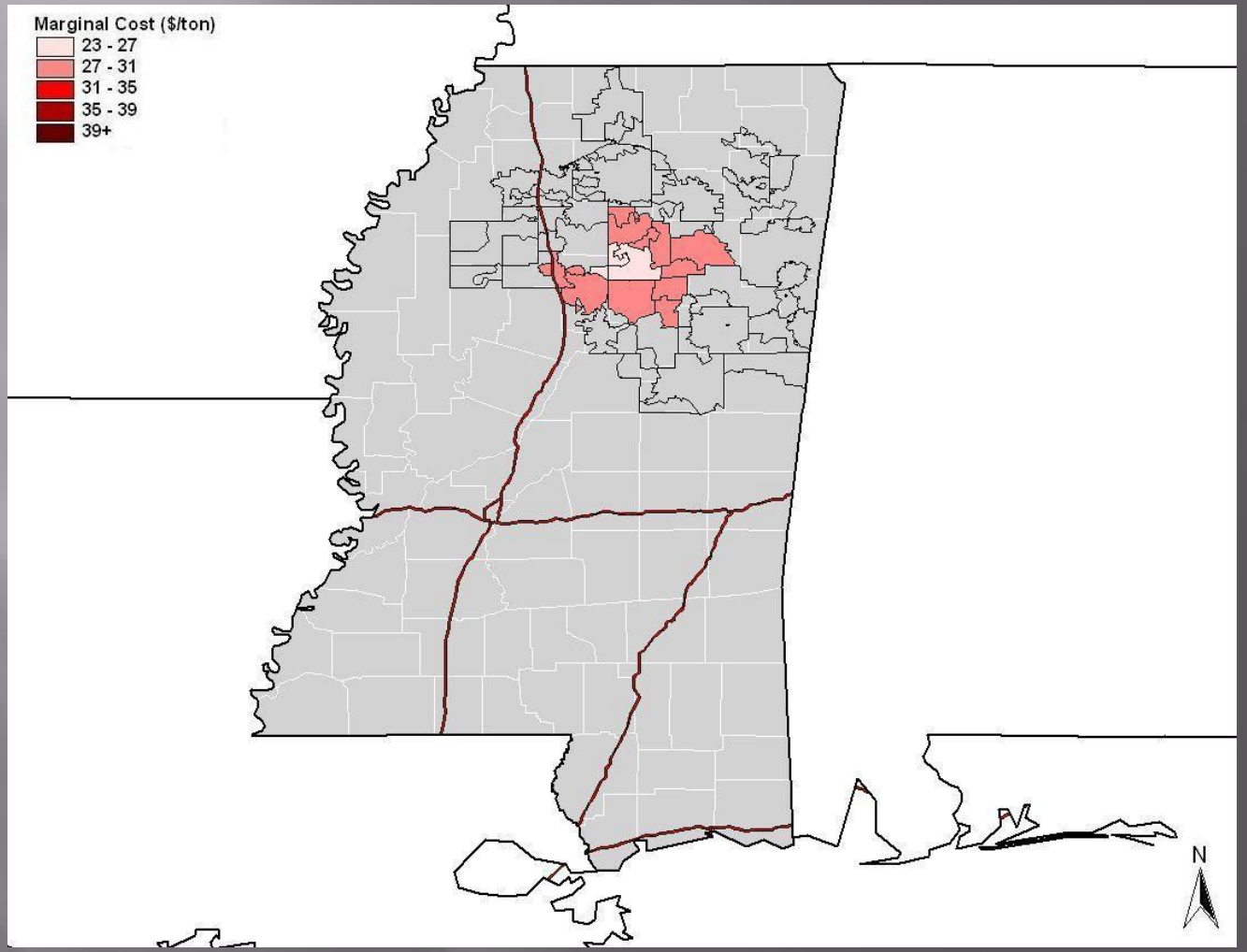

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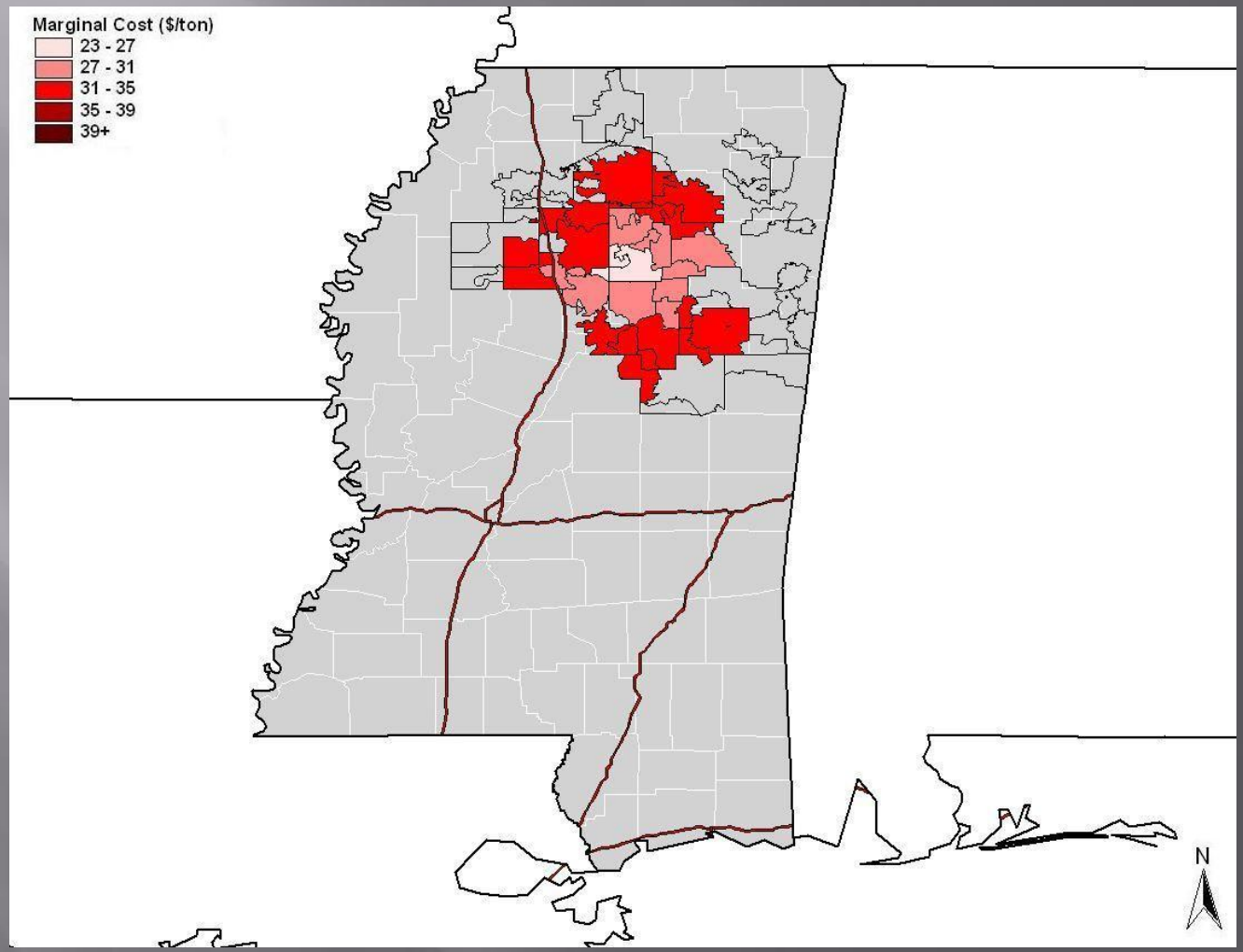

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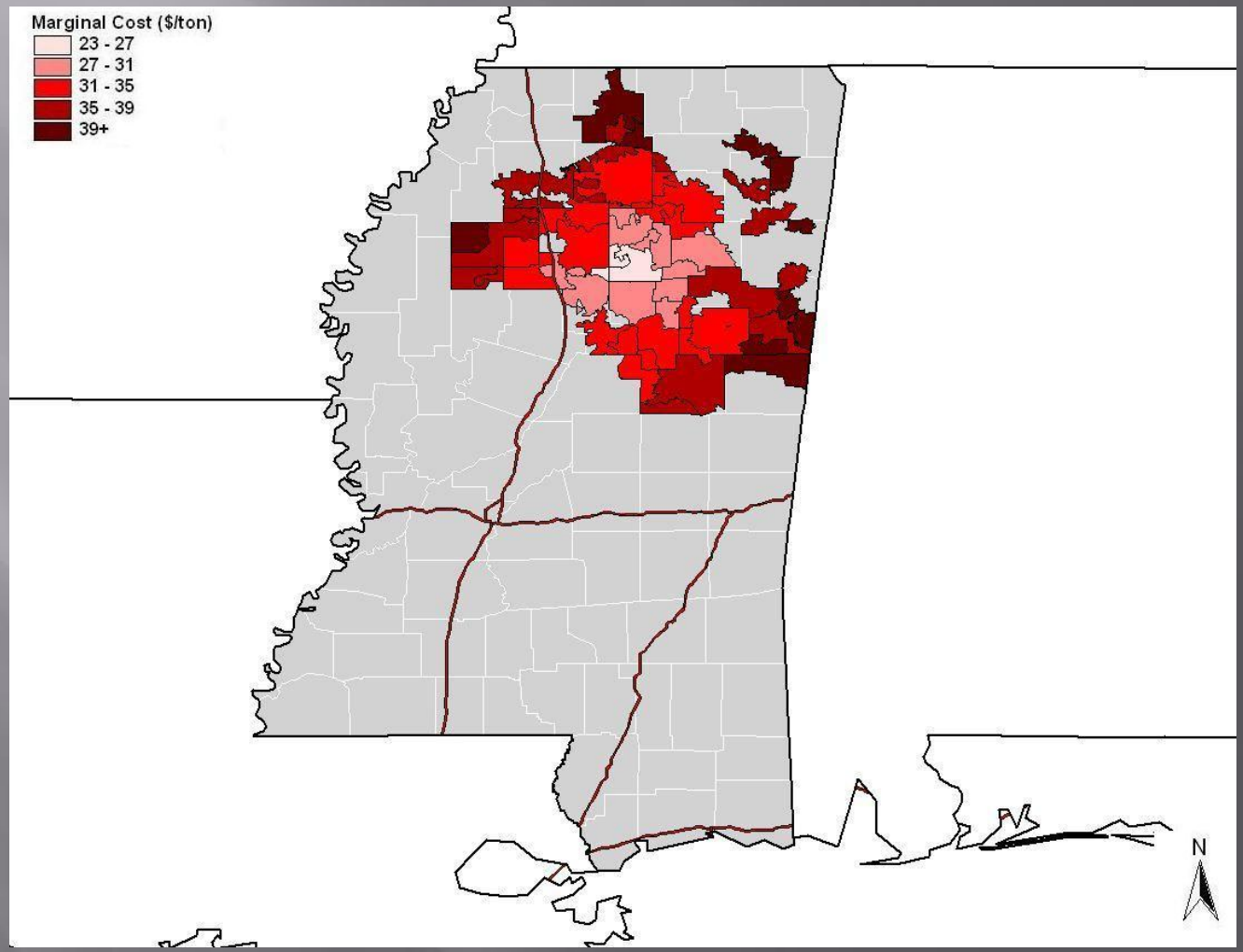
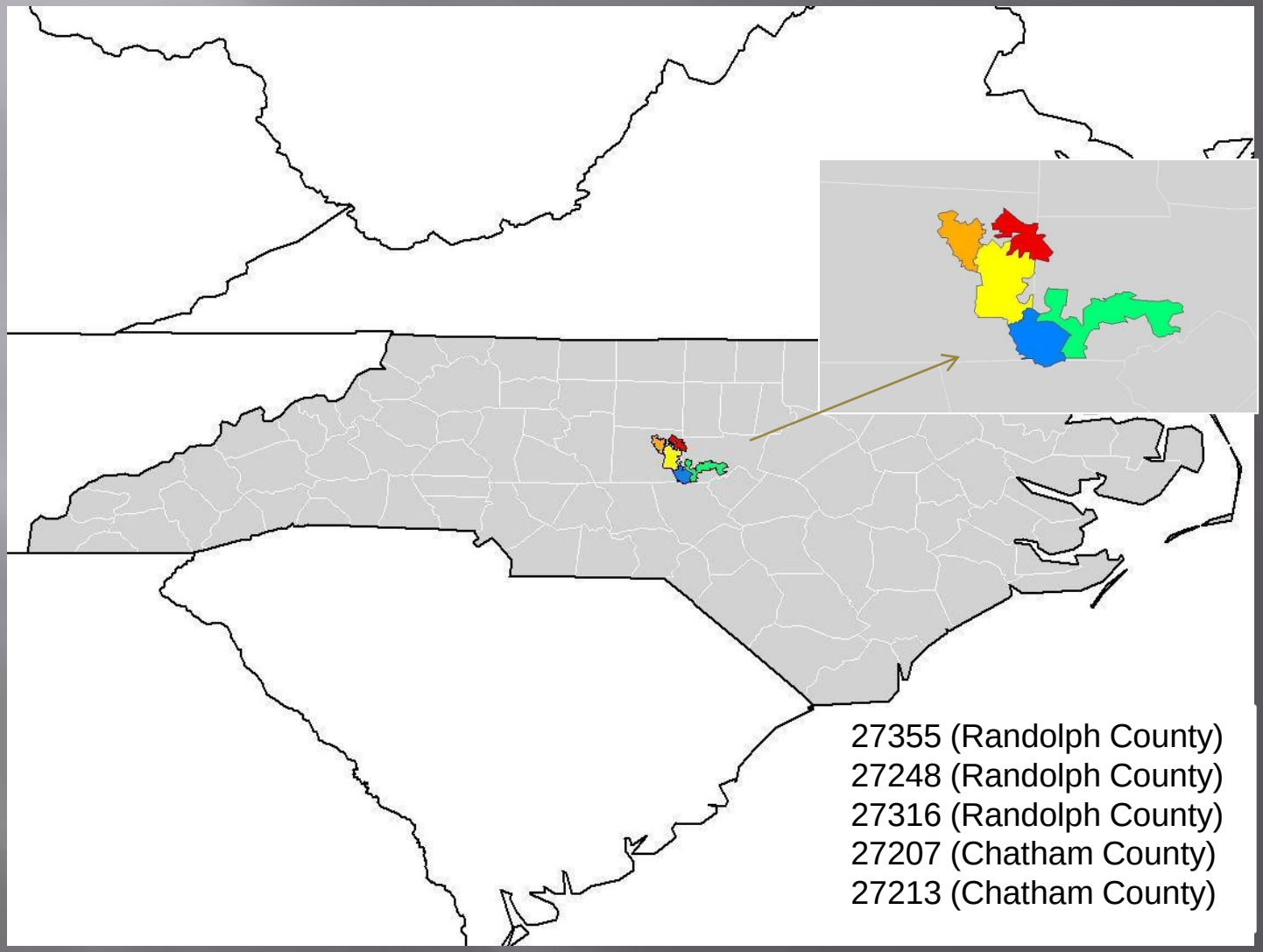


RESULTS

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



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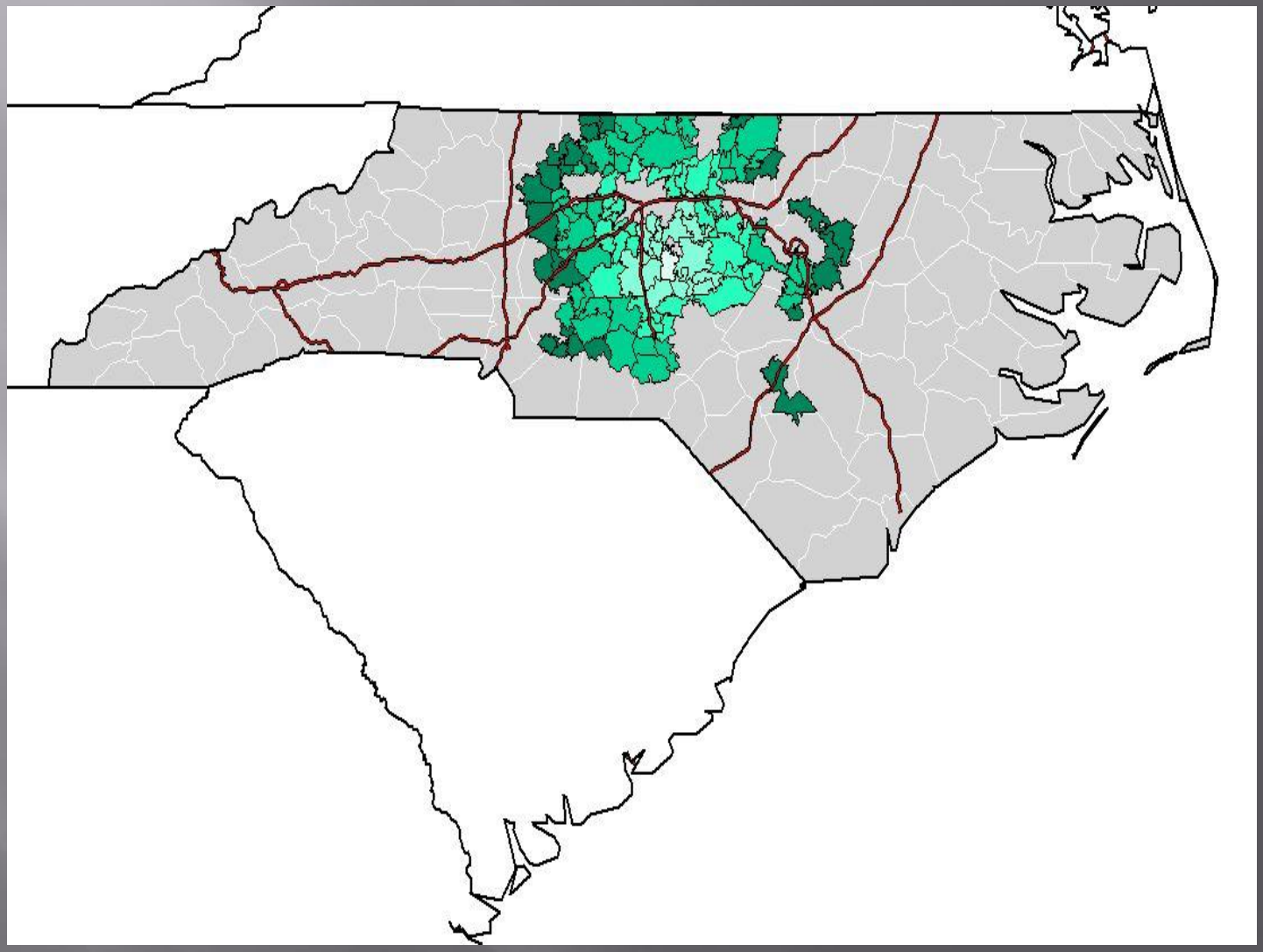

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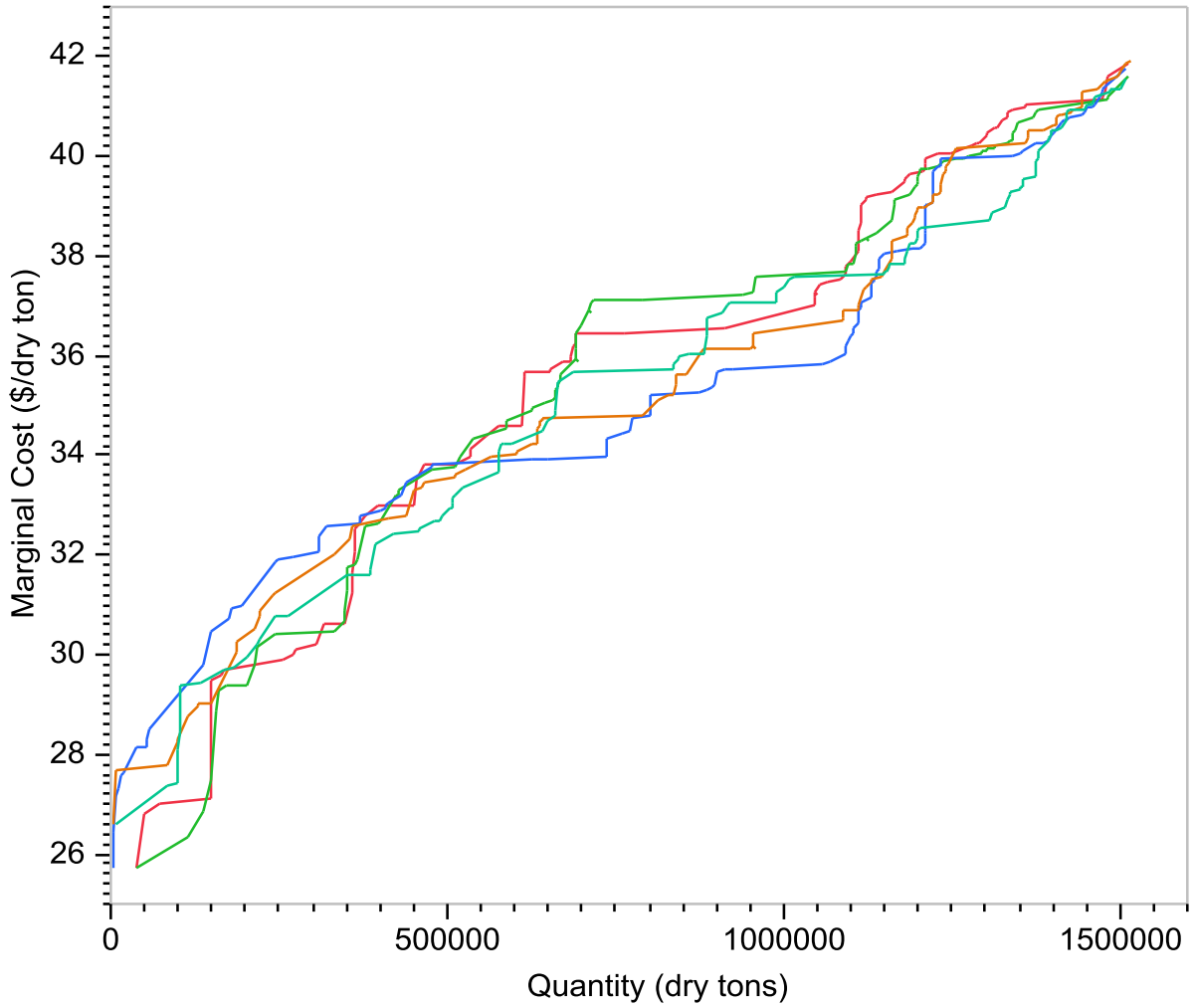

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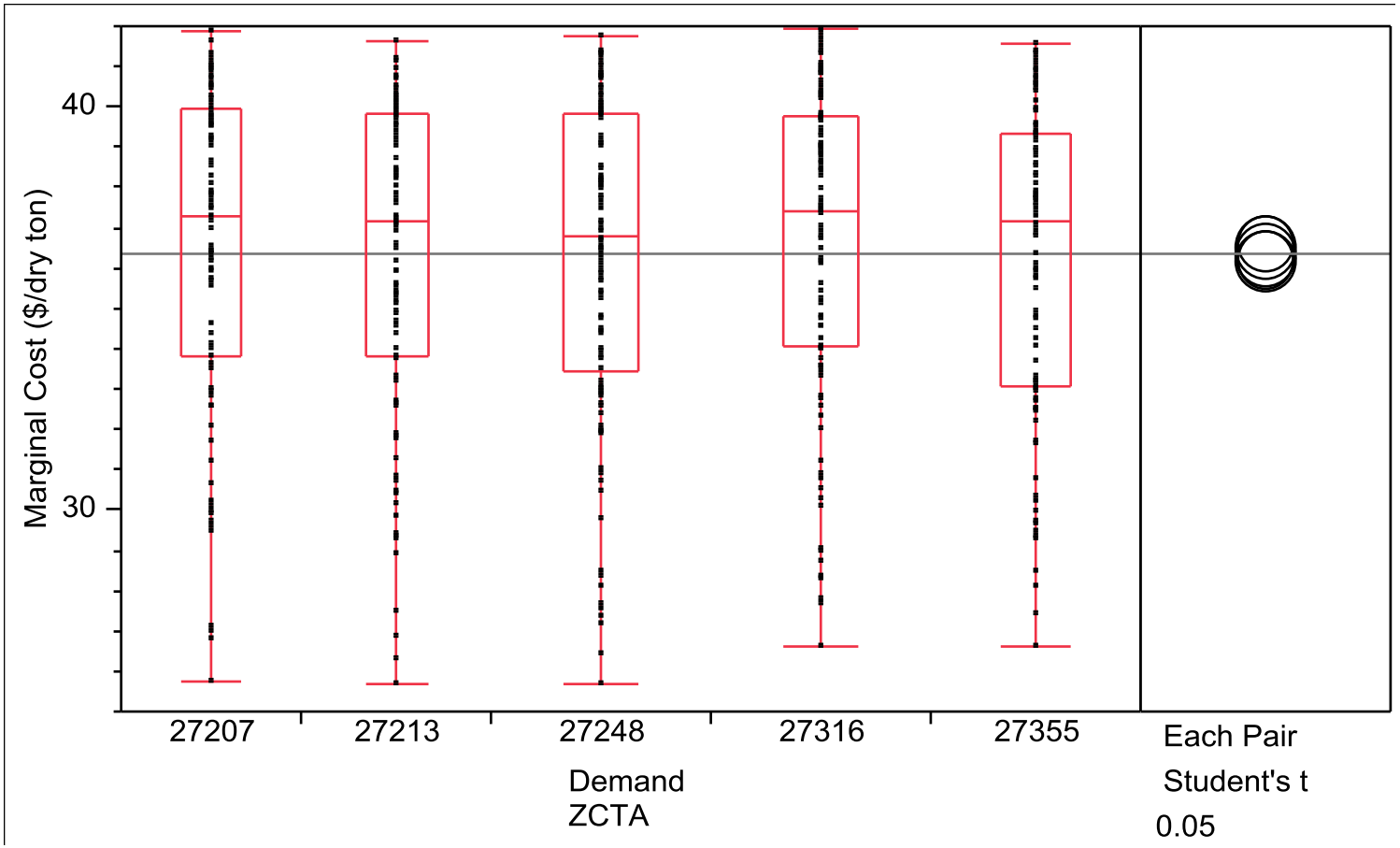

Level		Mean
27316	A	36.608678
27207	A	36.486000
27213	A	36.325192
27248	A	36.203525
27355	A	36.166810

RESULTS

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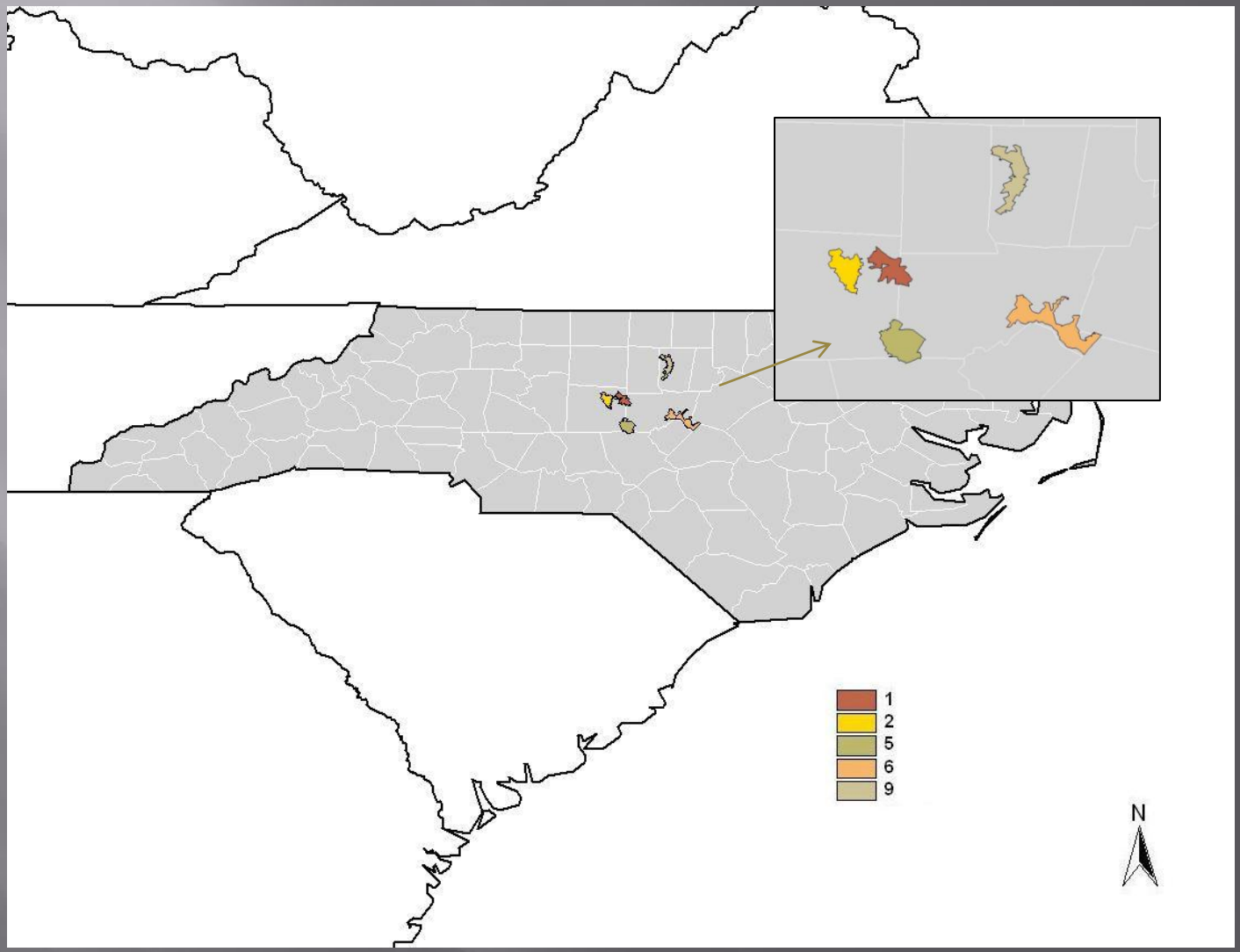
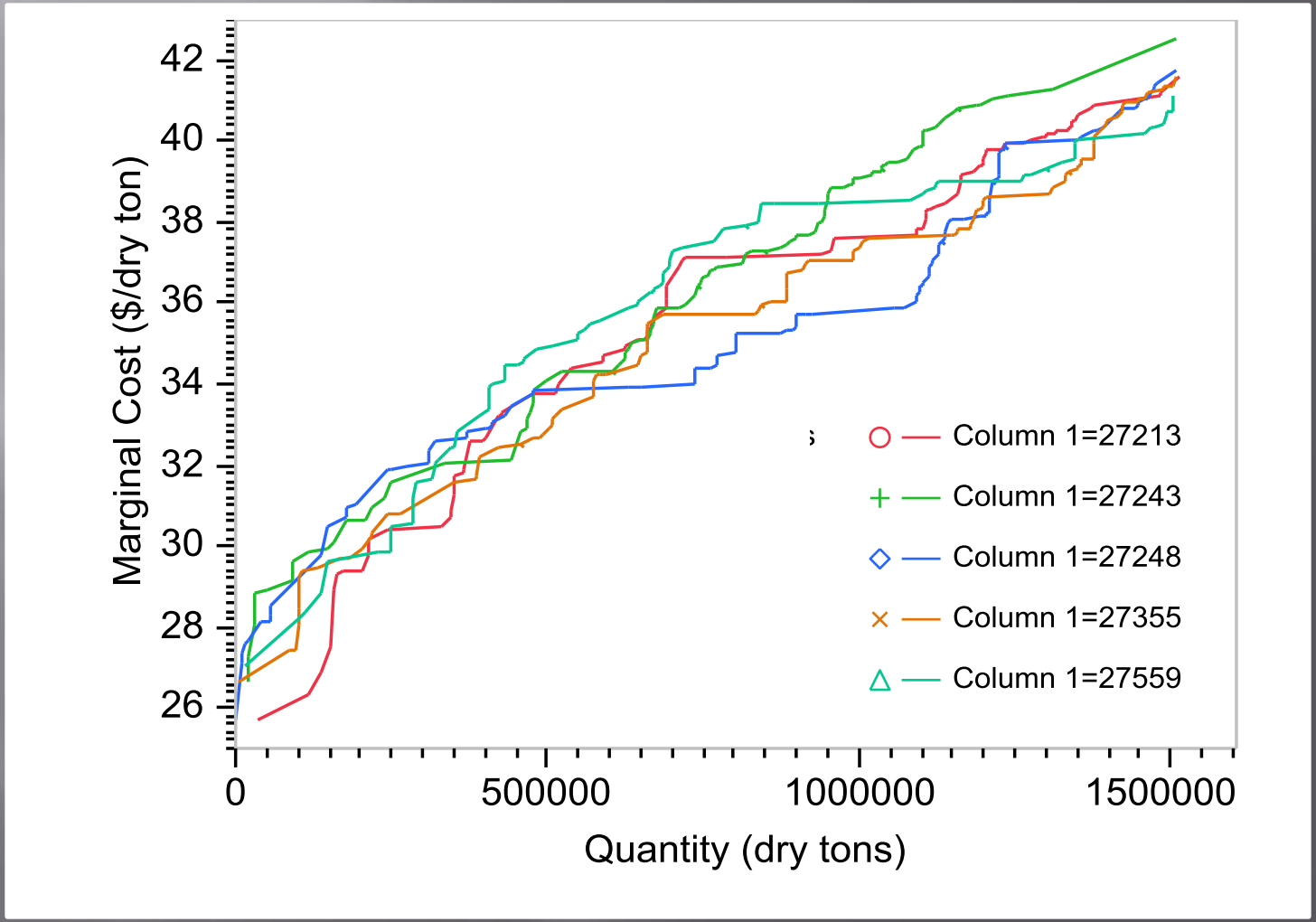


RESULTS

NC – "De-clustered" ZCTAs MC Curves (≤ 1.5 M Dry Tons per Year)



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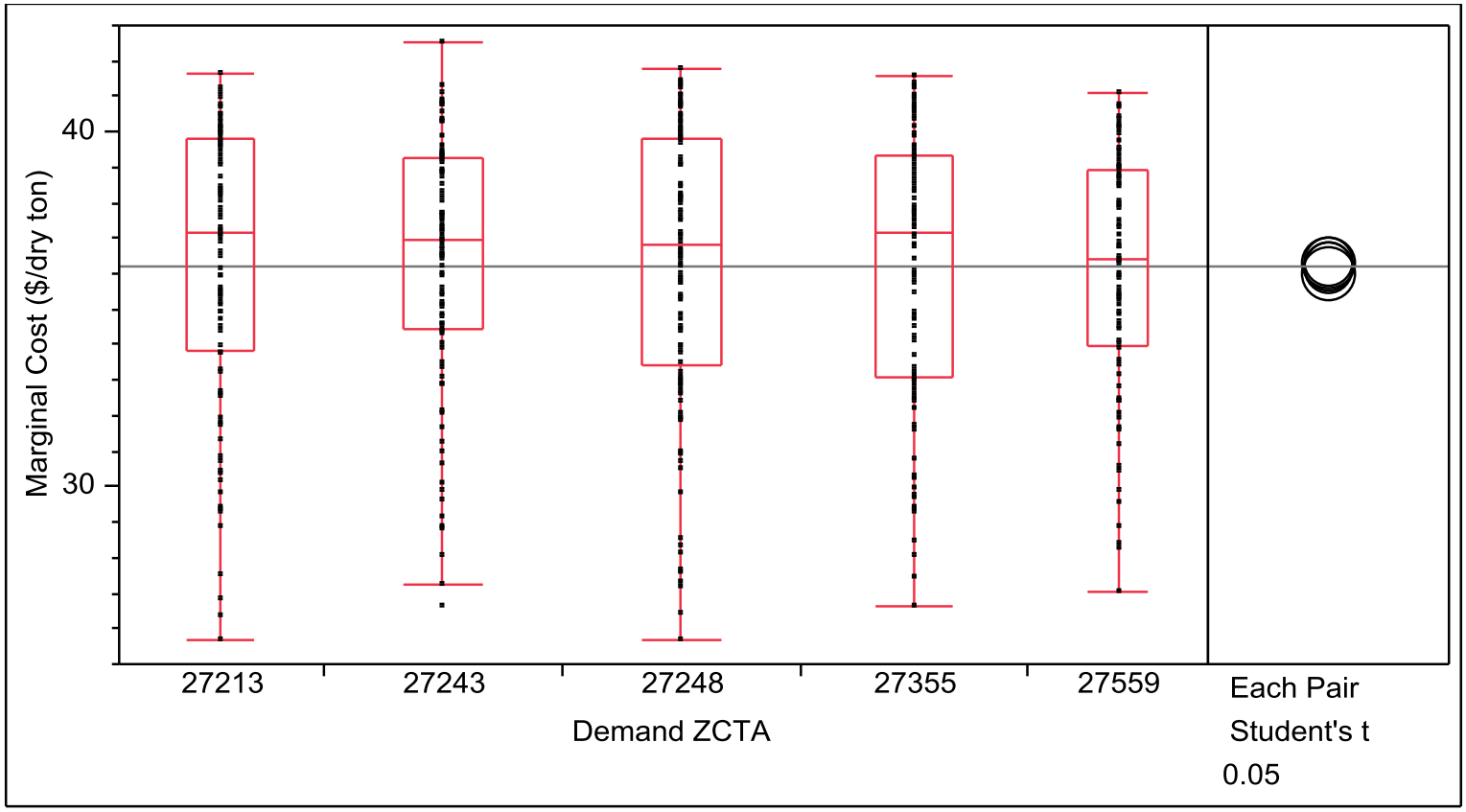
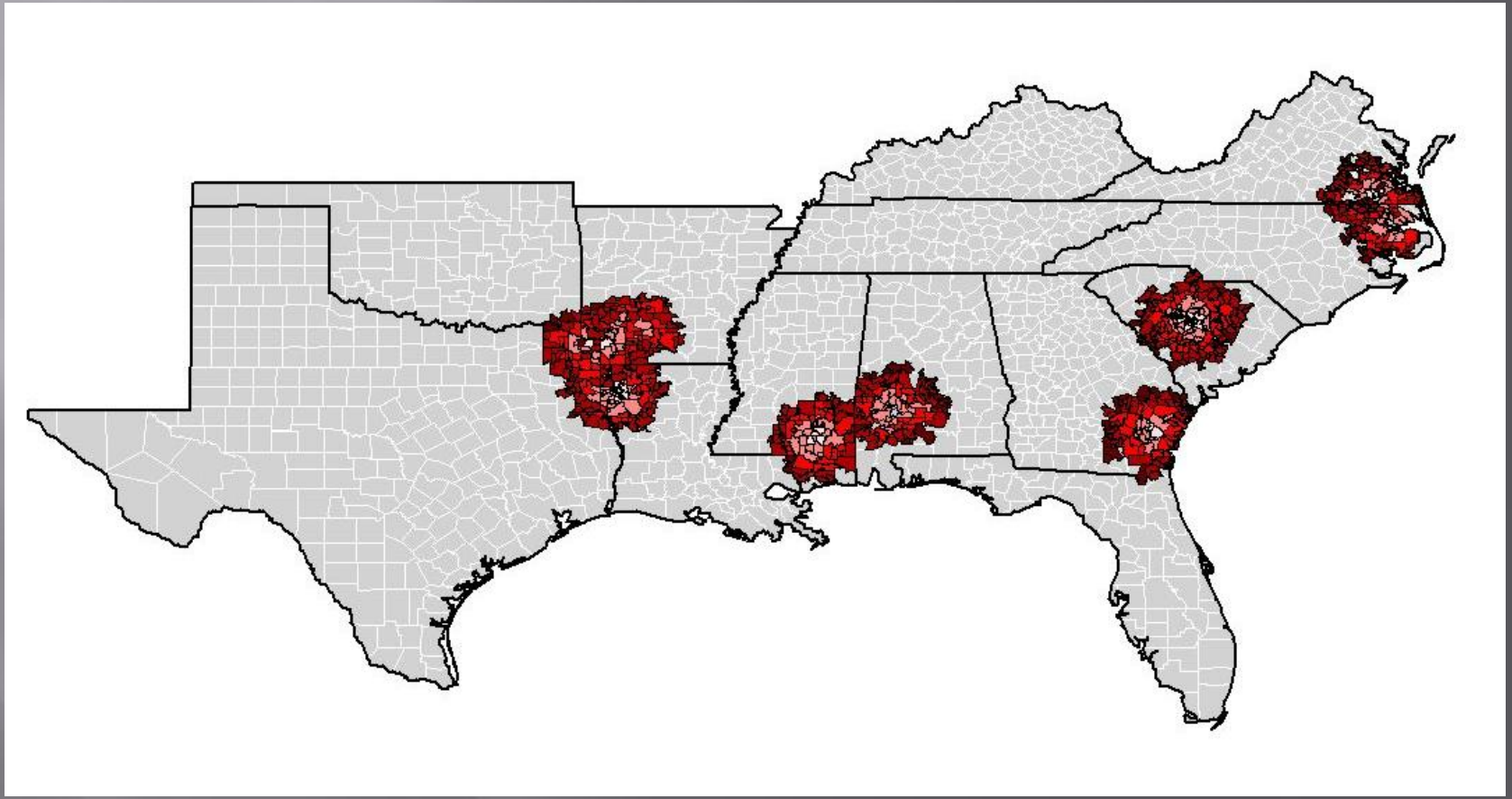


Level	Mean
27243 A	36.363115
27213 A	36.325192
27248 A	36.203525
27355 A	36.166810
27559 A	36.000000

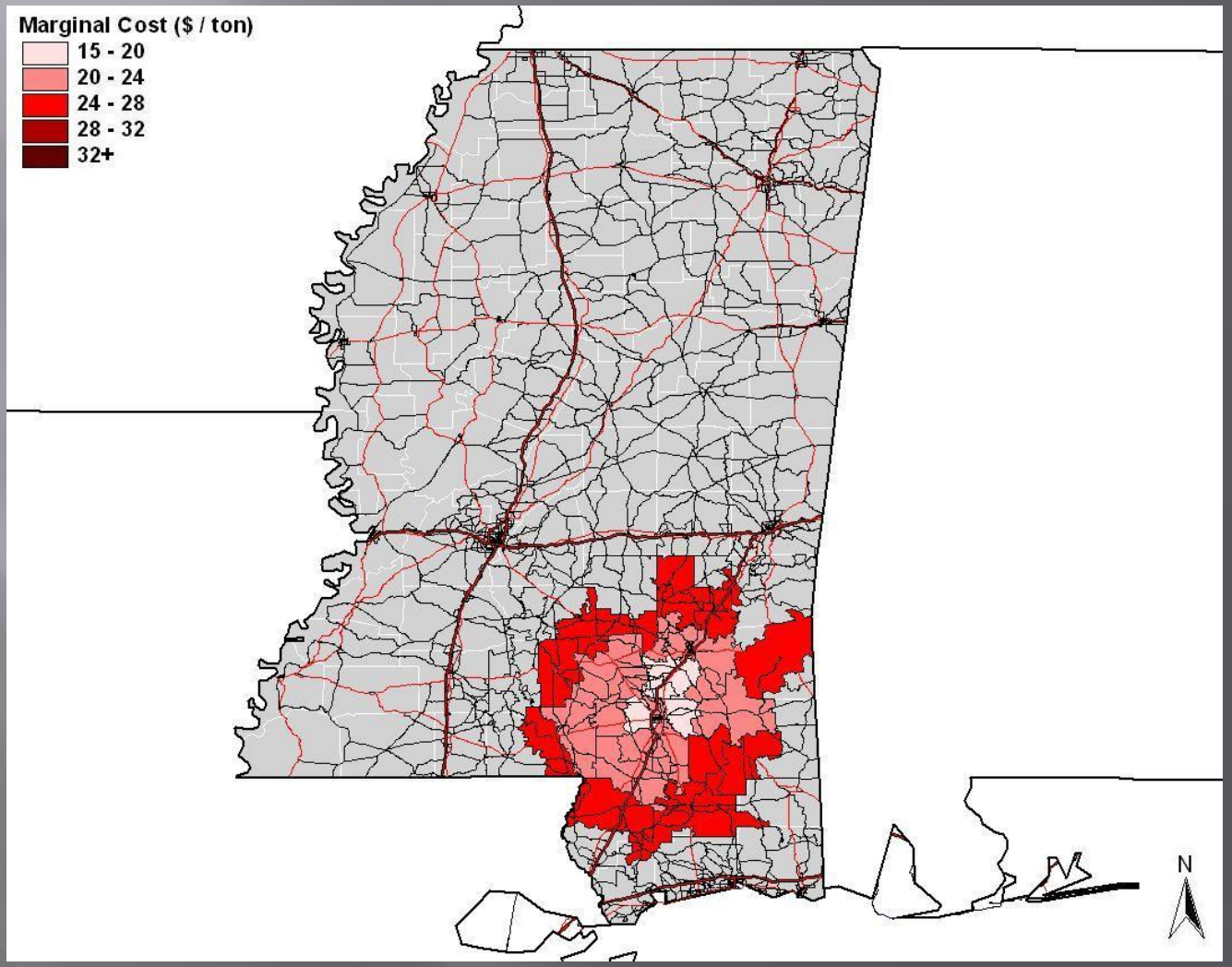
RESULTS

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



RESULTS

MS - Least Cost Logging Residue ("at-landing") Bioshed (≤ 1.5 M Dry Tons per Year)



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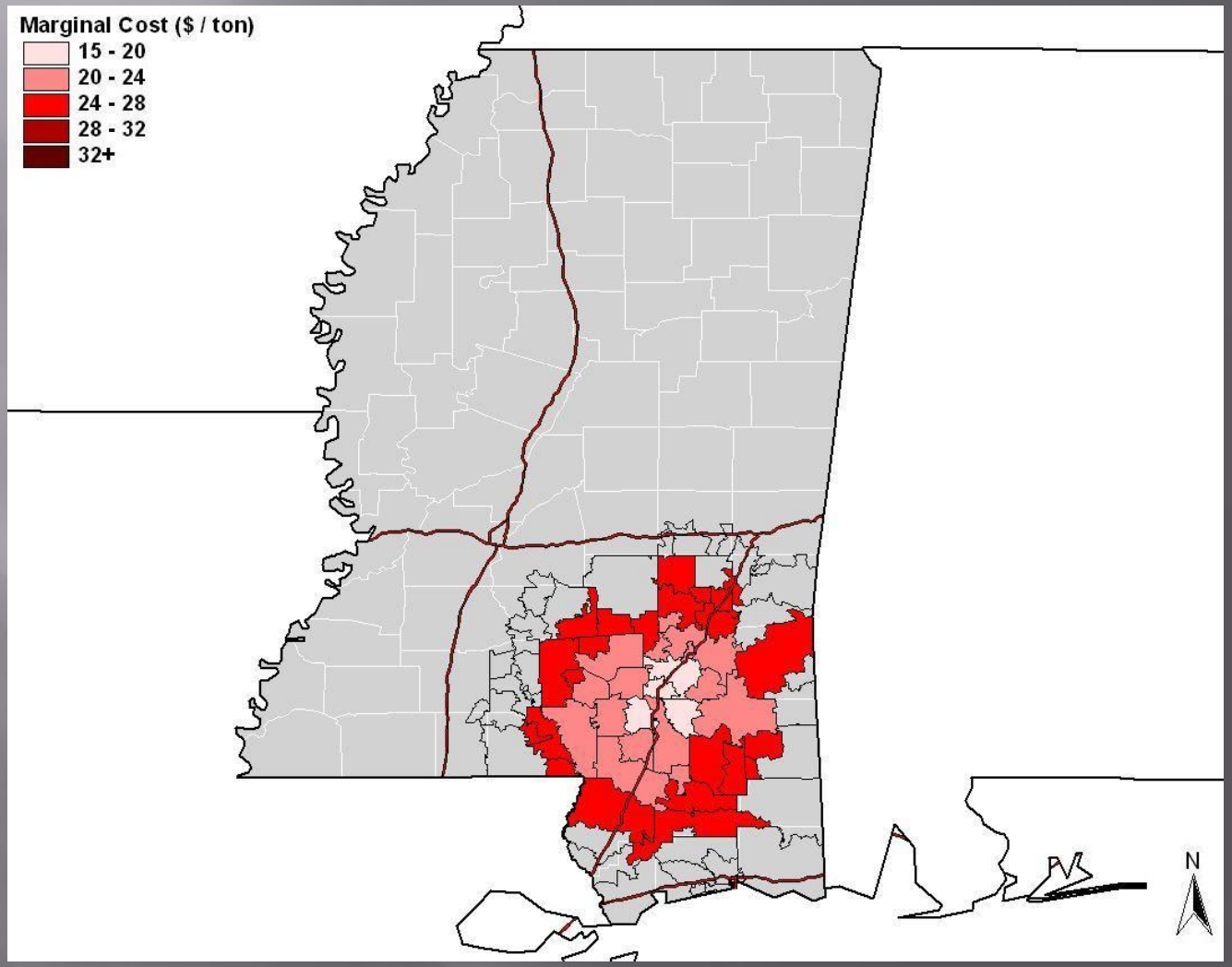

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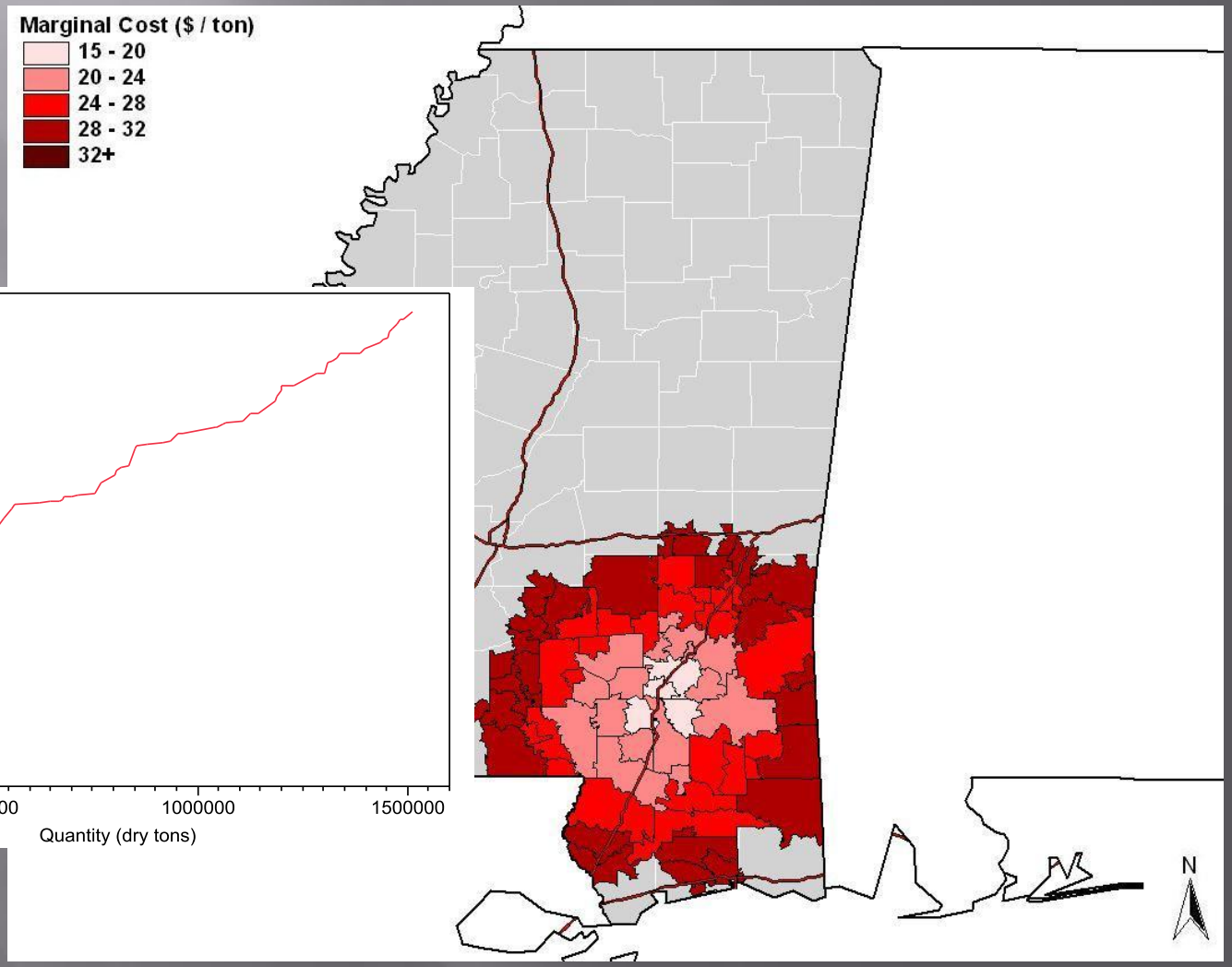

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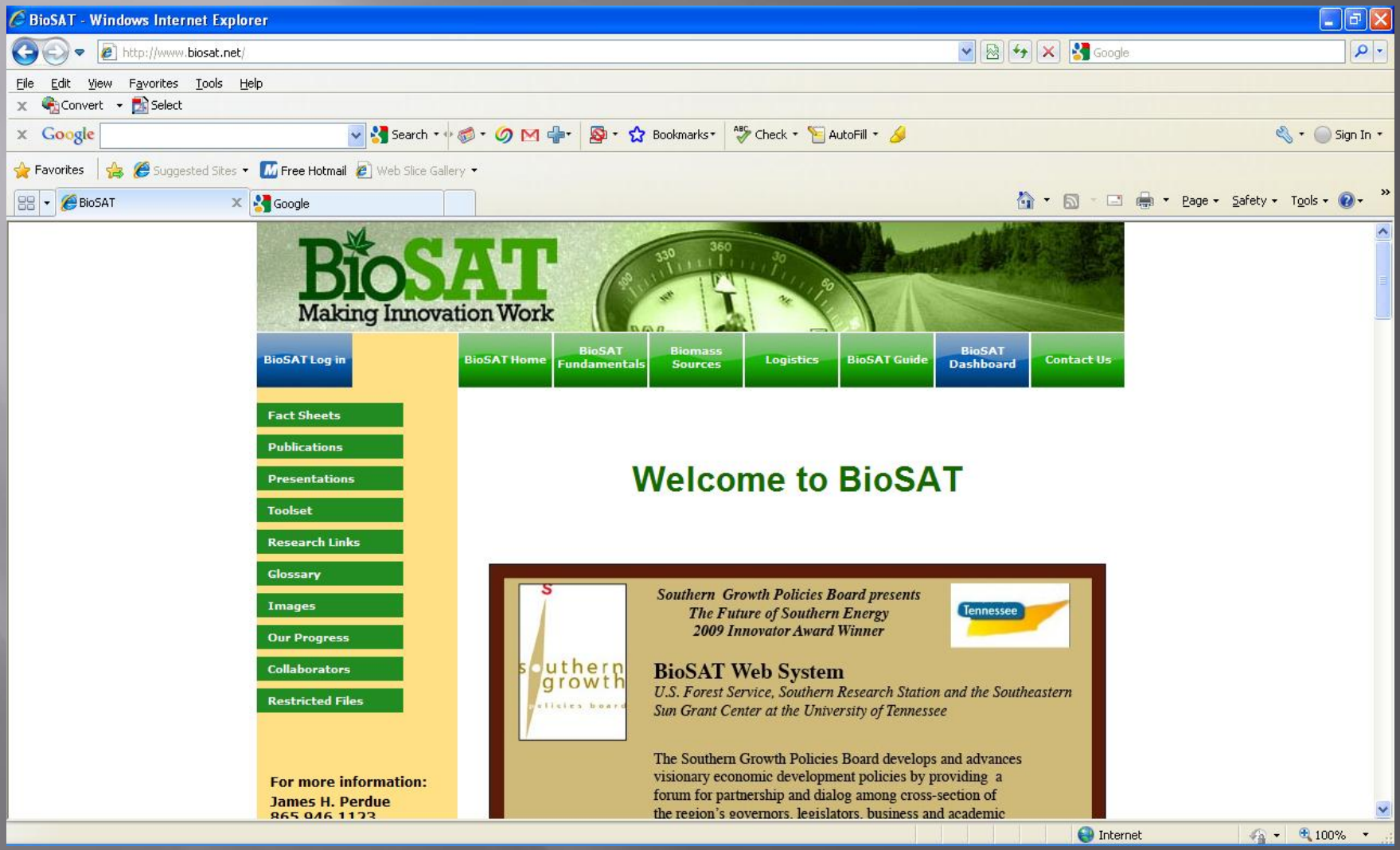
RESULTS



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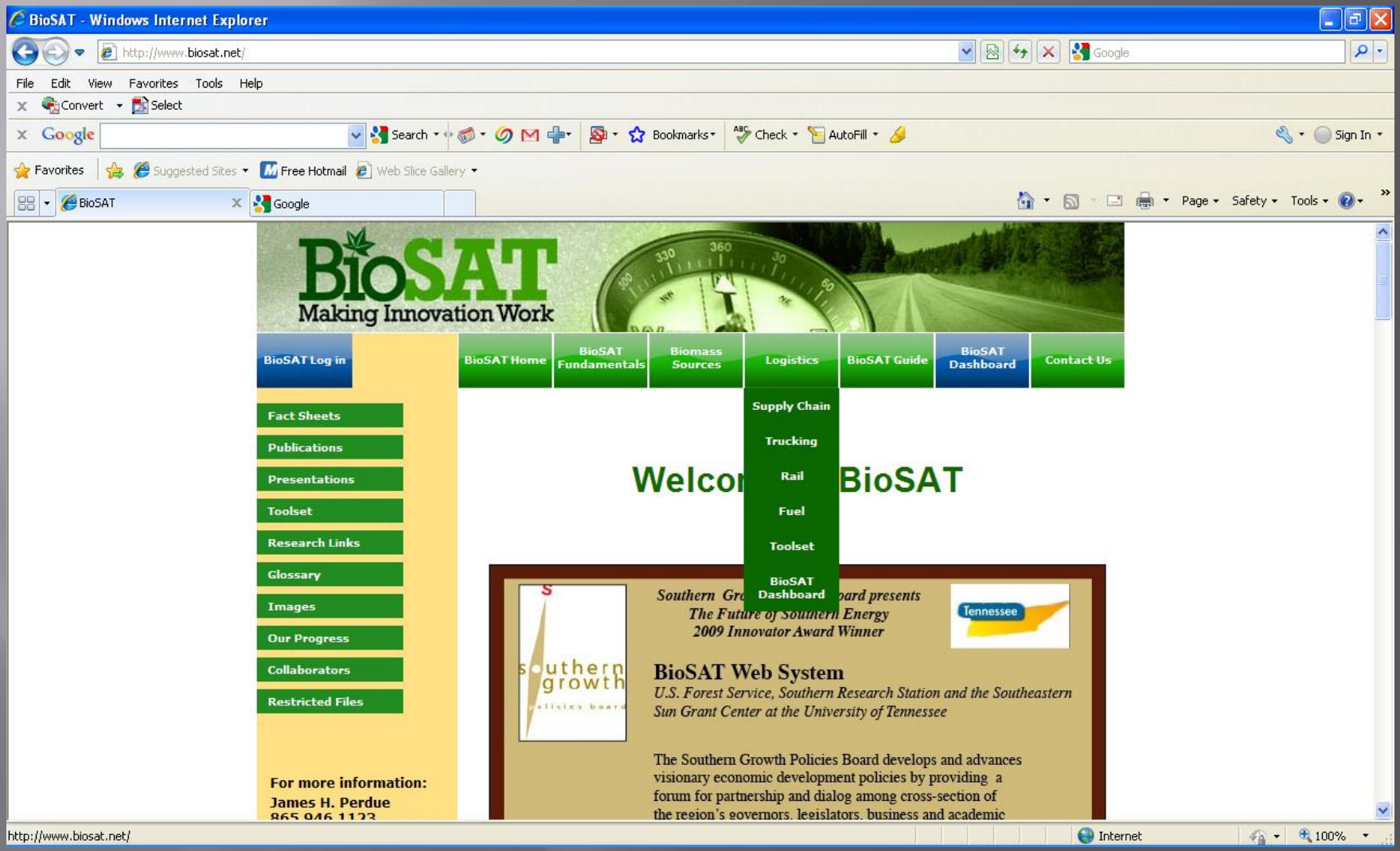

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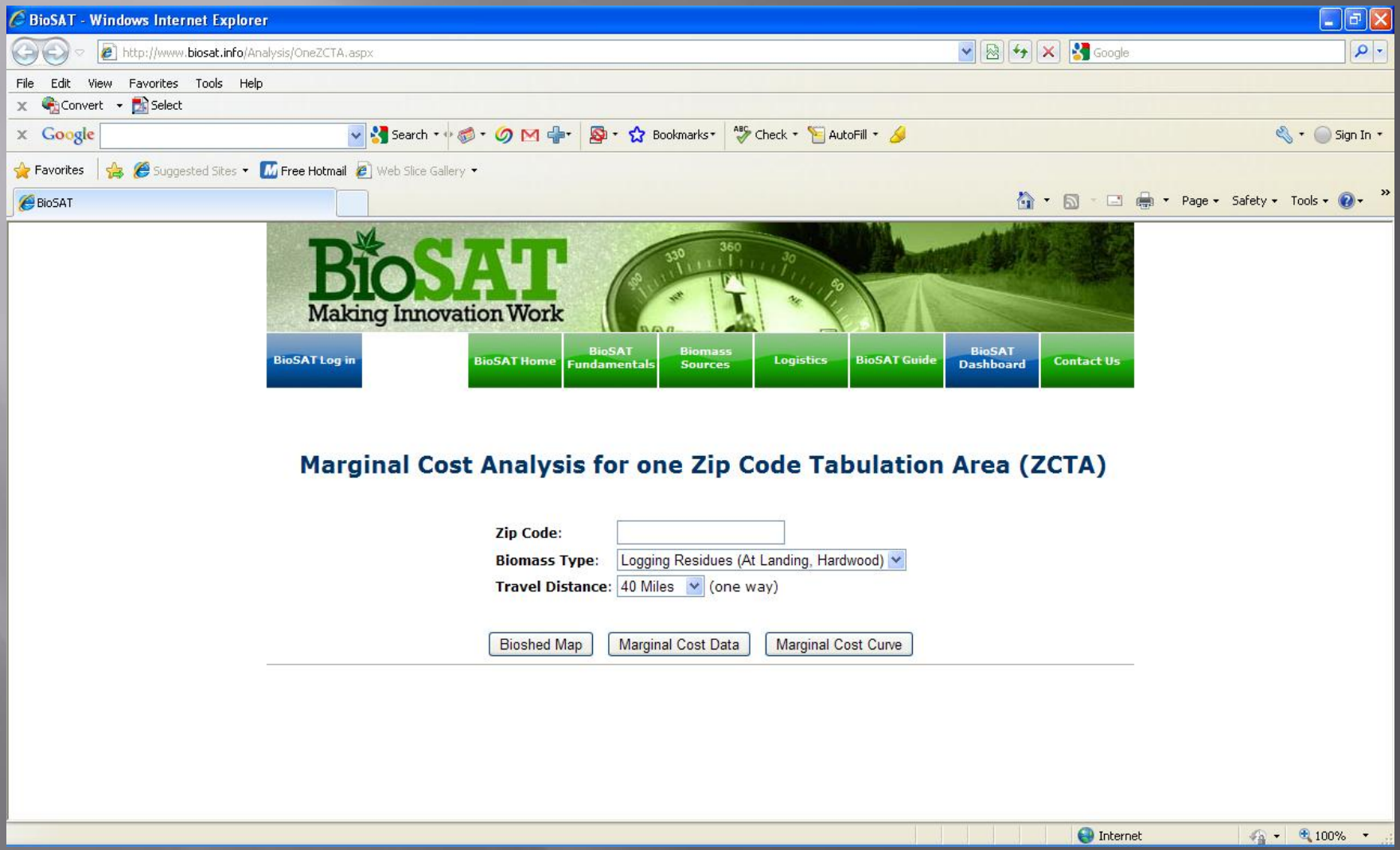

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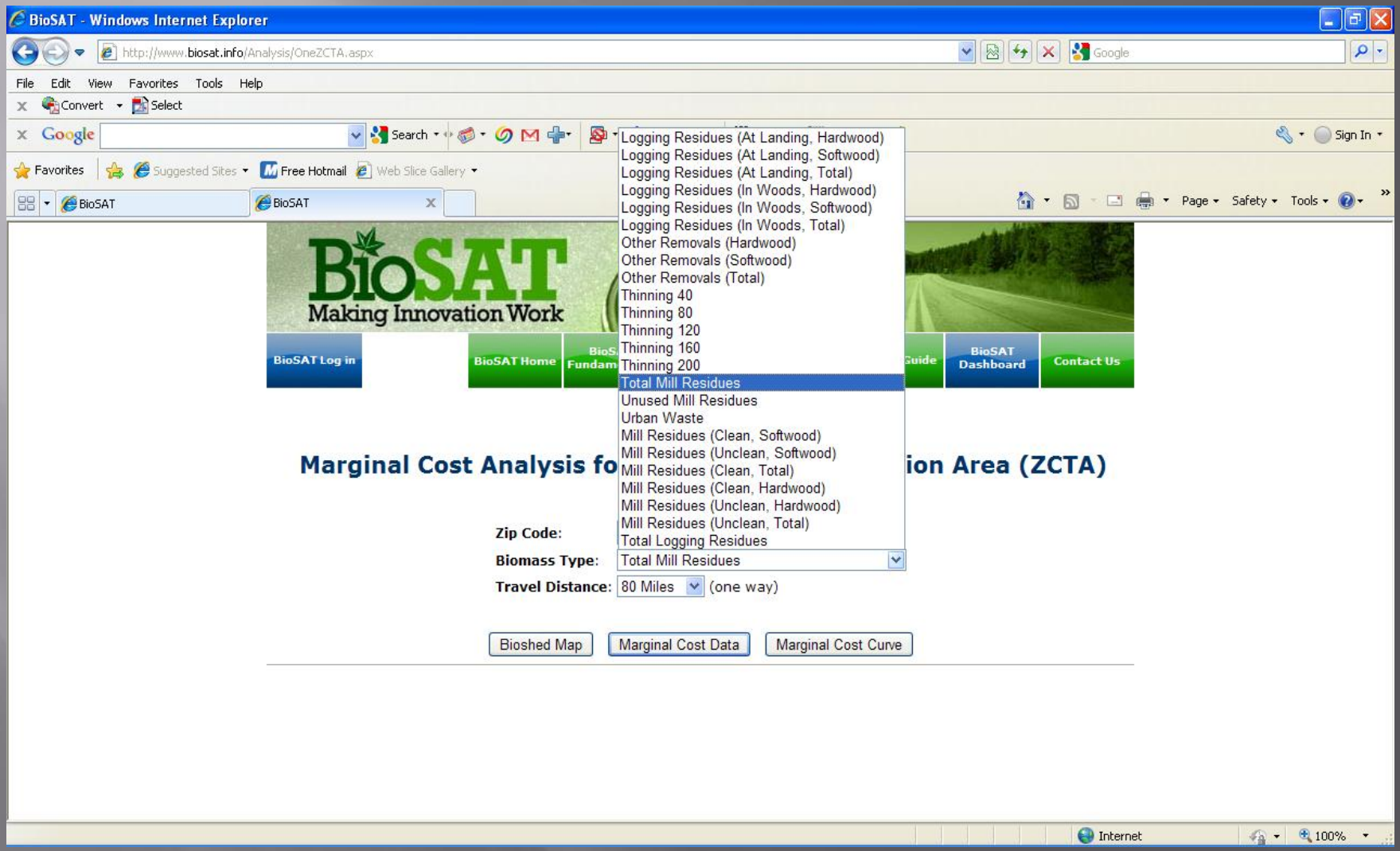

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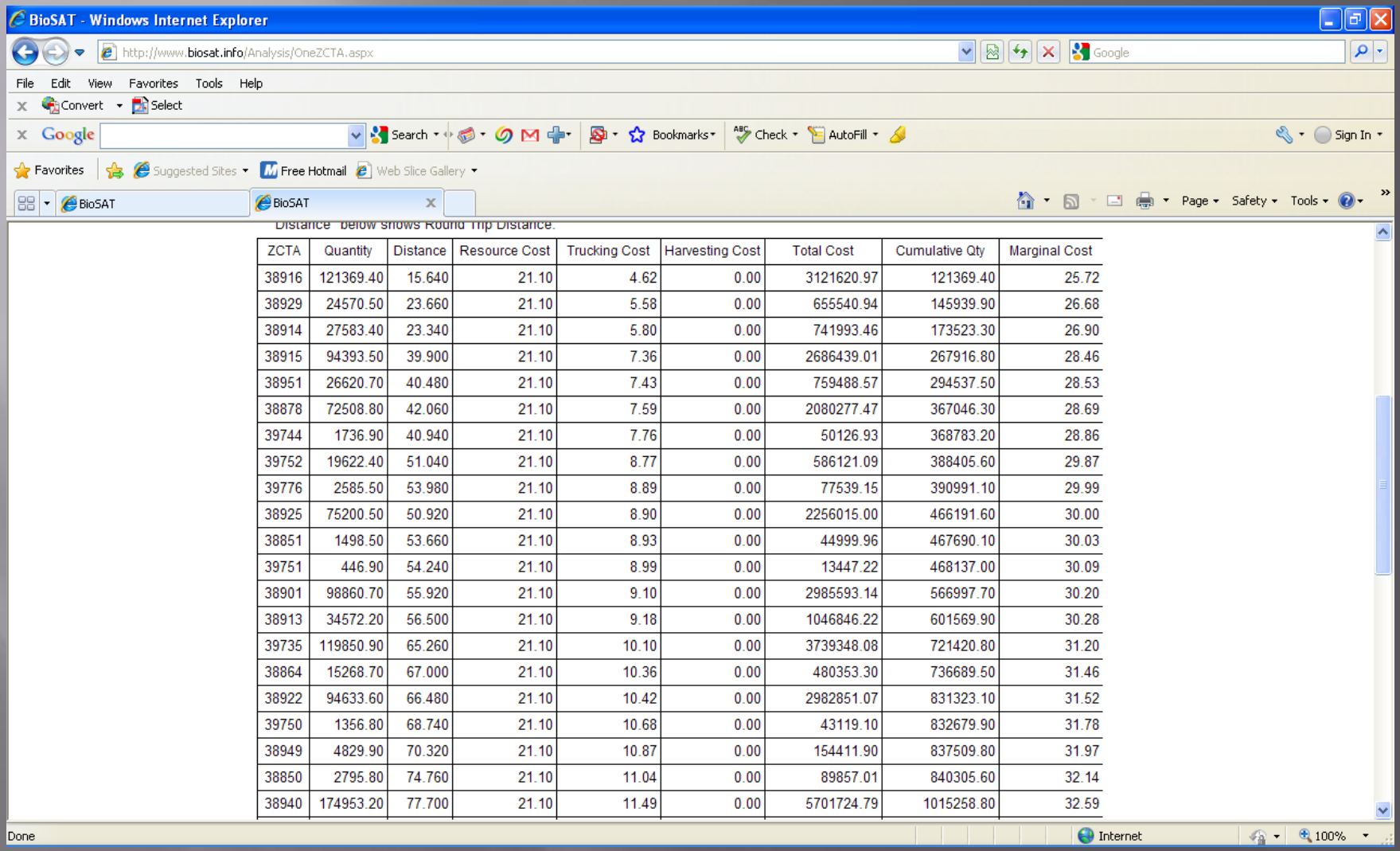

ZCTA	Quantity	Distance	Resource Cost	Trucking Cost	Harvesting Cost	Total Cost	Cumulative Qty	Marginal Cost
38916	121369.40	15.640	21.10	4.62	0.00	3121620.97	121369.40	25.72
38929	24570.50	23.660	21.10	5.58	0.00	655540.94	145939.90	26.68
38914	27583.40	23.340	21.10	5.80	0.00	741993.46	173523.30	26.90
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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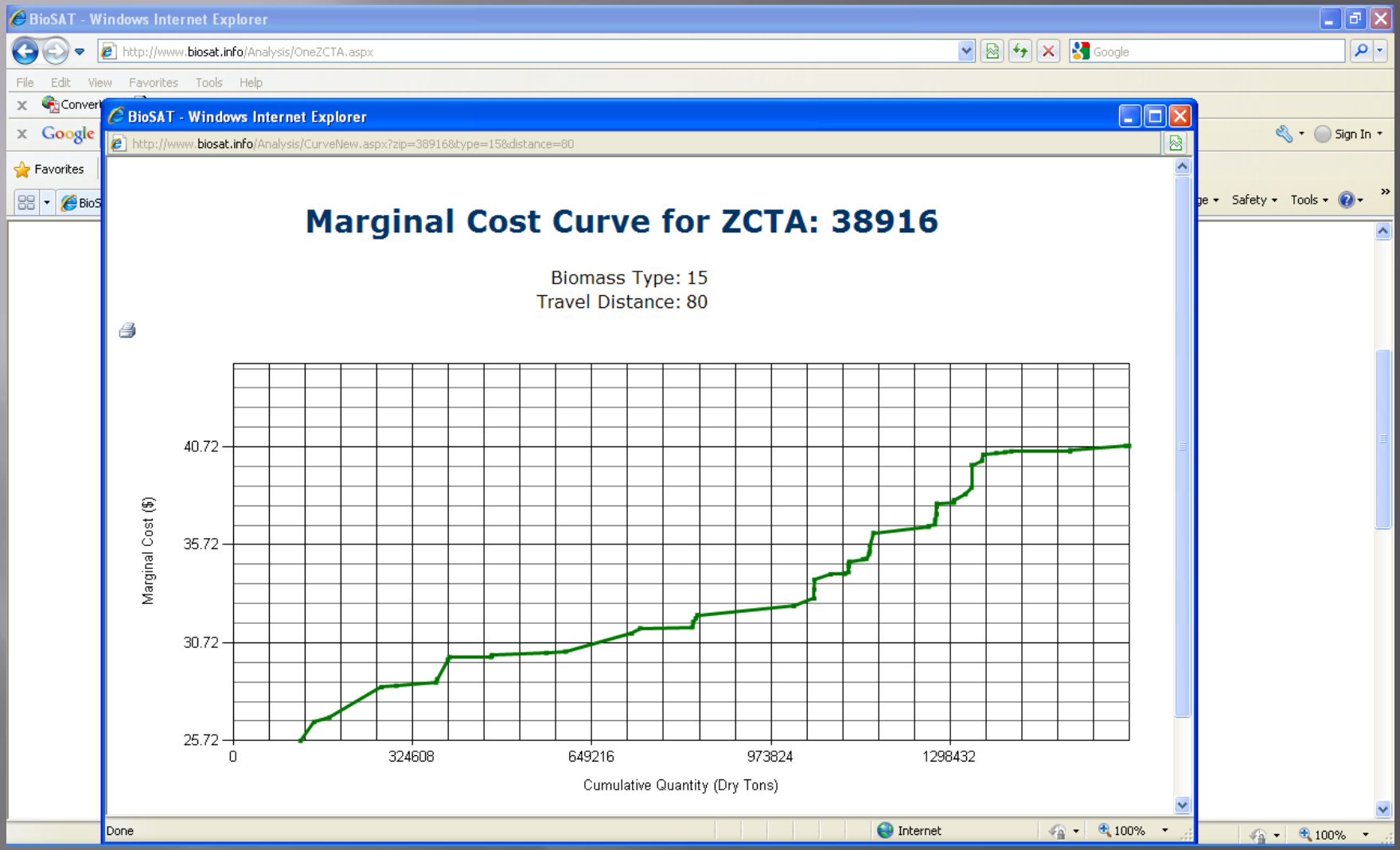
RESULTS



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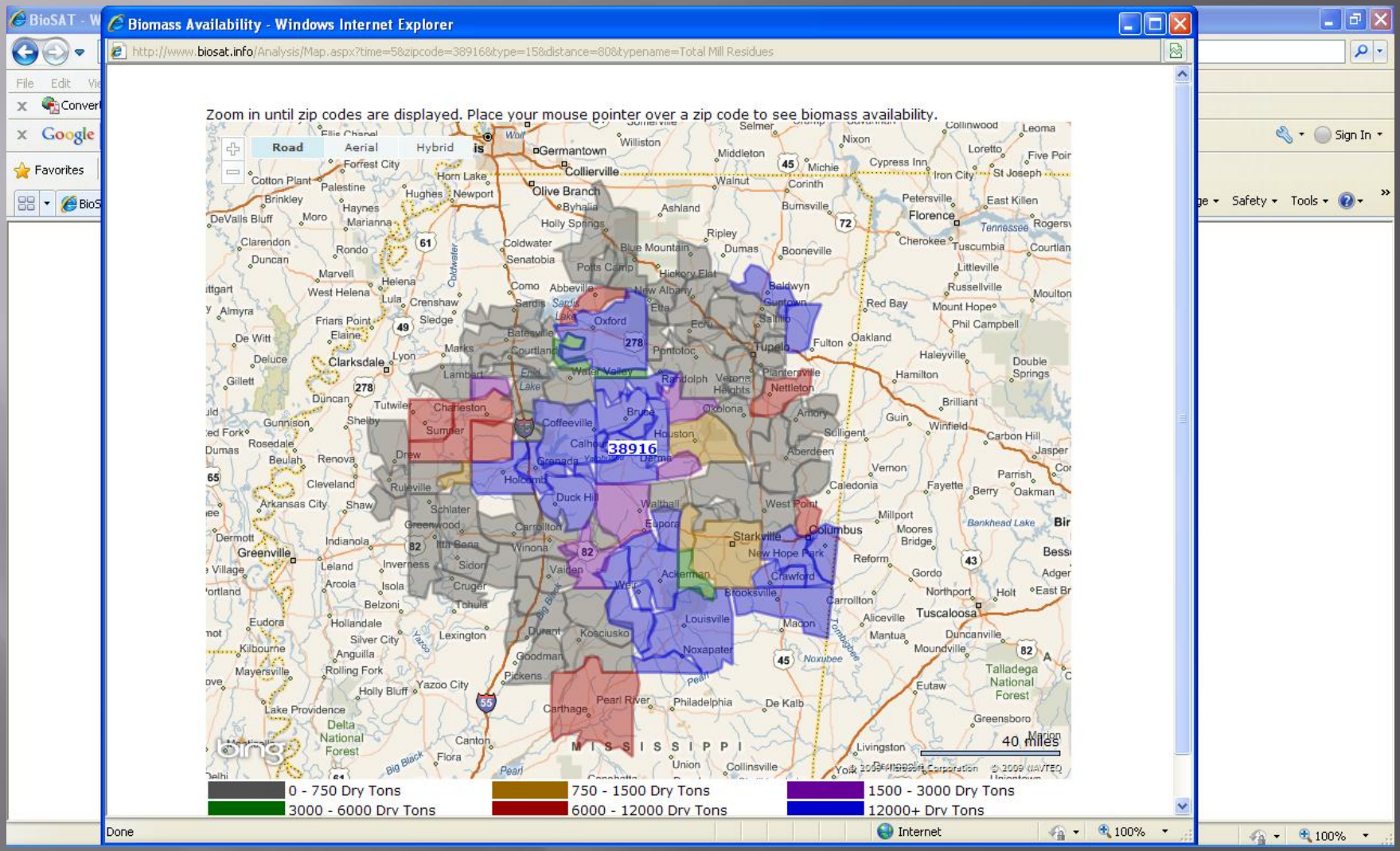

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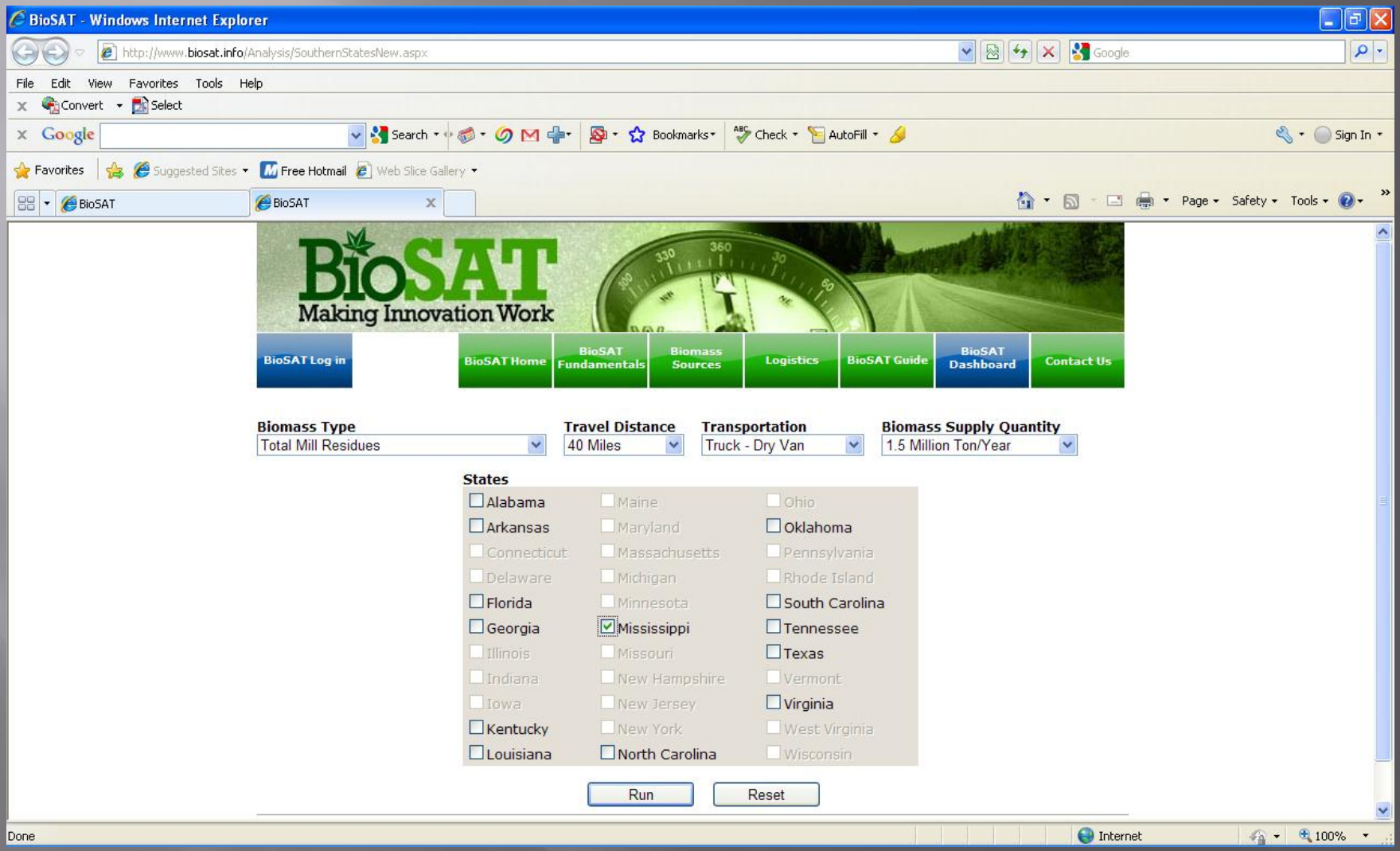

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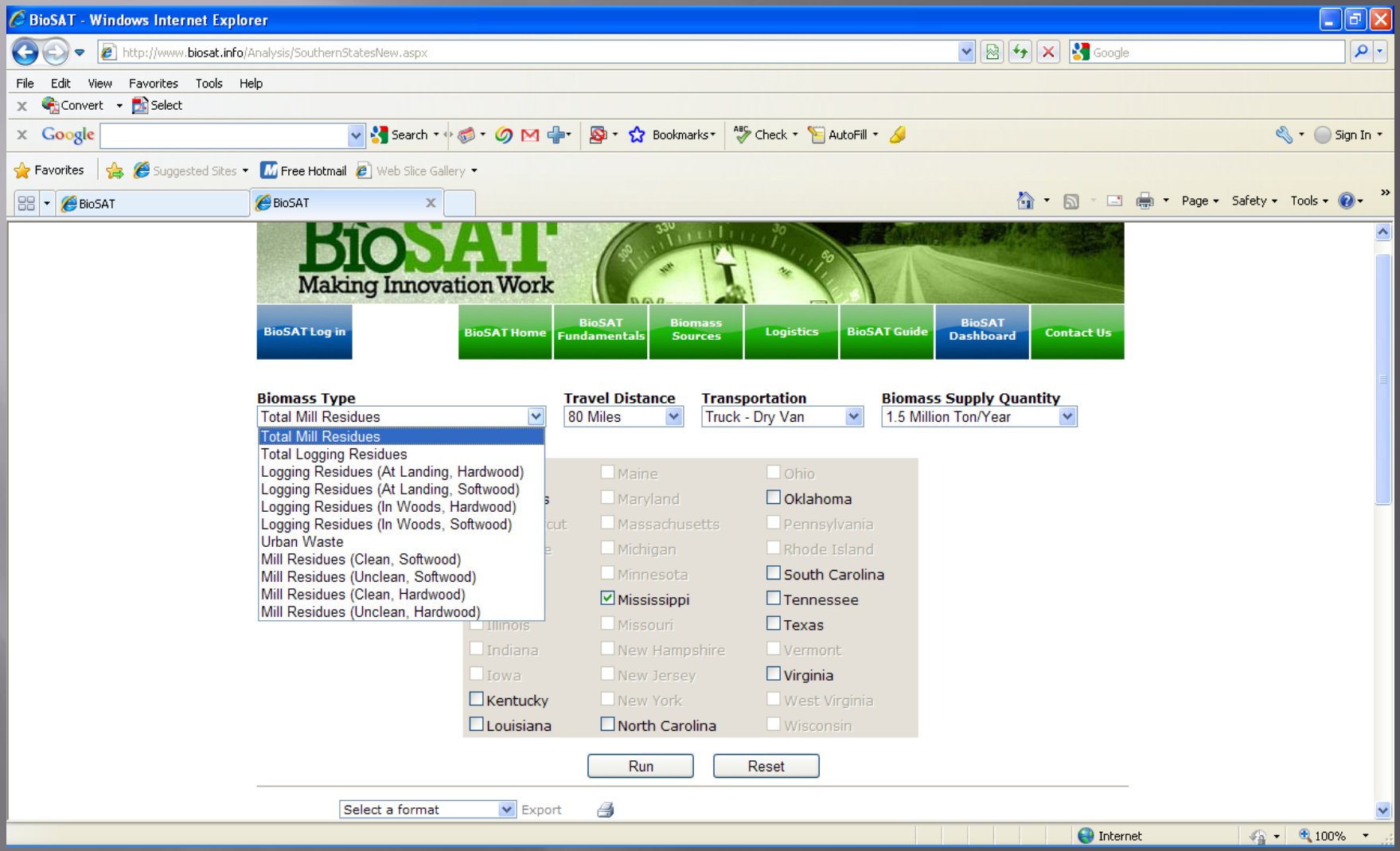

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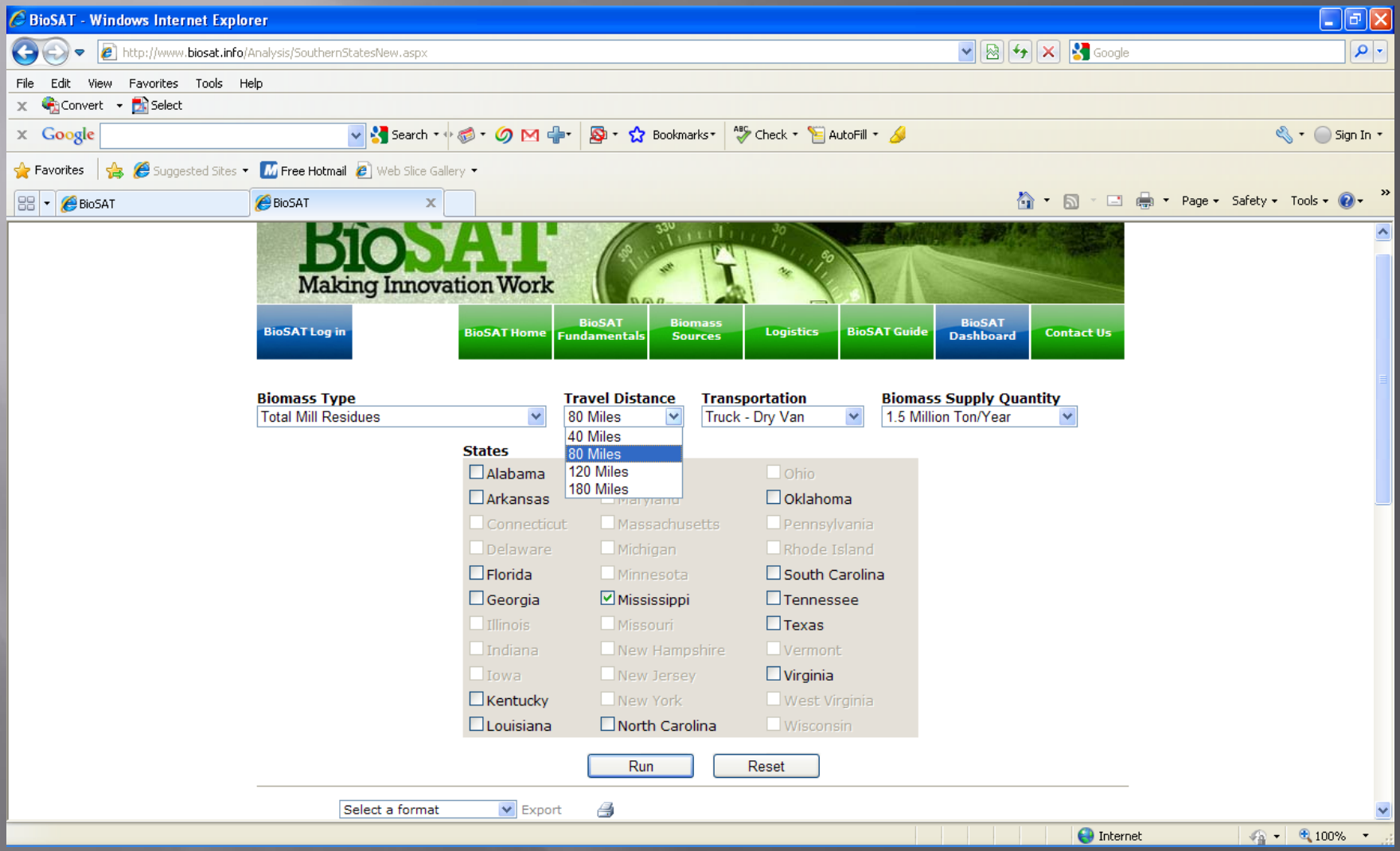

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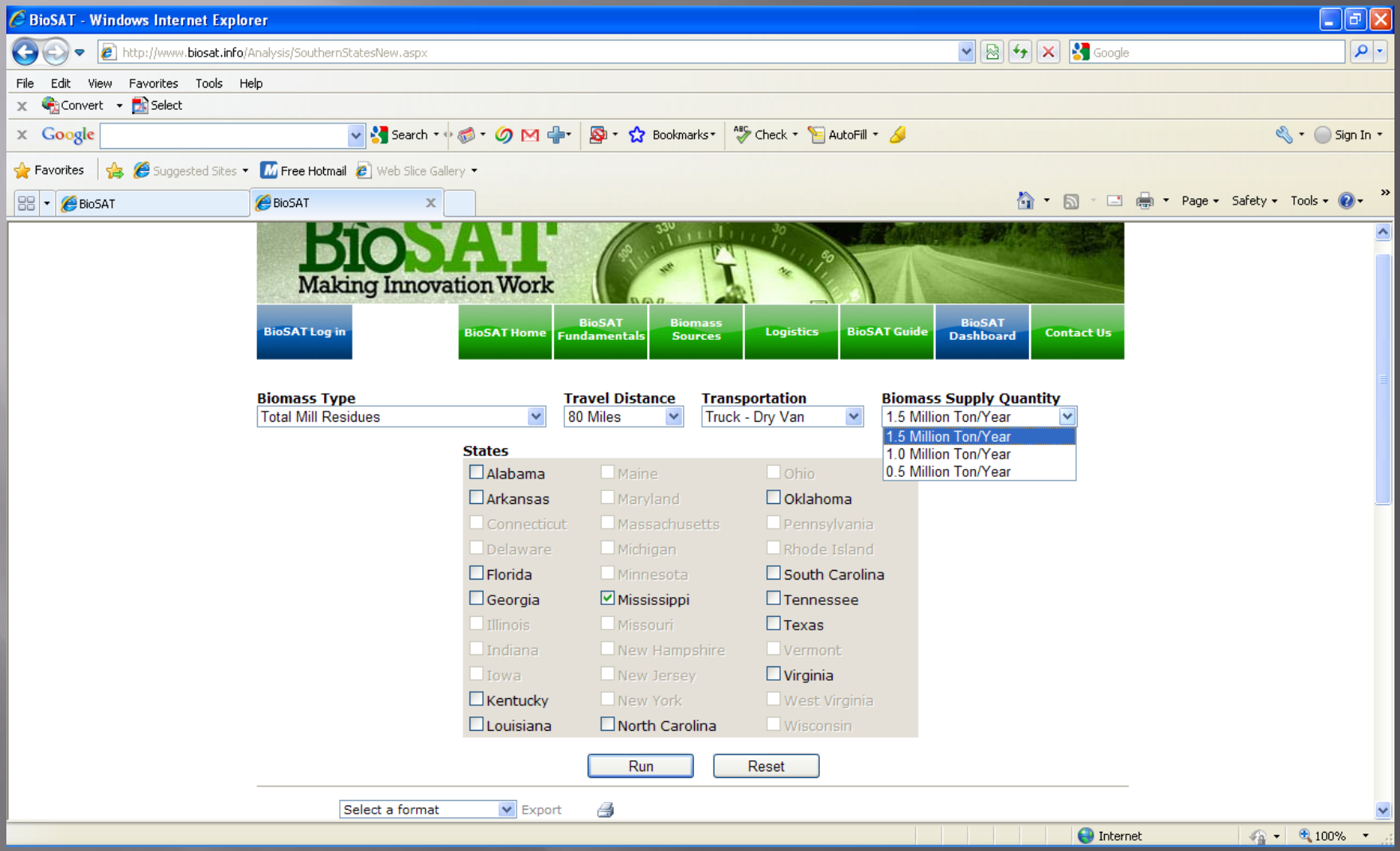
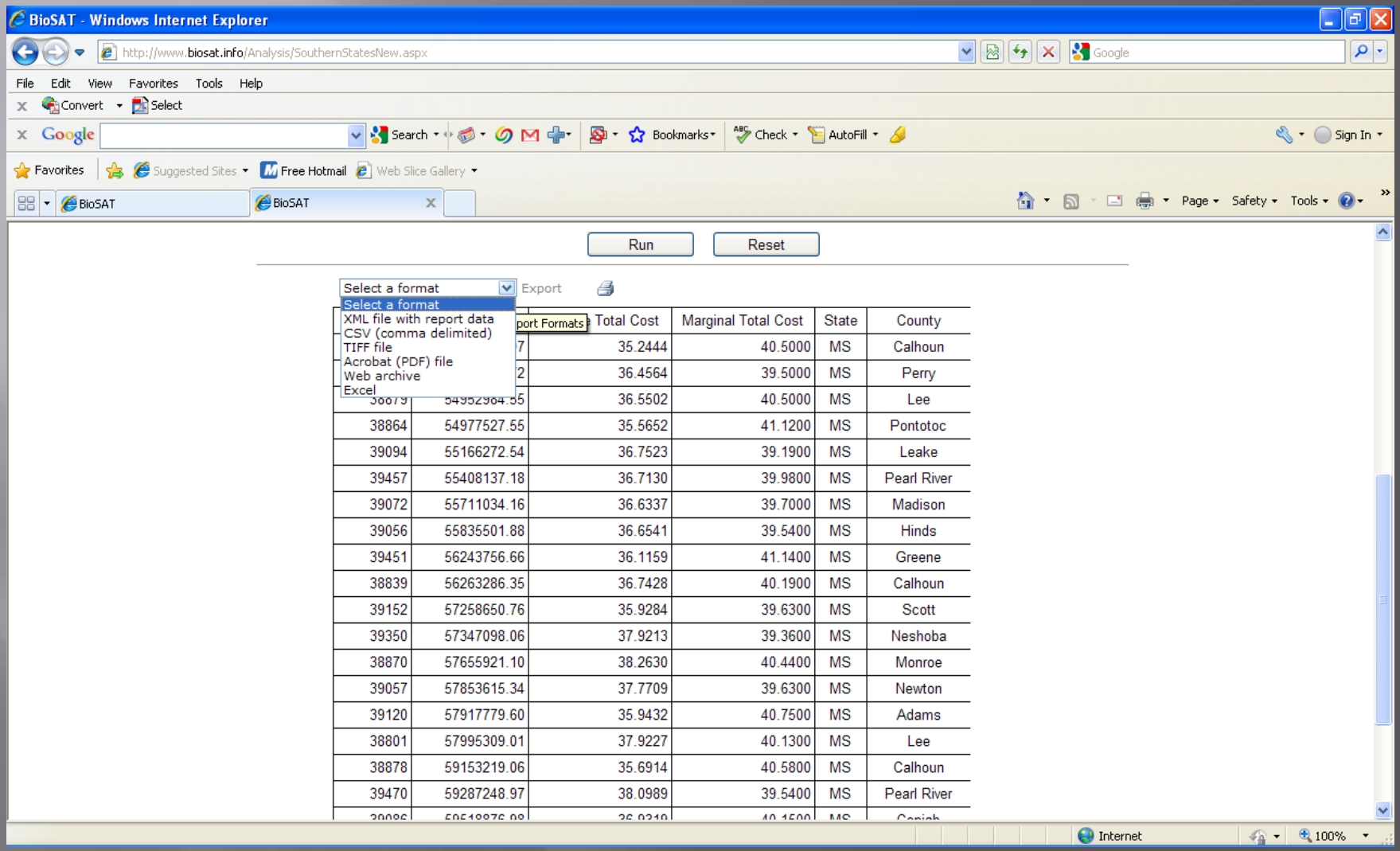


www.BioSAT.net

RESULTS

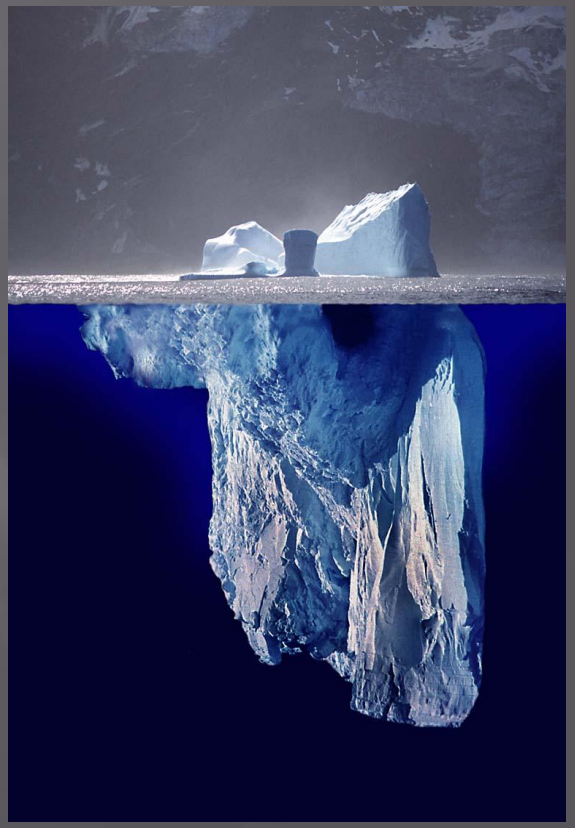


Summary

- 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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QUESTIONS

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