A web-based Biomass Site Assessment Tool

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Southern Research Station
FIA

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Southeastern Sun Grant Center
Center for Renewable Carbon

TAPPI PEERS Conference
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Motivation?

Nominal and Real Oil Prices
(Yearly Average 1946-2009)

Adjusted for inflation to January 2010 prices using CPI (U.S. Bureau of Labor)
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 resources as feedstocks, e.g., biorefineries, biopower, traditional biomass, etc.
Phased Roll-out

**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 (competition, 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 – BT²
   - 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, BT²)

Scope: 33 Eastern United States
Resolution: 25,044 Zip Code Tabulation Areas (ZCTA)
BioSAT Model Logic
“Data Fusion”
Phase I BioSAT Model

"Woody Residues"

USFS FIA

Mill Residues

Growth/Removals

Logging Residues SRTS
"Econometrics"

Resource Costs (TMS)

Harvesting Costs (FRCS)

ZCTA Allocation (GIS)

Select Demand Point (or State), Indicate Quantity Demanded

Bio-basin Road Networks (MapPoint 2006)

Truck Cost Model

Estimate Total Costs, ATC, MC

"Ag Residues"

USDA NASS

Harvesting Costs (Literature)
BioSAT – “Feedstocks”

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

“Ag Residues”
- Barley Straw
- Corn Stover
- Oat Straw
- Sorghum Straw
- Wheat Straw (Winter)
- Wheat Straw (All)
BioSAT – “Biobasins”

Aggregate of disjointed ZCTAs

- 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.

- 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 \( \tau \)
BioSAT – “Supply Biobasins”

- 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.

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- \( N \) - radius of curvature in the prime normal to \( M \) at \( \tau \)
BioSAT – “Road Network in Biobasin”

- For each potential neighboring supply ZCTA, the **driving time** (variable cost) and **distance** (fixed cost) 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.

- ZCTAs beyond 5-hour one-way haul are eliminated (assume **day-cab trucks with legal driving maximum of 11 hours**).
BioSAT – “Resource Costs”

South (Timber Mart South www.tmart-south.com)
- Mill Residues
  - Clean/Unclean
- Pulpwood
  - Softwood/Hardwood
- Sawtimber
  - Softwood/Hardwood
- Biomass

North (Timber Mart North and State Reporting Services)
- Timber Mart North
  http://www.prentissandcarlisle.com/content/4044/Timber_Mart_North/
- 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.
BioSAT – “Trucking Costs”

- Trucking Cost Model is an enhancement of Berwack and Farooq 2003 (enhancements to variable and fixed cost calculation to include trailers such as dry van, live bottom van, longwood log trailer, shortwood log trailer)

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

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%
BioSAT – “Trucking Costs”

Fixed Cost = \( \sum (\text{Equipment Cost, State Tax, State License Fee, Overhead Cost, Insurance Premium}) / a \times d \)

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
- \( k \) = empty truck miles/gallon
- \( m \) = miles/tire
- \( w \) = wage rate
- \( c \) = time loaded (%)
- \( i \) = labor time (hours)
- \( n \) = number of tires
- \( v \) = gross vehicle weight
- \( r \) = tire cost
BiOSAT – “Harvesting Costs”

- Logging Residue Costs (at-landing, in-woods)
- Fuel Reduction Cost Simulator (FRCS) – BT² (Dennis Dykstra)
- Merchantable Wood (pulpwood, sawtimber)
- Auburn Harvest Analyzer (AHA) (Enhancement by Dale Greene)

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<tr>
<th>Pine Plantation</th>
<th>Wheel F/FGrapple Skidders</th>
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BioSAT – “Harvesting Costs”

- Agricultural Residue Costs – (Barley Straw, Corn Stover, Oat Straw, Sorghum Straw, Wheat Straw [Winter], Wheat Straw [All])

**Literature:**

Wortmann C. Harvesting crop residue: what’s it worth? Crop Watch, University of Nebraska-Lincoln Extension, Institute of Agriculture and Natural Resources; 2009 (Jan).


etc.
Results — Mill Residues

“Low cost biobasins in southeast”
Phase I BioSAT Model – Results
(Mill Residues – Low Cost)
Phase I BioSAT Model – Results

(Mill Residues – High Cost)
BioSAT Model

Bio-basin selection: Example for Mill Residues for MS (≤ 1.5 M Dry Tons per Year)

- T2. 38879 (Lee Co.)
- T2. 38864 (Pontotoc Co.)
- 1. 38916 (Calhoun Co.)
- T2. 39094 (Leake Co.)
- 5. 39476 (Perry Co.)
BioSAT Model

Bio-basin selection: Example for Mill Residues for MS
($\leq 1.5$ M Dry Tons per Year)
BioSAT Model

Bio-basin selection: Example for Mill Residues for MS
(\leq 1.5 \text{ M Dry Tons per Year})
BioSAT Model

Demand ZCTA 38916 (Calhoun Co.) – Mill Residues
BioSAT Model

Demand ZCTA 38916 (Calhoun Co.) – Mill Residues
BioSAT Model
Demand ZCTA 38916 (Calhoun Co.) – Mill Residues

Map showing marginal costs ($/ton) by ZCTA in Calhoun County. The map is color-coded with the following ranges:
- 23 - 27
- 27 - 31
- 31 - 35
- 35 - 39
- 39+
BioSAT Model

Demand ZCTA 38916 (Calhoun Co.) – Mill Residues
Phase I BioSAT Model – Results

![Map and Graph]

- Marginal Cost ($/ton):
  - $22 - $27
  - $28 - $31
  - $32 - $35
  - $36 - $39
  - $40 and above

- Graph showing Marginal Costs ($/dry ton) vs. Quantity (dry tons):
Phase I BioSAT Model – Results
Phase I BioSAT Model – Results

![Graph showing marginal costs and quantity](image_url)
Phase I BioSAT Model – Results
## Phase I BioSAT Model – Results

(Low Cost “All” Logging Residues – “at the Landing”)

<table>
<thead>
<tr>
<th>Rank</th>
<th>ZCTA</th>
<th>County</th>
<th>State</th>
<th>City</th>
<th>Annual Quantity Available (dry tons)</th>
<th>Total Cost</th>
<th>Average Total Cost ($/dry ton)</th>
<th>Median MC ($/dry ton)</th>
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<td>1</td>
<td>27412</td>
<td>Guilford</td>
<td>NC</td>
<td>Greensboro</td>
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# Phase I BioSAT Model – Results

*(Low Cost “All” Logging Residues – “in the woods”)*

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<tr>
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<td></td>
<td></td>
<td>GA</td>
<td>Savannah</td>
<td>1,527,829</td>
<td>$270,658,985</td>
<td>$179.79</td>
<td>$183.39</td>
</tr>
</tbody>
</table>
Results – Ag Residues
(Wheat Straw)

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

Wheat Straw (Wheat All) Harvesting Cost By Z in the Southeastern United States
Results – Ag Residues
(Wheat Straw – Low Cost Demand ZCTAs)
Summary

- **www.BioSAT.net** provides decision tool for identifying least cost woody and ag residues (most useful for regional comparisons)
  - mill residues, logging residues, ag residues, merchantable wood
  - resource costs, transportation costs, harvesting costs

- Website is nearing completion (undergoing revision after beta-test site review)
US DOT Southeastern SunGrant Center - Final Report Available

Regional Comparative Advantage for Woody Biofuels Production

US Department of Transportation
Southeastern Sun Grant Center
Research Project Final Report

December 20, 2000
Future Research

- Water availability
- Competition
- Bayesian logistic regression models for site selection
- Policy influence
- “Some” sustainability criteria
- Population data, climatology data, fragmentation, etc.
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Questions?

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