Modeling Biomass Supply

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Southern Research Station
Temperate forest productivity of 4.5 tons/acre × 500 million acres =

2.25 Billion Tons/Year

Discounting (1) Public lands, (2) Foliage & roots, and (3) Current consumption leaves…

600 Million Tons

Add agricultural residue…

550 Million Tons, and

Municipal solid waste…

150 Million Tons

1.3 Billion Tons/Year
The New Beginning...

- The Billion-Ton Study launched a national dialogue
- Also prompted intense R&D effort to confirm or deny the findings
- The Billion-Ton II Study (aka, “Spawn of Billion-Ton”) will continue the conversation
A Plethora of Models...
The Research Need...

- A common data framework for communication between models
- Transparency of assumptions
- Increased attention to validation (data collection)
A Broader Perspective...

- Lignocellulosic biomass is a source of renewable carbon for production of power, fuels, chemicals, and materials.
- At the biorefinery, the source of the biomass is only an issue if it impacts conversion.
- New metrics are needed that reflect process considerations.
The New Beginning...

**BIOREFINERY SITING**

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>GOALS</th>
<th>RESEARCHERS</th>
<th>SPONSORS</th>
<th>SOURCES</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feature Extraction Models for Identifying Optimum Bioenergy Sites in the Southeastern U.S. with Sustainability and Policy Impact Modules</td>
<td>Create bioenergy supply and sustainability indices as criteria for biorefinery siting; develop statistical-based linear and non-linear feature extraction models</td>
<td>Tim Young, University of Tennessee-Forest Products Center; Don Hodges, University of Tennessee-Department of Forestry, Wildlife, and Fisheries; Frank Guest, University of Tennessee-Department of Statistics</td>
<td>Southeast Regional Sun Grant Initiative</td>
<td>Direct: $75,000 Indirect: $15,000 Leveraged: $5,000 Total: $95,000</td>
<td>In progress, final report available on website</td>
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**FEEDSTOCK SUPPLY**

<table>
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<tr>
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<tbody>
<tr>
<td>Regional Comparative Advantage for Woody Biofuels Production</td>
<td>Develop woody biomass feedstock cost projections for woods and process residue; and, create biomass transportation cost model</td>
<td>Tim Young, University of Tennessee-Forest Products Center; Bob Atchley, NC State University, Forestry &amp; Environmental Resources Dept.</td>
<td>USDA-FS, Southern Research Station</td>
<td>Direct: $60,000 Indirect: $20,000 Leveraged: $30,000 Total: $110,000</td>
<td>In progress</td>
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**INDUSTRY IMPACTS**

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<tr>
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<tbody>
<tr>
<td>BioSAT - Biomass Site Assessment Tools</td>
<td>Create web-accessible model to evaluate optimal locations for sustainable cellulose biorefineries in the 33 eastern states</td>
<td>Daniel De La Torre Ugartet, Burton English, and Brad Wilson, UT-Department of Agricultural Economics</td>
<td>USDA-FS, Southern Research Station</td>
<td>Direct: $400,000 Indirect: $150,000 Leveraged: $50,000 Total: $500,000</td>
<td>In progress</td>
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<tr>
<td>BioFLAME - A GIS Framework for Assessing Potential Biorefinery Locations</td>
<td>Build an alternative GIS approach, identify suitable biorefinery locations based on feedstock availability and cost, and transport cost</td>
<td>Tim Young, University of Tennessee-Forest Products Center; Jim Perdue, USDA-FS, Southern Research Station</td>
<td>USDA-FS, Southern Research Station</td>
<td>Direct: $120,000 Indirect: $24,000 Leveraged: $10,000 Total: $154,000</td>
<td>In progress</td>
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<td>Estimating the Effects of Climate Change Legislation on U.S. Biomass Supply</td>
<td>Link carbon market prices to farmers’ cost of production within POLYSYS, and relate offset price to biogeochemical sequestration rates</td>
<td>Chad Helvenning, UT-Department of Agricultural Economics; Tristant West, Oak Ridge National Laboratory</td>
<td>USDA-FS, Southern Research Station</td>
<td>Direct: $75,000 Indirect: $15,000 Leveraged: $40,000 Total: $130,000</td>
<td>In progress</td>
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<tr>
<td>Developing a POLYSYS Forest Sector Module - Demand Side</td>
<td>Using the Global Forest Products Model, develop protocols to incorporate demand considerations into projections of biomass cost provided by POLYSYS</td>
<td>Daniel De La Torre Ugartet, Burton English, and Brad Wilson, UT-Department of Agricultural Economics</td>
<td>USDA-FS, Southern Research Station</td>
<td>Direct: $50,000 Indirect: $60,000 Leveraged: $75,000 Total: $185,000</td>
<td>In progress</td>
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<tr>
<td>Developing a POLYSYS Forest Sector Module - Supply Side</td>
<td>Establish a forest supply side module that is integrated with the existing POLYSYS model framework for initial evaluation of biomass land-use changes</td>
<td>Daniel De La Torre Ugartet, Burton English, and Brad Wilson, UT-Department of Agricultural Economics</td>
<td>USDA-FS, Southern Research Station</td>
<td>Direct: $150,000 Indirect: $30,000 Leveraged: $75,000 Total: $255,000</td>
<td>In progress</td>
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<td>The Status of Wood-Based Bioenergy/Biofuels Technologies and Industries in North America</td>
<td>Using standardized LCA methodology, establish an accounting of the inputs/outputs for one ton of switchgrass fuel pellets; provide data to U.S. life-cycle inventory database</td>
<td>Sam Jackson and Tim Raas, UT-Office of Bioenergy Programs; Jim Perdue, USDA-FS, Southern Research Station</td>
<td>USDA-FS, Southern Research Station</td>
<td>Direct: $200,000 Indirect: $50,000 Leveraged: $50,000 Total: $270,000</td>
<td>In progress, continued work to maintain and enhance data</td>
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</table>
A New Dataset Is Available...

- Industrial Wood to Energy Users Online Database
- Locations and data for boilers, advanced biofuels, and other facilities in the US and Canada
- Wood to Energy State of the Science Report
- Objective overview of current technologies, paths to the future, and market sustainability is in review
The Policy Analysis System (POLYSYS) modeling framework was developed to simulate changes in policy, economic or resource conditions and estimate the resulting impacts for the U.S. agricultural sector.

At its core, POLYSYS is structured as a system of interdependent modules simulating crop supply for 305 production regions, national crop demand and prices, national livestock supply and demand, and agricultural income.

A forest sector module (supply and demand) near completion, allowing evaluation of agricultural and woody biomass components.
Biomass Site Assessment Tools...

- Durability
- Simplicity
- Accessibility
- Versatility
- Conformity

Assessment based on mill residue
Marginal Cost Data

Marginal Cost ($/dry ton) vs. Cumulative Quantity (dry tons)

- ZCTA=30056-GA
- ZCTA=30459-GA
- ZCTA=31085-GA
- ZCTA=31515-GA
- ZCTA=36458-AL
- ZCTA=36783-AL
- ZCTA=39657-MS
- ZCTA=39667-MS
- ZCTA=70444-LA
- ZCTA=71034-LA
Mississippi Assessment (BioSAT)

Best Five Demand ZCTAs for Mill Residues

(\leq 1.5 \text{ M DT/Yr})

1. 38916 (Calhoun Co.)
2. 38879 (Lee Co.)
2. 38864 (Pontotoc Co.)
1. 38916 (Calhoun Co.)
T2. 39094 (Leake Co.)
5. 39476 (Perry Co.)
Data Transparency…

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

<table>
<thead>
<tr>
<th>Level</th>
<th>Mean</th>
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<tbody>
<tr>
<td>39476</td>
<td>36.815208</td>
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<tr>
<td>39094 A</td>
<td>36.285510</td>
</tr>
<tr>
<td>39094 B</td>
<td>36.285510</td>
</tr>
<tr>
<td>38864 A</td>
<td>35.544375</td>
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<tr>
<td>38864 B</td>
<td>35.544375</td>
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<tr>
<td>38879</td>
<td>35.483049</td>
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<tr>
<td>38916</td>
<td>33.635556</td>
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[Box plots showing marginal cost (dollars/dry ton) for different demand ZCTAs, with mean values for each level presented in a table.]
BioSAT Characteristics

- Considers both agricultural and forest sources of biomass
- Emphasizes transportation networks – time and distance (not radius)
- Zip code tabulation areas (zcta) allows a gain in efficiencies at finer resolution
- Graphic representation from on-the-ground datasets, in contrast to GIS
Welcome to BioSAT

Beta Test Site

Phase 1: 13 Southern States

BioSAT Update  (Posted 01/27/2010 14:00:00)

Agricultural residue quantity and harvesting cost estimates for the South have been added to the BioSAT database. Residues included are: Barley Straw, Corn Stover, Oat Straw, Sorghum Straw, Wheat (All) Straw, and Wheat (Hard) Straw.
Concluding Remarks...

- The expanded woody market that bioenergy represents requires new metrics for the feedstock.
- There is a need to advance communication across model platforms through a uniform database structure.
- BioSAT will continue to grow in capabilities with new attributes and layers.
- Evaluation of individual model performance in a round-robin with a common dataset would be valuable.
Acknowledgements...

Program Sponsors

- USDA – Forest Service
- USDA-FS, Southern Research Station
- US-DOE, Office of the Biomass Program
- US Department of Transportation
- US Endowment for Forests and Communities
- University of Tennessee, Office of Bioenergy Programs
- Southeast Regional Sun Grant Center

Individual Contributors

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- Bob Longmire
- Kerri Norris
- Christy Pritchard
- Bob Rummer
- Ken Skog
- Adam Taylor
- Daniel de la Torre- Ugarte
- Yingjin Wang
“All models are wrong, some are useful”

George E.P. Box – Statistician (U of Wisconsin)