ECOWAS – GBEP REGIONAL BIOMASS RESOURCE ASSESSMENT WORKSHOP

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*The views and opinions of the author does not necessarily state or imply the policies of the Department.
Goal is to understand the structure and process of completing a national biomass inventory and assessing future potential using Billion-Ton Update as a model.
Billion-Ton Update

• Co-leads
  • Bob Perlack – Oak Ridge National Laboratory
  • Bryce Stokes – CNJV

• Goal
  • Update the 2005 assessment
  • Improve the methodologies
  • Provide inventory of current biomass and analyze potential under various scenarios to determine if U.S. could sustainably produce one Billion Tons annually.

Epic Effort
  • 50 contributors
  • Federal agencies, universities, etc.
  • 3 years
Preamble to Billion Ton Update

- Resource assessment – not demand estimates
- Excluded algal feedstocks
- Included “major” feedstocks
- Costs were only to roadside/farmgate
- No specified product end use or conversion process
- Raw material in form as described with losses only up to roadside
- Does not represent full cost or actual, usable tonnage at facility
Resource Base

Used defined land use classes and areas

A. Forestland
   I. Forestland
   II. Timberland
   III. Other forestland
   IV. Reserved (including roadless areas)
   V. Prescribed attributes
      a. Road access
      b. Ground slope
      c. Species type as surrogate for accessibility

B. Agricultural land
   I. Cropland
   II. Hay land
   III. Permanent pasture (non-irrigated)
   IV. Cropland pasture

Principle 1 – Used commonly accepted terminology and definitions of land use classes. Resolved differences of land area amounts from multiple sources.
Biomass Feedstocks

- Forest resources
  - Logging residues
  - Forest thinnings (fuel treatments)
  - Conventional wood
  - Fuelwood
  - Primary mill residues
  - Secondary mill residues
  - Pulping liquors
  - Urban wood residues (MSW)

Combined into composite so not to double count
Biomass Feedstocks (cont.)

- **Agricultural resources**
  - Crop residues
  - Grains to biofuels
  - Perennial grasses
  - Perennial woody crops
  - Animal manures
  - Food/feed processing residues
  - MSW and landfill gases
  - Annual energy crop

**Principle 2** – Had well- and consistently-defined feedstocks; from categories to a single feedstock.
Biomass Availability

Depends on

- Specific feedstock or feedstock category
- Sorts – currently used or potential
- Spatial interest
- Selected price
- Specific year
- Scenario

Information access

- Too complex to put all into written report
- Used website
  - Data tool
  - Mapping tool
  - Background info
  - Ancillary info
  - Q&As
  - Input from users

https://www.bioenergykdf.net/
Assessment Process

1. Identified goals and data/information resources
2. Established boundaries and sideboards
3. Wanted resource “inventory” with an “analysis” of potential future resources
   A. Analyses had “potential and what ifs”
      1. Land use changes, different management, etc.
      2. Sustainability requirements
      3. Numerous assumptions on accessibility, management, technology, yield, costs/prices, social aspects, etc.
   B. Included “modeling”
4. Primary concerns
   A. Reasonable and rational
   B. Replicable
   C. Practical and useful
   D. Acceptable level of error or even point estimate

Principle 3 – Determined desired outcomes and probable uses; available data and analytical resources; and, then determined the “best” approach.
Approach to Supply Curve Estimation in Billion Ton Update

- **Agricultural land resources**
  - Used agricultural policy/economic model (POLYSYS) to develop supply curves and land use change for crop residues and energy crops
  - Used public data
    - **U.S. Department of Agriculture** (yields, acres, crop prices, production, exports, etc.) to 2030
      - Census of Agriculture data
      - National Agricultural Statistics Service data
      - 10-year Commodity Outlook projections
  - Established resource sustainability criteria (crop residue retention, tillage practices, crop rotations, etc.)
  - Projected crop yields
  - Provided baseline production and logistical costs for model
  - Secondary processing residues and wastes are estimated using published information
  - Contributing authors helped develop technical assumptions and input data and workshops used to develop scenarios
Approach to Supply Curve Estimation (cont.)

- Forestland resources
  - Resource cost analysis used to estimate supply curves (cost-quantities) for forestland resources
    - U.S. Department of Agriculture Forest Service data
      - Forest Inventory and Analysis – current inventory and changes
      - Timber Product Output – historical wood use data
      - Resources Planning Act – 50-year projections
    - Forest residue access, recovery, and merchantability assumptions
    - Requirements for resource sustainability

- Depended on experts and used expertise from formulation to verification (developed assumptions and conducted analysis)

Principle 4 – Used various data sources (mostly publically available for transparency) and documented extrapolation; Relied on many disciplines and professionals to have the technical depth required.
Modeling Options

Models used in Billion-Ton Update
- National economic agriculture model – solves for 3,110 counties (political jurisdictions)
- Forestry spreadsheet cost simulator (FRCS)
- Simple mathematical calculations
- Deterministic – point values – some sensitivity analysis and ongoing efforts to determine error ranges

Principle 5 – Used various analytical tools dependent on availability of data and models; made best use of resources and documented.

\[ G_i = (\alpha + \alpha_1 P_i)(S_i) + u_i \]

\[ \sum_{i=1}^{n} f(i) = f(1) + f(2) + f(3) + \ldots + f(n) \]
Baseline

- US Department of Agricultural crop projections to 2030
- National corn yields and stover yields
- Assumes a mix of management practices - conventional till, reduced till, and no-till
- No residue collected from conventionally tilled acres
- Energy crop yields increase at 1% annually attributable to experience in planting energy crops and limited R&D

High-yield

- Same as Baseline Scenario except for the following
  - Corn yields increase more
  - Higher amounts of cropland in no-till to allow greater residue removal
  - Energy crop yields increase at 2%, 3%, and 4% annually (more R&D)
- Substantial effort into developing scenarios

Principle 6 – Scenarios played an important role but required additional data and analyses, and experts, to be both realistic and useable.

https://inlportal.inl.gov/portal/server.pt/community/bioenergy/421/high_yield_scenario/8985
Overcome Challenges

Addressed Agricultural Residue Retention Issues. Needed to leave enough biomass to
- Prevent erosion
- Maintain site productivity and biological activity
- Maintain soil organic matter

Focused on quantifying the limiting factors, so we can effectively develop the agronomic strategies such as
- Higher retention
- Reducing tillage
- Management practices, e.g., crop rotation

Had to step back and develop a new approach that required verification and review.
Residue Analysis Applications

Large Spatial Assessments

Sustainable Feedstock Production Analysis: Integrated Models Include-
• RUSLE2
• WEPS
• I-Farm
• DayCent
• CQESTR

Principle 7 – Put other models to work to overcome specific issues such as sustainability criteria.
Crop Residue Estimated Supply – An Example

- Developed Cost Supply Curves
  - Within acceptable cost ranges
  - Over time span
  - County levels and aggregates
  - For scenarios
- Applied sustainability criteria
- Developed tabular estimates
- Provided maps
Principle 8 – Worked at the most appropriate spatial level based on data and models. Tried to complete analysis for smallest spatial units and aggregate upwards to area, state, region, and national.

Counties in Iowa

Counties and States Aggregated into Crop Management Zones for Analysis

Combining geopolitical, ecological, and climatic attributes
Perennial Grasses – Production Costs and Productivity

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Northeast</th>
<th>Appalachia</th>
<th>Southeast</th>
<th>Delta</th>
<th>Corn Belt</th>
<th>Lake States</th>
<th>Southern and Northern Plains</th>
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<tr>
<td>Perennial grasses</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Stand life (Years)</td>
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<td>10</td>
<td>10</td>
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<td>4.0–7.5</td>
<td>5.5–8.5</td>
<td>3.5–6.5</td>
<td>3–7</td>
<td>4–7</td>
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<td>Seed (b/l)</td>
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<td>Replanting (percent)</td>
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<td>1-time</td>
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<td>1-time</td>
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<td>Phosphorous (lb P2O5/acre)</td>
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<td>40</td>
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<td>Potassium (lb K2O/ha)</td>
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<td>Total establishment costs</td>
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<td>$380</td>
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<td>Potassium (lb K2O/acre)</td>
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<td>0</td>
<td>0</td>
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<td>Harvest costs ($/dry ton)</td>
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<td>$14.00</td>
<td>$18.00</td>
<td>$22.00</td>
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</table>

Herbaceous crop productivity

- Baseline yields tonnes/ha (dry tons/acre)
  - 2014 – 7.6 – 24.9 (3.0 – 9.9)
  - 2030 – 9.1 – 30.2 (3.6 – 12.0)

Principle 9 – Provided and documented all background work and assumptions.
### Woody Crops – Production Costs and Productivity

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Poplar</th>
<th>Pine</th>
<th>Eucalyptus</th>
<th>Willow (copraed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation</td>
<td>Years</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>4 (5 harvests)</td>
</tr>
<tr>
<td>Spacing</td>
<td>24 ft</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>7.5</td>
</tr>
<tr>
<td>Productivity</td>
<td>dry tons/ha/year</td>
<td>12.6</td>
<td>12.6</td>
<td>12.6</td>
<td>2980</td>
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<td>Growing range</td>
<td></td>
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</tr>
<tr>
<td>Establishment - year 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuttings</td>
<td>$/tree</td>
<td>$0.10</td>
<td>$0.06</td>
<td>$0.10</td>
<td>$0.12</td>
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<tr>
<td>Planting</td>
<td>$/tree</td>
<td>$0.09</td>
<td>$0.09</td>
<td>$0.09</td>
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<tr>
<td>Replants</td>
<td>percent</td>
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<td>5</td>
<td>0</td>
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<tr>
<td>Moldboard blow</td>
<td>-</td>
<td>1-time</td>
<td>1-time</td>
<td>1-time</td>
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<tr>
<td>Disk</td>
<td>-</td>
<td>1-time</td>
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<td>1-time</td>
<td>1-time</td>
</tr>
<tr>
<td>Cultivate</td>
<td>-</td>
<td>2-times</td>
<td>2-times</td>
<td>2-times</td>
<td>2-times</td>
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<tr>
<td>Total kill herbicide</td>
<td>No. applications</td>
<td>1-time</td>
<td>1-time</td>
<td>1-time</td>
<td>1-time</td>
</tr>
<tr>
<td>Pre-emergent herbicide</td>
<td>Lb/a or/acre</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Lb/a or/acre</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Establishment costs</td>
<td>$/acre</td>
<td>$110</td>
<td>$960</td>
<td>$910</td>
<td>$130</td>
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<td>Maintenance - year 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultivate</td>
<td>2-times</td>
<td>1-time</td>
<td>1-time</td>
<td>1-time</td>
<td>1-time</td>
</tr>
<tr>
<td>Pre-emergent herbicide - year 2</td>
<td>Lb/a or/acre</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Lime - year 3</td>
<td>Lb/a or/acre</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>Nitrogen - year 4 and 6</td>
<td>Lb/a or/acre</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>100</td>
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<tr>
<td>Phosphorus - year 3</td>
<td>Lb/a or/acre</td>
<td>20</td>
<td>40</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Potassium - year 3</td>
<td>Lb/a or/acre</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>-</td>
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<tr>
<td>Maintenance costs - year 2</td>
<td>$/acre</td>
<td>$220</td>
<td>$200</td>
<td>$200</td>
<td>$30</td>
</tr>
<tr>
<td>Harvest costs</td>
<td>$/dry ton</td>
<td>$20</td>
<td>$200</td>
<td>$200</td>
<td>$100</td>
</tr>
</tbody>
</table>

### Woody crop productivity

- Baseline yields tonnes/ha (dry tons/acre)
  - 2014 – 8.8 – 15.1 (3.5 - 6.0)
  - 2030 – 10.6 – 18.1 (4.2 - 7.2)
Land use change at highest simulated prices by 2030
- 9 to 12 million ha (22 to 30 million acres) cropland
- 16 to 20 million ha (40 to 50 million acres) pasture

Principle 10 – Explained and documented the details of the analyses and the outcomes and the application of the results.

Estimating energy crop potential was the goal, but an effect was land use change.
U.S. Billion-Ton Update: Findings

- **Baseline scenario**
  - Current combined resources from forests and agricultural lands total about 473 million dry tons at $60 per dry ton or less (about 45% is currently used and the remainder is potential additional biomass)
  - By 2030, estimated resources increase to nearly 1.1 billion dry tons (about 30% would be projected as already-used biomass and 70% as potentially additional)

- **High-yield scenario**
  - Total resource ranges from nearly 1.4 to over 1.6 billion dry tons annually of which 80% is potentially additional biomass
  - No high-yield scenario was evaluated for forest resources, except for the woody crops
Potential County-level Resources at $60 Per Dry Ton or Less in 2030 for Baseline

County Level Biomass
Dry tons per square mile annually

0 - 5500
Principles Review

1. Used commonly accepted terminology and definitions of land use classes. Resolved differences of land area amounts from multiple sources.

2. Had well- and consistently-defined feedstocks; from categories to a single feedstock.

3. Determined desired outcomes and probable uses; available data and analytical resources; and, then determined the “best” approach.

4. Used various data sources (mostly publically available for transparency) and documented extrapolation; Relied on many disciplines and professionals to have the technical depth required.

5. Used various analytical tools dependent on availability of data and models; made best use of resources and documented.

6. Scenarios played an important role but required additional data and analyses, and experts, to be both realistic and useable.

7. Put other models to work to overcome specific issues such as sustainability criteria.

8. Worked at the most appropriate spatial level based on data and models. Tried to complete analysis for smallest spatial units and aggregate upwards to area, state, region, and national.

9. Provided and documented all background work and assumptions.

10. Explained and documented the details of the analyses and the outcomes and the application of the results.
Closing Comments

- Keep it simple at first – our first Billion Ton Report was just a strategic assessment at the national scale.
- Define the goals and the outputs – who will use and how will the results be used.
- Basic inventories are helpful - analyses of potential are useful if using practical assumptions.
- Some data is usually available – may need additional analysis and extrapolation.
- Pull in various experts and disciplines – broaden both the skills and the perspectives.
- Document and explain – make everything transparent.