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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.

Presentation Outline

First
- **Review Billion-Ton Update – a U.S. national biomass assessment**

Second
- **Discuss Methodologies and Principles**

Third
- **Q&A and Discussion**

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

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- 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

Similar to FAO and other international standards.

Specific to U.S.

Similar to FAO and other international standards.

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

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Depends on

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

The desired outcomes also provided the direction for the assessment.

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

    Examples
  - Established resource sustainability criteria (crop residue retention, tillage practices, crop rotations, etc.)

    Very important
  - 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)**

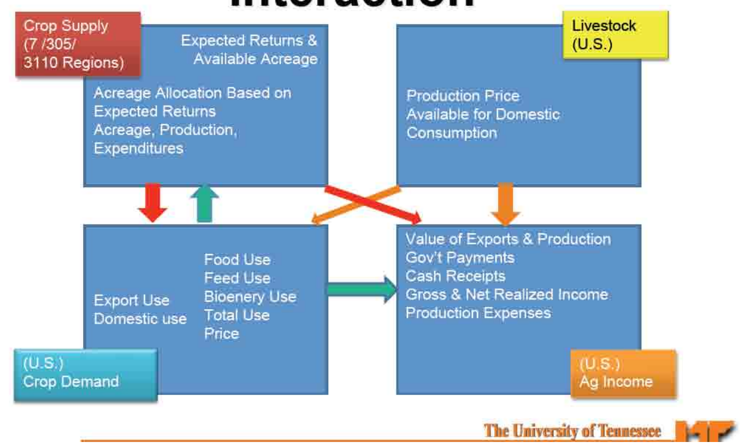
Principle 4 – Used various data sources (mostly publically available for transparency) and documented extrapolation; Relied on many disciplines and professionals to have the technical depth required.

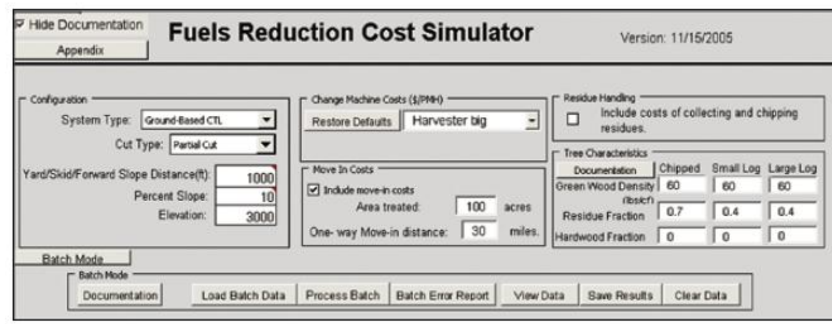
Modeling Options

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**

POLYSYS Modules and Interaction





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

$$Gi = (\alpha + \alpha 1 Pi)(Si)\gamma + ui$$

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

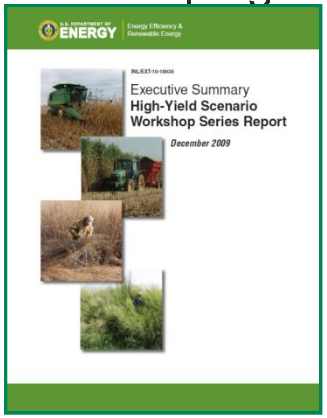
Baseline

- 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

Yields, either residues or crops, drove the scenarios



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

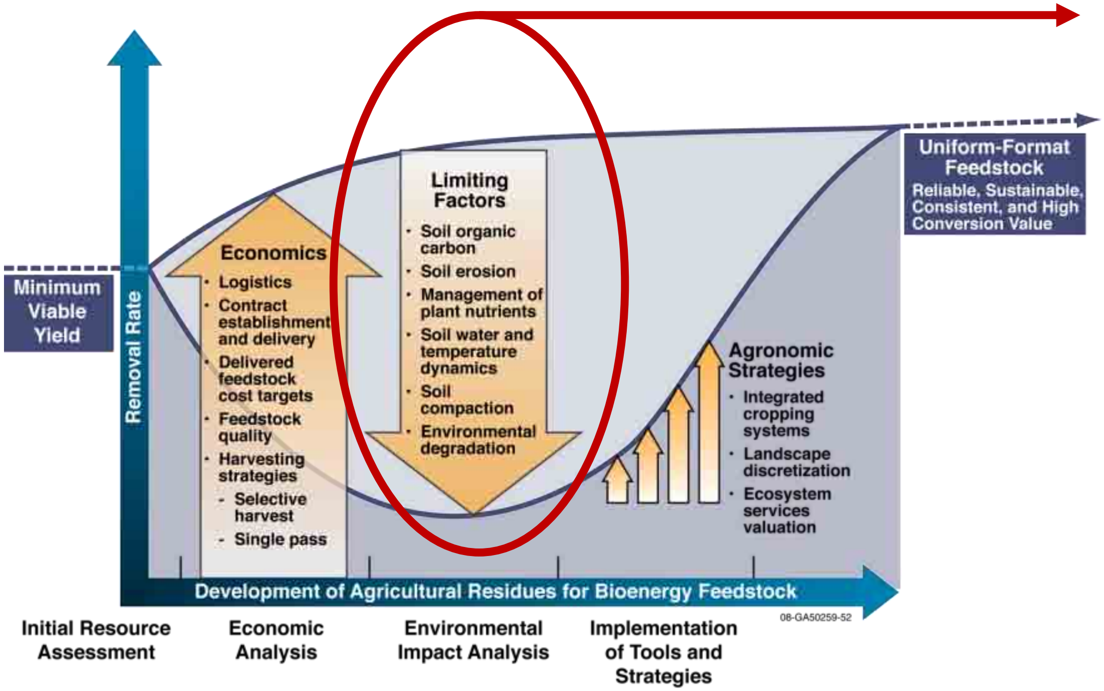
Principle 6 – Scenarios played an important role but required additional data and analyses, and experts, to be both realistic and useable.

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**

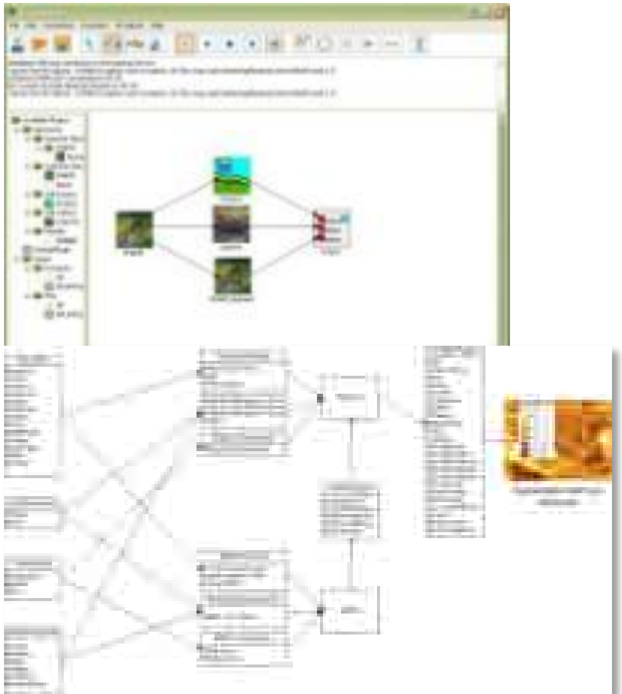
Had to step back and develop a new approach that required verification and review



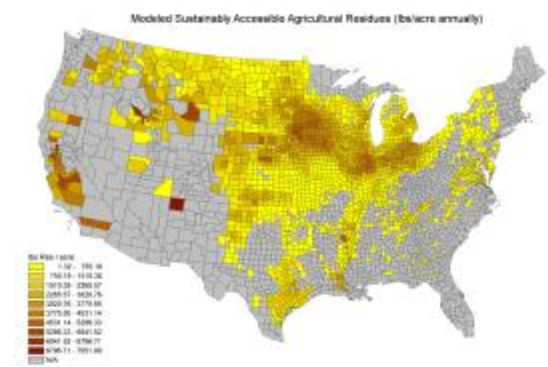
Focused on quantifying the limiting factors, so we can effectively develop the agronomic strategies such as

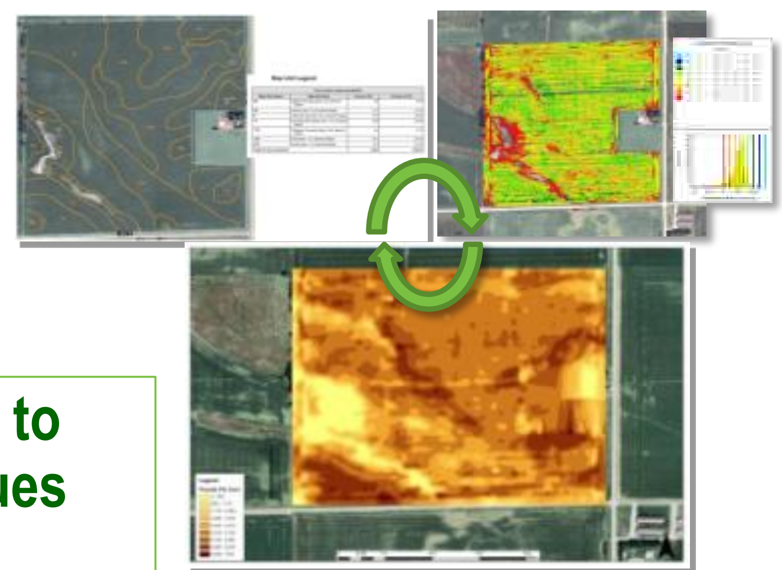
- Higher retention
- Reducing tillage
- Management practices, e.g., crop rotation

Residue Analysis Applications



Large Spatial Assessments





Other types of models and data

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

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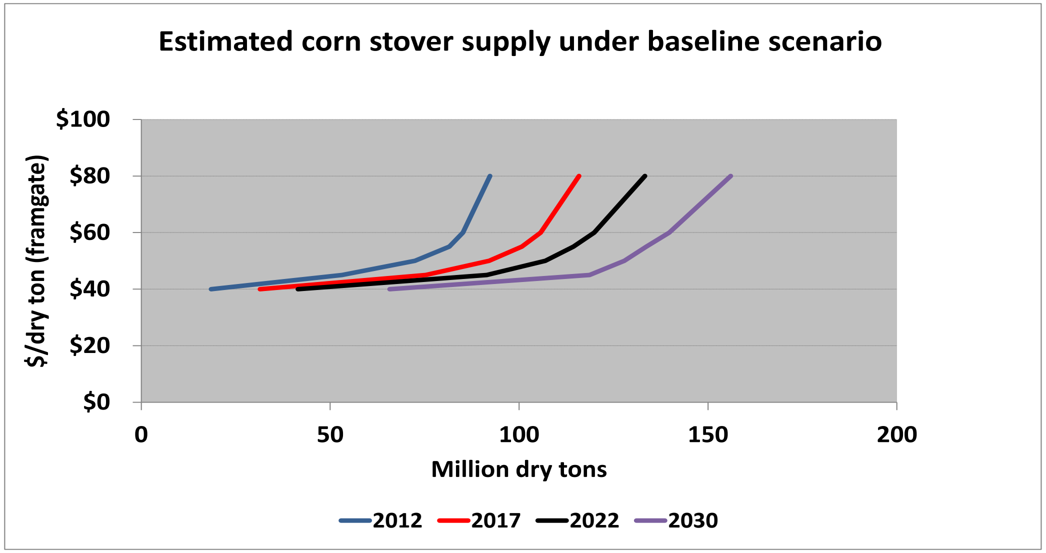
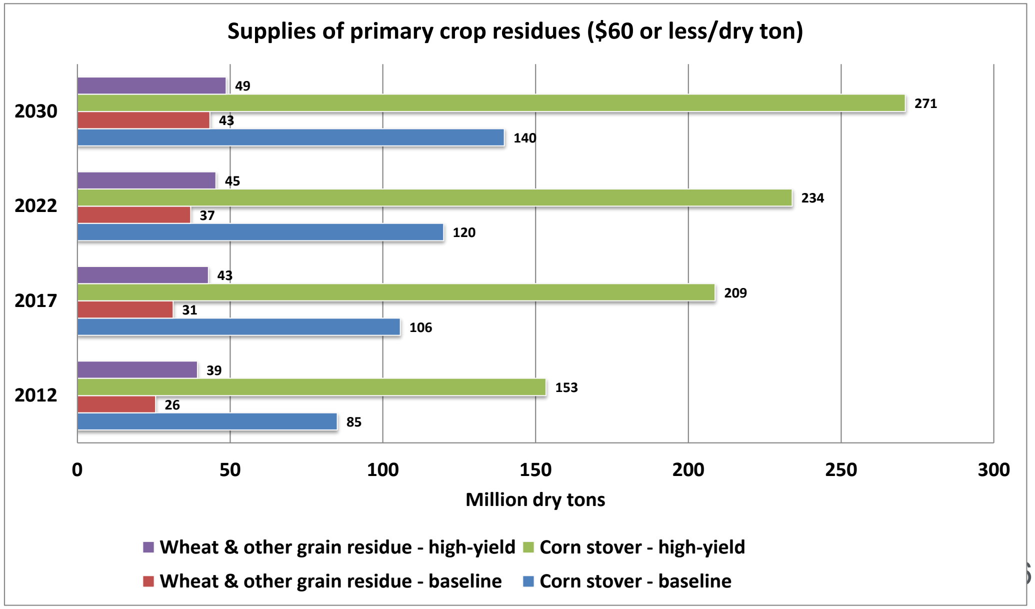
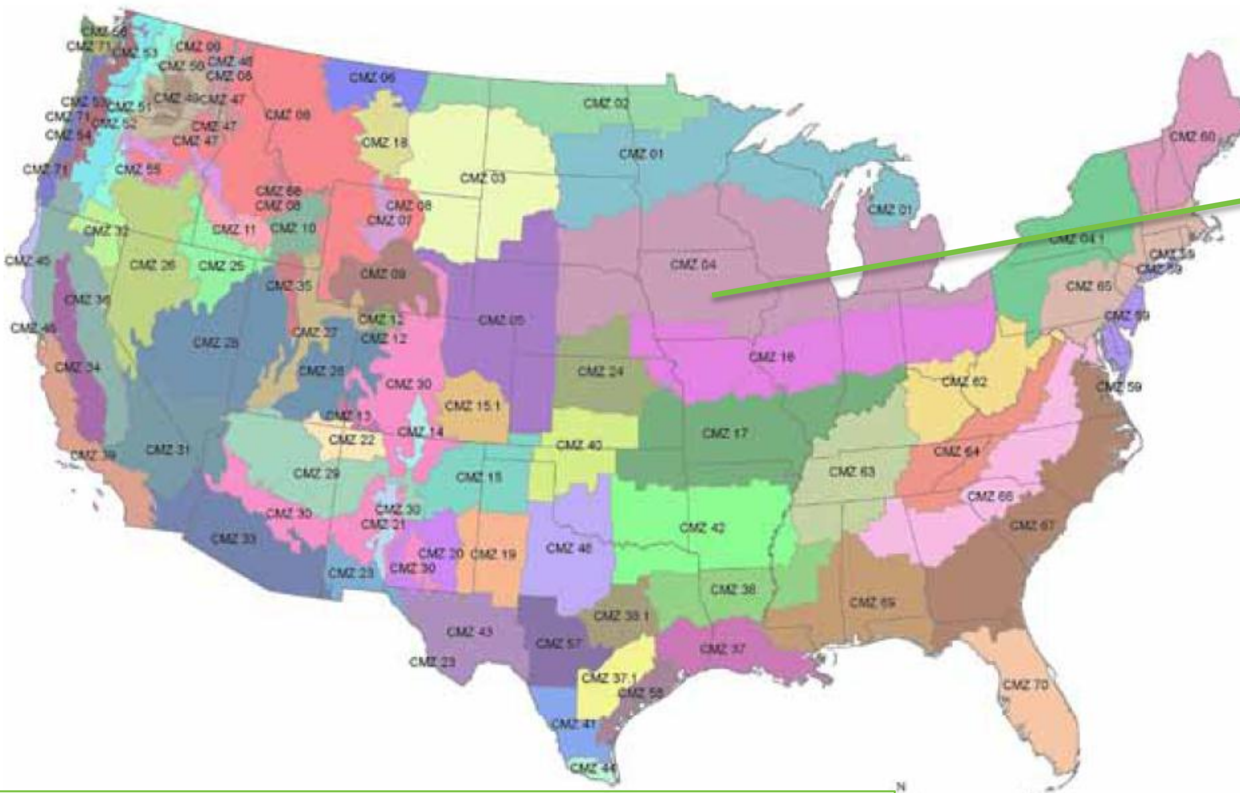
- Developed Cost Supply Curves
  - Within acceptable cost ranges
  - Over time span
  - County levels and aggregates
  - For scenarios
- Applied sustainability criteria
- Developed tabular estimates
- Provided maps





Spatial Scales

Counties in Iowa



Counties and States Aggregated into Crop Management Zones for Analysis

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.

Combining geopolitical, ecological, and climatic attributes

Perennial Grasses – Production Costs and Productivity

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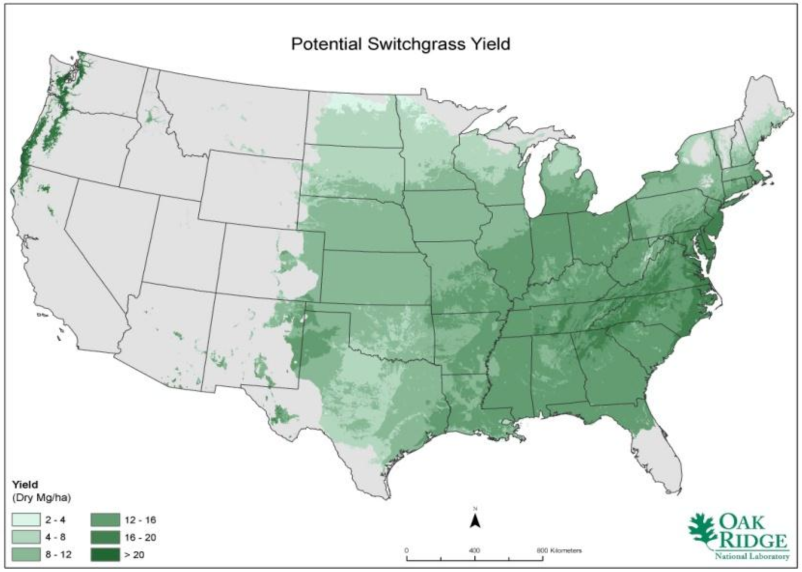
Item	Units	Northeast	Appalachia	Southeast	Delta	Corn Belt	Lake States	Southern and Northern Plains
Perennial grasses								
Stand life	Years	10	10	10	10	10	10	10
Productivity	dry tons/acre	4.0–7.5	5–9.5	3.5–9.5	3–7	4–7	3.5–5	2–6.5
Establishment								
Seed	$/lb	$10	$22	$22	$22	$10	$10	$22
Planting	lb/acre	5	5	5	5	5	5	5
Replants	percent	25	25	25	25	25	25	25
No-till drill	-	1-time	1-time	1-time	1-time	1-time	1-time	1-time
Total kill herbicide	No. applications	1-time	1-time	1-time	1-time	1-time	1-time	1-time
Pre-emergent herbicide	No. applications	1-time	1-time	1-time	1-time	1-time	1-time	1-time
Phosphorous	lbs P2O5/acre	40	40	40	40	40	40	40
Potassium	lbs K2O/ac	80	80	80	80	80	80	0
Lime	tons/acre	1	2	2	2	1	1	0
Total establishment costs	**$/acre**	**$210**	**$340**	**$330**	**$330**	**$200**	**$200**	**$220**
Maintenance years								
Reseeding	year applied	2	2	2	2	2	2	2
Pre-emergent herbicide	No. applications	0	0	0	0	0	0	0
Nitrogen	lbs/acre	60	70	70	50	60	40	40
Phosphorous	lbs P2O5/acre	0	0	80	0	80	0	0
Potassium	lbs K2O/acre	0	0	80	0	80	0	0
Harvest costs	**$/dry ton**	**$19.50–$21.00**	**$18.50–$19.90**	**$18.00–$20.20**	**$18.60–$20.60**	**$19.20–$20.60**	**$20.60–$21.90**	**$19.20–$22.10**
Annual Energy Crops								
Productivity	dry tons/acre	6–8.2	6–8.7	6–9	6–9	6.7–9	n/a	6.5–9
Production costs	$/acre	$310	$330	$300	$310	$420	n/a	$230
Harvest costs	$/dry ton	$12.50	$12.10	$11.80	$11.80	$12.20	n/a	$12.10



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

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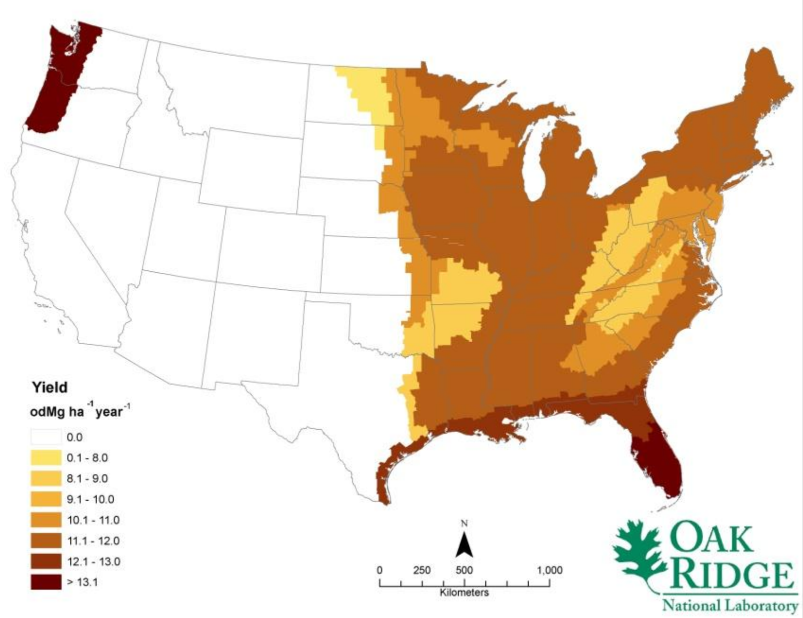
Item	Units	Poplar	Pine	Eucalyptus	Willow (coppiced)
Rotation	Years	8	8	8	4 (5 harvests)
Spacing	sq. ft.	60	60	60	7.5
	trees/acre	728	726	726	5800
Productivity	dry tons/acre-year	3.5–6.0	5.0–5.5	6.0	5.1
Growing range	Region	Northeast, Lake States, Northwest, Midwest, Plains	Southeast	Sub-tropics	Northeast and Lake States
Establishment - year 1					
Cuttings	$/tree	$0.10	$0.06	$0.10	$0.12
Planting	$/tree	$0.09	$0.09	$0.09	$0.02
Replants	percent	5	5	5	0
Moldboard plow	-	1-time	1-time	1-time	1-time
Disk	-	1-time	1-time	1-time	1-time
Cultivate	-	2-times	2-times	2-times	2-times
Total kill herbicide	No. applications	1-time	1-time	1-time	1-time
	lbs a.i./acre	1.5	1.5	1.5	1.5
Pre-emergent herbicide	No. applications	1-time	1-time	1-time	1-time
	lbs a.i./acre	1.5	1.5	1.5	1.5
Phosphorous	lbs/acre	0	40	0	0
Establishment costs	$/acre	$310	$280	$310	$1120
Maintenance years					
Cultivate – year 2	-	2-times	2-times	2-times	1-time
Cultivate – year 3		1-time	1-time	1-time	None
Pre-emergent herbicide – year 2	No. applications	1	1	1	1
	lbs a.i./acre	1.5	1.5	1.5	1.5
Lime – year 3	tons/acre	90	90	90	100
	year applied	-	year 3	year 3	-
Nitrogen – year 4 and 6	lbs/acre	90	90	90	100
	year applied	4 and 6	2,4, and 6	4 and 6	4
	-	-	-	-	-
Phosphorous – year 3	lbs/acre	20	40	15	-
	year applied	3	3	3	-
Potassium – year 3	lbs/acre	35	40	25	-
	year applied	3	3	3	-
Maintenance costs – year 2	$/acre	$60	$100	$100	$30
Maintenance costs – year 3–8	$/acre	$220	$200	$200	$100
Harvest costs	**$/dry ton**	**$20**	**$20**	**$20**	**$15**



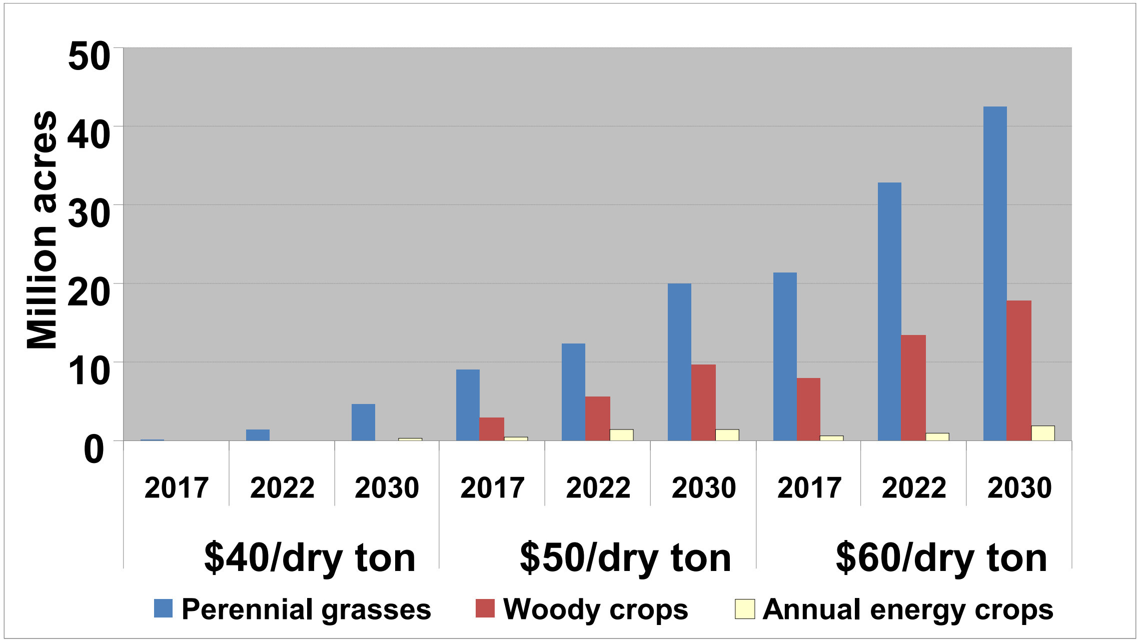
Woody crop productivity

- **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)**

Energy Crop Simulated Land Use Change

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

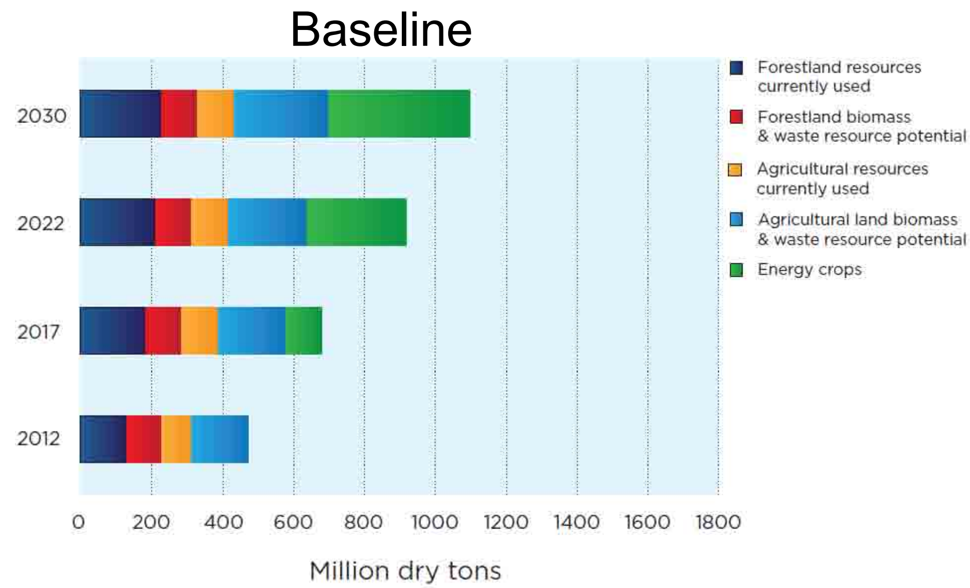


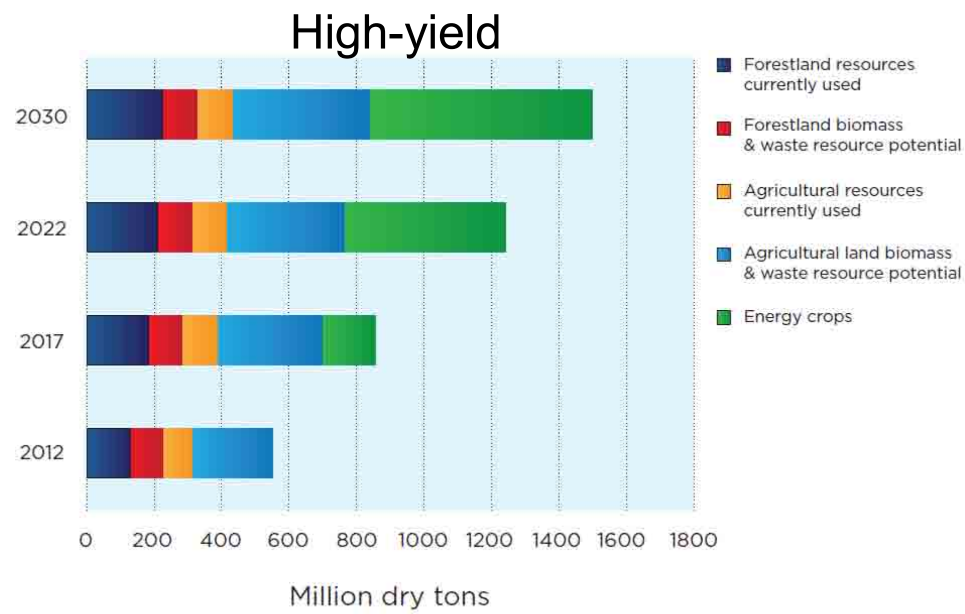
Principle 10 – Explained and documented the details of the analyses and the outcomes and the application of the results.

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

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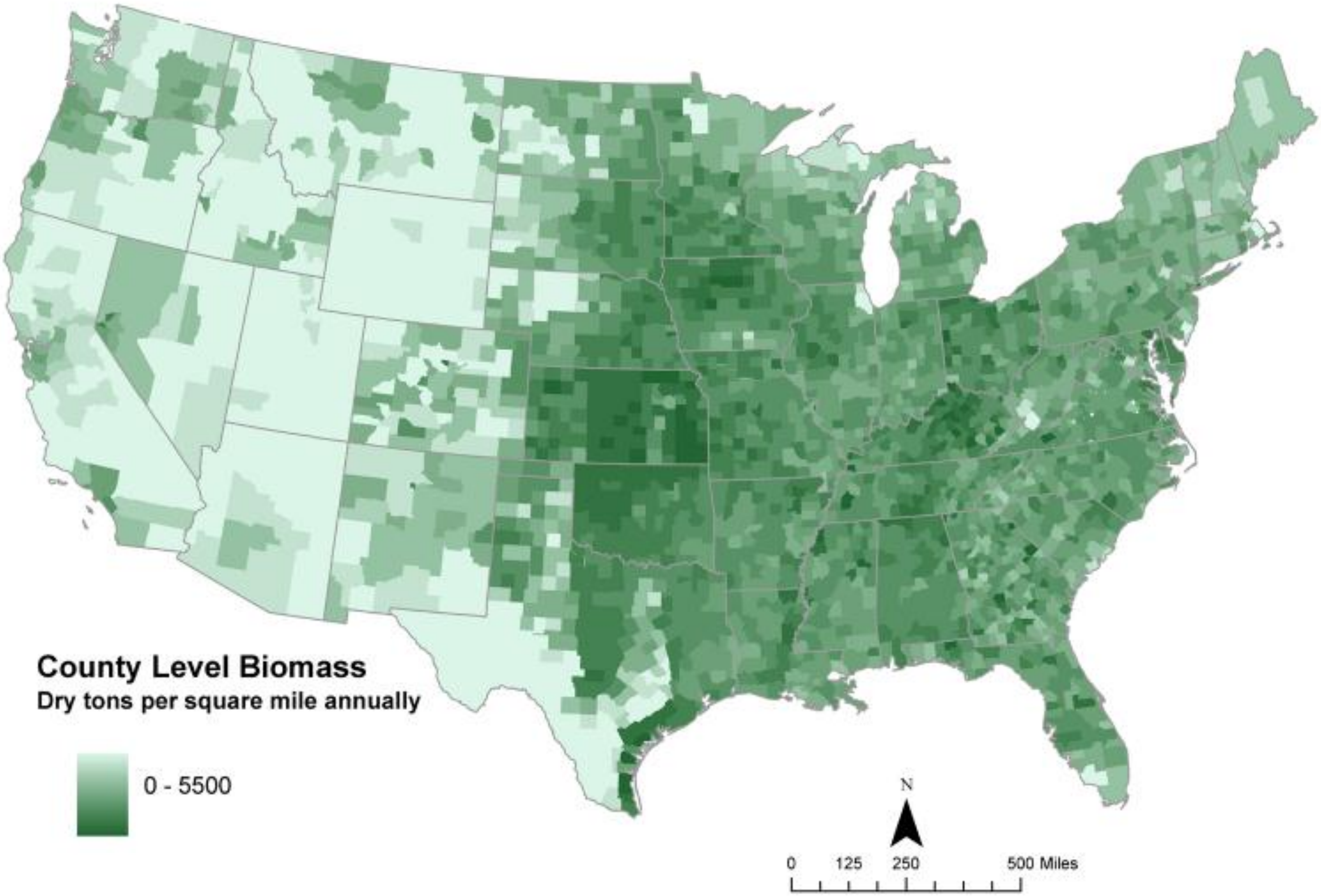

Principles Review

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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 every thing transparent