Billion Ton Study: What can be Learned about Bioenergy Sustainability?

Workshop Report
December 6, 2011

WORSKHOP OVERVIEW

Background on workshop

An informal workshop focused on the implications of the US Billion Ton Update[1] for understanding bioenergy sustainability was held at Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee 28-30 September 2011. The workshop was sponsored by the U.S. Department of Energy's Office of Biomass Program and the Center for BioEnergy Sustainability (CBES) at Oak Ridge National Laboratory (ORNL). The workshop included researchers from the US Department of Energy and its national laboratories, the US Department of Agriculture, the US Environmental Protection Agency, academic institutions, and private industry. This report, all presentations, and some photographs can be found at the CBES web site: http://www.ornl.gov/sci/ees/cbes/workshop.shtml. In addition, the agenda and a list of attendees are in appendixes to this report.

Topics covered by workshop

The topics covered included sustainability issues associated with bioenergy feedstock production. Overall goals for the workshop included:

- Providing understanding of the assumption and goals of the Billion Ton Update (BT2) to the broad community who are focused on feedstock supply
- Discussing next steps in resource analysis, including establishing an approach and framework for using resource analysis data and tools to address environmental and socioeconomic implications of bioenergy production
- Discussing ways to use the BT2 data to evaluate bioenergy sustainability

Workshop participants shared their current research and perspectives in a format that promoted communication among all participants. This workshop increased awareness of what research is occurring as well as research needed in this rapidly developing field.

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[1] http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf and http://www1.eere.energy.gov/biomass/pdfs/BT2_summary_findings.pdf

KEY FEATURES OF Billion Ton Update (BT2)

Purpose of BT2

- Evaluate biomass resource potential
- Improve upon the 2005 Billion Ton Study
  - Assess production and costs
  - Address sustainability
  - Model land-use change

Table 1. Major Differences Between the 2005 BTS (Billion Ton Study) and the 2011 BT2

2005 BTS	2011 BT2
National estimates – no spatial information	County-level with aggregation to state, regional and national levels
No cost analyses – just quantities	Supply curves by feedstock by county – farm gate/forest landing
No explicit land-use change modeling	Land-use change modeled for energy crops
Long-term, inexact time horizon (2005; ~2025 & 2040-50)	2012 – 2030 timeline (annual)
2005 USDA agricultural projections; 2000 forestry Resource Planning Act (RPA)/ Timber Production Output (TPO)	2010 USDA agricultural projections: 2010 Forest Inventory Analysis (FIA) inventory and 2007 forestry RPA/TPO
Crop residue removal sustainability addressed from national perspective; erosion only	Crop residue removal sustainability modeled at soil level (wind & water erosion, soil carbon)
Erosion constraints to forest residue collection	Greater erosion plus wetness constraints to forest residue collection

BT2 scenarios differ in annual increase in yield by feedstock

- Baseline
  - United States Department of Agriculture (USDA) projections extended to 2030
  - National corn yield: 160 bu/ac (2010) increases to 201 bu/ac in 2030
  - Stover to grain ratio of 1:1
  - Small grain and sorghum residue
  - Assumes a mix of 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 scenarios is the same as Baseline Scenario except for
  - Corn yields increase to a national average of 265 bu/acre in 2030
  - Higher amounts of cropland in reduced and no-till cultivation

- Energy crop yields increase at 2%, 3%, and 4% annually

BT2 approach to supply curve estimation

- Focused on major primary feedstocks
- Treated currently used and potential feedstocks separately (did not consider movement of currently used to bioenergy with exception of some conventional pulpwood)
- Used farm gate or roadside analysis
  - Costs to acquire or produce the resource
  - Costs to collect/harvest and move to the field edge or forest roadside ready for transport
- Assumed supply curves do not represent the total cost or the actual available tonnage to a biorefinery or conversion facility
  - No supply chain logistics and losses beyond farm or forest
  - No end-use or conversion processes specified
- Had separate methods for agriculture and forest resources
  - Agricultural land resources - Agricultural policy model (POLYSYS) used to estimate supply curves, land use change
    - ✓ USDA data – USDA projections, US Census, NASS, extended to 2030
    - ✓ Sustainability – wind and water erosion, soil carbon, BMPs in costs
    - ✓ Costs – Grower payments, production costs for energy crops, collection /harvest based on modeling by Idaho National Laboratory (INL) and Oak Ridge National Laboratory (ORNL)
  - Forestland resources - Resource cost analysis used to estimate supply curves (cost-quantities)
    - ✓ Used USDA/Forest Service (FS) data – Forest Inventory Analysis (FIA), Timber Product Output (TPO), Resource Planning Act (RPA)
    - ✓ Sustainability focused on roadless areas, steep and wet sites, road building, biomass retention, best management practices in costs
    - ✓ Costs included stumpage based on USDA/FS FRCS (Fuel Reduction Cost Simulator)
- Estimated secondary processing residues and tertiary wastes using technical coefficients

BT2 sustainability assumptions differ by feedstocks

- Crop residues - Residue removal tool used to estimate retention coefficients for wind and water erosion and soil carbon loss
  - Separate retention coefficients for reduced and no-till
  - No residue removal with conventional till
  - Yield and time dependent in agricultural policy model POLYSYS
- Energy crops
  - Crops include
    - Perennial grasses (switchgrass and other grasses)
    - Woody Crops (eucalyptus, southern pine, poplar, willow)

        - Annual Energy Crop (sorghum)
    - Allowed on cropland, cropland pasture, permanent pasture
    - Not allowed on irrigated cropland or pasture
    - No supplemental irrigation
    - Intensification of pasture land required to meet lost forage
    - Conversion of pasture constrained to counties east of the 100th meridian except for northwestern US
    - Energy crops returns must be greater than pasture rent plus additional establishment and maintenance costs
- Forest residues
    - Land base – 504 million acres of timberland and 91 million acres of "other forestland"
    - Roadside supply curves
    - Includes stumpage and chipping
    - Fuel Reduction Cost Simulator (FRCS) used to estimate harvest
    - Projections based on RPA/TPO
    - Uneven-age thinning
    - With and without federal land
    - Sustainability
    - Removed reserved and roadless designated stands
    - Removed steep and wet areas, and sites requiring cable systems; no road building
    - Biomass retention levels by slope class
    - Logging residues - 30% left on-site
    - Fuel treatment thinning:–
        - Slope <40% - 30% of residue left on-site
        - Slope >40% to <80% - 40% of residue left on site
        - Slope >80% - no residue removed (no limbs or tops yarded)
    - Establishment and maintenance costs

Major results from BT2

- Enough resource potential to meet the 2022 advanced biofuel goals
- Potential resources are widely distributed
- Energy crops are the single largest source of new feedstock
- Different feedstocks combine to provide the billion tons of feedstocks under different scenarios
- Baseline scenario results
    - 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 results

    - 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

Summary of BT2

- Biomass feedstock resources in 2030 range from 1.1 to 1.6 billion dry tons at $60/dry ton or less with 70 to 80% of the total available for new uses
- Results are relatively robust with little competition between crop residues and energy crops, for the deployment delay simply shifts supply curves forward
- Biomass resources are widely distributed across the nation except for the arid west
- Enough resource potential is enough to meet the 2022 biofuel goals as well as provide significant biopower generation
- Bioenergy Knowledge Discovery Framework (KDF) provides specific results of the update (//bioenergykdf.net)

FINDINGS FROM WORKSHOP

SWOT[2] analysis of BT2

- **Strengths**
    - Comprehensive (economics, sustainability)
    - Provides common framework, process, and assumptions for future work
    - Assists in developing and understanding resources related to feedstock sustainability
    - Encourages discussion
    - Process of vetting adds knowledge
    - Linking/coordination/optimization of multiple models has been done with extensive collaboration
- **Weaknesses**
    - It is inherently difficult for one report to be all things (the general dearth of information in this area will lead to over-use of the report)
    - Hard to understand all the assumptions and resulting impacts
    - Linking models can propagate uncertainties, confuse assumptions and complicates quantification of uncertainty
    - Title may oversimplify understanding of potential
    - Spatial resolution is better but still limiting for many analyses
- **Opportunities**
    - To help encourage sustainable feedstock options.
    - Enable users to play around with the effects of changing the assumptions.
    - Refinement and enrichment of the modeling.
    - Evaluate the effects of uncertainties
- **Threats**

[2] Strengths, Weaknesses, Opportunities and Threats

- Misuse of the BT2 data may be used to discredit or oversell bioenergy.
- Misperception of the results as being static.
- Possible lack of funding for updates

Issues in using the BT2 data to explore feedstock sustainability and apply that knowledge across the full biofuel supply chain.

- Of interest to state governments, multi-state regions, consultants, nongovernmental organizations (NGOs)
- Use of BT2 data requires firm understanding of 1) assumptions and 2) external/downstream implications/omissions
- It is important to recognize that the BT2 does not capture all feedstock opportunities (e.g., algae, oilseeds) nor all parts of the bioenergy supply system

Comparison of feedstock aspects of bioenergy to other energy sources

- Support assessment of effects of feedstock choice and how that choice influences land-management practices and bioenergy deployment on air, water, soils (erosion and fertilizer use), greenhouse gas (GHG) emissions, productivity, biodiversity, etc.
    - Of interest to policy makers and NGOs
    - Needs to be linked to other models and have ability to control assumptions and clarify operational conditions
    - Could be risk assessment, Life Cycle Analysis (LCA), cost/benefit analysis, net benefit analysis or other approaches
- Support identification of how feedstock options might influence the mix of technology and conversion processes for various locations (of interest to private industry which needs to identify and develop clusters and scales of deployment)
- Regional analyses
    - Evaluate if economics of scale means that deployment of particular feedstock options may work in some areas and not in others (e.g., places with low density of biomass)
    - Evaluate the spatial aspects of feedstock options related to energy production and consumption compared to volume produced
    - Consider topography and logistics obstacles
    - Evaluate the lack of certainty around supply estimates
    - Identify regions for development or conduct site, project potential assessment, and logistics analysis
        - ✓ Of interest to private sector, consultants, researchers/modelers
        - ✓ Consider the lack of certainty around supply estimates (but there may not be enough local scale information to do this)
        - ✓ Consider that reliability of projections over time decreases.
        - ✓ Validation of adoption rate/cultural values/behaviors (e.g., adoption of no-till, Use of external markets, etc.)
- Use as reference for field validation (of interest to researchers and modelers who must evaluate assumptions and down-stream omissions)

- Use estimates of feedstock production in Biomass Scenarios Models (BSM) and National Energy Modeling System (NEMS) (of interest to agencies that need to be able to inform policy)
- Enhance private sector and research investment decisions and due diligence
  - Of interest to private companies, financial institutions, and consultants
  - While this was not the intended use of the BT2, there is nothing else that is appropriate for such analyses. There is a lack of certainty around supply estimates that justifies further investment in that kind of research.
- Evaluate major environmental and socioeconomic issues of interest to policy makers, state agriculture departments, researchers and consultants
  - Land-use changes and their effects
  - Food/fuel trade-offs
  - Effects of price and its variability
  - Invasiveness of feedstock crops
  - Damage assessment of potential disturbances
- Conduct energy and environmental policy evaluations (but must recognize the uncertainties and that the BT2 was not designed for fine-scale policy analysis)
  - Agencies and industry groups making decisions about resource allocation funding
  - Opportunities include developing incentive programs, encouraging landscape diversity, features for certification systems, permitting guidelines, Best Management Practices (BMPs), and pollutant thresholds
- Guide research and its funding (of interest to researchers and managers)
  - How do we know the appropriate scale for environmental assessment?
  - What needs to be considered in addressing advancing technology and perennial crop choices?
  - Where is it best to grow what crop for different goals?
  - What are appropriate landscape management schemes for enhancing ecosystem services?
- Evaluate social impacts such as quality adjusted life years, disability adjusted life years ($), valuation of ecosystem services
  - Of interest to nongovernmental organizations (NGOs) and communities
  - Habitat for wildlife (game and non-game), [e.g. concern about conversion of conservation reserve programs (CRP) lands, location issues – recognizing the interest in locations being "not in my back yard" (NIMBY), etc.]

Next Steps for enhancing use of the BT2

- Acknowledge what went right for BT2
  - The BT2 has broad engagement and peer-review
  - The open source, open access and interactive nature of BT2 data that are available in the Bioenergy Knowledge Discover Framework (KDF)[3]

[3] https://bioenergykdf.net/

- The BT2 has appropriate spatial resolution in having information available by county for a national assessment
  - It was useful to add energy sorghum
  - The BT2 is based on current data
  - The BT2 includes assumptions that are more defensible in comparison to the 2005 report, for they are more data-based (e.g., variable stover removal rates)
  - An informal survey of the workshop attendees suggests that the BT2 included a balance of opinions about estimates of biomass availability (choices were: too conservative versus too optimistic versus just right)
- Provide information that is needed to understand BT2 data (such as on the KDF)
  - The main assumptions that could have a large effect on results
  - The cost impacts of BT2 assumptions and constraints (e.g., what is the impact of the 25% land conversion cap on feedstock price?)
  - Underlying input data that are not currently in the KDF
  - The changes in land use/crop production that occur over time
  - Information other than dry tons of feedstock by country (e.g. sugars, lignin)
- Related questions that should be addressed
  - Feasibility of biomass feedstock sources
  - Consider biomass diversity versus consistency in both supply and quality within an area
  - How to analyze BT2 data in conjunction with additional environmental, production, and other data to verify ecological effects
  - What are appropriate sustainability indicators for energy crops and other biomass in system
- Next steps to consider for improving the BT2
  - Providing the ability to manipulate assumptions and constraints (This might be done in specific studies)
  - Coordinating/comparing with state assessments.
  - Conducting sensitivity analyses/uncertainty analyses such as Monte Carlo analysis (e.g., considering weather, climate impacts, input costs, yields, etc.)
  - Clarifying production assumptions for LCA.
  - Conducting field validation [with information from the USDA National Agricultural Statistics Service (NASS), SunGrant, or independent studies . The feedback would be useful for researchers who developed the initial yield assumptions.]
  - Performing more field research on yields, operations, production practices, etc.
  - Comparing BT2 baseline with Biomass Scenario Model projections.
  - Accounting for projected international competing demand for biomass
  - Including potential climate changes by region
  - Comparing results of BT2 to those derived from others models such as agent based models that couple human dimension issues with logistics model
  - Making analysis tools accessible for linkage to other models

  - Coupling with environmental models
  - Including forest module that handles commodities
  - Including land allocation submodel
  - Improving energy crop input parameters
  - Evaluating policy instruments such as demand driven shocks effects (but this activity would require new model runs)
- Develop interoperability of the BT2 components (meaning the ability of the component parts of a system to operate successfully together)
  - Expand interoperability of:
    - ✓ Input data and reference data sets including common reference points (issue of multiple, incomparable, road-maps discussed)
    - ✓ Model output
    - ✓ Definitions
    - ✓ Baseline scenario assumptions
  - Explore ways the BT2 can be extended (for example to add other modules, operate at multiple scales, communicate with or link with other models)
  - Work toward having the BT2 be reflected in inter-agency efforts for national analysis (USDA-USFS-DOE-EPA) The BT2 is a valuable foundation and starting point for further collaboration.
  - Have a systematic approach and standards as a pre-requisite for inter-operability
    - ✓ Standards needed for depositing, sharing, managing information, and one that retains clear ownership
    - ✓ Examples such as "Gen Bank" for NCBI, CDIAC, ARM
    - ✓ Need trusted library function
    - ✓ Need common language
  - Have KDF-like platforms give appropriate credit to contributors (branding issues)
    - ✓ Need to acknowledge/share ownership, help market partners
    - ✓ Citations, footnotes
    - ✓ Function as a library – depository
    - ✓ Quality control, data limitations, data quality definitions (sources, temporal basis, time-date stamps, tools and definitions defined to permit replication, etc.)
  - Recommended actions for developing interoperability
    - ✓ Get user feedback on KDF user interface
    - ✓ BT2 framework should be living document. Hence a system is needed to time-stamp, track changes
    - ✓ Need KDF-like platform to support ongoing analyses (which requires co-funding from multiple stakeholders)
    - ✓ Need to improve data (temporally, spatially, and consistency) to facilitate validation
    - ✓ Need to incorporate analyses of disturbance and resilience

        - ✓ Effort must have sustained support – need funding for data quality control, maintenance, and sharing of information, corrections and updates
        - ✓ Conduct sensitivity analysis
- Identify missing pieces and considerations for moving forward
    - Feedstocks
        - ✓ Woody biomass in the West
        - ✓ Sugarcane/energy cane, sweet/biomass sorghum
        - ✓ Intercrops, cover crops
        - ✓ Double cropping
    - Farm gate versus biorefinery gate
        - ✓ All feedstocks are not created equal!
            - Physical quality* (e.g., sugar content)
            - Timing/storage* (e.g., woody biomass easier to store)
            - Supply density regionally

          * These are probably easier to incorporate
    - Consider improved and altered assumptions and models
        - ✓ Better land use/management data- but it is not clear how to obtain this information!
        - ✓ Explore different assumptions such as
            - Requirements for intensification of pastureland
            - Farmer/rancher decisions, cultural changes and (perceived) risk exposure
            - Where the meridian line is drawn.
            - Forestry (too conservative on fuel wood) – infrastructure
            - Is all harvest of woody biomass qualified under the Renewal Fuel Standard 2[4]?
            - What's the cost of not harvesting the biomass (i.e., the value of "fire control")?
            - Investigate some sustainable irrigation scenarios (e.g. snowmelt, waste water)
            - Assess impact of price changes in other commodities/sources of energy
        - ✓ Could KDF users/stakeholders explore different assumptions themselves?
    - Consider data content
        - ✓ Need more replicated and/or long-term field studies that improve estimates of resource availability AND the impacts of using that resource across the landscape
        - ✓ Continued incorporation of those field studies and other new sources of data (such as those being compiled in databases)
    - Revise approach to data analysis and representation

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[4] http://www.epa.gov/otaq/fuels/renewablefuels/index.htm

- ✓ Consider ways to overlay maps onto other data content (land tax categories, Congressional districts, Census statistics, Employment statistics, Google Earth, soils maps, critical habitats)
- ✓ Provide assumptions for models in visible/downloadable form

WORKSHOP OUTCOME: POTENTIAL NEXT STEPS

Work with other projects and actors to consider how to identify impacts of pressures other than biofuel development and how biofuel expansion might affect those pressures. One example focus area is fire and it's affect on forestry issues. This topic requires the ability to enhance sustainability of fire mitigation. It involves examination and communication about the opportunity to use the bioenergy feedstock to reduce fire risks. Next step might be another workshop.[5]

Consider way to build or adapt a library for storage, interoperability, and use of a common language related to bioenergy sustainability.[6] There may be private or government funding available to support it. The CBES website has posted the presentations from this workshop that may help the ideas move forward.

Expand abilities of the KDF (some examples are listed below)

- Host forums on particular issues. For example, the KDF could host a forum or list server to which one could subscribe as a means to communicate. [7]
- Develop a sustainability component to the KDF that would be a working place for analysis and discussion of topics – for example
  - Ways to use the BT2 data to explore feedstock sustainability issues
  - Diverse sustainability topics (e.g., forum discussion threads, new data added, analyses completed, publications, etc.)

Develop a purpose and then a plan for targeting a bigger and more diverse group for a follow-on work on data availability issues may be of interest to those involved in the BT2 or use of its projections. This effort would require the establishment of a broad working group. It may require new data, using the KDF for discussions and depository for the data, or subsequent workshops. There may be private sponsorship for such an activity. Perhaps the KDF could draw information from the other databases and keep all information in one source instead of different areas. Now some of the same information plus new material is stored in different databases. Maybe in 12 month's time, it would be appropriate to share

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[5] Ken Skog will convene a conference call with Virginia Dale, Helene Cser, Matt Langholtz, Peter Tittman, and Jamie Nettles to explore this option.

[6] Alex Ruane, Tom Hertel, and Simon Liu had a meeting in Washington DC the week of October 1, 2011, to initiate such an activity. The KDF could be a part of this effort and should consider coordinating with Simon's work.

[7] KDF has this capability, and Ranyee Chiang is exploring this opportunity. Yetta Jager is talking with Aaron Myers, to check for multiple ways to connect KDF.

research with private industries and communities about how to access this information and perhaps link several databases together.[8] The idea is to get people together to talk about a funding proposal to assess the costs in entering data and retrieving it. Linking private resources would help in funding, for nobody has enough resources or money to do this. The BT2 Workshop endorsed this need so that support can be referred to when proposal comes up. Doug Karlen and Mike Edgerton agreed to come up with a statement to endorse a need for a workshop and funding action.

A special session could be held at the Ecological Society of America 2012 annual meeting on information needed for sustainability bioenergy testing. The idea would be to challenge researcher to consider developing a manuscript documenting opposing views on how bioenergy might affect biodiversity, habitat, and invasive species.[9]

Assess the potential role of the BT2 output data for use in other studies.

- Develop a review paper of the BT2 results and assumptions pertaining to use and inference on sustainability
- Identify specific models and what questions could be addressed with the spatial specific county assessments.
- Develop a review paper on the implications of climate change for the assessment
- Assess the impact of removing the irrigation assumption, or other critical assumption

Strategically expand the BT2 database with ancillary information for sustainability analysis. Some examples are the retention index for agricultural residues, erosion rates, average field size, slope, etc.

[8] This is a reminder that in September 2012 Doug Karlen and Ranyee Chiang will consider this option and determine if another workshop could be held.

[9] Chris Clark, Yetta Jager, Caroline Ridley, and Zakiya Leggett are looking at this opportunity.

Appendix I: WORKSHOP AGENDA:

Field Trip – Agenda

Wednesday, September, 28, 2011 - Field Trip

Time	Event	Lead
8:00 am	Depart from lobby of Comfort Inn Distribute visitor badges (please have photo ID available)	Becky Bowman
8:30 – 9:45 am	UT Arboretum: Forest Residue Collection	Richard Evans and Mark Downing
9:45 – 10:00 am	Travel to NTRC	
10:00 – 11:30 am	National Transportation Research Center • Material compatibility with biofuels • Vehicle Evaluation (Chassis dynamometer lab) • Biofuel engine optimization (Engine test cell) • Emissions issues with biofuels (Analytical lab)	Tim Theiss and Mark Downing
11:30 – 12:30 pm	Travel to Vonore restaurant	
12:30 – 1:30 pm	Working lunch – Overview of the University of Tennessee (UT) Biofuels Initiative and Switchgrass Program	Sam Jackson
1:30 – 3:30 pm	Travel to switchgrass field to discuss growing bioenergy crops	UT/Genera Energy (Sam Jackson/Ken Goddard/Jon Walton)
3:30 – 5:00 pm	Travel to Genera Energy LLC Biomass Innovation Park to discuss biomass logistics, processing and conversion	Genera Energy LLC (Sam Jackson/Clay Dye)
5:00 – 6:00 p.m.	Travel to hotel	

Point of Contact: Becky Bowman (cell: 505-699-3641 or rzl@ornl.gov)

Billion Ton Study: What can be Learned about Bioenergy Sustainability?

Workshop – Agenda

Thursday, September 29, 2011 - Workshop – Day 1 – Building 1505, DJ Nelson Auditorium

Time	Event	Lead
7:50am	Bus leaves hotel traveling to ORNL Visitor Center (please have a photo ID available)	Becky Bowman
8:30 – 9:00 am	Welcome, introductions, and purpose of workshop	Martin Keller Virginia Dale
9:00 – 9:30 am	Value of Billion Ton Study and sustainability to DOE	Ranyee Chiang
9:30 am – noon	Plenary: Background on Billion Ton (BT) Study	
9:30 – 9:50 am	• BT overview and long-term perspective	Bob Perlack
9:50 – 10:10 am	• Assumptions and implications involving residues	Richard Nelson
10:10 – 10:40 am	Break	
10:40 – 11:00 am	• Assumptions and implications involving forest resources	Bryce Stokes
11:00 – 11:20 am	• Economic assumptions and implications	Burt English
11:20 am – noon	• Discussion with speaker panel	
noon – 1:00 pm	Group picture / Lunch –continued discussion	
1:00 – 2:00 pm	Plenary: Use of the BT for sustainability analyses	
1:00-1:25 pm	• Environmental and socioeconomic indicators of bioenergy sustainability	Allen McBride and Paul Leiby
1:25- 1:50 pm	• Demo of Knowledge Discovery Framework (KDF)	Aaron Myers
1:50-2:00 pm	• Breakout group assignments	
	✓ Topic 1: Next steps for incorporating sustainability in resource analysis	Robin Graham
	✓ Topic 2: Ways to use the Billion Ton Study data to explore bioenergy sustainability across the full biofuel supply chain	Mark Downing

2:00 – 2:30 pm	Break	
2:30 – 4:30 pm	Breakout group meetings	
4:30 – 5:30 pm	Plenary – Reports from breakout groups	Robin Graham
5:30 – 6:00 pm	Travel from ORNL to restaurant – Flatwater Grill	
6:00 – 8:00 pm	Dinner / Speaker: switchgrass production	Ken Goddard
8:00 – 8:30 pm	Travel from restaurant to hotel	

Friday, September 30, 2011 – Workshop – Day 2

Time	Event	Lead
8:00 am	Bus leaves hotel traveling to ORNL	Becky Bowman
8:30-8:40 am	Plenary: New thoughts from prior day	
8:40 – 11:10 am	Plenary: How to use the Billion Ton Study to address sustainability concerns	
8:40 – 9:00 am	• Large-Scale Biofuel Water Sustainability Assessment	May Wu
9:00 – 9:20 am	• Use of BT data for water quality estimates at large scales	Yetta Jager
9:20 –9:40 am	• University researcher use of the BT Data	Peter Tittmann
9:40 – 10:00 am	• USDA ARS researcher use of the BT Data	Doug Karlen
10:00 – 10:30 am	Break	
10:30 – 10:50 am	• Industry research use of the BT Data	Jami Nettles
10:50 – 11:10 am	• Other use of the BT Data	Esther Parish
11:10 am – 12:30 pm	Breakout groups continued from Thursday	
12:30 – 1:30 pm	Lunch with breakout group discussions	
1:30 – 2:30 pm	Plenary: Breakout reports and discussion	Mark Downing
2:30-3:00 pm	Break & completion of workshop evaluation forms	
3:00 -4:00 pm	Plenary: Next steps	Virginia Dale
4:00 pm	Adjourn workshop - bus departs for Knoxville Airport	

Appendix II: LIST OF WORKSHOP PARTICIPANTS

Barney	Jacob	Virginia Tech
Baskaran	Latha	Oak Ridge National Laboratory
Bobzin	Steve	Ceres Co.
Brandt	Craig	Oak Ridge National Laboratory
Chiang	Ranyee	Department of Energy
Clark	Chris	Environmental Protection Agency
Cser	Helene	North Carolina State University
Dale	Virginia	Oak Ridge National Laboratory
Dedrick	Daniel	Sandia National Laboratory
Dornburg	Veronika	Shell International Exploration and Production Inc.
Downing	Mark	Oak Ridge National Laboratory
Eaton	Laurence	Oak Ridge National Laboratory
Edgerton	Mike	Monsanto
English	Burt	University of Tennessee
Goddard	Ken	University of Tennessee
Graham	Robin	Oak Ridge National Laboratory
Hellwinckel	Chad	University of Tennessee
Hess	Richard	Idaho National Laboratory
Inman	Daniel	National Renewable Energy Laboratory
Jackson	Sam	University of Tennessee
Jacobs	Gary	Oak Ridge National Laboratory
Jager	Yetta	Oak Ridge National Laboratory
Karlen	Doug	USDA-Agricultural Research Service (ARS), National Laboratory for Agriculture and the Environment (NLAE)
Keller	Martin	Oak Ridge National Laboratory
Kellogg	Chev	Alabama A&M University
Keyes	Michael	Scientific Certification Systems
Kline	Keith	Oak Ridge National Laboratory
Kubista-Hovis	Kristi	U.S. Department of Agriculture
Langholtz	Matt	Oak Ridge National Laboratory
Leggett	Zakiya	Weyerhaeuser, Co
Lightle	David	USDA- Natural Resources Conservation Service
McBride	Allen	Oak Ridge National Laboratory
Moore	Gerard	U.S. Department of Agriculture
Myers	Aaron	Oak Ridge National Laboratory
Nelson	Richard	Kansas State University
Nettles	Jamie	Weyerhaeuser, Co

Parish	Esther	Oak Ridge National Laboratory
Perdue	James	USDA - Forest Service
Perlack	Bob	Oak Ridge National Laboratory
Rials	Timothy	University of Tennessee
Ridley	Caroline	Environmental Protection Agency
Scott	David A.	USDA - Forest Service
Singh	Nagendra	Oak Ridge National Laboratory
Skog	Ken	USDA - Forest Service
Smith	Ray	Environmental Protection Agency
Snowden-Swan	Lesley	Pacific Northwest National Laboratory
Stokes	Bryce	Department of Energy
Theiss	Timothy	ORNL - National Transportation Research Center
Thelen	Kurt	Great Lakes Bioenergy Research Center
Tiller	Kelly	University of Tennessee
Tittmann	Peter	University of California, Davis
Turhollow	Anthony	Oak Ridge National Laboratory
Uria-Martinez	Rocio	Oak Ridge National Laboratory
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