2016 Billion-Ton Report, Volume 2:
Environmental Sustainability Effects of Select Scenarios from Volume 1

Bioeconomy 2017

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OAK RIDGE
National Laboratory

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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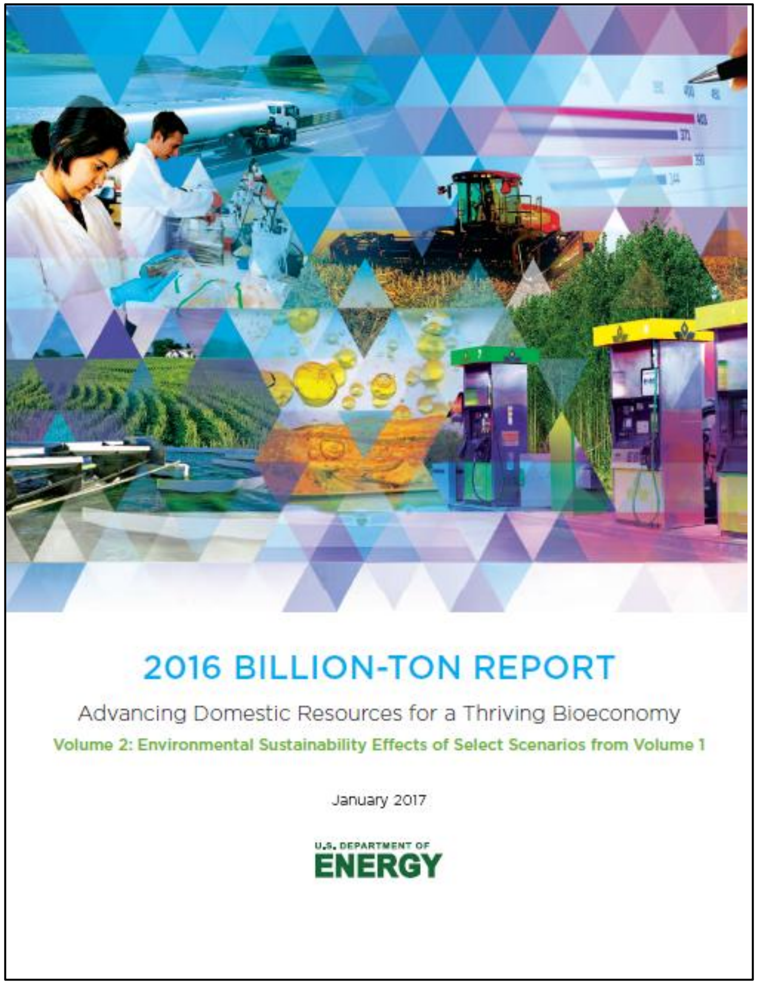
Outline of Presentation

- Significance of 2016 Billion-ton Report (*BT16*) volume 2
- Background on *BT16* volume 1
- Objectives
- Approach
- High-level conclusions
- Enhancing environmental outcomes
- Closing remarks
- KDF resources

Importance of *BT16* volume 2

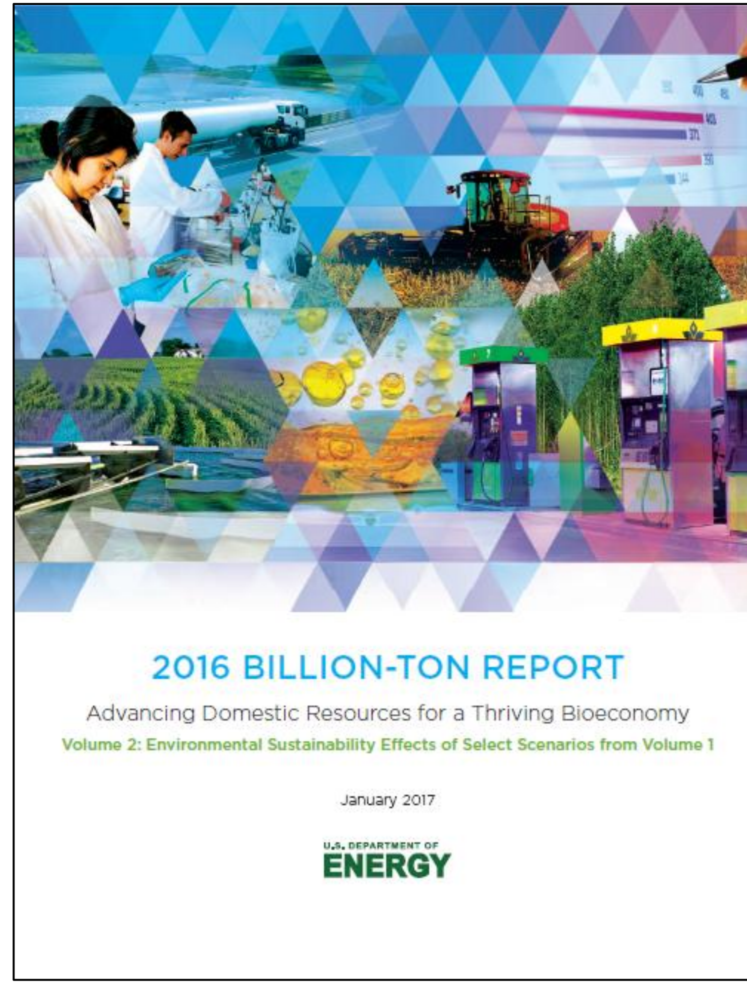
- Previous Billion-Ton studies focus on quantifying potential biomass supplies.
- Volume 2 is the first effort to address a critical knowledge gap about potential environmental implications.
- Volume 2 provides an extensive online resource to enable additional analyses and inform future R&D.



BT16 volume 2 Outline

Volume 2

- Land Allocation and Management
- Greenhouse Gas Emissions (Agriculture and Forestry)
- Water Quality
Water Quantity
Water Consumption Footprint
(Agriculture and Forestry)
- Biodiversity (Agriculture and Forestry)
- Air Emissions (Agriculture and Forestry)
- Qualitative Analysis of Environmental Effects of Algae Production
- Climate Sensitivity of Agricultural Feedstock Productivity
- Strategies to Enhance Environmental Outcomes



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Air Emissions

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Land-use Change (LUC)

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Climate Change Impacts on Feedstock Productivity

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Algae

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Discussion and Enhancing Environmental Outcomes

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Knowledge Discovery Framework and Visualization

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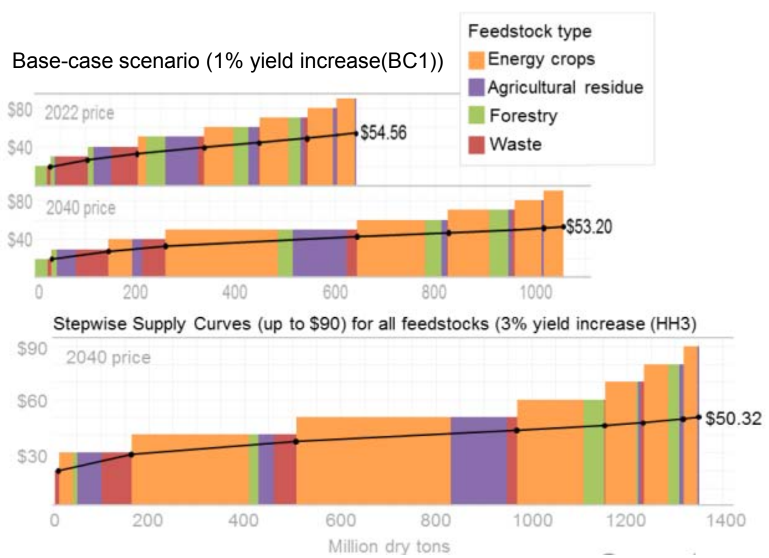
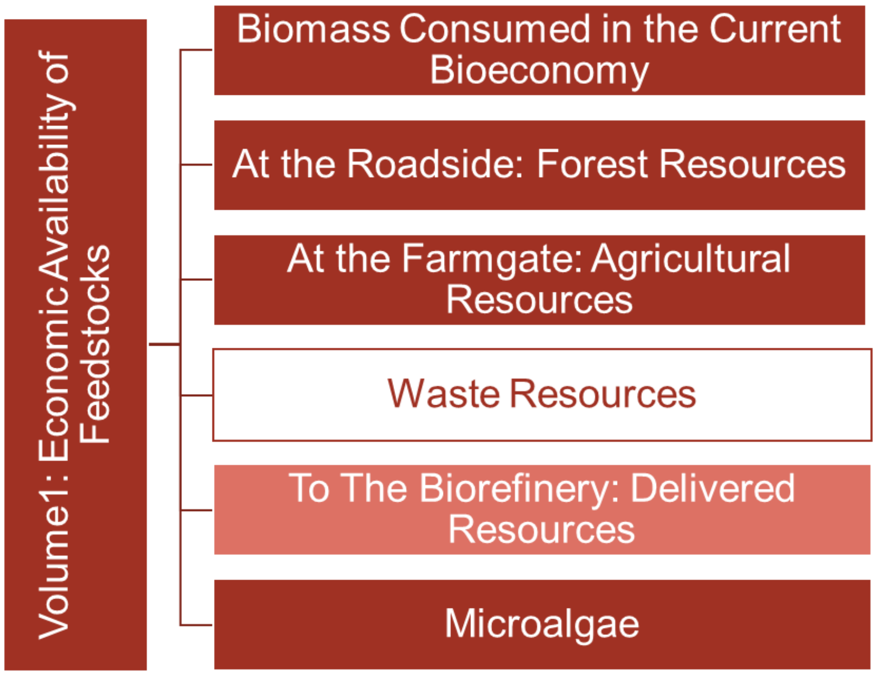
Background on *BT16* volume 1

2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy: Volume 1. Economic Availability of Feedstocks

- Data: NASS Census of Agriculture, USDA Baseline Projections, Forest Inventory and Analysis, Sun Grant Initiative, and USFS Forest Products Lab
- Models: version of POLYSYS for agriculture and ForSEAM for forest resources, both operating at a county-level

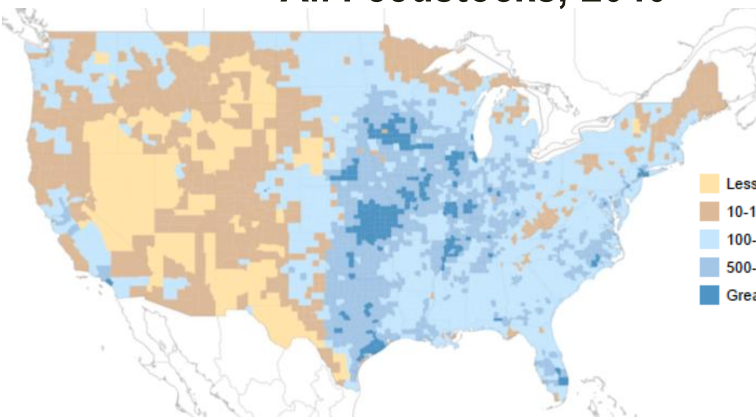
Output: Feedstock Supply and Price Assessments



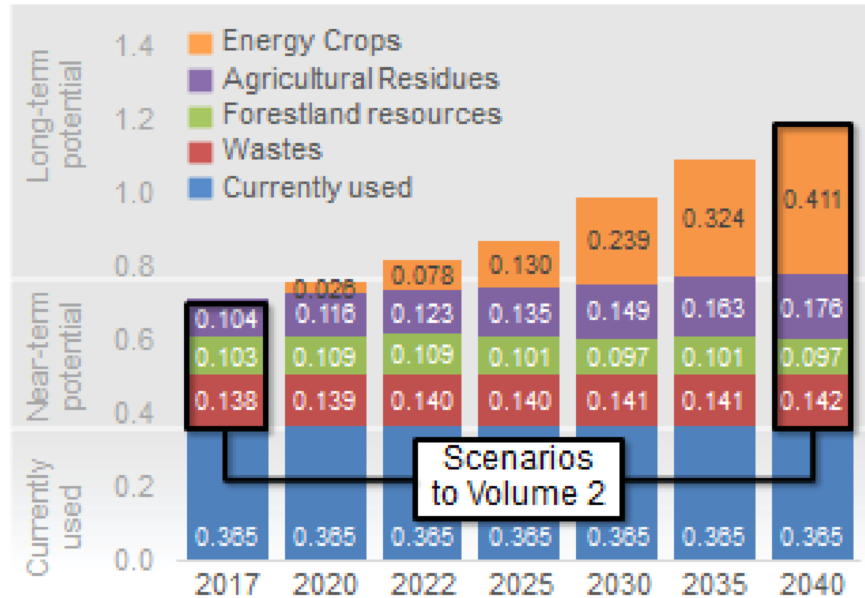


Primary Objectives of *BT16* volume 2

All Feedstocks, 2040



*2040, combined potential supplies, at $60 or less, roadside, base-case scenario, including wastes. Source: https://www.bioenergykdf.net/billionton2016/1/2/tableau



Use national set of county-level output data from *BT16* volume 1 to

- Describe land management effect of agricultural and forestry scenarios that lead to environmental change
- Investigate greenhouse gas emissions, soil organic carbon, water quality and quantity, air emissions, and biodiversity
- Consider near-term (2017) and long-term (2040) effects
- Consider base yield and high yield scenarios (2040)
- Provide an extensive online resource to enable additional analyses.

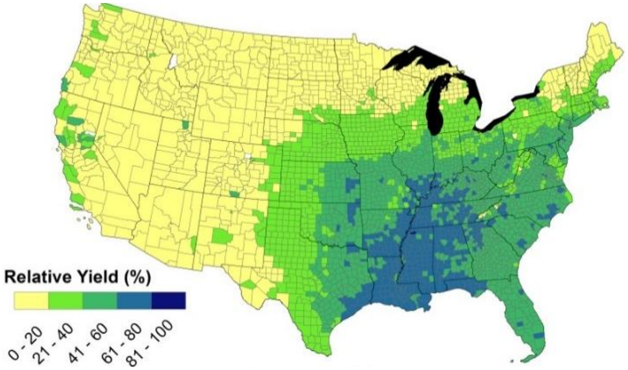
Additional Objectives of *BT16* volume 2

Land-use change

Clarify land-use change (LUC) implications of *BT16* in light of model constraints and assumptions relative to other LUC studies

Sensitivity of energy crops to climate

Simulate climate sensitivity of agricultural energy crop productivity



Microalgae

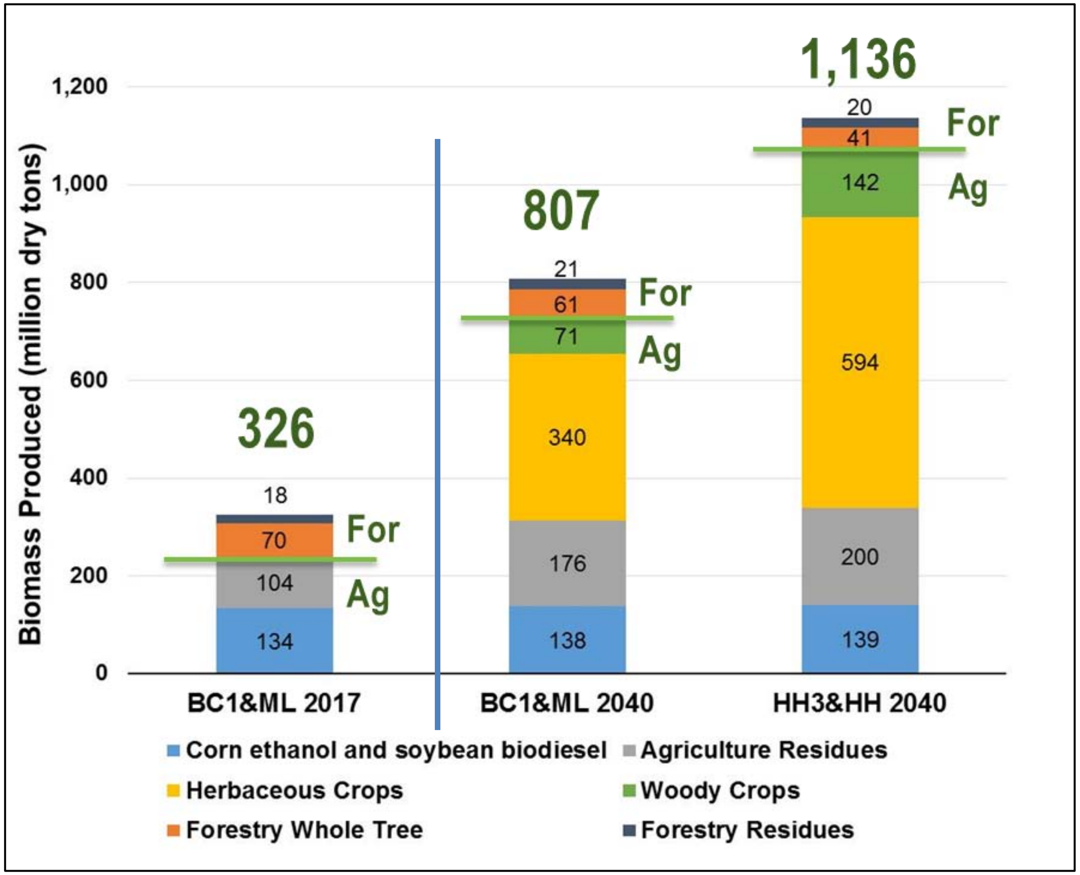
Assess qualitative environmental effects of potential algae biomass production from *BT16* volume 1

Enhancing environmental outcomes

Describe strategies for enhancing environmental benefits and minimizing concerns

Approach: Supply Scenarios Analyzed

- Three specific scenarios from *BT16* volume 1 were selected to include a low- and a high-yield scenario and near- and long-term estimates.



	Agriculture (Ag)	Forestry (For)	Annual Yield Increase
2017	base case, BC1	baseline, ML	1%
2040	base case, BC1	baseline, ML	1%
2040	high yield, HH3	High housing, high wood energy, HH	3% (ag) or specified wood energy demand

Approach: Environmental Indicators

	Indicator
Soil quality (ANL)	1. Total organic carbon (TOC)
	2. Total nitrogen (N)
	3. Extractable phosphorus (P)
	4. Bulk density
Water quality and quantity (ANL, ORNL, USFS)	5. Nitrate loadings to streams (and export)
	6. Total phosphorus (P) loadings to streams
	7. Suspended sediment loadings to streams
	8. Herbicide concentration in streams (and export)
	9. Storm flow
	10. Minimum base flow
	11. Consumptive water use (incorporates base flow)
	Addition: Water yield

McBride et al. (2011) *Ecological Indicators* 11:1277-1289

	Indicator
Greenhouse gases (ANL)	12. CO_2 equivalent emissions (CO_2 and N_2O)
Biodiversity (ORNL, USFS)	13. Presence of taxa of special concern
	14. Habitat area of taxa of special concern
Air emissions (NREL)	15. Tropospheric ozone
	16. Carbon monoxide
	17. Total particulate matter less than 2.5 μm diameter ($PM_{2.5}$)
	18. Total particulate matter less than 10 μm diameter (PM_{10})
	Additions: VOCs, SO_x, NO_x, NH_3
Productivity	19. Aboveground net primary productivity or Yield

Light orange—indicators in *BT16* volume 2

White—other BETO- and ORNL-recommended indicators

Inputs	Models Used	Outputs

Inputs

Land cover + management practices for scenarios

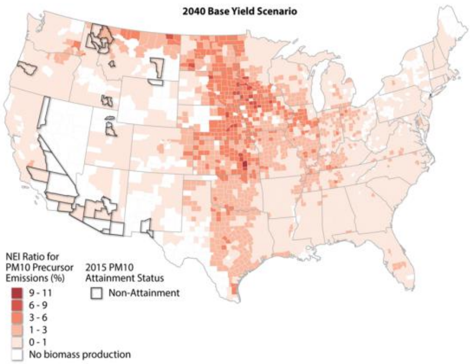
+ Equipment budgets for scenarios

+ Model-specific inputs (climate, land-use history, downscaled landscapes, habitat suitability, etc.)

Models Used

- Surrogate CENTURY Soil Organic Carbon model
- Greenhouse gases, Regulated Emissions, and Energy use in Transportation Model (GREET)
- Soil and Water Assessment Tool (SWAT)
- Empirical model
- Water Supply Stress Index (WaSSI) Ecosystem Services Model
- Water Analysis Tool for Energy Resources (WATER)
- Feedstock Production Emissions to Air Model (FPEAM)
- Species distribution model, Bio-EST
- Habitat suitability framework

Outputs



County-level Environmental Effects

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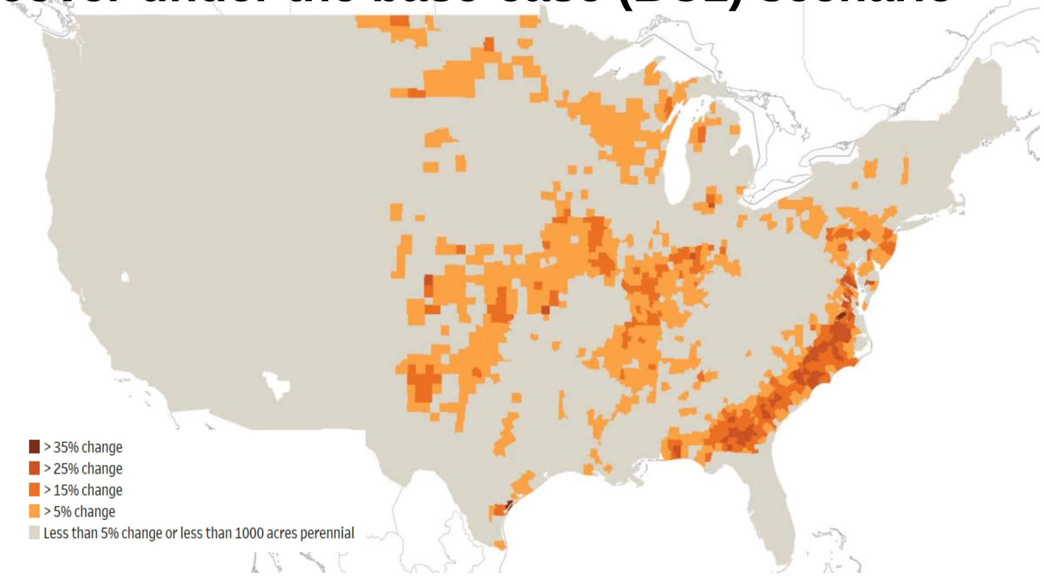
Comparisons among scenarios

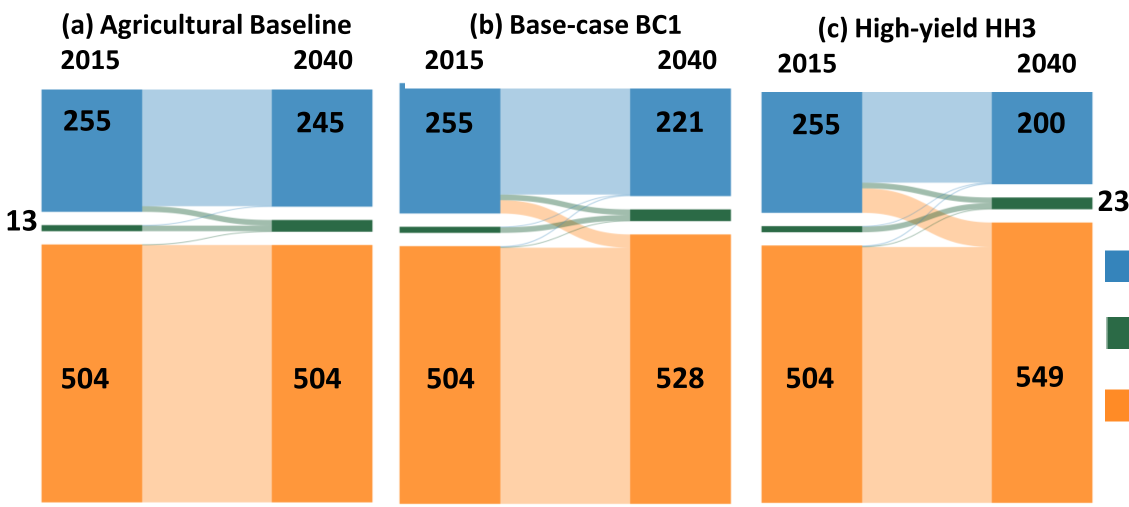
Chapter 3 – Land Allocation and Management Main Findings

Geospatial distribution of changes in perennial cover under the base-case (BC1) scenario

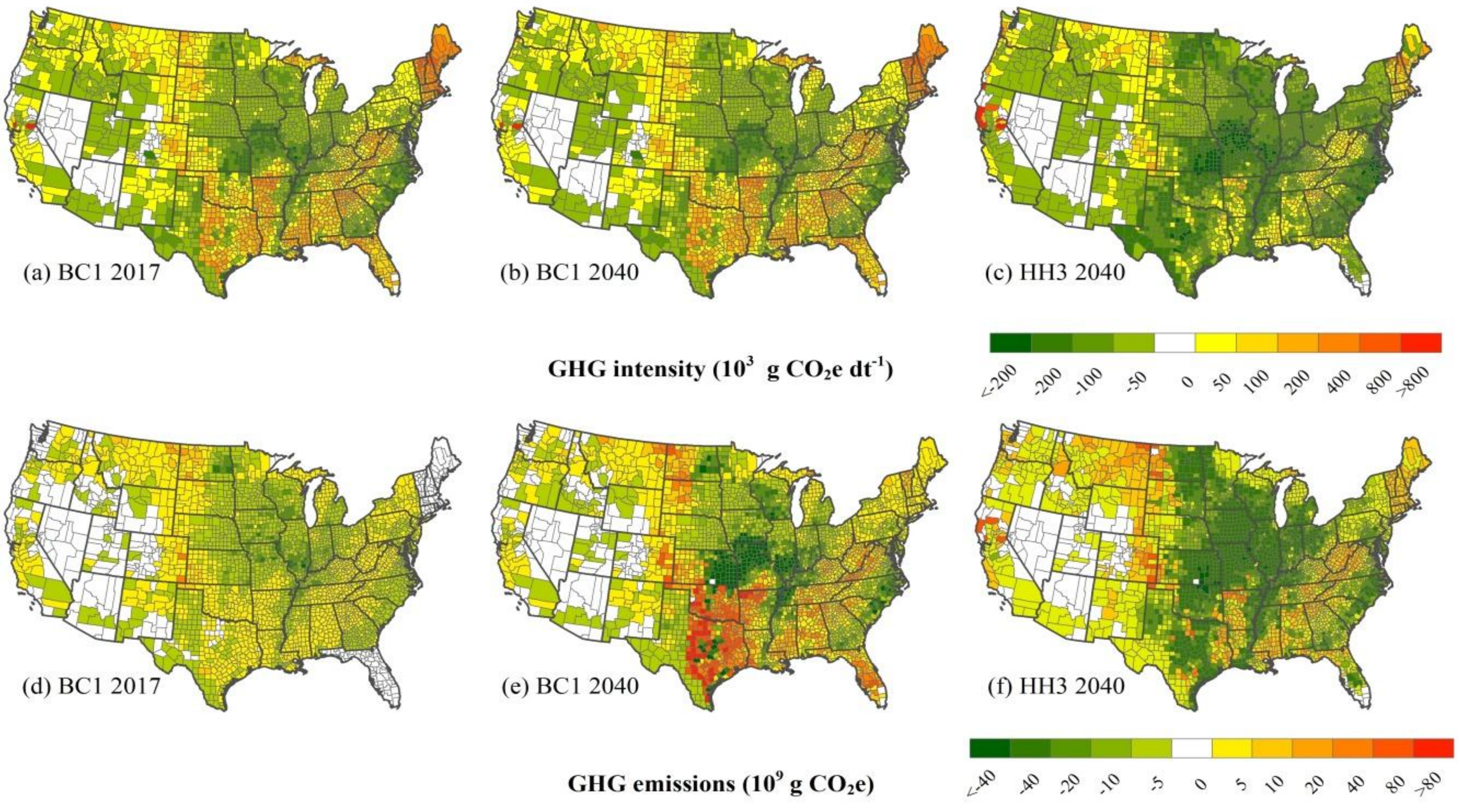


Difference between the percentage of total agricultural acres (cropland +pasture +idle land) managed as perennial cover in BC1 2040 and the percentage managed as perennial cover in the 2015 agricultural baseline.

- Maximum county-level increase was 38%. Change in majority of counties was below 5% increase or decrease.
- Larger increases occur on agriculture land in Southeastern Plains and areas where simulated returns from conventional crops are not as competitive with energy crops.



County-level SOC changes highly dependent on yield, local soil characteristics, and weather



High-Level Conclusions of BT16 volume 2

- Environmental effects vary by location, biomass type, and previous land management:
  - In most cases, potential for an increase in biomass production with negligible or manageable effects on water quality, water quantity, and air pollutant emissions.
  - In some contexts, potential challenges for water quality, water quantity, and air quality.
  - Biodiversity effects dependent on species and location, with possible increases in richness and range for some species and potential adverse impacts to others that may require additional safeguards.
  - Potential for deep-rooted, high-yielding energy crops to contribute to soil organic carbon gains; some transitions lead to soil organic carbon losses.
  - Favorable performance of cellulosic biomass relative to conventional feedstocks in terms of soil organic carbon, GHG emissions, air emissions, and water quantity.
- Future research, science-based monitoring, and adaptive management are needed.

Enhancing Environmental Outcomes: Going Beyond Analyses in this Report

Best management practices

- Common implementation in forestry and agriculture with emphasis on soil and water quality
- Could develop BMPs for air quality, biodiversity, GHG emissions

Landscape design

- Integrated management across multiple scales
- Optimization of land and other resources

Precision agriculture

- Based on subcounty and subfield variability

Purdue photo

Multipurpose biomass production and removal

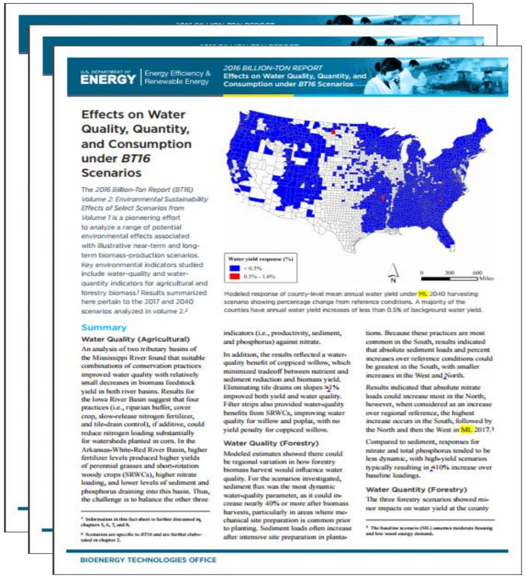
- Mineland reclamation
- Phytoremediation
- Fire-risk reduction

Research Needs and Knowledge Gaps

- Monitoring and model validation to:
  - increase confidence in the results for these scenarios and to quantify uncertainty.
  - help identify drivers of multiple benefits or adverse effects in particular regions.
  - help reveal limitations of county-level analyses at higher resolution.
- Consideration of environmental tradeoffs
- Investigation of environmental, social, and economic effects
- Improved visualization

Orientation to KDF Resources

- How to access materials
  - Report and chapter download
  - Data sets
  - Forthcoming videos
  - Factsheets
- How to submit questions
  - Email billionton@ornl.gov



Relevant links:

https://bioenergykdf.net

https://bioenergykdf.net/billionton2016vol2

Thank you!

On behalf of the entire *Billion-Ton Report volume 2* team,

Thank you for attending Bioeconomy 2017!

For more information on BT16 Volume 2, visit:

https://bioenergykdf.net

We welcome additional questions at billionton@ornl.gov.

Oak Ridge National Laboratory

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