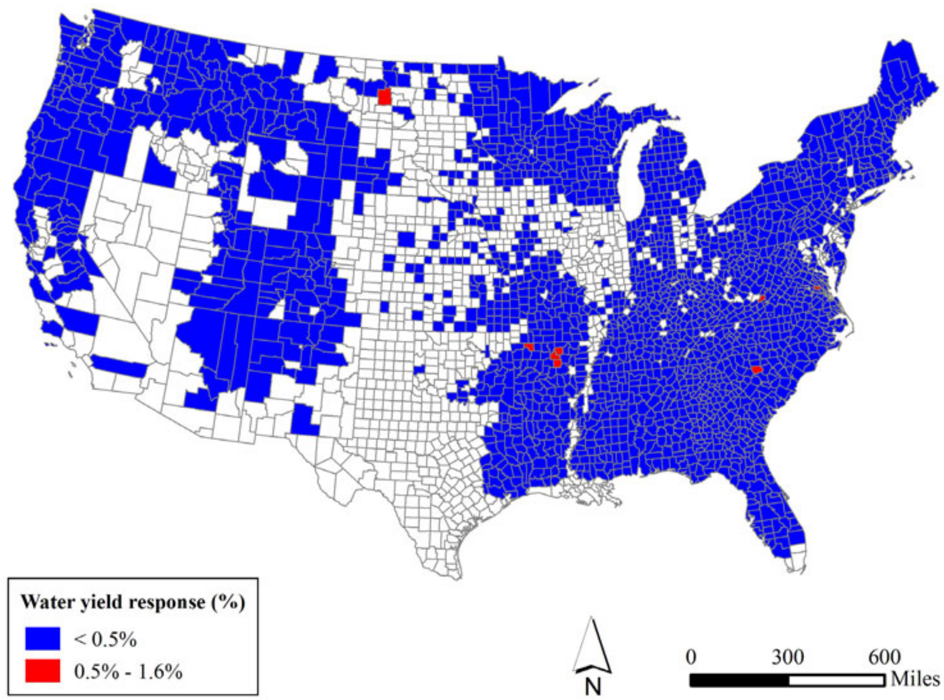
Effects on Water Quality, Quantity, and Consumption under *BT16* Scenarios

The *2016 Billion-Ton Report (BT16) Volume 2: Environmental Sustainability Effects of Select Scenarios from Volume 1* is a pioneering effort to analyze a range of potential environmental effects associated with illustrative near-term and long-term biomass-production scenarios. Key environmental indicators studied include water-quality and water-quantity indicators for agricultural and forestry biomass.[1] Results summarized here pertain to the 2017 and 2040 scenarios analyzed in volume 2.[2]



Modeled response of county-level mean annual water yield under baseline (ML) 2040 harvesting scenario showing percentage change from reference conditions. A majority of the counties have annual water yield increases of less than 0.5% of background water yield.

Summary

Water Quality (Agricultural)

An analysis of two tributary basins of the Mississippi River found that suitable combinations of conservation practices improved water quality with relatively small decreases in biomass feedstock yield in both river basins. Results for the Iowa River Basin suggest that four practices (i.e., riparian buffer, cover crop, slow-release nitrogen fertilizer, and tile-drain control), if additive, could reduce nitrogen loading substantially for watersheds planted in corn. In the Arkansas-White-Red River Basin, higher fertilizer levels produced higher yields of perennial grasses and short-rotation woody crops (SRWCs), higher nitrate loading, and lower levels of sediment and phosphorus draining into this basin. Thus, the challenge is to balance the other three indicators (i.e., productivity, sediment, and phosphorus) against nitrate.

In addition, the results reflected a water-quality benefit of coppiced willow, which minimized tradeoff between nutrient and sediment reduction and biomass yield. Eliminating tile drains on slopes greater than 1% improved both yield and water quality. Filter strips also provided water-quality benefits from SRWCs, improving water quality for willow and poplar, with no yield penalty for coppiced willow.

Water Quality (Forestry)

Modeled estimates showed there could be regional variation in how forestry biomass harvest would influence water quality. For the scenarios investigated, sediment flux was the most dynamic water-quality parameter, as it could increase nearly 40% or more after biomass harvests, particularly in areas where mechanical site preparation is common prior to planting. Sediment loads often increase after intensive site preparation in plantations. Because these practices are most common in the South, results indicated that absolute sediment loads and percent increases over reference conditions could be greatest in the South, with smaller increases in the West and the North.

Results indicated that absolute nitrate loads could increase most in the North; however, when considered as an increase over regional reference, the highest increase occurs in the South, followed by the North and then the West in baseline (ML) 2017.[3]

Compared to sediment, responses for nitrate and total phosphorus tended to be less dynamic, with high-yield scenarios typically resulting in a less than 10% increase over baseline loadings.

Water Quantity (Forestry)

The three forestry scenarios showed minor impacts on water yield at the county

1 Information in this fact sheet is further discussed in *BT16* volume 2 chapters 5, 6, 7, and 8.

2 Scenarios are specific to *BT16* and are further elaborated in chapter 2.

3 The baseline scenario (ML) assumes moderate housing and low wood energy demand.

level, with responses increasing 0.3% or less, largely because of the small areas of harvesting (less than 5%) in most counties. The small magnitude of hydrological response to biomass removal may not have much significance, positive or negative, in terms of water supply at the county level; however, concentrated biomass-removal activities may cause substantial local impacts on watershed hydrology, such as increasing stormflow volume and potentially causing water-quality concerns.

Water Consumption Footprint

The water footprint analysis illustrated greater rainfall use on a volume basis for both agricultural and forest biomass in 2040 scenarios,[4] compared to the 2017 scenario,[5] with more biomass produced and harvested in the 2040 scenarios. Lower consumption of irrigation water was associated with the water footprint of 2040 scenarios compared to 2017. Irrigation for corn was attributed to the grain rather than the residues. Overall, water consumption to produce a ton of biomass remained unchanged in the scenarios.

Insights and Implications

In terms of water quality, further development and testing of conservation practices (e.g., riparian buffer, cover crop, slow-release nitrogen fertilizer, and tile-drain control) could achieve a win-win situation in which biomass production helps to reduce downstream nutrient loadings. Continued adherence to and increased adoption of forest best management practices should minimize biomass-harvest impacts; however, additional field-scale empirical studies are needed to measure effects of biomass removal.

For water availability, future watershed-scale studies should focus on the regions identified as most likely to experience hydrological impacts. Additional research is needed to place the water consumption findings in the context of regional water availability.

Background

As estimated in *BT16* volume 1, 0.8 billion dry tons or 1.2 billion dry tons of biomass are potentially available annually by 2040 at $60 per dry ton or less,[6] under base-case and high-yield production scenarios,[7] respectively. Scenarios from 2017 and 2040 were selected to examine effects of a large increase in biomass production with an emphasis on cellulosic biomass in the future, as well as effects of increasing biomass yield.

The agricultural water-quality study focused on conservation practices, which are how agriculture stakeholders refer to best management practices, and tradeoffs among indicators/environmental effects (e.g., nitrate, phosphorus, total suspended sediment).

The study on forestry water quality considered the same indicators and developed a simple, empirical modeling approach to estimate sediment and nutrient response to the total acres harvested for biomass within a given county. Results were aggregated to three regions of the United States: the South, the West, and the North.

The forestry water quantity analysis investigated how prescribed forest-harvesting scenarios affect mean seasonal and annual water yield at the county level. The amount and distribution of live forest biomass is closely related to water yield (outflow from a drainage basin) and water supply. Biomass harvesting has the potential to alter water-quantity indicators by altering ecohydrological processes (evapotranspiration in the ecosystem, in particular).

The water footprint analysis investigated water-resource demand for the three select *BT16* scenarios (agricultural combined with forestry scenarios) by estimating the water footprint and conducting geospatial analyses to examine the interplay between feedstock mix and water consumption at three scales: county, state, and national.

Further detail on the approaches taken can be found in *BT16* volume 2 chapters 5, 6, 7 and 8.

[4] Base-case yield & baseline 2040 and high yield & high housing–high wood energy 2040

[5] Base-case yield & baseline 2017

[6] This price is at farmgate or roadside, marginal cost. In greenhouse gas-emission analyses and air-emissions analyses, supplies delivered to the biorefinery (up to a price of $100 per dry ton at the reactor throat) are included.

[7] Base case refers to a 1% annual yield increase. High yield refers to a 3% annual yield increase.

This fact sheet refers to the following documents:

U.S. Department of Energy. 2017. *2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, Volume 2: Environmental Sustainability Effects of Select Scenarios from Volume 1*. R. A. Efroymson, M. H. Langholtz, K.E. Johnson, and B. J. Stokes (Eds.), ORNL/TM-2016/727. Oak Ridge National Laboratory, Oak Ridge, TN. 640p.

Download and view the report, explore its data, and discover additional resources at www.bioenergykdf.net.

U.S. DEPARTMENT OF ENERGY

Energy Efficiency & Renewable Energy

For more information, visit:
bioenergy.energy.gov

DOE/EE-1550 • February 2017