Evaluating the environmental sustainability of woody biomass production for bioenergy in the southeastern US

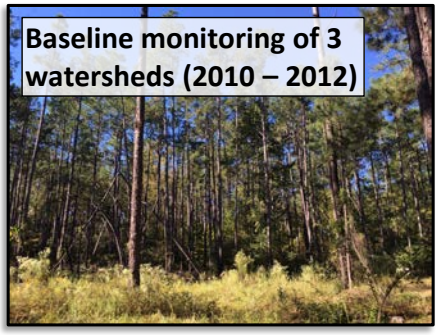
OAK RIDGE National Laboratory

Context:
The southeastern US will be a dominant source of bioenergy feedstocks. Water and soil impacts of intensive silviculture practices for bioenergy (mechanical site preparation, multi-year weed control and fertilization) coupled with advanced genetics have not been evaluated in combination at the watershed scale.

Project goals:
Use a watershed-scale experiment and a distributed watershed modeling approach to evaluate the environmental sustainability (water quality, water quantity, water use, soil quality, and productivity) of short-rotation pine management for bioenergy in the southeastern US.

Determine whether current forestry Best Management Practices (BMPs; e.g., maintaining streamside management zones, minimizing soil compaction) are adequate to protect water and soil resources.

Experimental design: Before-After Control-Intervention (BACI) approach using 3 adjacent, highly instrumented, forested watersheds in South Carolina (1 reference, 2 treatment watersheds).



Timeline:
- Monitored baseline conditions of the 3 watersheds for 2 years (2010-2012).
- Harvested 40% of the 2 treatment watersheds (2012).
- Planted advanced genetic MCP family of loblolly pine seedlings in cut areas (2013).
- Currently managing trees for high yields over a short rotation (10-12 years).
- Measurement of water and soil indicators will occur through 2018 (first half of the rotation).

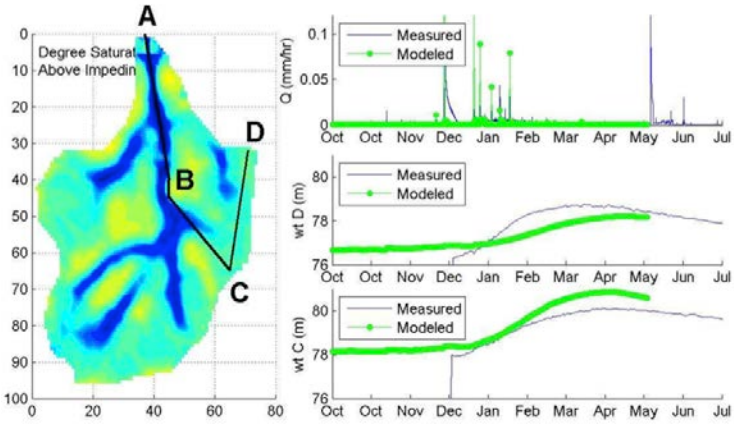
Measured environmental sustainability indicators:

- Water quality (nitrate, ammonium, phosphate, dissolved organic carbon, and herbicide concentrations in stream water, interflow, and groundwater; nitrate water isotopes as an N cycling indicator).
- Hydrology (stream flow, subsurface flow, concentrated flow tracks, groundwater dynamics, stable water isotopes to delineate dominant flowpaths).
- Stand-level water use and carbon fluxes (via an eddy covariance system).
- Soil quality and productivity (plot-scale manipulations of herbicide and fertilizer levels to examine effects on nitrate leaching, N mineralization, nitrification, soil and tree N budgets, tree biomass and growth).

Eddy covariance system for measuring water and carbon fluxes (left photo). Outflow pipes collecting subsurface flow from an interflow interception trench (middle photo). Stream flume and autosampler to measure stream flow and collect water quality samples, respectively (right photo).

Watershed modeling:

- Process-level field observations are used to develop a watershed model specific to the Coastal Plains area of the southeastern US.
- Model will evaluate impacts of forest management scenarios for bioenergy at larger spatial and temporal scales than achieved in the watershed-scale experiment.
- Results from the watershed model will be compared to findings from standard hydrologic models (MIKE-SHE, SWAT).



Modeled hydrology at the watershed scale.

Relevance:

Woody biomass grown in the southeastern US will be a dominant bioenergy feedstock, and understanding the effects of intensive production on water and soils is critical. Research will inform whether current forestry BMPs are adequate to protect soil and water resources or whether bioenergy-specific BMPs are needed.

Collaborators: Oak Ridge National Laboratory, US Forest Service-Savannah River, University of Georgia, Oregon State University, University of Alabama, University of Saskatchewan.
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