Watershed Scale Optimization to Meet Sustainable Cellulosic Energy Crop Demand

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One of the grand challenges in meeting the US biofuel goal is supplying large quantities of lignocellulosic materials that are produced in an environmentally sustainable and economically viable manner. We will conduct a watershed-scale sustainability assessment of multiple species of energy crops and removal of crop residues within two watersheds representative of conditions in the Upper Midwest. The sustainability assessment will include bioenergy feedstock production impacts on environmental quality, economic costs of production, and ecosystem services. The assessment will be conducted through a series of eleven tasks under the following objectives:

Objective 1: Improve the simulation of cellulosic energy crops, such as miscanthus, switchgrass, and hybrid poplar, in the Soil and Water Assessment Tool (SWAT) model.
We will develop parameters and processes through a synthesis of existing data and collection of new data on field plots of these energy crops, then validate the model improvements for use by others.

Objective 2: Use the improved model to evaluate the environmental and economic sustainability of likely energy crop scenarios on a watershed scale, including sensitivity to climate variability.
We will develop watershed landscape scenarios or experiments representing various combinations of energy crops in collaboration with local stakeholders, and evaluate their sustainability using SWAT model simulations, economic analyses, and ecosystem impact models. Sustainability metrics will include (1) soil erosion and its impact on long-term productivity, (2) water quantity, including high-flow frequency, streamflow distribution, streamflow variability, low flows, groundwater recharge, (3) water quality, including suspended sediment, nitrogen (nitrate, TKN, total), phosphorus (dissolved and total), and pesticides, (4) biomass and crop production, (5) profitability, and (6) aquatic biodiversity and associated ecosystem services.

Objective 3: Identify and communicate the optimal selection and placement of energy crops within a watershed for sustainable production.
We will use our optimization tool combining SWAT with a genetic algorithm to derive optimal watershed landscape designs. Results will be compared to targeting strategies to determine the optimal design and implementation strategies for the sustainable production of selected energy crops and other cellulosic feedstock production systems at the watershed scale. We will communicate results and the methods including the modeling system through reports, papers, presentations, a web site, and workshops.
The project team consists of nationally recognized hydrologists and watershed modelers, agronomists, a natural resource economist, climate modeler, aquatic ecologist, and extension faculty. This assessment will benefit from existing funded projects through which we are collecting field and watershed scale data related to energy crop production, evaluating watershed models, developing methods to optimize watershed landscapes to improve water quality, and discussing optimization results with stakeholder groups in the study watersheds. The result will provide a method for determining preferred watershed-scale designs for sustainable bioenergy feedstock production.