Assessing Water Use and Water Quality Change with Respect to Large-Scale Expansion of Ethanol Feedstock Production in United States

Lixia He
Department of Agricultural Economics
310D Morgan Hall, 2621 Morgan Circle
University of Tennessee, Knoxville, TN 37996
Tel: (865)974-8726
Email: lixiahe@gmail.com/llamber3@utk.edu

Burton C. English
Department of Agricultural Economics
302 Morgan Hall, 2621 Morgan Circle
University of Tennessee, Knoxville, TN 37996
Tel: (865)974-3716
Email: benglish@utk.edu

Daniel G. De La Torre Ugarte
Department of Agricultural Economics
310A Morgan Hall, 2621 Morgan Circle
University of Tennessee, Knoxville, TN 37996
Tel: (865) 974-5005
Email: danieltu@utk.edu

Verel W. Benson
College of Agriculture, Food & Natural Resources
215 Ag Engineering Building, Room 229
University of Missouri, Columbia, Missouri 65211
Tel: (573) 882-0689
Email: bensonv@missouri.edu

Bradley Wilson
Department of Agricultural Economics
310B Morgan Hall, 2621 Morgan Circle
University of Tennessee, Knoxville, TN 37996
Tel: (865) 974-3713
Email: driver8@utk.edu

Poster prepared for presentation at the Agricultural & Applied Economics Association 2010 AAEA, CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010

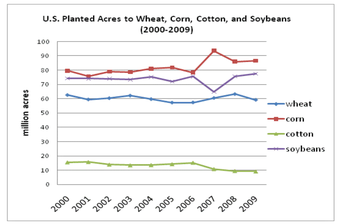
Assessing Water Use and Water Quality Change with Respect to Large-Scale Expansion of Ethanol Feedstock Production in the United States

Lixia He, Burton C. English, Daniel De la Torre Ugarte, Verel Benson, and Bradley Wilson
The University of Tennessee
Department of Agricultural and Resource Economics

Overview

The strong national interest in biofuel production from agricultural crops including corn, crop residue and perennial grasses complicates the design and implementation of water conservation policy. The potential impacts of the 2007 biofuel mandate (*produce 36 billion gallons of ethanol by 2022 with 21 billion gallons of ethanol from feedstock other than corn*) on water demand and quality will be experienced locally or regionally and difficult to anticipate.

Ethanol produced in the United States primarily depends on corn growers in the Midwest. And in recent years, cotton and soybean acres have shifted to corn as producer respond to incentives. Producers choose pesticides, fertilizers, and irrigation to maximize corn production. For the Midwest, ensuring maximum production of corn as a primary ethanol feedstock may increase sediment erosion and accelerate runoff into nearby streams and rivers, unless producers voluntarily participate in conservation programs and implement best management practice.



Source: USDA's National Agricultural Statistics Service Data

The potential emergence of a cellulosic feedstock-based biofuel industry may improve water quality and availability. Cellulosic crops such as native perennial grasses (e.g., switchgrass) and crop residues could use less water, pesticides, and fertilizers than traditional crops currently under cultivation. However, the potential improvement in water quality due to cellulosic feedstock is uncertain. For example, removing corn stover (a likely first generation cellulosic feedstock) could exacerbate erosion if farmers collect too much stover after harvest. Large scale monoculture production of a new energy crop may also increase the threat of pests and weeds compared to production practices that incorporate a diversity of crops and/or plant species. In the case of switchgrass, herbicide use could increase substantially during early establishment because weeds may invade when stands are still thin.

Research Questions

- How will water requirements for crop production change in order to the ethanol feedstock demand ?
- With different cropping patterns and management practices, how would that affect the chemical runoffs hence the water quality in different regions across the nation?

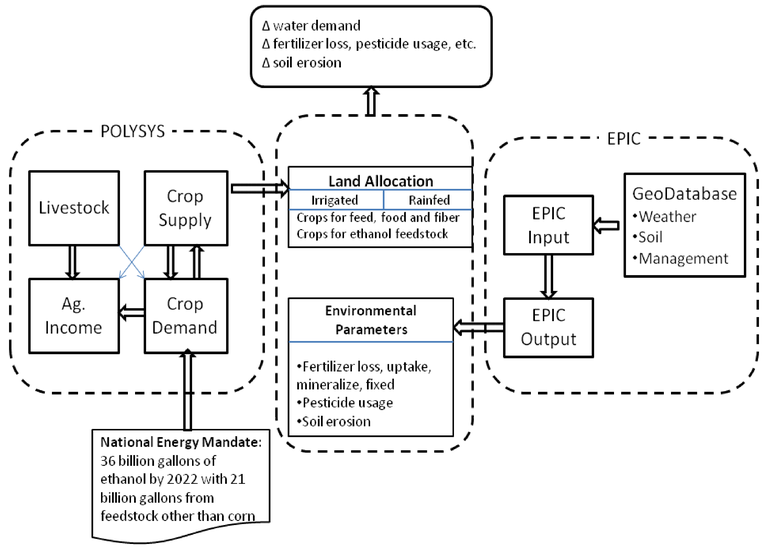
For both corn and cellulosic ethanol feedstock production, water demand is difficult to monitor because the same crop could consume different amounts of water, depending on where the crop is grown, the irrigation technologies used, and field management practices. Water quality impacts may be even more difficult to monitor because fertilizers and other chemical runoff depend on application rates, frequency, and quantity of water applied to the field.
(Image from:
http://www.accessscience.com/IOW/iow.aspx?iowID=14)

Objectives

- Quantify the gross water use required and water quality changes at county (n = 3011) and Agricultural Statistic District (n = 305) levels to meet the anticipated demand for ethanol feedstock under different cropping scenarios.
- Identify policies that will enhance water quality and water conservation under mandated ethanol production goals and estimate the impacts of potential national water policy tools.

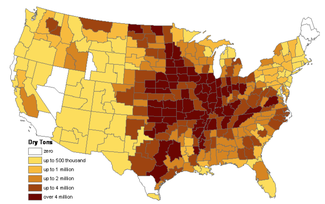
Methodology

- POLYSYS (Agricultural Policy Analysis Systems): an agricultural sector model of United States.
- EPIC: a field level soil and water influence model used to generate environmental parameters.
- Integration of POLYSYS and EPIC will be useful in analyzing agricultural production impacts on water resources in United States assuming that crop and residue production goals will be achieved through the National Energy Mandate in 2022.



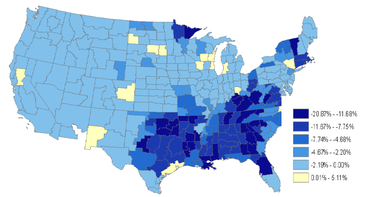
Preliminary Results

Figure 1: Geographic Distribution of the Production of Cellulosic Feedstock



The majority of cellulosic feedstock production occurs in the central, south central, and heartland regions of the United States. Switchgrass is produced primarily in the southeast, while corn stover is produced in the corn growing areas of the Midwest.

Figure 2: Geographic Distribution of Water Use Changes



Indicative mean value of crop water needed were used to calculate the water demand. The southeastern United States, where much of the dedicated energy crop production would occur, achieves the greatest percentage declines in water use.

Figure 3: Nitrogen Expenditure Changes

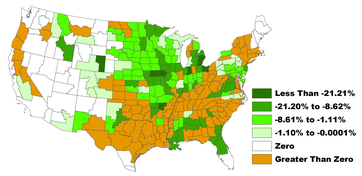
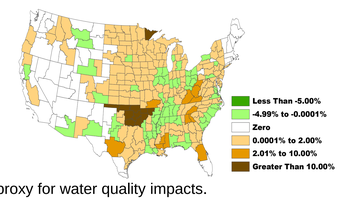


Figure 4: Herbicide Expenditure Changes



Nitrogen and herbicides expenditures are used as a proxy for water quality impacts.

The largest percentage decrease in nitrogen use occurs in the southeast, mid-north, and mid-west regions, where the decrease can be as much as 21%.

Herbicide use declines where crops such as soybeans are being converted to dedicated energy crops, while herbicide use increases in areas where pasture is converted to a dedicated energy crop. This may be because large scale of production of new energy crops, such intensive cultivation of native grasses, may increase pest and weed threats.

Discussion and Ongoing Research

- The growth of bioenergy sector and cellulose-to-ethanol development will affect water demand and chemical use mainly in southeast region.
- Regional differences in land use and environmental conditions denote the need to incorporate specific regional conditions in the design of policy instruments encouraging biofuel feedstock production.
- It is important to understand the complex changes anticipated by the growth of the bioenergy sector in terms of local capacity and regional constraints as they pertain to water quality, water and soil conservation, and community well-being .
- Ongoing research focuses on providing timely information about the economic environmental, agricultural water demand, and agricultural economic and environmental trade-offs under multiple policy scenarios; including: (1) technical changes in bioenergy production, (2) different production targets, (3) conservation tillage practices, and (4) agricultural policies as related to expanding ethanol feedstock supply.