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Dedicated Energy Crops and Competition for Agricultural Land

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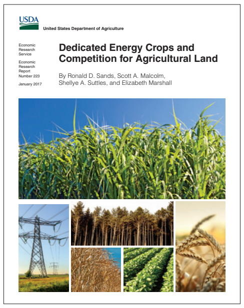

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What Is the Issue?

Dedicated energy crops, such as switchgrass in the United States, are viewed as potential renewable feedstocks for liquid fuels or bioelectricity. However, markets do not presently exist for large-scale use of this resource. This study examines three policy scenarios that could create a market for bioelectricity using dedicated energy crops: a subsidy for bioelectricity generation, a national Renewable Portfolio Standard (RPS), and a national cap-and-trade policy to limit carbon dioxide (CO_2) emissions. Many States already have an RPS that requires a percentage of electricity production to be generated from renewable energy sources. A policy with a cap on CO_2 emissions would have the potential to create demand for combustible biomass to generate electricity, including crops grown solely for their energy content.

What Did the Study Find?

The introduction of dedicated energy crops on a large scale could affect other agricultural land uses, prices of other crops, and trade in agricultural products. Each scenario provides 250 terawatt-hours (TWh) of electricity generation from switchgrass and approximately 50 TWh from forest residue.

- A policy that provides incentives for bioelectricity generation of 250 TWh per year from switchgrass would require 25 to 29 million acres (10.1 to 11.8 million hectares) of land in 2030, an area about one-half that used now for U.S. wheat production. However, this estimate depends directly on the average yield for energy crops and the rate of yield growth over time for both energy crops and other crops. For a sense of scale, the United States produced 267 TWh of electricity from hydropower in 2013, providing 6.6 percent of total U.S. electricity generation of 4,070 TWh.

- Generation of 250 TWh of bioelectricity from switchgrass plus 50 TWh from forest residue would require 234 million short tons of dry biomass in 2030. A feasibility study of biomass supply by the U.S. Department of Energy provides a similar estimate.

- Energy crops would be grown in regions where they have a comparative yield advantage relative to other crops. Model results suggest that switchgrass as a share of total cropland in 2030 would be highest in Appalachia, the Southeast, and the Northern Plains.

Regions with the greatest number of acres in switchgrass would be the Northern Plains (11.1 million acres), Appalachia (8.6 million acres), the Corn Belt (4.2 million acres), and the Southeast (3.0 million acres). Due to the large area of cropland in the Corn Belt, switchgrass would account for a small share of total cropland, less than 5 percent.

- Extensive planting of switchgrass coupled with reduction of acreage of nonenergy crops reduces soil erosion by 5 percent nationally, with greater reductions in regions with high energy crop plantings—17 percent in Appalachia, 12 percent in the Southeast, and 9 percent in the Northern Plains. The amount of nitrogen lost to water declines compared with the reference scenario by about 4 percent. Nitrogen fertilizer application intensity increases, but increased planting of switchgrass leads to more nutrient retention.

- By scenario design, the amount of land used for switchgrass is similar across policy scenarios. Production declines for major field crops as land shifts to switchgrass from cropland, pasture, and forest. Changes in harvested area, production, and price by 2030 are similar between the subsidy and RPS scenarios for wheat, coarse grains, and oilseeds. For these nonenergy crops, harvested area declines 3.6 to 7.2 percent, production declines 0.6 to 4.0 percent, and prices increase 1.9 to 3.5 percent. Crop exports decline to compensate for most of the decline in production, with small changes in consumption and imports. Percentage increases in crop prices are greater in the CO_2 cap-and-trade scenario.

- Some impacts of energy crop production differ widely across policy scenarios. By 2030, the price of electricity increases 55 percent with cap-and-trade but declines 0.5 percent with a bioelectricity subsidy. In all scenarios, U.S. CO_2 emissions decrease relative to the no-policy reference scenario. Emissions reductions are greatest in the cap-and-trade scenario (40 percent) but are also significant with an RPS (10 percent). The emissions reduction in the bioelectricity subsidy scenario is small (1.2 percent).

How Was the Study Conducted?

This study uses two ERS models: the Future Agricultural Resources Model (FARM) provides a global computable-general-equilibrium platform with the ability to simulate alternative energy and climate policies, and the Regional Environment and Agriculture Programming (REAP) model provides finer detail on crops and land use in the United States. In both models, switchgrass competes in land markets with other crops, pasture, and managed forests. The primary biofuel pathway is solid biomass—either forest residue or switchgrass—to bioelectricity. The pathway of corn to ethanol is not a focus of this study but is part of the reference scenario.

The global model provides results on the mix of electricity-generating technologies, the price of electricity, CO_2 emissions, and the cost relative to a no-policy reference scenario. The national model allocates production of energy crops among regions with differing yields. Analysis is coordinated between the models with targets of 50 TWh from forest residue and 250 TWh from switchgrass in 2030, for a total of 300 TWh from solid biomass in each scenario. The analysis provides variations on these scenarios with alternative switchgrass yields and alternative bioelectricity targets.