POTENTIAL ENVIRONMENTAL EFFECTS OF ACHIEVING RFS2 CONSUMPTION MANDATE IN 2022

Statement of

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Good afternoon, Mr. Chairman and members of the Committee. My name is Indy Burke. I am the Director of the Haub School and Ruckelshaus Institute of Environment and Natural Resources and Wyoming Excellence Chair and Professor at the University of Wyoming. I served as the Cochair of the Committee on Economic and Environmental Effects of Increasing Biofuels Production of the National Research Council (NRC). The Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology. The report *Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy* is the product of an NRC study mandated by Congress in the Energy and Independence and Security Act of 2007 and the 2008 Farm Bill.

The study committee was asked to discuss the potential environmental harm and benefits of biofuel production if it is to be increased in the United States to meet the biofuel consumption mandate of the Renewable Fuel Standard 2 (RFS2). The study relies on data from literature published up to the time of its preparation, and it found that if the consumption mandate of 36 billion gallons of biofuels is to be met in 2022, the effect on greenhouse-gas emissions compared to using the energy-equivalent of petroleum-based fuel is uncertain. Greenhouse gases are emitted into the atmosphere or removed from it during different stages of biofuel production—for example, carbon dioxide is removed from the air by plants during photosynthesis, but it is also emitted from fermentation and the use of fossil fuels when biofuels are produced, as well as from the combustion of biofuels themselves. Many factors, including the type of biofuel feedstock and the management practices used in growing it, influence greenhouse-gas emissions of biofuels. For example, biofuel feedstock type and site location affect carbon storage in soil; farmer choices about nutrient management practices, also determined by the biofuel feedstock type and site location, affect fertilizer input and gaseous losses of nitrous oxide, another greenhouse gas, through denitrification.

Increasing biofuel feedstock production also could cause direct and indirect land-use changes that might alter the greenhouse-gas balance. If the expanded biofuel feedstock production involves removing perennial vegetation on a piece of land and replacing it with an annual commodity crop, then the land-use change would incur a one-time greenhouse-gas emission from biomass and soil that could be large enough to offset greenhouse-gas benefits gained by displacing petroleum-based fuels with biofuels over subsequent years. Furthermore, such land conversion may disrupt any future potential for storing carbon in biomass and soil. In contrast, planting perennial crops in place of annual crops could potentially enhance carbon storage in that site.

In addition to land-use conversion that is directly linked to biofuel feedstock production, indirect land-use change occurs if land used for production of biofuel feedstocks causes new land-use changes elsewhere through market-mediated effects. The production of biofuel feedstocks can constrain the supply of commodity crops and raise prices. If agricultural growers anywhere in the world respond to the market signals (higher commodity prices) by expanding production of the displaced commodity crop, indirect land-use change occurs. This process might lead to conversion of noncropland (such as forests or grassland) to cropland. Because agricultural markets are intertwined globally, production of biofuel feedstock in the United States are likely to result in land-use and land-cover changes somewhere in the world, which could in turn result in one-time greenhouse-gas emissions from biomass and soil. Because greenhouse gases are well mixed in the atmosphere, their effects are global irrespective of where they were emitted. The extent of those biofuel-induced market-mediated land-use changes and their net effects on greenhouse-gas emissions are uncertain.

Among the different types of biofuel feedstocks, crop and forest residues will likely not contribute much greenhouse-gas emissions from land-use or land-cover changes because they are products of existing agricultural and forestry activities. However, adequate residue would have to be left in the field to maintain soil carbon. If dedicated energy crops such as switchgrass and *Miscanthus* are to be grown to meet the consumption mandate for cellulosic biofuels, conversion of uncultivated cropland will likely be required resulting in the displacement of commodity crops and pastures. Although RFS2 imposes restrictions to discourage biofuel feedstock producers from land-clearing or land-cover change in the United States that would result in net greenhouse-gas emissions, the policy cannot prevent market-mediated effects in the United States or abroad, nor can it control land-use or land-cover changes in other countries. In summary, because net greenhouse-gas emissions depend on all of these issues described above—site, biofuel feedstock, fertilization, irrigation, direct and indirect land-use change, and residue management, the extent to which increasing biofuel production in the United States to meet the RFS2 consumption mandate will result in savings in greenhouse gas emissions compared to using petroleum-based fuels is uncertain.

As in the case of greenhouse-gas emissions, comparison of other air-pollutant emissions from biofuels and petroleum-based fuels needs to be considered over the life cycles of the fuels. Production and use of ethanol results in higher concentrations of such pollutants affecting air quality as volatile organic compounds, nitrous oxides, particulate matter, and ammonia than gasoline on a national average. On the whole, estimates of emissions of pollutants affecting air quality from using corn-grain or cellulosic ethanol and gasoline in vehicles (including tailpipe emissions and evaporative emissions from vehicles and filling station) are comparable. However, the pollutant amounts emitted during the fuel-production phase (including feedstock production and transportation) are typically higher for corn-grain or cellulosic ethanol than for petroleum-based fuels. Unlike greenhouse gases, pollutants affecting air quality have local and regional effects on the environment. The potential extent to which these pollutants harm human health and well-being depends on whether the pollutants are emitted close to highly populated areas or to agricultural areas.

Other than greenhouse-gas emissions, the water-quality effects of increasing biofuel production also largely depend on feedstock type, site-specific factors such as soil and climate, management practices used in feedstock production, land condition prior to feedstock production, and conversion yield. There is evidence that RFS2 and the push of biofuels has caused more land to come into corn production. Increases in corn production have contributed to increasing nutrient loadings to surface water and to exacerbating eutrophication and hypoxia. A recent analysis of data from the National Water Quality Assessment showed increasing concentration and flux of nitrate in the Mississippi River. Increasing corn production to produce corn-grain ethanol for meeting RFS2 likely will have additional negative environmental effects. Perennial and short-rotation woody crops for cellulosic feedstocks hold promise for improving water quality under RFS2 because those crops require lower agrichemical inputs than corn, and their perennial root systems can be used to decrease nutrient loadings to streams compared to other crop management regimes. Harvesting crop residues for biofuel would not require much additional nutrient input but an adequate amount of residues would have to be left in the field to prevent soil erosion. Certain sites could withstand about 40 to 50 percent crop-residue removal. Taking the consumption mandates for different types of biofuels into account, the effect of producing biofuels in the United States adequate to meet the RFS2 in 2022 on water quality is uncertain. The effect on water quality will depend on site-specific details of the implementation of RFS2, and particularly the balance of feedstocks and levels of inputs.

Consumptive water use is generally higher for biofuel production than for petroleum-based-fuel production on an energy-equivalent basis. (The energy content of ethanol is about two thirds of that of an equivalent volume of gasoline.) The range of estimates for biofuels (2.9-1,500 gallons per gallon of gasoline equivalent) is much wider than that for petroleum-based fuels (1.9-6.6 gallons per gallon of gasoline equivalent). The large range of estimates for biofuels can be mostly attributed to absence or presence of irrigation during biomass production. Estimates for consumptive water use in biorefineries that convert biomass to fuels are between 2.9 and 20 gallons of water per gallon of gasoline equivalent (4 gallons of water per gallon of gasoline-equivalent average). Water efficiency at ethanol production facilities has been improving, but withdrawals from confined aquifers may still be a problem in certain locations.

The effects of increasing biofuel production on soil and biodiversity can be positive or negative depending on feedstock type and management practices used. Thus, the effects of achieving RFS2 on those two environmental variables cannot be readily quantified or qualified largely because of the uncertainty in the future.

Thank you for the opportunity to testify. I would be happy to answer any questions the Subcomittee might have.