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The Impacts of Large-Scale Biofuel Use on Climate Change

Global warming, caused by the collection of carbon dioxide and other greenhouse gases in the earth's atmosphere, could impose large costs on society, ranging from a rise in sea level to an increase in the frequency and severity of droughts, storms, heat waves and floods; to the spread of vector-borne diseases; to the destruction of fragile ecosystems and massive species extinction. Since the U.S. transportation sector is responsible for more than one-third of man-made carbon dioxide emissions in this country, considerable attention has been focused on finding alternatives to burning fossil fuels in automobiles.

1. Conventional models that estimate the greenhouse gas (GHG) emissions associated with corn ethanol and soy biodiesel may underestimate ethanol and biodiesel's GHG impacts.

Researchers who develop lifecycle analysis models (LCAs) of biofuels attempt to capture all of the GHG emissions associated with a fuel from sources such as: the cultivation and harvest of the feedstock; the transport of the feedstock to the conversion facility; the conversion of the feedstock to a finished biofuel; the distribution of the finished biofuel to end user; and the use of the fuel in vehicles.

Most biofuel LCAs, which provide the bases for GHG impact estimates, are incomplete in a number of significant ways. For example, most assume a fixed, rather than dynamic, world and thus fail to capture important interactions such as those between changes in production and consumption of energy and materials, and changes in prices of major goods and services throughout the global economy. In addition, most conventional LCAs do not adequately account for many pollutants that affect climate, such as nitrogen oxide, carbon monoxide, and aerosols; do not account for the carbon-cycle and biogeophysical impacts of land-cover changes; and do not adequately represent the nitrogen cycle. Some recently developed LCA models, which have attempted to account for some of these factors, suggest that future average corn ethanol and soy biodiesel systems could have similar or greater GHG emissions than future gasoline or diesel fuel, although the uncertainty in these estimates is large. (See, e.g., M.A. Delucchi, Lifecycle Analyses of Biofuels (University of California, Davis, 2006); <http://www.its.ucdavis.edu/publications/2006/UCD-ITS-RR-06-08.pdf>)

2. The GHG emissions associated with corn-based ethanol could be reduced given appropriate incentives.

The actual GHG emissions associated with any single lot of ethanol vary widely, depending on the agricultural management practices, processing technology, and processor fuel choices employed in making that ethanol, among other factors.

Significant sources of GHG emissions, ripe for policy attention, include:

- **Land use practices:** High prices for corn will encourage farmers in other countries to convert rain forests, wetlands and grasslands to croplands. Burning or clearing forests and grasslands to make way for crops could result in large carbon releases. Protecting these native lands could significantly reduce future GHG emissions.
- **Farm management practices:** Farmers' agricultural management practices can have significant impacts on GHG emissions. Employing conservation tillage, minimizing the

use of petroleum-based fertilizers and pesticides, and adopting practices that minimize nitrogen losses could significantly reduce future GHG emissions.

- **Processing choices:** Biorefineries – particularly coal-powered refineries – represent a significant source of GHG emissions. Powering refineries with natural gas – or better yet, creating closed-loop refineries that run on captured methane gas produced by nearby livestock – could reduce GHG emissions.

Recommendations

Policy alternatives that should be investigated further include:

- **Development of a GHG emissions certification system.** Once a method of documentation is in place, steps can be taken to create incentives to reduce GHG emissions. California's Low Carbon Fuel Standard, enacted by Executive Order S-01-07, is a good first step toward differentiating fuels based on their carbon footprint.
- **Creation of incentives for, or requiring, farmers to employ best management practices and ethanol refineries to employ environmentally sound production practices.**
- **Adjustment of prices to reflect the true value of land.** Governments should find ways to incorporate the true value of land into its price – for example, include the value of carbon sequestration provided by the land in its price. This is particularly important where markets are distorted by energy crop subsidies.

Research Needed

The following issues should be investigated further:

- **Consensus on ethanol LCA model.** There is an urgent and critical need for scientific consensus on the high-level methodological differences evident in various LCA models, such as the extensiveness, structure, and detail of models, and the values of key parameters. The consensus should reflect communication between the LCA community and policymakers, producers, and consumers.
- **Refinement of LCAs of competing energy sources.** There is a need to refine the LCAs of GHG emissions from gasoline – the backdrop against which we compare ethanol. The LCA of gasoline will presumably change as greater amounts of fossil fuels are used to extract oil. The LCA of GHG emissions associated with wind, solar, hydro-, and nuclear power also should be refined.
- **Acceleration of cellulosic technology.** Given the apparent GHG emissions advantage of cellulosic ethanol over corn ethanol, research that could expedite commercial-scale processing technology should be intensified.
- **Research of other promising bio-based fuel technologies, such as Fischer-Tropsch (F-T) gasification.** This technology is closer to commercialization than cellulosic ethanol, utilizes the whole plant, and could accept a wide range of feedstocks. LCAs of F-T gasification suggest that GHG emissions could be much lower than for cellulosic, particularly if low-input biomass crops such as mixed prairie grasses, rather than intensively cultivated switch grass or other crops, are used as feedstocks. (See Tilman et al., Carbon-Negative Biofuels from Low-Input, High-Diversity Grassland Biomass, *Science* 314, 1598 (2006).)