POLICY BRIEF
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Ethanol and Land Use Changes

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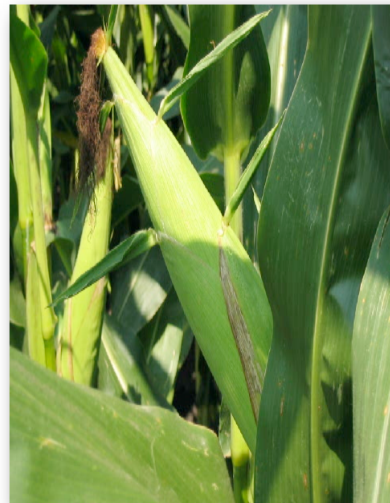

Background

On February 7, *Science* published two studies that examined the greenhouse gas impact of land use changes caused by the growing demand for biofuels. Within hours, news of the studies was carried by a remarkable number of media outlets.[1] Reporters summed up the findings in dire terms. *National Public Radio* declared, "Study: Ethanol Worse for Climate Than Gasoline." The *New York Times* headline read, "Biofuels Deemed a Greenhouse Threat."[2]

Statements by the studies' authors confirmed the headlines. Timothy Searchinger, co-author of one study told National Public Radio, "Right now there's little doubt that ethanol is making global warming worse."

In using the present tense, Dr. Searchinger draws a conclusion not supported by his own data. Both studies offer data that can be used in "What If" scenarios (e.g. what happens if an increase in corn ethanol consumption results in the destruction of tropical rainforest). The studies estimate the carbon released if different lands are converted to cropland (e.g. rainforests, savannah, grassland, abandoned cropland). Thus, in evaluating the impact of biofuels on greenhouse gas (GHG) emissions, the key questions become, how much new land is brought into production and how does that affect the net GHG impact of biofuels? As we will discuss in more detail below, the evidence appears to support the contention that, at least as of 2007, U.S. ethanol production, including land use changes, reduced GHG emissions.

The *Science* studies were inspired by passage of the federal Energy Independence and Security Act in December 2007 and the California Low Carbon Fuel Standard earlier in 2007. California requires a 15 percent reduction in carbon intensity of transportation fuels. The federal Energy Act mandates a six-fold increase in biofuels consumption and requires all new biofuels to reduce by at least 20 percent the GHG produced by using gasoline, and requires further that two-thirds of the additional biofuels reduce GHG by 50-60 percent below those emitted by gasoline.[3]

The federal Act directs the government, by December 2008, to develop a life cycle analysis for biofuels. The life cycle analysis must include

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GHG "emissions related to direct and indirect land use changes..."[4] The studies published in *Science* can inform that analysis.

The studies published in *Science* are not the first to quantify how land use changes affect the environmental impact of biofuels.[5] They are, however, far more comprehensive than previous studies.

The studies consider two types of land use changes. One is direct: the conversion of non-crop lands into energy crop lands (e.g. grassland is plowed up to plant corn for ethanol). The other is indirect: the displacement of food and feed crops on existing cropland by energy crops, which may result in expanding crop production in other parts of the world into native habitats to make up for the loss of food and feed. (e.g. Corn is grown on acreage previously planted in soybeans. To make up for the loss of soy-based animal feed, other countries plow up savannahs or grassland or forests.) The authors examine second order effects as well (e.g. an expansion of soybean production into pastureland leads to rainforests being converted into pastureland).

The two studies evaluate the impact of land use changes by different measures. One estimates the number of years it would take for the reductions in GHG emissions from substituting ethanol for gasoline (20 percent) to make up for the GHG emissions resulting from converting different types of land.[6] For grassland the authors estimate a payback period of 93 years. For abandoned cropland (e.g. Conservation Reserve Program land) the estimate is 48 years.

The other study estimates the impact based on the grams of GHGs (CO_2 eq.) per megajoule of energy in the fuel.[7] The authors estimate that without taking into account land use changes, corn ethanol would reduce GHGs compared to those emitted by gasoline by 20 percent. Including land use changes results in an increase in corn ethanol increasing GHG emissions by 93 percent.

The impact of direct land use changes can be empirically determined. The impact of indirect land use changes, however, moves us into a more speculative area, as we discuss in more detail below.

Direct Land Use Changes

The vast majority of corn that will be grown in 2008 will be on land that has been in corn production for many years, perhaps for generations. Until 2007, corn acreage in the U.S. had not increased in more than a generation, despite ethanol production having soared from zero to almost 5 billion gallons. Annual production of corn increased because of yield increases, not because of acreage expansion. Therefore, at least up to this production level, no direct (or indirect) land use changes have occurred.

In 2007, corn was planted on an additional 14 million acres. About 60 percent of these may have come from acres previously growing soybeans.[8] Two million acres or so may have come from land planted previously in cotton or other crops. Some came from the Conservation Reserve Program (CRP) land, that is, retired crop land planted in grasses under 10-15 year government contracts. A very rough estimate might be that 2 million acres of the 14 million acre increase came from CRP land.

Thus, in 2007, some 12 million additional acres of corn were grown on existing cropland while some 2 million acres came from CRP land. Depending on how the assumptions regarding the indirect land use changes occurring from the substitution of corn for soybeans,[9] the likely overall conclusion is that as of early 2008, ethanol production continues to reduce greenhouse gases.

As for the future, the USDA estimates that 4 million acres of CRP land will come out of production over the next four years. It seems reasonable that virtually all of the 4 million acres are being brought back into production because of high commodity crop prices. But to determine what portion of the production on CRP land is a result of biofuels, we must determine what portion of the new crop prices is a result of increased demand for biofuels. This is a difficult process, but certainly biofuels cannot be the only factor.[10]

Given the cap on corn derived ethanol in the new federal mandate, it is doubtful that corn to ethanol production would rise much beyond 15 billion gallons, or about 8 billion gallons above the level reached by the end of 2007. Some 30-50 percent of this could be met by increased yields.[11] Assuming no increase in ethanol yield per bushel, and excluding imports, this would imply the need for an additional 10 million acres of new land.

As noted above, one of the *Science* studies estimated the number of years for GHG reductions from the substitution of ethanol for gasoline to reach the level of GHGs released by bringing new land into production.

To arrive at these payback estimates, the study relied on estimates from the Argonne National Laboratory's GREET model. That model estimates the reduction of GHGs by substituting ethanol for gasoline, based on industry-wide (and average farm) emissions in 2006. The estimated reduction was 19 percent.

However, for at least two reasons, that estimate significantly understates the GHG comparative reductions from future plants.

1. Increasing amounts of gasoline will come from unconventional fuel sources, such as tar sands that will contribute more GHG emissions per gallon. By some estimates, the increase may be 30-70 percent.[12]

2. Future ethanol plants can be expected to be at least as efficient as the more efficient existing plants. Currently, natural gas fueled ethanol plants produce ethanol that reduces GHGs by some 28 percent below those emitted by gasoline. Ethanol plants fueled by wood chips or other forms of biomass produce ethanol that reduces GHG emissions by 52 percent. And ethanol plants using cellulose as their feedstock produce ethanol that reduces GHGs by some 86 percent.[13]

Thus it is likely that future corn ethanol plants will achieve 2-4 times greater GHG emission reductions than the GREET model currently estimates.

One more factor must be taken into consideration when we examine the GHG impact of biofuels derived from crops grown on new land. No-till cultivation of corn increases soil carbon by .4-.6 tons per acre per year, based on the price the Chicago Climate Exchange allows for carbon offsets by farmers that adopt no-till.[14] This is not much less than the estimates of the studies published in *Science* of carbon in CRP land. Carbon buildup in existing cropland using no-till cultivation would offset at least part of the carbon losses resulting from bringing new land into production.

Indirect Land Use Changes

We come now to the more speculative and difficult to estimate category used in the studies: indirect land use changes. These occur when existing crop land is displaced for fuel crops. The authors assume that an equivalent amount of food or feed crops will have to be produced elsewhere. This could result in the plowing up of savannah or even tropical forests, which would raise the payback period of biofuels (as discussed earlier) to as high as over a thousand years!

The authors appear to presume that an acre of food or feed crops taken out of production by the expansion of energy crops requires at least an acre of new production abroad.[15]

But corn made into ethanol produces as a byproduct Distillers Grains (DG), a high protein animal feed. Sixteen and a half pounds of DG is produced from every bushel of corn used to make ethanol in a dry mill. Per acre, DG produces far more protein than soybeans.[16] One cannot substitute one pound of DG protein for one pound of soybean meal protein. There is a limit to the percentage of a livestock's diet that DG can constitute. Much of the DG produced will substitute for corn rather than soybeans. Some estimate that 70 percent of DG substitutes for corn while 30 percent substitutes for soy meal.

Nevertheless, at least until the limit of DGs in animal diets is reached, that is, until there is no longer a market for DGs as animal feed, an acre for acre substitution is not accurate. If corn used to produce ethanol replaces an acre of soybeans, only a fraction of an acre of new land would have to be used to make up the loss in animal feed.

The use of indirect land use changes to estimate GHG impacts raises questions that go beyond the impact of that methodology on biofuels.

1. The authors conclude that if other countries substitute homegrown food and feed for imported food and feed, global warming is

accelerated. They do not take into account the reduction in transportation required to move food and feed around the world. In any event, one can expect that this greenhouse gas argument against food self-reliance will be vigorously opposed by farmers and rural communities here and abroad.

2. The vast majority of existing land conversion occurs because the construction of malls, parking lots, workplaces, roads, and subdivisions. The American Farmland Trust estimates that 200 million acres of U.S. Farmland have been lost since 1970 and another 2.2 million acres are lost every year. The U.S. Department of Agriculture estimates that between 1992 and 1997 the nation lost 12.8 million acres of agricultural land: cropland (5.3 million acres), pastureland (6.1 million acres), rangeland (1.4 million acres). Presumably this required an equal expansion of acreage abroad in crops and pasture. It might be possible to empirically examine whether this occurred. In any event, the new direct and indirect land use change methodology will undoubtedly be used in many other arenas. For example, to evaluate whether states and counties are meeting their greenhouse gas goals.

3. The other issue that arises regards livestock. The studies assume that an acre of pasture or soybeans converted into energy crops must be replaced in order to feed livestock (97 percent of soy meal worldwide goes for animal feed). But there is significant evidence that livestock are part of the global warming problem. A recent Food and Agriculture Organization (FAO) study concluded that livestock is responsible for 18 percent of global GHGs, more than the transportation sector.[17] World Watch notes, "Worldwide, the amount of coarse grain converted to energy…(is)…still small compared with the 627 million tons devoted to another relatively inefficient use-livestock feed." So it may be presumptuous, at least from a greenhouse gas perspective, to presume that agricultural acreage should expand to feed a rapidly expanding number of cattle.

Final Thoughts

The studies in *Science* maintain that only the use of cellulosic wastes or the growing of perennial prairie grasses could result in greenhouse gas reductions. But their own data seem to clearly show that cellulosic energy crops, even if they are grown on existing grassland and especially if they are grown on CRP land, significantly reduce GHGs. Indeed, the data might be viewed as an argument to convert CRP land to the growing of cellulosic energy crops as a climate change strategy.

In any event, because of economics and availability, we can expect that a significant portion of the cellulosic ethanol mandated under the Energy Act will be derived from wood wastes and agricultural residues. Indeed, some studies estimate that sufficient cellulosic wastes are available to meet the 2022 mandate.

The studies published in *Science*, as well as other studies in the field, have brought together in one place a great deal of information about the carbon stored in lands of different uses. These studies will be useful in fashioning policies that encourage a low carbon economy. For example, California is developing guidelines for taking into account greenhouse gas emissions from new commercial and housing developments. It is likely that when the released carbon is taken into account, especially for developments on the edge of urban areas that plow under grass land and cropland, that the GHG impact of these developments will be significantly greater, and therefore the offsets required will be significantly greater.

With regard to agriculture and biofuels, the studies present part of the data needed for a what-if scenario, but not all of it. For example, the efficiencies of future ethanol plants and the increased greenhouse gas emissions from extracting crude oil should be taken into account. More analytical work is needed to estimate the net loss in animal feed from growing corn for ethanol on soybean acres. Soil carbon buildup through the use of no till cultivation also needs to be factored in.

Even without taking into account these additional factors, the authors data would seem to indicate that there is a net GHG reduction from using ethanol produced in 2007. If the additional factors are taken into account, it appears that future corn-derived ethanol would also result in net GHG reductions. Cellulosic ethanol under virtually all conditions would reduce greenhouse gas emissions.

End Notes

[1] Timothy Searchinger, et.al. , "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change". Joseph Fargione, et. al., "Land Clearing and the Biofuel Carbon Debt". *Science*. February 7, 2008. The studies examined both biodiesel and ethanol but virtually all of the public discussion has focused on ethanol. For this reason, and because biodiesel has its own separate dynamics, this ILSR Policy Brief focuses specifically on ethanol.

[2] *NPR*. February 7, 2008. *New York Times*, February 8, 2008

[3] Part of the increase beyond the 15 billion gallons cap for corn ethanol will come from non-corn feedstocks, which must reduce GHGs by 50 percent. An increasing part will come from cellulosic feedstocks, which must reduce GHGs by 60 percent. Energy Independence and Security Act of 2007. Sec. 202(a)(1)

[4] It is unclear what impact the inclusion of land use changes in the Life Cycle Analysis of biofuels will have on the amount of ethanol derived from corn. Any "change in the analytical methodology use for determining life cycle greenhouse gas emissions" will "apply only to renewable fuels from facilities that commence construction after the effective date of the change." It is unlikely any rule change would be made final before mid 2009, at which point there will probably be 11-12 billion gallons of corn ethanol production and another 2-4 billion gallons in the construction stages. However, the land use change analysis may have an important impact on the development of cellulosic energy crops. *Ibid*. Sec. 232(b)(3)

[5] Bruce Babcock, "Is Corn Ethanol A Low Carbon Fuel?" *Iowa Ag Review*. Iowa State University. Fall 2007. Michael Wang writes, "In the late 1990s, the USDA conducted a detailed simulation of land use changes to accommodate corn ethanol production of 4 billion gallons per year. The simulation included some crop switches and use of CRP lands. Based on the results from that simulation, we estimated soil CO2 emissions of 195 g/bushel of corn, and incorporated this estimate into the GREET model. Nevertheless, land use changes need to be simulated for a much greater expansion of corn ethanol production to reflect future corn ethanol production in the United States." Michael Wang, May We, Hong Huo, "Life-cycle energy and greenhouse gas emission impacts of different corn ethanol plant types." *Environmental. Research. Letters* 2 (2007).

[6] Fargione, et. al. *Op. Cit.*

[7] Searchinger, et. al. *Op, Cit.*

[8] While corn acreage rose by 14 million acres, U.S. soybean acres fell by about 8 million acres.

[9] It is unclear how the studies would account for the substitution of corn for non food crops like cotton.

[10] Global demand for grains (and soybeans) have been increasing dramatically as a result of increased population, increased wealth, and increased consumption of meat. In 2007, global coarse grains (corn, barley, sorghum, etc.) increased by about 200 million tons, while the increased used of corn for ethanol was 40-50 million tons. (*World Grain Production.* World Watch Institute. 2007. It is unclear how much less the price of grains or soybeans would have risen if there had been no increase in biofuels demand. Consider that wheat acreage increased in 2007, but wheat prices have soared to new highs.

[11] The increase in per-acre corn yields before the 1970s resulted from increased application of chemicals, especially nitrogen fertilizer. Since the 1970s, the increase in corn yield is the result of an increase in corn productivity through better seed variety, better farming practices, and other agricultural measures. Between 1970 and 2005 corn yield increased by 90%, while nitrogen fertilizer application increased by only 22%, phosphorus fertilizer application was reduced by 25%, and potash fertilizer application was reduced by 6%. See Michael Wang. May We, Hong Huo, "*Op. Cit.*

[12] A. E. Farrell and A.R. Brandt, "Risks of the oil transition," *Environmental Research Letters* 1(2006)

[13] Michael Wang. May We, Hong Huo, *Op. Cit*

[14] National Farmers Union. Carbon Credit Program. nfu.org/issues/environment/carbon-credits. See also Jim Hettenhaus, Corn Stover: Realizing Its Environmental Value. 22nd Symposium. Gatlinburg Conference. May 9, 2000.

[15] The authors indicate that since farmers abroad are less productive than US farmers, more land might be needed. The studies do allocate to the byproduct of corn ethanol, Distillers Grains, 15-17 percent of the GHG emissions but it is unclear how they take this byproduct into account when determining indirect land use changes.

[16] Corn yields are about 150 bushels per acre and 16.5 pounds of DG per bushel is the byproduct when making ethanol. Soybean yields are about 40 bushels per acre. There are 48 pounds of soy meal (SBM) per bushel. DG is about 28 percent protein and is high in fat and high in fiber. SBM is 40-44 percent protein and low in fat and relatively low in fiber.

[17] H. Steinfeld, et. al, *Livestock's Long Shadow*. FAO. 2006.

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