Biofuels in Oregon from an Economic and Policy Perspective

William Jaeger, Thorsten Egelkraut and Greg Perry[1]

March 11, 2009

The debate over biofuels has intensified over the past two years, especially in reaction to the global rise in food prices in 2007-08. Research conducted at OSU has focused on the economic and policy aspects of biofuels, both in Oregon and nationally (see publications at http://extension.oregonstate.edu/catalog/pdf/sr/sr1078-e.pdf). Moreover, OSU's Department of Agricultural and Resource Economics sponsored a conference in October 2008 entitled "Rising Food and Energy Prices: US Food Policy at a Crossroads."

As a policy issue, the central questions concerning biofuels can be summarized as follows:

1. Can biofuels help reduce our use of fossil fuels by a significant amount, and can they do it at a reasonable cost?
2. Can biofuels help reduce our greenhouse gas emissions by a significant amount, and can they do it at a reasonable cost?

In the context of these questions, many people believe that replacing one gallon of fossil fuel with one gallon of biofuel will reduce our use of fossil fuel by one gallon's worth. They also believe that if they have to pay a little more per gallon for biofuels compared to fossil fuels, this difference in price represents the cost of achieving our goals of reducing our use of fossil fuels. The same logic is applied to reducing greenhouse gas emissions by substituting ethanol or biodiesel for gasoline or petroleum diesel. Unfortunately, the facts are much more complex and less encouraging than this simple logic suggests.

Let's start with the facts about energy. Ethanol contains only about two-third as much energy per gallon as gasoline. Also, energy is required to make biofuels, and for some biofuels the energy used to produce them is quite high. We want to determine the net energy contribution from biofuels, so it is important to account for these facts when evaluating whether biofuels can reduce our use of fossil fuel by "a significant amount" and "at a reasonable cost." *To replace one gallon of gasoline, we have to produce four or five gallons of corn ethanol according to the best peer-reviewed research* – because of the extra energy it takes to grow and process the feedstocks from which ethanol is made. This makes it harder to replace a "significant amount" of fossil fuel energy, and it also makes the cost higher when we measure these cost in terms of the net, per unit reductions in fossil fuel use. Other kinds of biofuels perform somewhat better than corn ethanol in terms of their "net energy" contribution, but they also tend to have higher processing costs.

[1] The authors are professor, assistant professor and professor, respectively, Department of Agricultural and Resource Economics, Oregon State University. Contact: wjaeger@oregonstate.edu.

Turning to greenhouse gas emissions, the same issues apply. Although growing biofuel crops will "take up" or remove some carbon from the atmosphere, because it takes energy to produce biofuels there are also some increases in greenhouse gas emissions. Nearly all peer-reviewed studies estimating the net result when based on a "life-cycle analysis" show a reduction in greenhouse gas emissions for corn ethanol when compared to using fossil fuels. The gains are somewhat larger for some types of biodiesel and for cellulosic ethanol.

However, life-cycle analysis of greenhouse gas emissions does not take account of one potentially-important source of emissions – the effect of biofuel production on land use. When agricultural land is used for biofuel production it displaces food and other kinds of agricultural crops that had previously been grown on those lands, shifting them onto other lands in other locations. Food prices will rise and farmers will respond to these incentives by expanding production on lands that were not previously cultivated. This effect is referred to as the "indirect land use change" (ILUC) effect. Put simply, the laws of supply and demand ensure that if you increase the demand for agricultural land by promoting biofuels, this production will displace other crops, resulting in relatively more land being cultivated. When the amount of land under cultivation is expanded, this will lead to increased carbon emissions when previously-uncultivated lands are cleared and plowed. The carbon that was sequestered on those lands in vegetation such as forests and grasslands, and in soils through roots and organic matter, will subsequently be released into the atmosphere. These releases of greenhouse gases have been estimated to be larger than the direct reductions in greenhouse gas emissions from substituting biofuels for fossil fuels (see appendix no. 3, FAQ #1). *The result of is a negative net overall effect, implying that biofuels actually accelerate greenhouse gas emissions and climate change*.

The importance of ILUC effects has gained great attention in the past year. Two papers on the topic appeared in the highly-respected peer-reviewed journal *Science* (Searchinger et al., 2008; Hill et al. 2008). The most cited study estimates that instead of reducing greenhouse gases, corn ethanol increases greenhouse gas emissions by 90% compared to gasoline. Ethanol from switch grass increases greenhouse gases by 62%. Estimates for biodiesel from soybeans or canola appear to be even worse, since the yield of biodiesel per acre of crop land is much lower than for corn ethanol. Estimates vary by biofuel and by location, and there is clearly a need for more study and refinement of these estimates. *Nevertheless, the best research on this topic suggests that the overall effect of biofuel production is likely to increase greenhouse gas emissions rather than reduce them* (see appendix no. 3, FAQ #1).

Biofuel cost-effectiveness

To answer the questions posed at the beginning, we need to combine economic, energy, and greenhouse gas information and life-cycle accounting. This is what we have done in our research at OSU. We estimated the cost of reducing our fossil fuel use by substituting biofuels for fossil fuels, and we compared these costs to the costs of achieving the same goal using other policies such as a gas tax or increased fuel economy standards. We do the same thing for reducing greenhouse gas emissions by substituting biofuels for fossil fuels.

Our results (see appendix no. 1, table 1), which provide a cost-effectiveness measure for reducing fossil fuel use with biofuels, are not encouraging: *corn ethanol can achieve reductions in fossil fuel use, but at a cost that is about 10 times as high as raising the gas tax and five times as high as improved fuel economy*.[2] *Our cost-effectiveness estimates for reducing greenhouse gas emissions are also not encouraging: use of corn ethanol is likely to increase rather than reduce emissions due to the ILUC effects*. As a result, we are unable to compute a measure of the cost-effectiveness for reducing greenhouse gas emissions because corn ethanol appears to make emissions worse rather than better (see appendix).

Some observers anticipate improvements in biofuel production technologies, such as innovations that could reduce energy inputs or regulations that would limit ILUCs. However, even with highly optimistic predictions about future improvements of this kind, the cost-effectiveness measures remain discouraging. *Even if indirect land use change effects could be reduced by half, and if the energy requirements for producing corn ethanol could also be lowered by 30 percent, the cost of reducing greenhouse gas emissions by promoting corn ethanol would still be 150 times as high as with a gas tax*.

Potential contribution of biofuels

We now want to turn to the question of scale: can biofuels provide enough energy to reduce our fossil fuel energy use by a "significant amount", say, something like 10 or 20 percent? For Oregon, as for the US overall, we estimate the net energy generated with biofuels on a Btu basis, accounting for energy inputs and outputs. When we recognize the limits on production of feedstocks, the potential contribution of these biofuels is surprisingly small. For example, last year about 30% of the U.S. corn crop was used to produce ethanol. *If we double that, and used 60% of the U.S. corn crop to produce ethanol (13 billion gallons), the net contribution would amount to less than 0.5% of U.S. fossil fuel energy consumption.* If we compare this energy contribution to U.S. gasoline consumption alone, the contribution of ethanol is still only 2%.[3] And if we compare it to petroleum, the fraction is less than 1%. Calculations for Oregon based on local limits for production and regional markets for co-products generate similarly small percentages: the net contribution is extremely small on a net BTU basis. *Indeed, given currently available technologies it is difficult to see the net contribution of biofuels rising above 1% of our current fossil fuel energy consumption – for either Oregon or the U.S.*

What about the potential scale for greenhouse gas emission reductions? Here the estimates are even more discouraging. Because of ILUCs, biofuels are likely to accelerate greenhouse gas emissions. And even if we make enormously optimistic assumptions about mitigating these unintended consequences, any positive effects will be extremely small, negligible in comparison to levels of greenhouse gas reductions needed in the context of the policies being discussed nationally and internationally.

---

[2] Cost estimates for a gas tax are from West and Williams (2005) and Davis and Kilian (2009), and estimates for raising CAFE standards are from National Research Council (2002).

[3] Even with the requirement that gasoline contain 10% ethanol, this amounts to only about 2 to 2.5% on a net Btu basis. One gallon of ethanol represents a net energy contribution equivalent to 0.2 to 0.25 gallons of gasoline.

Our analysis of biodiesel from soybeans or canola and for cellulosic ethanol leads to similar conclusions in terms of the cost effectiveness for reducing fossil fuel use. The results are even more negative for reducing greenhouse gas emissions. For other feedstock options, such as algae, there are significant technical challenges that remain for commercial production. In the case of sugarcane, Brazil appears to have a distinct cost and climate advantage.

It should be noted that our analysis does not address the potential payoffs from research and development of alternative energy sources. Indeed, historically, private and publicly-funded R&D related to technology in agriculture has often had a high social rate of return. Whether this will be true for research on biofuels is unknown, but our analysis did not include an attempt to evaluate the potential or likely success of research on new alternative biofuels.

Summary evaluation

Returning to the questions posed at the outset: *Can biofuels help us reduce our use of fossil fuels by a significant amount, and can they do it at a reasonable cost? The answers from our analysis to both parts of the question would appear to be "no."* Concerning the second question: *Can biofuels help us reduce our greenhouse gas emissions by a significant amount and can they do it at a reasonable cost? The answers to both parts of this question appear to be an even more resounding "no."*

Alternative ways of reducing fossil fuel use and carbon emissions are well known, and have been studied for many years by economists: a gas tax, raising fuel economy standards, a carbon tax, a cap-and-trade program for carbon emissions. These approaches are much more efficient because they create decentralized incentives, and these incentives influence choices made by producers, consumers, processors, and businesses at every level of the economy. They encourage substitution of clean energy for fossil fuels, and they promote energy efficiency and conservation. And because of this, they have the potential to achieve not just 1% reductions, but 10 or 20% reductions. Indeed, a recent study from the National Bureau of Economic Research estimates that a mere 10 cent increase in the gas tax would reduce gasoline consumption by 4% (Davis and Kilian 2009). Policies that raise average fuel economy standards could achieve similar improvements, at a somewhat higher cost.

Energy policy and greenhouse gas policy involve both ends and means. If we accept the goal or "ends" as reducing our fossil fuel use and reducing our greenhouse gas emissions, then the real question is: What is the best means to achieve those ends?

A recent example of choosing the best means to achieve a specific end is the Oregon Department of Transportation's (ODOT) choice among alternative designs for a replacement bridge over the Willamette River on I-5 in Eugene. There were three main alternatives. The lowest cost option was an old design costing $140 million. An improved and more appealing design was estimated to cost $150 million, and an aesthetically appealing and very popular design was estimated to cost $170 million. ODOT recognized that all three designs would do the job of connecting both sides of the river. In the end, ODOT decided that incurring a cost 20% higher than the lowest-cost approach (the $170 million design option) was not justified. But ODOT did conclude that incurring a cost 8% higher than the least-cost approach (the $150 million design option) was justified given other secondary considerations.

If we place our analysis of biofuels in this context, relying on biofuels to achieve the goals of reduced fossil fuel use and greenhouse gas emissions, would be like having ODOT pick a bridge design costing at least 900 percent more than the least cost alternative, and one that would only reach a fraction of the distance across the river.

By contrast, efficient market-based policies such as a gas tax, carbon tax, or cap-and-trade policy could reduce fossil fuel use and greenhouse gases by more than 10% at the same cost as a biofuel policy that would achieve less than a 1% improvement in terms of reducing our fossil fuel use, and likely no reduction in greenhouse gas emissions.

Our research on this topic is consistent with the work of other U.S. and European economists. Moreover, our economic evaluation only reinforces the growing doubts about biofuels that have emerged over the past year internationally. *Rising food prices and recognition of the importance of indirect land use changes have led many high-level and highly-respected government and non-government organizations to express strong reservations about biofuels*. These include the OECD, European Commission, the UN Food and Agricultural Organization, the World Bank, the U.K. Renewable Fuels Agency, and the German Marshall Fund (see appendix no. 2).

REFERENCES

Darlington, T.L., 2009. Land use effects of U.S. corn-based ethanol. Unpublished paper for Renewable Fuels Association (http://www.ethanolrfa.org/)

Davis, L.W. and L. Kilian, 2009. Estimating the effect of a gasoline tax on carbon emissions. National Bureau of Economic Research Working Paper 14685.

Hill, J., E. Nelson, D. Tilman, S. Polasky and D. Tiffany, 2006. Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. *Proceedings of the National Academy of Sciences* 103: 11206-11210.

Jaeger, W.K., R. Cross and T. Egelkraut, 2007. Biofuels Potential in Oregon: Background and Evaluation of Options. Special Report 1078. Oregon State University Extension Service, July. (http://extension.oregonstate.edu/catalog/pdf/sr/sr1078.pdf)

Jaeger, W.K. and R. Siegel, 2008. Economics of Oilseed Crops and Their Biodiesel Potential in Oregon's Willamette Valley. Special Report 1081. Oregon State University Extension Service, May. (http://extension.oregonstate.edu/catalog/pdf/sr/sr1081.pdf)

Kim, H. et al., 2009. Biofuels, Land Use Change, and Greenhouse Gas Emissions: Some Unexplored Variables. *Environ. Sci. Technol.*, 43 (3), pp 961–967.

Low, S.A. and A.M. Isserman, 2009. Ethanol and the local economy: industry trends, location factors, economic impacts, and risk. Economic Development Quarterly vol. 23(1), 71-88.

Mercer-Blackman, V. H. Samiei,and K. Cheng 2007,Biofuel demand pushes up food prices. IMF Research Department. IMF Survey Magazine.

Mitchell, D. 2008. A note on rising food prices. World Bank Policy Research WP 4682, July.

National Research Council, 2002. Effectiveness and impact of corporate average fuel economy (CAFE) standards. National Academy of Sciences.

OECD General Secretariat Round Table on Sustainable Development. "Biofuels: In the Cure Worse than the Disease?" Paris, September 2007 (R. Doornbosch and R. Steenblik).

Searchinger, et al., 2008. Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change, *Science* 29 February, Vol. 319: 5867, 1238–1240.

Swenson, D. (2008). *The economic impact of ethanol production in Iowa.* Ames: Iowa State University. Retrieved March 5, 2008, from http://www.econ.iastate.edu/outreach/menuCommOutreach.asp?code=3C

Urbanchuk, J.M. (2008). Contribution of the ethanol industry to the economy of the United States. Prepared for the Renewable Fuels Association, Feb. 20. (http://www.ethanolrfa.org/resource/facts/economy/documents/2007_ethanol_economic_contribution.pdf)

West, S.E. and R.C. Williams III, 2005. The cost of reducing gasoline consumption. American Economic Review 95(2): 294-299.

Appendix Material

Appendix No. 1. Cost-effectiveness of biofuels

The table below summarizes estimates of the costs associated with using biofuels to reduce fossil fuel consumption and to lower greenhouse gas emissions. These are then compared to the costs of achieving the same outcome, but using a gas tax or other market-based incentives (such as a well-designed cap-and-trade program).

Table 1. Summary of biofuel cost-effectiveness analysis

	Corn ethanol	Soy biodiesel	Switchgrass ethanol
Cost of reducing fossil fuel use ($/million Btus)	$ 15.00	$ 14.60	$ 35.80
Cost using a gas tax increase ($/m Btus)	$ 1.57	$ 1.57	$ 1.57
Cost effectiveness of biofuel relative to gas tax (percent higher cost)	**955%**	**930%**	**2280%**
Cost of reducing greenhouse gas emissions ($/mBtu)	(infinite)	(infinite)	(infinite)
Cost when omitting land use change effects ($/mBtu)	$ 470.00	$ 180.00	$ 627.00
Cost using a gas tax increase ($/mBtu)	$ 15.00	$ 15.00	$ 15.00
Cost effectiveness of biofuel relative to gas tax (percent higher cost)	**3133%**	**1200%**	**4180%**

Source: W. Jaeger, Oregon State University, Dept. of Agricultural and Resource Economics

Appendix No. 2. Quotes from Recent High-Level Reports and Analyses on Biofuel Policies

European Commission Joint Research Committee. *Biofuels in the European Context: Facts and Uncertainties, May 2008.*

> "It is obvious that the cost disadvantage of biofuels is so great . . . that even in the best of cases, they exceed the value of external benefits that can be achieved."

U.N. Food and Agricultural Organization. *The State of Food and Agriculture 2008*

> "Some biofuels may, under certain conditions, help reduce greenhouse gas emissions," but land use change is a "key determining factor," and for "many locations, emissions from land-use change –whether direct or indirect—are likely to exceed, or at least offset, much of the greenhouse gas savings obtained by using biofuels for transport."

OECD. *Economic Assessment of Biofuel Support Policies, July 2008*

> "… without counting the effects of land use change, sugarcane ethanol … and biodiesel from rapeseed … would reduce world greenhouse gas emissions by .5 to .7 percent at a cost of $960-$1,700 per ton of greenhouse gases saved (carbon dioxide equivalent.) The costs of reducing greenhouse gas emissions by conserving energy are cheaper, and emissions reductions are often substantially cheaper in other sectors. … In addition, many estimates of direct land use change indicate that conversion of grassland alone will eliminate greenhouse gas benefits for many biofuels, and effects of indirect land use change are "potentially as important." "

U.K. Renewable Fuels Agency. *Gallagher Review of the Indirect Effects of Biofuel Production, July 2008.*

> "Second generation biofuels using feedstocks grown on existing agricultural land may cause greater net land-use change than first generation biofuels that also produce co-products that avoid land use."
>
> "… targets within the Renewable Energy Directive and Fuel Quality Directive should recognise the need to avoid both direct and indirect land use change that leads to significant loss of carbon stocks."
>
> "Biofuels policies need to require the utilisation of feedstock that does not cause a net additional pressure on current agricultural land. This includes use of appropriately defined idle agricultural land, marginal lands, wastes and residues and intensification of current production."

German Marshall Fund. *Transatlantic Taskforce on Development, 2009*

> "What needs to be done: Climate Change: A global price of carbon that reflects its externalities should be established. U.S./EU mandates and subsidies for biofuels should be phased out."
>
> **"**Feed an extra three billion people. All possible options should be considered: Eradicate biofuel subsidies and mandates. Focus on crop-specific solutions to improve yields,…"
>
> "A significant new factor was the diversion of food commodities—such as corn, soybean oil, rapeseed oil, and palm oil—to biofuels production … The Taskforce views these policies as reprehensible, given their impact on the price and availability of food, which has a negative impact on the poorest in developing countries. Biofuels production between 2005 and 2007 absorbed the bulk of the world's increased production of cereals and vegetable oil. … Studies by the World Bank, FAO, OECD, academic economists, and think tanks attribute a significant part of the food price rise to biofuels (30 percent or more).

Appendix No. 3. Answers to Frequently Asked Question (FAQs)

The topic of biofuels is complex and increasingly controversial. Interpreting all the details and conflicting information is difficult and time-consuming. There are many claims and counterclaims about biofuels that can leave the general public confused.

Nevertheless, there are an increasing number of high-quality scientific studies published in peer reviewed journals that provide valuable information and analysis. However, there are other studies and reports that sometimes contradict the majority of peer reviewed research. Some studies circulated by industry and interest groups contain questionable types of information.

The information presented here attempts to summarize the best available answers to a number of "frequently asked questions."

<u>FAQ #1: What is the significance of indirect land use change effects?</u>

Land use change effects occur because the promotion of biofuels causes an increase in the demand for agricultural lands (as illustrated below in figure 1 by a shift in the demand curve). The result of this is an increase in price (higher food prices lead to increased demand for agricultural land, which in turn pushes up land prices). This will lead to an increase in the quantity of land under cultivation (see figure 2 below). Since uncultivated land stores and sequesters carbon, expanding cultivation is estimated to produce large releases of stored carbon in the form of CO_2 (see table 2 below).

Figure 1. Supply and Demand for Agricultural Lands

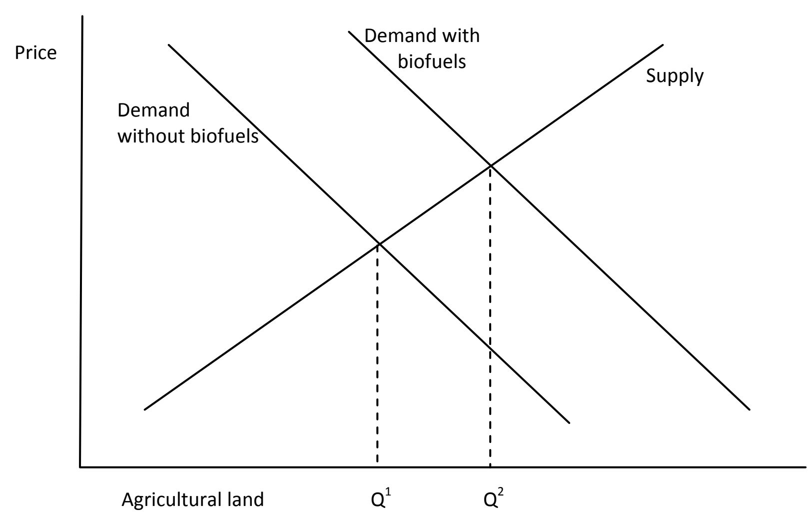
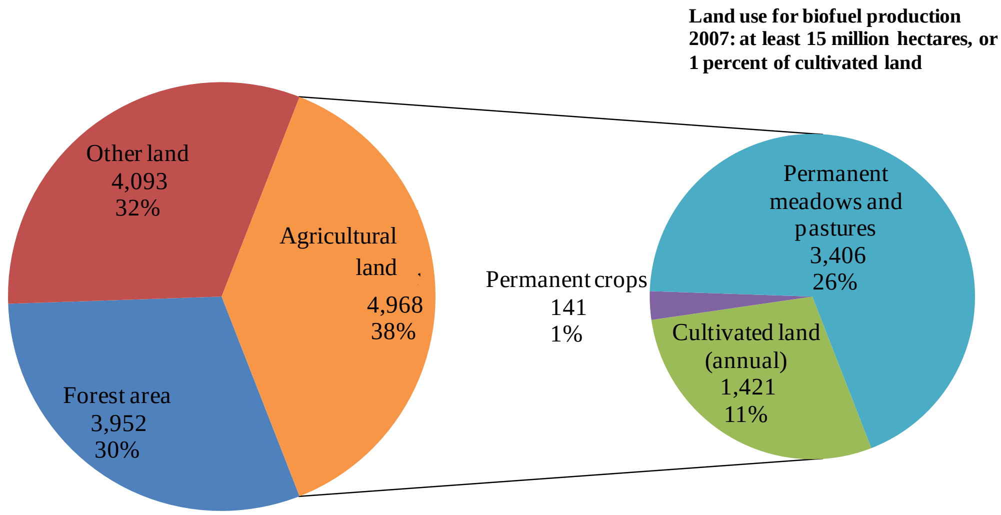


Figure 2. Global land area (left pie chart), agricultural land, and types of agricultural land uses (right pie chart) (millions of hectares)



Source: U.N. Food and Agricultural Organization, 2005

Table 2. Biofuels: carbon impacts and the land needed to produce them

Carbon Benefits	Per hectare of land per year
Corn ethanol	1.8 metric tons
Cellulosic ethanol	8.6 metric tons
Carbon Costs	
Fallow land/ forest regeneration	7.5 metric tons
Existing forest	15 – 35 metric tons
Existing grasslands/savannah	2.5 – 10 metric tons
Weighted average	10 metric tons

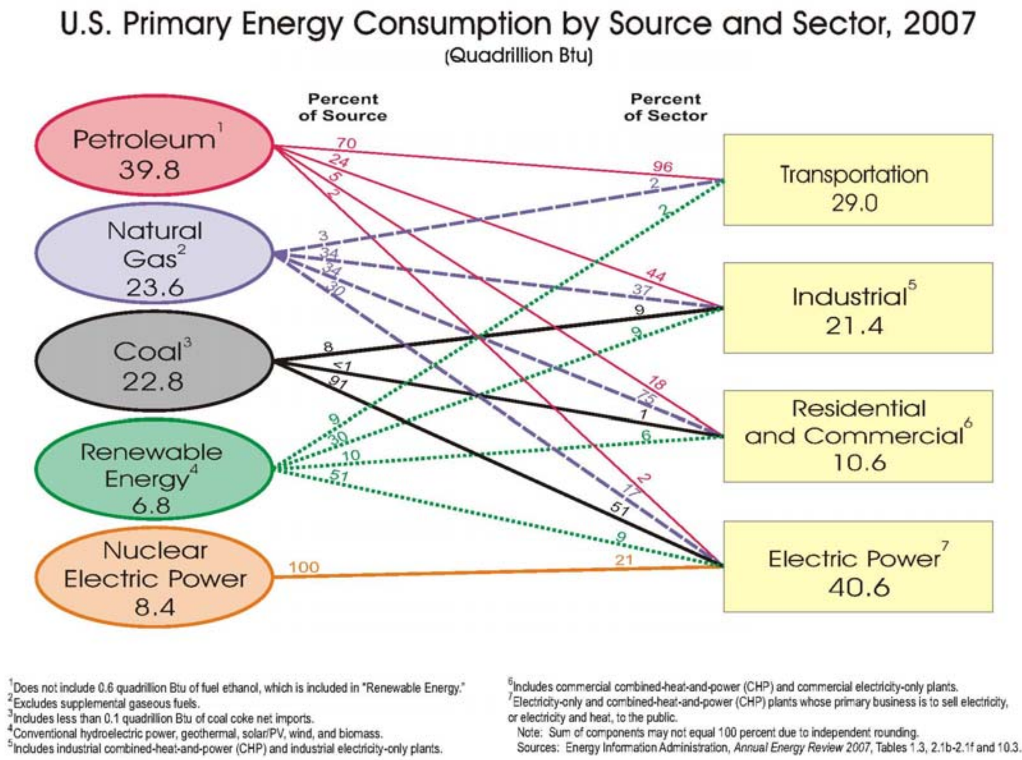
Source: Searchinger, et al., 2008.

The paper by Searchinger et al. (2008) in *Science* has drawn a great deal of attention because, if correct, their results undermine the idea that biofuels, as currently produced, can help reduce greenhouse gas emissions. Some biofuel advocates have been highly critical of the Searchinger analysis, but many neutral observers in government as well as academics have scrutinized Searchinger et al's methods and assumptions in order to better judge the merits of these findings. One particularly careful critique was commissioned by the UK Renewable Fuels Agency and involved a team of seven experts. The report was authored by Prof. Roger Sylvester-Bradley of ADAS UK ltd (http://www.renewablefuelsagency.org/_db/_documents/ADAS_Seachinger_critique.pdf). THis critique concludes that biofuels initiatives intended to reduce GHGs cannot ignore land use change effects. The report finds that although the Searchinger work has caused many objections and concerns, "it remains eminently feasible" that indirect GHG emissions could be significant in relation to intended GHG savings, although there are numerous sources of uncertainty surrounding the likely magnitude of the effects. For example, the critique finds that Searchinger's treatment of corn ethanol co-products (distiller dry grains) may have understated their value in feed markets by 23% (and thus overstated indirect land use change effects). By contrast, they find that Searchinger's assumptions about losses of soil carbon when land is switched from un-cropped to cropped is conservative, and that a value 20%-60% higher would be "more appropriate" (and thus Searchinger has understated land use change effects).

FAQ #2. Don't we need to focus primarily on liquid fuels to replace gasoline for transportation?

Much attention has been focused on liquid fuels for transportation, and some observers view the energy problem narrowly as a need for alternative liquid fuels. However, there is actually considerable scope for substitution among fuels and uses. This point is illustrated to some degree in figure 3 below where energy from five different primary fuels is allocated across four different sectors. Each sector draws energy from multiple sources and types of fuel. Since biofuels only have the potential to contribute about 1% of our fossil fuel consumption, alternative approaches such as a gas or carbon tax would create incentives that shift some energy among uses and between primary energy sources. And although 96% of transportation fuel currently comes from petroleum, U.S. automakers have recently showcased forthcoming electric vehicles. Moreover, a much larger reductions in the use of petroleum energy for transportation could be achieved with increased fuel economy or gas taxes than with biofuels. Indeed, investments in energy efficiency and conservation throughout the economy can result in larger percentage reductions in fossil fuel energy use than can biofuels.

Figure 3. Substitution of energy sources among energy uses in U.S. Economy



Source: Energy Information Administration, Annual Energy Review 2007.

<u>FAQ #3. Do ethanol processing plants have large employment benefits for rural communities?</u>

Although some industry groups have suggested that biofuels can have important job creation benefits in rural areas, the number of jobs created appears to be lower than estimates from industry groups such as the Renewable Fuels Association. The RFA estimates that a 100 million gallon ethanol plant will generate more than 1,100 direct and indirect jobs (Urbanchuk 2008). By contrast, studies published in peer-reviewed journals estimate 30 to 50 direct jobs and 170-250 indirect jobs for the same size plant (Low and Isserman 2009; Swenson 2008). For plants where the feedstock is not produced locally, as is the case for corn ethanol in Oregon, the job creation estimates are at the low end of these ranges.

Indeed, given the $0.51 per gallon federal tax credit for ethanol production and Oregon incentive programs, including the Business Energy Tax Credit, these subsidies represent more than $1 million per direct job per year.

FAQ #4. Isn't it true that U.S. exports of food could stay the same even with projected increases in our use of corn for biofuel production? If so, doesn't this mean that there might be no indirect land use change effects at all?

Whether future U.S. exports of food are expected to rise or fall, or whether they do in fact stay the same, does not say anything about the effect of biofuels on land use and the implications for carbon release when previously uncultivated lands are farmed. This way of framing the question confuses a "before-and-after" comparison with a "with-and-without" comparison.[4] What we want to know is the effect of biofuel production on market prices, production decisions, and land use decisions compared to a situation without biofuels. This is a "with-and-without" comparison, and it will tell us how biofuel production would affect land use. This represents the valid way to evaluate the implications of biofuel promotion.

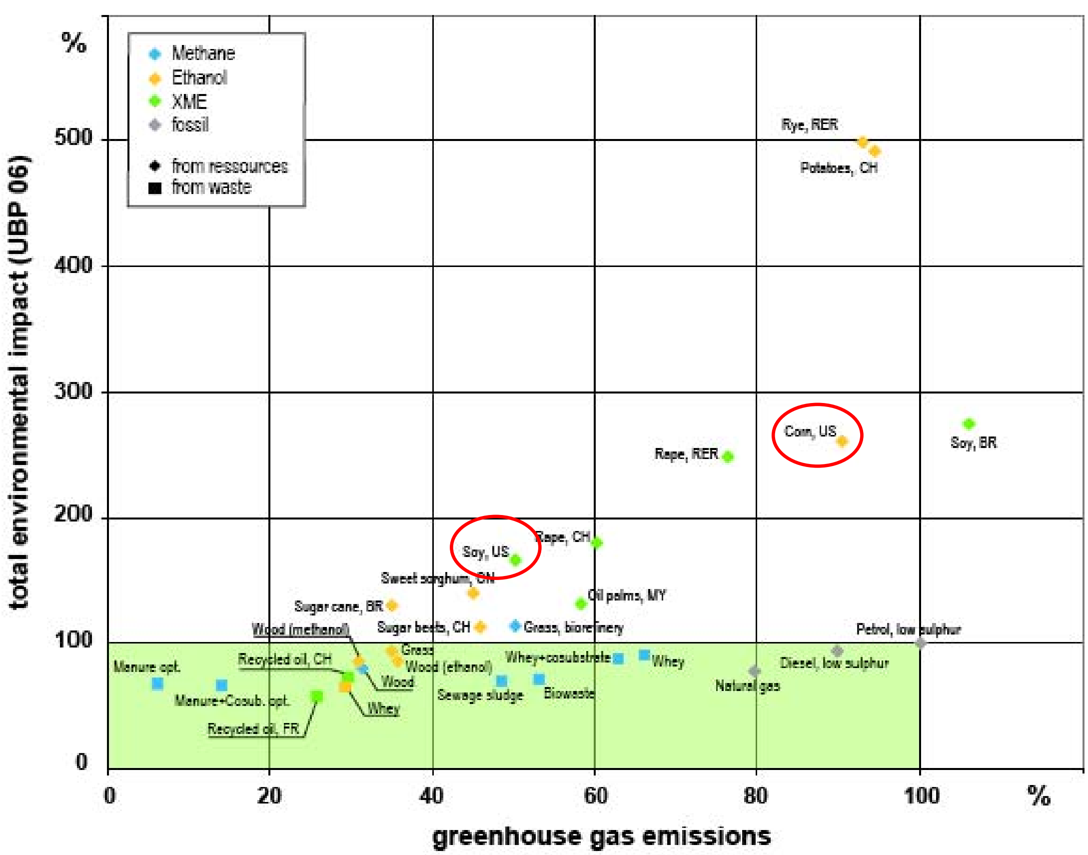
By contrast, one can make assumptions about yields, demand, and market prices trends into the future that might lead to a plausible scenario in which U.S. food exports do not decline. But such a scenario only suggests that without large scale biofuel production U.S. exports might have risen even more. To suggest that non-declining food exports in the future means that biofuels have no land use change effects is analogous to arguing that if an individual is going to receive a $3,000 raise in income next year, that taking $2,000 of that raise will not reduce that person's income.

[4] For examples of analyses that mistakenly draw conclusions about indirect land use change effects without employing appropriate "with-and-without" market adjustment comparisons, see Kim et al. (2009) and Darlington (2009).

FAQ #5. Aren't the overall environmental impacts of biofuels better than fossil fuels?

Biofuels have been seen as a way to reduce greenhouse gas emissions relative to fossil fuels (before studies emerged showing their indirect land use change effects), but there may be other adverse environmental side effects of biofuels that have not received much attention. Indeed, in some cases, these adverse effects have been estimated to be greater than those associated with fossil fuels. Some estimates of these kinds of effects are shown below. Biofuel processing can result in significant increases in demands for other resources, as well. For example, it is estimated that a 100 million gallon ethanol plant requires an amount of water similar to the water used by a community of 15,000 people per year (Low and Isserman, 2009).

Figure 4. GHG emissions of biofuels related to their gasoline or diesel alternatives and overall environmental impact assessment



Source: OECD General Secretariat. Round Table on Sustainable Development. "Biofuels: Is the Cure Worse than the Disease?" Paris, 11-12 September 2007. (Ricard Doornbosch and Ronald Steenblik). Note: 100% on each axis represents the environmental effects of the relevant fossil fuel comparator. Indirect land use change effects are not included.

Question # 6. How much of the recent increase in food prices is due to biofuels?

In 2007 and early 2008, prices for staple foods such as corn, rice and soybeans more than doubled. Most experts agree that these worldwide increases were due to many factors. There are a range of estimates of the contribution of biofuel production to these increases. It is important to recognize, too, that the long-term impact of biofuels on food prices will be different from their impact during the extraordinary rise in food prices over the past two years. With those caveats in mind, there are several economics studies that have attempted to estimate the impact of biofuels on food prices. A summary of each follows:

- In a study by the International Food Policy Research Institute (IFPRI), it is estimated that biofuels "accounted for 30 percent of the increase in weighted average grain prices. The biggest impact was on maize prices, for which increased biofuel demand is estimated to account for 39 percent of the increase in real prices. Increased biofuel demand is estimated to account for 21 percent of the increase in rice prices and 22 percent of the rise in wheat prices" (Testimony by Joachim von Braun, IFPRI Director-General, June 2008) (http://www.ifpri.org/pubs/testimony/vonbraun20080612.asp).

- A World Bank study by Donald Mitchell (2008) finds that "the combination of higher energy prices and related increases in fertilizer prices and transport costs, and dollar weakness caused food prices to rise by about 35-40 percentage points from January 2002 until June 2008. These factors explain 25-30 percent of the total price increase, and most of the remaining 70-75 percent increase in food commodities prices was due to biofuels and the related consequences of low grain stocks, large land use shifts, speculative activity and export bans."

- The International Monetary Fund found that "The rise in food prices reflects a combination of factors. Higher biofuel demand in the United States and the European Union (EU) has not only led to higher corn and soybean prices, it has also resulted in price increases on substitution crops and increased the cost of livestock feed by providing incentives to switch away from other crops" (Mercer-Blackman 2007).