July 2, 2008

Dr. Blake A. Simmons
Manager, Energy Systems Department
Sandia National Laboratories
Livermore, CA

Re: Letter to California Air Resources Board

I write to correct an important inaccuracy in your recent letter to the California Air Resources Board regarding our publication, Searchinger T., R. Heimlich, R.A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, T. Yu, "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change," *Science* 319:1238-40 (2008).

As evidence of the uncertainty of indirect land use, your letter claims that our February 2008 study "maintain[s] that the United States has already experienced a 62% reduction in corn exports." That change of exports has of course not occurred. But your assertion is inaccurate. In fact, our study estimated that corn exports would decrease by 62% only in response to an increase in corn ethanol from roughly 15 to 30 billion gallons in 2016/17. And that decrease would not be in comparison to previous export levels but to the exports that would otherwise exist in 2016/17 at only 15 billion gallons of ethanol. (Technically, the study predicted these results in a yet future equilibrium condition after 2016/17 once markets fully responded to that rise in ethanol by 2016/17). If you consider the matter, it would have been rather remarkable for us to offer, and for *Science* to publish, a paper in February 2008 offering estimates that were already verifiably false at the time with only a few clicks of the mouse -- and even more remarkable for such an error to be made by economists at Iowa State University who devote much of their efforts to tracking and analyzing agricultural commodity markets, often at the request of Congress or USDA.[1]

Your misunderstanding probably derives from the open letter about our study written by Michael Wang on February 14th, which you reference. [2] After we pointed out this error to

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[1] It is curious that our paper was misinterpreted. The relevant reference in the published paper states: "To estimate land use changes, we used a worldwide agricultural to project increases in cropland . . . In response to a possible increase in U.S. corn ethanol *of 56 billion liters above projected levels for 2016*." (emphasis supplied) Supporting materials made available online by *Science* also included an extensive discussion of the agricultural modeling at page 9 identifying the levels of corn ethanol and dates analyzed, and identified the changes in crop exports in Table 2A, clearly marked by the levels of corn ethanol and date of the comparison.

[2] One of the interesting features of that letter is that it simultaneously made the statement you reiterate, which incorrectly treats our analysis as focused on the level of biofuels already in existence, and also accused us of improperly analyzing a higher level of corn ethanol production that so far exceeds present levels, it would never be achieved. As I explain in the "Response to NFA and Wang and Haq," our analysis focused not on an absolute level of land use change emissions, which obviously varies by level of ethanol, but rather on the level of emissions per unit of ethanol. When we examined a much smaller level of ethanol, the emission rate from land use change increased.

Michael, he issued a revised letter on March 14th, which deleted this assertion. (You can see our guide to other inaccuracies in Wang's letter in "Response to NFA and Wang and Haq" available at www.princeton.edu/~tsearchi.)

Our analysis focused on the rate of emissions through land use change from corn ethanol and not the absolute amount: Obviously, at lower ethanol levels, the absolute impact on agricultural markets and the level of land use change both in the U.S. and abroad would be lower although the rate would be roughly comparable. Although ethanol production levels in 2007 and 2008 have been below or will be just above 8 billion gallons, the market responses to date very much show the kinds of effects predicted by our study. In 2007, the U.S. managed to maintain corn exports only by planting 19 million more acres of corn, at the expense of other crops, including soybeans. Even so, exports could be maintained because of favorable weather and only by drawing down stocks heavily. Responding to higher soybean prices, themselves in part the result of this planting behavior in 2007, U.S. farmers are planting less corn in 2008 than in 2007, and there will probably be below average yields due to weather in the Midwest. The result will be sharp competition between domestic and foreign consumers, leading to a sharing of declines in exports and U.S. meat production and a further drawdown of stocks. However, overseas producers cannot respond immediately, so the primary result of these changes in the short term is higher prices, which are setting records. Over time, foreign grain production will rise in response to these higher prices, causing significant declines in U.S. exports compared to what they otherwise would be without ethanol. (Prior to ethanol, corn exports regularly rose and in the absence of ethanol increases, would be expected to rise still.)

Indeed, it is odd that your letter denies the market impacts of biofuels precisely in a year when world crop prices have reached price levels 300% higher for cereals than 2000 and 400% higher for vegetable oil. The UN's Food and Agricultural Organization, the World Bank, the International Food and Policy Research Institute and the former Chief Economist for USDA, among others, have all identified biofuels as a significant although not exclusive contributor to this rise in prices. The reason is obvious. Between 2005 and 2007, the entire world increase in total cereal production and most of the increase in vegetable oil went into biofuels, leaving increased food demand to be met out of stocks. These high prices will spur agricultural expansion, without which impacts on world hunger would be even worse.

Since I write to correct your misrepresentation of our study, I shall offer a few other observations to your suggestion that California should ignore indirect land use change.

Calculating indirect land use change simply recognizes that the same land used to produce biofuels is already taking up carbon from the atmosphere and would continue to provide carbon benefits in the form of storage or food even if not diverted to producing biofuels. Lifecycle analyses for biofuels assign a "feedstock credit" to the biofuel for the carbon dioxide taken up by plants incorporated into the fuel. Without this credit, conventional lifecycle analyses show that most biofuels would increase greenhouse gases compared to gasoline and diesel. But typical lifecycle analyses ignore the fact that land would already be providing carbon benefits, which are sacrificed when the land is diverted to producing biofuels. Calculating land use change simply means calculating the carbon storage and annual uptake

that is foregone directly or indirectly by using land to produce biofuels. Unless land use change is included, lifecycle accounting assumes that land is a cost-free asset from a carbon perspective. That is no more accurate than an economic assessment of biofuels that assumes that land is available rent free.

When forest is converted to biofuel production, the carbon cost is "direct" and measured as the loss of carbon storage and any ongoing sequestration. When food is diverted (and after accounting for the food value of by-products), the cost is indirect and shared among three possible results. The first is that some of the food is not replaced because of higher prices. That is probably the worst result because much of that reduction in food consumption comes from the world's poorest and already malnourished people. The second result is that farmers plow up more forest and grassland, which triggers the same greenhouse gas emissions indirectly. The third result is that farmers will invest more resources to boost yields on existing cropland beyond the yield increases that would already occur (and that too will in part spur additional greenhouse emissions and cause other environmental impacts). By the basic principles of economics, some of all three effects will occur the net effect on average yields faces a countervailing effect from bringing less productive lands under cultivation.

There is some uncertainty among economists about the relative significance of the second and third effects – our study accounted for some additional price-induced yields (balanced by use of more marginal land) and some others argue for a net increase in yields. But even if the additional effect of biofuel demand and higher prices on yields is substantial, emissions from indirect land use change will remain large in the overall calculation. That is true because the amount of carbon stored by forests and most grasslands per hectare is vast compared to the annual advantage of using a hectare of biofuel to replace gasoline. More generally, reasonably productive land always provides carbon benefits, whether used for biofuels or not. Accounting for the cost of using land to make biofuels as well as the benefit obviously produces a very different result than just counting the benefit. Making biofuels out of waste products avoids these costs. We may also be able to grow new biofuel grasses and trees productively on otherwise unproductive land, resulting in land use benefits that greatly exceed the costs. [3] But your letter does not encourage these alternatives that avoid or minimize land use costs. Instead, it calls for ignoring the cost of using land altogether.

There are inherent uncertainties in the precise estimates of land use change emissions if only because they depend in part on how governments respond to higher crop prices.[4] If you

[3] That is particularly likely to occur using otherwise unproductively used grassland, such as much tropical grassland. There is still a risk that while that grassland is relatively unproductive, ranchers will burn down productive land, i.e., forest, to produce replacement grassland. But there may be ways to boost the yields of adjacent grassland to replace the forage lost and avoid the add-on effect.

[4] For example, the latest farm bill decreased the size of the Conservation Reserve Program, allowing more cropland in the U.S., which comes at the expense of significant carbon storage and sequestration but less than rain forest. On the other hand, in response to higher prices and the food crisis, Blairo Maggi, the Governor of the principal soy-producing state in Brazil, has proposed clearing more of the Amazon, carbon rich land.

believe that the carbon costs of land use change are too uncertain to estimate, that does not mean you can rationally assume that the net effect of using land is advantageous, let alone that there is no cost to land use at all that need not be deducted from the benefits. The logically consistent alternative would be to leave out both emissions from land use change and the feedstock credit generated by using land to take up carbon. In that event you will discover that crop-based biofuels increase greenhouse gas emissions overall compared to gasoline, and that cellulosic crops, if they are ultimately used, decrease them only very modestly. It is no surprise that you can find a carbon benefit for biofuels if you count the carbon benefits and ignore the carbon costs of their most significant input.

The practical effect of following your advice to count only direct land use effects would be to favor some of the most environmentally harmful biofuels over those that hold promise of true benefits. Biodiesel from palm oil provides a good illustration. It is well known that the drainage of peat lands in Southeast Asia for palm oil plantations triggers enormous soil oxidation and release of carbon dioxide. Palm oil is a valuable and growing vegetable oil, and even absent biofuels, it will continue to grow rapidly. Using palm oil to produce biodiesel, as planned in that region, would require that palm oil expand even more. If California counted direct but not indirect land use change, the palm oil industry could sell to California without any change in practice. It would simply need to maintain separate tanks. In some, it would store palm oil from already cleared forests, and sell that for biodiesel in California. In others, it would store palm oil from newly cleared and drained lands, and use that to replace the vegetable oil.

Other biofuels tend to trigger a more complicated series of agricultural adjustments, but the principle is the same. For example, biodiesel from soybean or rapeseed will use vegetable oil that is in part replaced by palm oil. The Joint Research Commission of the European Union has estimated that if even 2.4% of European rapeseed oil diverted to biodiesel is replaced by palm plantations on peat forests, the emissions from that 2.4% alone would wipe out any greenhouse gas benefits from 100% of the biodiesel.

Lifecycle analysis of biodiesels from palm, soybeans and rapeseed tend to calculate large greenhouse gas benefits if you ignore land use change. Your advice would therefore have California promote one of the world's most destructive agricultural practices. That would undercut biofuels that hold promise by avoiding or minimizing impacts from land use change.

I suspect that we will continue to hold differences of view of many of these matters. But I also trust that you will inform your letter co-authors of the inaccuracy regarding our paper, and take other appropriate steps to keep this inaccuracy from being further repeated. In this age of the internet, your repetition of the error from Michael Wang's letter indicates the potential persistence of these kinds of inaccuracies.) Thank you for your attention.

Sincerely,

Timothy D. Searchinger
Visiting Scholar, Princeton University
403 Robertson Hall
Princeton, NJ 08544

Cc: Mary Nichols
Editors of Science