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Complete Letter to the Editor of *Science*
February 16, 2008

Dear Editor:

The recent papers in *Science* by Fargione, et al (1) and by Searchinger, et al, (2) connect increased demand for corn for biofuel production with large, indirect land use changes to satisfy the demand for animal feed left unfilled because of the increased demand for corn. These indirect land use changes are in turn linked to large emissions of greenhouse gases (GHGs), thereby incurring a "carbon debt" that the authors believe may take many years to repay. (No mention is made of how long it will take to repay the "carbon debt" resulting from petroleum-derived gasoline.) Both studies have major omissions and deficiencies. I will discuss only those deficiencies that relate to life cycle analysis (LCA).

LCA is an internationally-recognized procedure for determining the environmental impacts of products and processes. LCA follows specific standards (eg, the ISO 14040 series) so that the both the procedure itself and the analytical results are transparent, verifiable and credible. We use LCA in combination with biophysical agroecosystem models to better understand and improve the environmental performance of biofuels and bioproducts (3, 4, 5). LCA is data driven, but these two papers do not depend much on actual data. Instead an assumption-driven economic model is linked to land use decisions and these land use decisions are in turn linked to GHG emissions through another undifferentiated, assumption-driven model.

Department of Chemical Engineering and Materials Science
2527 Engineering Building
East Lansing, MI 48824-1226
517/355-5135
FAX: 517/432-1105
EMAIL: chems@egr.msu.edu

In contrast, consider the following situation. Corn and ammonia are inputs used to make ethanol. One can legitimately use LCA to test the effect of different means of producing ammonia (eg, from coal vs. natural gas) on the greenhouse gas profile of corn ethanol, but only if actual data on both ammonia production routes are available. Similarly, one can legitimately test the effects of corn produced by two different means (eg, conventional tillage vs. conservation tillage) on the greenhouse gas profile of ethanol, but only given actual data on the GHG effects of these two tillage practices. There are no real, verifiable data in either of these papers on the land use changes that actually occur as more corn is processed to ethanol—hence these papers are not LCA studies. They are in fact highly speculative and uncertain scenarios for what might happen as a result of increased demand for corn grain.

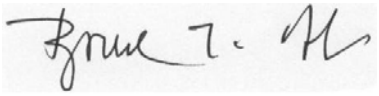
Even if there were such data connecting increased corn demand for ethanol with land use changes, ethanol produced in the United States would not be "responsible", in a strict LCA sense, for anything but its own environmental profile. "New" corn produced in Brazil by clearing savannah to satisfy animal

feed demand is responsible for its environmental profile as an animal feed, not as an ethanol feedstock. For example, plastic bottles are made from ethylene. Ethylene can also be used to make carpets. If demand for ethylene to make plastic bottles grows, then more ethylene will be needed to satisfy the unfilled demand for ethylene for carpets. But we do not make plastic bottle producers responsible for the environmental performance of carpet manufacturers. Likewise, it is arbitrary and unreasonable to make corn or switchgrass growers who are producing feedstock for biofuels responsible for the highly uncertain land use decisions of individuals thousands of miles away who are producing animal feed. We are much more likely to make environmental progress by holding individuals and corporations responsible for their own behavior rather than assigning to them responsibility for the behavior of other independent decision makers.

This is clearly different from the situation in which tropical wet lands are converted to oil palm production for the express purpose of providing oil for biodiesel production. It is also different from the situation in which Conservation Reserve Program (CRP) grasslands are actually converted to produce additional corn for ethanol production. In both of these cases, we can and should assess the biofuels produced with the environmental impacts of a specific, direct land use change. Direct land use change as a result of biofuel production is a legitimate subject for LCA and carries a reasonable level of certainty. In contrast, indirect land use change supposedly caused by biofuel production is tenuous, uncertain and highly speculative. It does not meet the standards of life cycle analysis.

Why this somewhat tedious emphasis on the arcane discipline of LCA? Because the recent U.S. legislation dealing with clean renewable fuels requires that certain “lifecycle greenhouse gas emission” standards be achieved for these fuel, including emissions caused by land use changes. Direct land use changes caused by biofuels can be studied by life cycle analysis. Indirect land use changes currently cannot. We should not make biofuel policy decisions on such an uncertain scientific foundation.

Sincerely,



Bruce E. Dale, Ph. D.
University Distinguished Professor of Chemical Engineering
Michigan State University
bdale@egr.msu.edu

Phone 517-353-6777

1. Fargione, J., J. Hill, D. Tilman, S. Polasky, and P. Hawthorne, 2008, "Land Cleaning and Biofuel Carbon Debt," Sciencexpress, available at www.sciencexpress.org, Feb. 7.

2. Searchinger, T., R. Heimlich, R.A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T.H. Yu, 2008, "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases through Emissions from Land Use Change," Sciencexpress, available at www.sciencexpress.org, Feb. 7.

3. Kim, S. and Dale, B E. “Allocation Procedure in Ethanol Production System From Corn Grain I. System Expansion” *International Journal of Life Cycle Assessment* **7** (4), 237-243 (2002)

4. Kim, S.; Dale, B. E.; “Life cycle assessment of various cropping systems utilized for producing biofuels: Bioethanol and biodiesel” Biomass & Bioenergy 29, 426-439, (2005).

5. Kim, S.; Dale, B. E.; “Life cycle assessment study of biopolymers (poly-hydroxyalkanoates) derived from no-tilled corn” International Journal of Life Cycle Assessment 10, 200-210, (2005).