

## Response from Simpson

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Source: BioScience, 60(4) : 257

Published By: American Institute of Biological Sciences

URL: <https://doi.org/10.1525/bio.2010.60.4.18>

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**Biofuels: The Devil in the Details**

In a recent Viewpoint on biofuels (*BioScience* 59: 926–927), Tom Simpson addressed important shortcomings of corn ethanol production: low net energy gain, competition with food production, and the loss of nitrogen from fertilizers and its environmental consequences. Simpson proposed an agricultural landscape that could produce food, feed, and fuel while improving water, air, and habitat quality by relying more on perennial biomass. However, other environmental problems are related not only to ethanol production but also apply to production of perennial biomass.

To call anything a sustainable biofuel strategy requires specifying a time frame. If the chosen time frame is short enough, anything becomes sustainable and degenerates to an oxymoron (Flueck and Smith-Flueck 2006). Generally accepted sources put US reserves of easily mined phosphorus deposits as sufficient to last for another 25 years at current application levels. Corn grain harvest, though, removes about 7.2 kilograms (kg) of phosphorus (P, expressed as  $P_2O_5$ ) per metric ton of corn grain, and 1.64 kg per metric ton of corn silage. Any crop will, however, remove P and thus necessitate replacement.

Twenty-five years is a mere blink of time. China, having a major deposit of easily accessible P deposits, has very recently taken measures to prevent P leaving China, for obvious reasons. Since the year 2000, P prices have increased several-fold, and “peak phosphorus” is commonly mentioned.

Another consequence of biomass export is soil acidification, which requires corresponding countermeasures such as liming. As inputs necessary

for biofuel production are becoming scarcer, their further production in itself will require more external energy (as with P), or compete with easy energy sources (natural gas for nitrogen fertilizer). If corn ethanol production does not pass the sustainability test regarding the environment according to Simpson, I posit that neither can perennial biomass pass the test.

Switchgrass removes about 4.55 kg of P per metric ton, and because it leads to higher biomass export than corn grain, it also results in greater P loss. Moreover, others have pointed out that it requires much more pesticide than corn, and considering the initial two years of no harvest and declining yields after a few years, corn yields outperform switchgrass by a factor of 2 or more.

Overall, it is not appropriate to label biofuels as sustainable alternatives, as if we can get something for nothing (i.e., as if it involves only solar energy conversion). Given the mentioned constraints, in addition to several others (Flueck and Smith-Flueck 2006, Flueck 2009), it would be more precise to label biofuels as temporary solutions to give us time to rethink the current level of dependence on energy.

WERNER FLUECK

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doi:10.1525/bio.2010.60.4.17

**Response from Simpson**

I appreciate Werner Flueck's comments and generally agree with the opening concern and ending statement, but have a different perspective on much of what lies between the two. “Peak phosphorus” (P) is real and should be a general concern, not just with biofuels. However, many of the biomass uses I discussed, such as gasification or pyrolysis, concentrate the P in char or ash, thus facilitating recycling. Further, many soils in the United States and elsewhere have excessive P levels from long-term manure application. Biomass production may allow “mining” and recycling of excess P without affecting crop yields while improving water quality.

Flueck refers to high pesticide use and declining yields in a “few years” with switchgrass, which is counter to my knowledge. Pesticide use is primarily at establishment, and even then, may not be what is needed annually to grow corn. Most research I have seen indicates about a 20-year productive life span for a switchgrass stand. Improved seeds and seeding methods are reducing time of establishment to one year. I agree with his conclusion that biofuels, of all kinds, should be an interim solution to liquid energy security, so critical, productive land resources can be returned to food production.

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doi:10.1525/bio.2010.60.4.18