

1. Challenges for Bioenergy Emission Accounting

Keith L. Kline, Virginia H. Dale, Alan Grainger

Center for Bioenergy Sustainability, Oak Ridge National Laboratory, Oak Ridge, TN 37831-6038, USA

T. Searchinger *et al.* propose "Fixing a critical climate accounting error" (Policy Forum, 23 October 2009, p. 527). We agree that greenhouse gas (GHG) emission accounting needs to be more comprehensive, but believe that Searchinger's proposal would make matters worse by increasing the complexity and uncertainty of calculations. Solutions must be practical and verifiable to be effective.

Country borders have been chosen as system boundaries to inventory GHG emissions under the Kyoto Protocol. The use of country boundaries is clear and allows summing over all countries. The country inventories purposefully account for where and when both fossil-fuel combustion emissions occur, and changes in the biological stocks of carbon occur. The approach can be widely adopted, but this accounting is hampered by uncertain data (1, 2) and two basic shortcomings: Not all countries are required to report, and not all biological carbon stocks are inventoried. A first step to improve inventories would be to address these issues through concerted cooperation to improve the reliability of land cover and carbon stock data and establish comprehensive accounting of current stocks.

Under the Kyoto approach, sequestration is assumed to offset bioenergy emissions over the long term. On a short-term basis, emission reductions in one country (e.g., where bioenergy is used to replace fossil fuel) can be associated with emission increases elsewhere (where biomass is harvested). Such transfers are not unique to bioenergy. Developed countries import manufactured goods that are often produced with GHG emissions in developing nations (3). Fossil fuel exploration can lead to significant land-use emissions in supplying nations that go unaccounted in consuming nations (4–6).

To "fix bioenergy accounting," Searchinger *et al.* propose that all net changes in greenhouse gases (not just carbon) be traced globally (not by country) along with indirect effects, or "leakage emissions resulting from changes in land use." Unfortunately, national statistics and the organizations that compile them cannot come close to fulfilling this proposal. Searchinger's fix would require complex allocation of net emissions among diverse non-energy co-products as well as attribution among fluid and site-specific forces affecting land-use change, including governance, economic growth, international trade, poverty, energy and food production, policies, and demographics (7, 8). Such boundless indirect effects are impossible to measure or validate in practice (9) and although debate continues, the contribution of land-use change to global emissions is acknowledged to be small (10 to 15%) and shrinking compared with that of fossil fuels (10).

Calculating the effects of bioenergy on GHG emissions should be based on life-cycle analyses with the use of consistent systems boundaries and specifications supported by empirical evidence. Because accounting for emissions has implications for the treatment of biofuels in climate legislation, an appropriate and scientific approach that can be implemented by all nations is essential. We can greatly improve GHG accounting if all countries participate, all biological carbon sinks and sources are included, and all parties use consistent, verifiable methods. Better data on carbon stocks are essential for all the above.

Keith L. Kline, Virginia H. Dale

Center for Bioenergy Sustainability, Oak Ridge National Laboratory, Oak Ridge, TN 37831–6038, USA.

Alan Grainger

School of Geography, University of Leeds, Leeds LS2 9JT, UK.

References

1. A. Grainger, *Proc. Nat. Acad. Sci. U.S.A.* 105, 818 (2008).

2. P. Waggoner, *Resources for the Future Discussion Paper 09-29* (2009).
3. G. P. Peters, E. G. Hertwich, *Environ. Sci. Technol.* 42, 5 (2008).
4. A. J. Liska, R. K. Perrin, *Biofuel., Bioprod. Bior.* 3, 318 (2009).
5. M. Finer *et al.* *PLoS ONE* 3(8), e2932 (2008).
6. S. Wunder, *CDR Working Paper 97.6* (Danish Institute for International Studies, 2007).
7. H. J. Geist, E. Lambin, *Bioscience* 52, 143 (2002).
8. K. L. Kline, V. H. Dale, R. Lee, P. Leiby, *Issues Sci. Technol.* 25(3) (2009); www.issues.org/25.3/kline.html.
9. B. A. Babcock, *Iowa Ag. Rev.* 15, 9 (2009); www.card.iastate.edu/iowa_ag_review/summer_09/article2.aspx.
10. G. R. van der Werf *et al.*, *Nat. Geosci.* 2, 737 (2009).

Published 2 March 2010

Science. ISSN 0036-8075 (print), 1095-9203 (online)

<http://www.sciencemag.org/cgi/eletters/>