

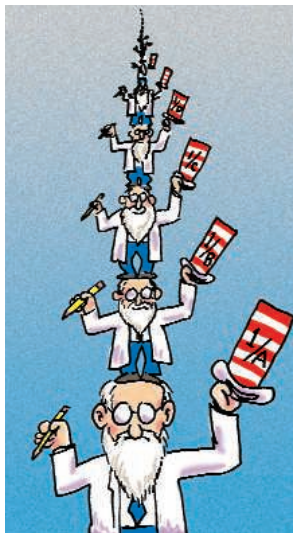
LETTERS

edited by Jennifer Sills

Quantifying Coauthor Contributions

FIFTY YEARS AGO IN *SCIENCE*, D. MCCONNELL ARGUED THAT “FOR anything short of a monographic treatment, the indication of more than three authors is not justifiable” (1). He was never cited. Coauthor numbers kept rising, and it has been recently suggested that in some fields “multiple authorship endangers the author credit system” (2). In 2006, more than 100 papers had over 500 coauthors, and one physics paper had a record 2512 coauthors (3). With research groups growing larger (4), this trend will continue. Given the increasing interest in the quantification and standardization of scientific impact with various metrics like the *h* index (5, 6) and the growing debate on potential biases (7, 8) and unethical behavior (4, 9, 10), a standardized method to quantify coauthor contributions is needed (10–13).

Rarely do all coauthors contribute to a paper equally. However, academic search engines (such as Google Scholar, Scopus, and Web of Science) calculate citations, *h* indices, and rankings without regard to author rank.



Quantification of coauthor contributions will motivate coauthors to clarify each person's percent of contribution.

I propose that the *k*th ranked coauthor be considered to contribute $1/k$ as much as the first author. This way, coauthors' contributions can be standardized to sum to one, regardless of the author number or how authors are ranked. Author rank can be different from author order, provided that this is declared in the paper. Multiple authors can have the same rank, as long as this is stated and is reflected in the calculations.

Quantifying coauthors' contributions will encourage a healthy dialogue about the meaning of coauthorship and author rank (2, 4, 10, 13), will promote better consideration of author rank in assessing scientific impact, and will lead to improved ways to measure and report coauthor contributions.

CAGAN H. SEKERCIOGLU

Department of Biology, Center for Conservation Biology, Stanford University, Stanford, CA 94305, USA. E-mail: cagan@stanford.edu

References

1. D. McConnell, *Science* **128**, 1157 (1958).
2. M. Greene, *Nature* **450**, 1165 (2007).
3. C. King, *Sci. Watch* **18**, 1 (2007).
4. P. A. Lawrence, *Curr. Biol.* **17**, R583 (2007).
5. J. E. Hirsch, *Proc. Natl. Acad. Sci. U.S.A.* **104**, 19193 (2007).
6. P. Ball, *Nature* **448**, 737 (2007).
7. C. D. Kelly, M. D. Jennions, *Nature* **449**, 403 (2007).
8. D. C. Mishra, *Nature* **451**, 244 (2008).
9. P. A. Todd, R. J. Ladle, *Nature* **451**, 244 (2008).
10. D. Kennedy, *Science* **301**, 733 (2003).
11. R. Hunt, *Nature* **352**, 187 (1991).
12. J. V. Verhagen, K. J. Wallace, S. C. Collins, T. R. Scott, *Nature* **426**, 602 (2003).
13. W. F. Laurance, *Nature* **442**, 26 (2006).

Biofuels: Clarifying Assumptions

THE REPORT BY T. SEARCHINGER *ET AL.* (“Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change,” 29 February, p. 1238) provides one scenario for the conversion from a fossil-based energy economy to a bio-based, renewable-energy economy. However, Searchinger *et al.* failed to include several important considerations.

It is inaccurate and misleading to allocate the cutting down of Brazilian rainforest, which is done often for timber production, to biofuels use. The economic signals driving biofuels or agricultural land-use changes are

different from the timber-driven economic signals driving land-use change patterns. The deforestation estimates of Searchinger *et al.* are appropriate for biodiesel production in the Far East. A cheaper and more likely use of land for increased biofuels production is the 6 billion acres of underutilized or unused rain-fed agriculture land available, according to a Food and Agriculture Organization report (1).

Searchinger *et al.* analyze switchgrass as an energy crop when miscanthus and sorghum have much higher yields [a recent study estimated that miscanthus yields are 250% that of switchgrass (2)] and would dramatically reduce the demand for land. Furthermore, because these crops have not been optimized for biomass, they are likely to produce substantial further yield increases per acre. Given the the-

oretical maximum yield of 40 to 50 tons per acre in a region with an average of 40 inches of rain, practical yields of 50 to 60% of this maximum are likely. It has even been suggested that maximum theoretical yield values will be reached and possibly surpassed (3).

Searchinger *et al.* assume that crops grown in developing countries will have lower yields. The yields are lower because of low prices and lack of farmer income. In these conditions, farmers cannot afford the best seed crops and other inputs such as fertilizer (1). It is likely that if farmer incomes improve, yields will also increase.

Searchinger *et al.* state that “[h]igher prices triggered by biofuels will accelerate forest and grassland conversion there even if surplus croplands exist elsewhere.” Energy

costs influence the food Consumer Price Index (CPI) three times as much as does the basic price of corn (4, 5). Implying that these price increases are principally caused by biofuels production is inaccurate.

Cellulosic ethanol will probably be so much cheaper to produce (even at \$50 per dry ton feedstock costs) that it will displace all corn ethanol based on price alone, thus freeing up much of the more than 20 million acres of land used in 2007 for corn produced for ethanol.

The potential for biomass from other sources is grossly underestimated. If biomass-oriented winter crops were planted on annual crop lands, it would improve land ecology and produce substantial biomass for cellulosic biofuels. A yield of 3 tons per acre on 50 to 70% of our annual crop lands (320 million acres) would yield 480 to 672 million tons of biomass; a yield of 5 tons per acre by 2030 (assuming crop optimization for biomass by then) could yield 800 to 1120 million tons of biomass or sufficient biomass for more than 100 to 145 billion gallons with no additional land use. If corn stover and crop waste are included, even larger quantities of biomass can be made available without land use.

Sustainable removal of stover from corn crops is estimated to be between 1.5 and 2.0 additional tons per acre.

The potential-for-waste outline in the U.S. Department of Energy biomass study (6) is completely ignored. The study concludes that up to 1.3 billion tons of sustainable biomass can be available “without a significant change in agricultural practices.” Additional cellulosic and waste production will result from organic municipal waste, sewage, and other waste sources.

The authors assume that more marginal lands will be used for food cultivation, when in fact “land recovery” can happen with proper crop rotation practices on marginal and degraded agriculture lands and especially with perennial, polycultured energy crops, which are likely to dominate the energy crop field (7, 8).

In allocating land displacement, Searchinger *et al.* fail to account for the most attractive regions in the world, namely, parts of Africa where biomass income is sorely needed.

Furthermore, the baseline for carbon emission costs of biofuels should be incremental alternative sources of new oil like tar

sands and oil shales, not an average value of emissions for oil.

VINOD KHOSLA

Khosla Ventures, Menlo Park, CA 94028, USA. E-mail: vk@khoslaventures.com

References and Notes

1. FAO, *World Agriculture Towards 2015/2030: An FAO Perspective* (FAO, Rome, 2003).
2. S. P. Long *et al.*, *Global Change Biol.* **14**, 2000 (2008).
3. S. P. Long *et al.*, *Plant Cell Environ.* **29**, 315 (2006).
4. J. Urbanchuk, “The relative impact of corn and energy prices in the grocery aisle” (LECG Report, 2007); www.ncga.com/news/notd/pdfs/061407_EthanolAndFoodPrices.pdf.
5. P. A. Sanchez, *Science* **295**, 2019 (2002).
6. R. D. Perlack *et al.*, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply* (U.S. Department of Energy and U.S. Department of Agriculture, April 2005); <http://woodycrops.org/reports/Billion%20Ton%20Supply.pdf>.
7. D. Tilman *et al.*, *Science* **294**, 843 (2001).
8. D. Tilman, J. Hill, C. Lehman, *Science* **314**, 1598 (2006).
9. Khosla Ventures is an investor in various biofuels startups; a full list can be seen at www.khoslaventures.com/presentations/Flower_Chart.ppt.

Response

ON BALANCE, KHOSLA’S LETTER PROMOTES hope for biofuels that use agricultural and forest residues, cover crops, and municipal

waste, and that therefore do not divert the capacity of productive land. Our Report also encouraged such biofuels. We similarly encouraged a focus on lands that would otherwise provide little food or carbon storage but that might produce ample biofuels. We even cited the U.S. Department of Energy's (DOE's) "billion-ton study," precisely because most of the potential biomass it estimates is waste. Yet DOE's full 1.3 billion tons also relied on diverting millions of hectares of cropland to grow biofuel crops. All cellulosic biofuels are not the same, and policies should support only those that do not use productive land.

Unfortunately, the Food and Agriculture Organization's (FAO's) estimate of roughly 6 billion acres of potential new rain-fed cropland referenced by Khosla in fact consists primarily of the world's wetter forests and grasslands, not "underutilized or unused" agricultural land (1). Studies predicting future cropland expansion point heavily to carbon-rich areas in Latin America and sub-Saharan Africa, which contain most of the best potential cropland (1, 2). The U.S. Department of Agriculture now predicts that future food growth will rely more heavily on

cropland expansion and less on yield growth than on past growth because cereal yield growth has fallen below 1% per year (3), well below the rate of population growth. Khosla correctly notes the capacity to boost yields in many developing countries, but the world must already unleash that capacity to feed a larger, selectively richer, world population while also reducing deforestation. Biofuels should not exacerbate this already imposing challenge.

The plight of the Amazon is a matter of both forestry and agriculture. Typical logging removes a few trees per hectare, causes collateral damage, and facilitates conversion through road-building, but forests regrow carbon if the land is not subsequently converted to agriculture (4). Biofuels that use good cropland anywhere in the world raise crop and meat prices and help spur the actual conversion to pasture or cropland by increasing their net economic return.

For cellulosic ethanol grown on corn land, our study found increased greenhouse gas emissions, even with dramatically higher yields (18 tons per hectare) and conversion rates (362 liters per hectare) than now broadly

obtainable. As Khosla indicates, researchers using Illinois cropland to grow the hybrid *miscanthus giganteus* have obtained higher yields, but planting this hybrid requires digging up the roots to sever and then replant the rhizomes, which implies an expensive, slow process of expansion (5). Efforts to use seed-producing varieties continue to face obstacles (5). Yet even with major breakthroughs that double our assumed biomass yields, cellulosic ethanol grown on corn land would only reduce emissions compared with gasoline by 37% counting land-use change. By avoiding land use change, biofuels from wastes and residues could achieve far greater reductions.

Although Khosla correctly points out that rising crop prices only modestly increase food prices in U.S. grocery stores, the poor around the world eat basic cereals and vegetable oil. Their prices worldwide rose 300 and 400%, respectively, between 2000 and spring 2008 (6). Nearly all analyses assign a major role to biofuels (6, 7): Biofuels consumed the vast bulk of the world's growth in cereals and vegetable oil between 2005 and 2007, requiring the world to deplete stocks to meet growing food demand (8).

Khosla's high confidence in a quick transition to better biofuels, however welcome, also seems excessive. Even the latest hopeful DOE research plan in 2005 envisions 15 years of research and development before cellulosic production can start to scale up (9). Optimistic scenarios predict modestly lower costs after many years (10), but some studies conclude that cellulose will indefinitely remain more expensive than corn ethanol (11). It will be a great achievement if cellulosic biofuels can supply the 21 billion gallons (79 billion liters) of noncorn biofuel now required by U.S. law in 2022, let alone the additional 15 billion gallons mandated (57 billion liters) that corn ethanol may supply. Yet, because some corn ethanol is cheaper than gasoline at reasonably high oil prices, corn ethanol from existing plants will probably remain with us, regardless of the supply of cellulosic biofuels (7, 11).

Contrary to Khosla's claim, our analysis actually did predict a modest expansion of cropland in Africa in response to U.S. biofuels. More expansion there would not change our result because it generates greenhouse gases comparable to the world average (12). Sub-Saharan Africa already imports much of

its food and has roughly 400 million hungry people who together suffer 85% of the world's calorie gap (13). Climate change could decrease yields by 50% in the region (14). Although small-scale bioenergy production might justifiably help local people fill unmet needs or switch from inefficient use of fuel wood, as a whole, sub-Saharan Africa needs to use its good arable land for food even more than other regions.

Finally, our result would change little even if all alternative gasoline to biofuels originated in tar sands (and only some will) (15).

**TIMOTHY D. SEARCHINGER¹ AND
R. A. HOUGHTON²**

¹Woodrow Wilson School, Princeton University, Princeton, NJ 08544, USA. ²Woods Hole Research Center, Woods Hole, MA 02540, USA.

References

1. J. Bruinsma, Ed., *World Agriculture: Towards 2015/2030: An FAO Perspective* (FAO, Rome, 2003).
2. Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being: Scenarios, Findings of the Scenarios Working Group* (Island Press, Washington, DC, 2005).
3. USDA Interagency Agricultural Projections Committee, *USDA Agricultural Projections to 2017* (OCE-1008-1, Washington, DC, 2008).
4. A. Verissimo, P. Barreto, M. Mattos, R. Tarifa, C. Uhl, *For. Ecol. Manag.* **55**, 169 (1992).
5. D. G. Christian, N. E. Yates, A. B. Roche, *Industrial Crops Prod.* **21**, 109 (2005).
6. D. Mitchell, *A Note on Rising Food Prices* (Policy Research Working Paper 4682, World Bank Development Prospects Group, Washington, DC, 2008).
7. P. C. Abbott, C. Hurt, W. E. Tyner, *What's Driving Food Prices* (Farm Foundation, Oak Brook, IL, 2008).
8. Organization for Economic Cooperation and Development, Food and Agricultural Organization of the UN, *OECD-FAO Agricultural Outlook 2008-2017 Highlights* (OECD-FAO, Paris, 2008), tables 2.3 and 2.5, pp. 41 and 43.
9. U.S. Department of Energy, *Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda* (DOE/SC-0095 2006).
10. International Energy Agency, *Energy Technology Perspectives 2008: Scenarios and Strategies to 2050* (IEA, Paris, 2008).
11. M. L. Baker, D. J. Hayes, B. A. Babcock, *Crop-Based Biofuel Production Under Acreage Constraints and Uncertainty* (Working Paper 08-WP 460, Center for Agricultural and Rural Development, Iowa State University, Ames, IA, 2008).
12. As shown in table E-1 in the supporting online material of our Report, the average hectare converted to cropland in the 1990s in sub-Saharan Africa caused carbon emissions comparable to the world average, yet African cropland also has lower yields and therefore requires more land for the same crops.
13. S. Meade, S. Rosen, S. Shapouri, *Food Security Assessment, 2006* (GFA-18 Economic Research Service, USDA, Washington, DC, 2007).
14. IPCC, *Climate Change 2007: Synthesis Report Summary for Policymakers* (2007).
15. H. K. Gibbs et al., *Environ. Res. Lett.* **3**, 034001 (2008).

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 3 months or issues of general interest. They can be submitted through the Web (www.submit2science.org) or by regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

CORRECTIONS AND CLARIFICATIONS

Random Samples: "Motormouth" (22 August, p. 1023). "Silicon" in "silicon tongue" and "silicon skin" should have been "silicone."

Research Articles: "Essential cytoplasmic translocation of a cytokine receptor-assembled signaling complex" by A. Matsuzawa *et al.* (1 August, p. 663). There was inadvertent duplication of some of the loading control panels in two of the figures. In Fig. 1A, the JNK loading controls for the phospho-JNK blot (but not for the JNK kinase assay) were inadvertently duplicated between the *TRAF3*^{-/-} and *TRAF6*^{-/-} lanes. In Fig. 6D, the TAK1 loading controls in the TAK1 immunoprecipitate were inadvertently duplicated. The corrected figures are shown to the right. Neither error alters the scientific content of the figure or its interpretation.

News Focus: "Reinventing rice to feed the world" by D. Normile (18 July, p. 330). The article should have included Dhaka University, in Bangladesh, as among the institutions collaborating on research on salt-tolerant rice varieties.

Perspectives: "Long-distance dispersal of plants" by R. Nathan (11 August 2006, p. 786). There was an error in the formula used to create Fig. 2, panels A and C. The corrected panels are shown to the right. The figure caption is correct, but the error affects two sentences in the text. On page 786, the text at the top of the second column should read "In the hypothetical case shown in Fig. 2, the expected time for a single effective dispersal event to occur is longer than 1 million years beyond 250 km. Nevertheless, an effective LDD event 415 km from the source, expected to occur once in almost 10 million years under the mean trend, may occur once in 25 years as a result of processes or events that 'break the rules.'"

