On Brazilian Ethanol and the Ecological Footprint

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Marcelo Dias de Oliveira and colleagues assess the environmental impacts of ethanol production in Brazil and in the United States (*BioScience* 55: 593–602), and conclude that "the use of ethanol as a substitute for gasoline proved to be neither a sustainable nor an environmentally friendly option."

Their paper offers interesting insights into ethanol production, but we are nevertheless in disagreement with their conclusion for Brazilian sugarcane-based ethanol. The reason for this is that their conclusion follows from a common but problematic use of the ecological footprint concept.

Dias de Oliveira and colleagues estimate the ecological footprint of burning gasoline as the forest area required for capturing the associated carbon dioxide (CO_2) emissions. For ethanol, the footprint is estimated as the amount of land used for the sugarcane production plus the forest area required for capturing the CO_2 emissions from energy input in the production (which is assumed to be fossil fuel–based). In total, the footprint for the ethanol car is approximately 0.56 hectare and that of a gasohol car (76 percent gasoline, 24 percent ethanol) about 0.63 hectare. Thus, according to their calculation of the ecological footprint, an ethanol car seems to be essentially equivalent to a gasohol car.

The major problem with their approach is that it fails to consider that the sequestration of CO_2 in a forest cannot continue forever. This means that when the established forest matures, the carbon sink ceases, a new area has to be planted, and the old area has to be managed so that the carbon stock remains intact.

Taking this dynamic feature into account yields a different picture. The footprint for ethanol remains constant, whereas the footprint for gasohol grows over time. This is illustrated in figure 1. Here we have assumed that bioenergy (instead of fossil fuels) is used in ethanol production, which gives a somewhat lower area requirement in this case.

Finally, although our analysis suggests that ethanol is preferable to gasoline from a dynamic footprint perspective, this does not necessarily mean that it would be unproblematic if sugarcane ethanol became a dominant fuel in the transportation sector. If the 200 million cars in Europe ran on ethanol, they would require some 40 to 100 Mha of land (7 to 15 times the area used today for sugarcane in Brazil). Clearly, the scale of the potential demand is a cause for concern about potential negative environmental impacts. Other, complementary ways to solve the energy problem for transport are thus warranted.

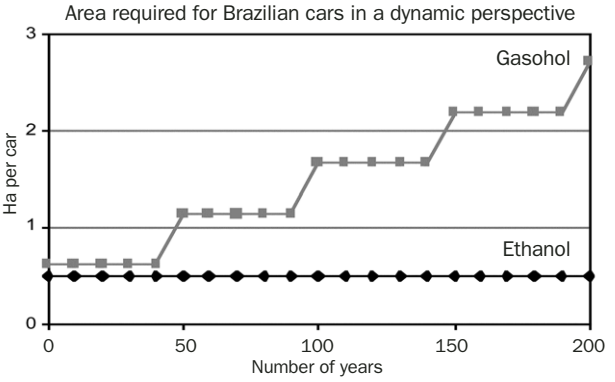

Figure 1. The footprint of Brazilian ethanol and gasoline in a dynamic perspective.

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Response from Dias de Oliveira and Vaughan

Professor Azar and colleagues raise a number of interesting points. We agree that forest sequestration cannot continue indefinitely—we addressed the issue of uncertainty about forests' potential to sequester CO_2 in our article—and we do not advocate it as a solution to the problem. Azar and colleagues note that the land area required to grow sugarcane or corn for 200 million cars fueled with ethanol is unrealistic. Indeed, that was one of the main points we tried to make, and it is true despite the imprecision involved in determining ecological footprint values, which we pointed out was problematic in some aspects. Nonetheless, the ecological footprint approach is still a valuable screening tool.

Regarding Azar and colleagues' argument that the footprint of gasohol-fueled (but not ethanol-fueled) cars will grow over the years, it seems to us that the assimilation area needed per car would increase as well for ethanol. Consider the production of sugarcane: If only labor-intensive agricultural production (as in Brazil) is taken into account, the assimilation component with regard to ethanol would remain smaller. However, with any major scale-up of production, most countries would turn to industrial agriculture (e.g., supplementary nitrogen, pesticide, and fuel inputs) for biomass production, which would mean that the ecological footprint would increase.

Another important observation: After 30 years of the ethanol program, Brazilian production is still far from deserving the label of "clean energy."

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Marcelo E. Dias de Oliveira (e-mail: dias_oliveira@msn.com) was a graduate student at Washington State University (WSU) Tri-Cities, in Richland, Washington, when he and his coauthors wrote "Ethanol as Fuel: Energy, Carbon Dioxide Balances, and Ecological Footprint." Burton E. Vaughan, a coauthor of the article, is an adjunct professor of biological sciences at WSU Tri-Cities.

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