

How Green Are Biofuels?

Jörn P. W. Scharlemann & William F. Laurance

Smithsonian Tropical Research Institute, Apartado 0843-03092, Balboa, Ancón, Panama Email: jscharlemann@gmail.com

Background

Global warming and escalating petroleum costs are creating an urgent need to find ecologically friendly fuels. Biofuels—such as ethanol from corn (maize) and sugarcane—have been increasingly heralded as a possible savior. But others have argued that biofuels will consume vast swaths of farmland and native habitats, drive up food prices, and result in little reduction in greenhouse-gas emissions.

To date, most efforts to evaluate different biofuels have focused on their merits for reducing greenhouse-gas emissions or fossil fuel use. Some studies suggest that corn-derived ethanol in the United States and Europe consumes more energy than it produces; others suggest a modest net benefit. Relative to petroleum, nearly all biofuels diminish greenhouse-gas emissions, although crops such as switchgrass easily outperform corn and soy. Such comparisons are sensitive to assumptions about local growing conditions and crop by-products, but even more importantly, their focus on greenhouse gasses and energy use is too narrow. Environmental impacts of biofuels are often ignored in comparisons among biofuels.

An innovative study by Zah *et al.*, commissioned by the Swiss government, could help to resolve this debate by providing a detailed assessment of the environmental costs and benefits of different transport biofuels.

Methods

Using life cycle assessment, Zah *et al.* compared gasoline, diesel and natural gas with 26 different biofuels produced from a wide range of “crops” used in Switzerland. Total environmental impact of each fuel was assessed by aggregating natural resource depletion and damage to human health and ecosystems into a single indicator. The indicator measures how much the environmental impacts exceed legal limits. Further, greenhouse-gas emissions for each fuel were calculated during the entire process chain relative to gasoline.

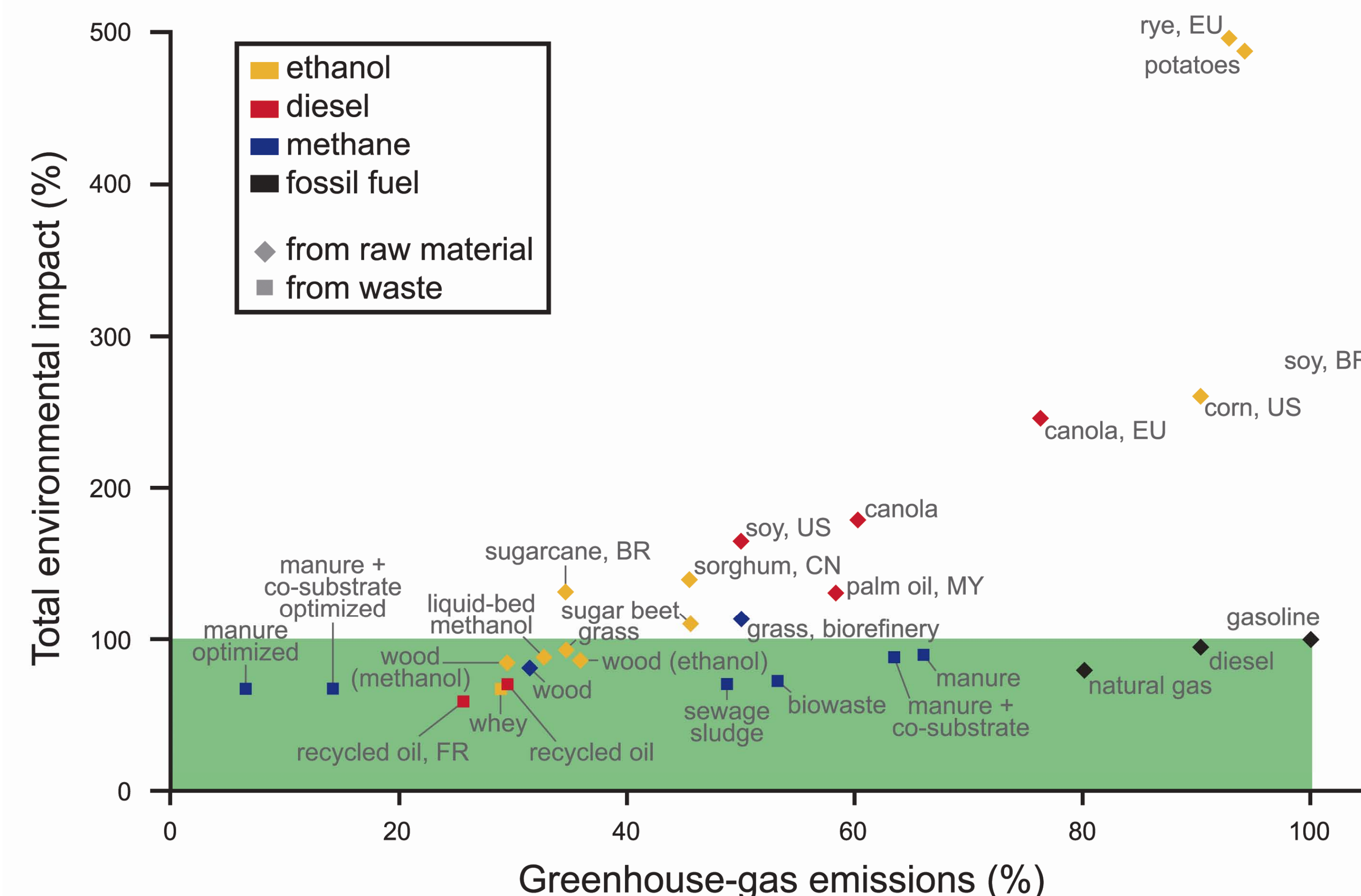


Figure 1. Greenhouse-gas emission are plotted against overall environmental impacts of 29 transport fuels, scaled relative to gasoline. Fuels in the shaded area are considered advantageous in both their overall environmental impacts and greenhouse-gas emissions. The origin of biofuels produced outside Switzerland is indicated by country codes: Brazil (BR), China (CN), European Union (EU), France (FR), and Malaysia (MY).

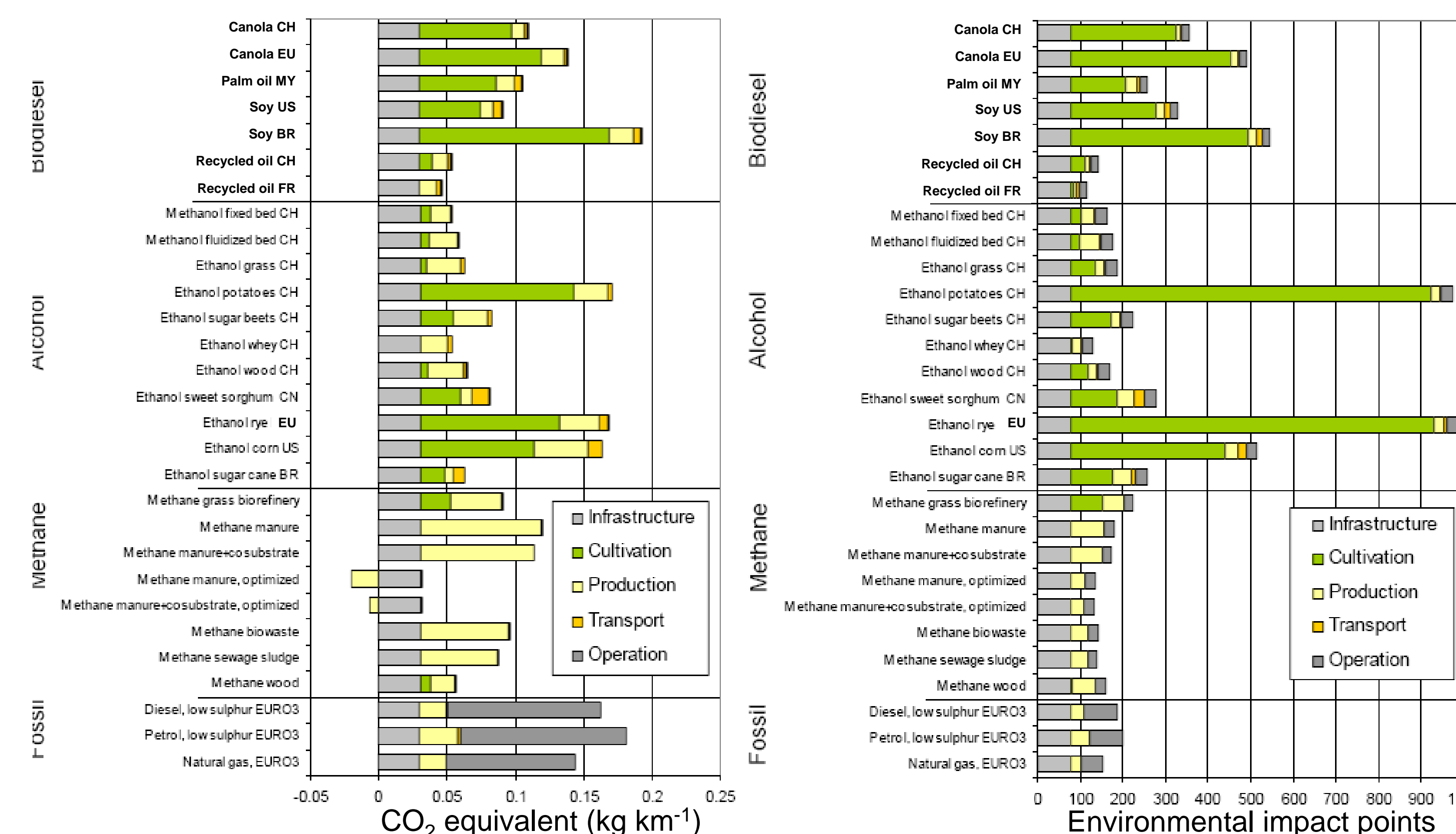


Figure 2. Comparison of the greenhouse-gas emissions emitted (left) and aggregated environmental impacts (right) of biofuels in relation to fossil fuels. The emissions and environmental impacts are given for 5 processes during the production chain, agricultural cultivation, fuel production, transport to gas station, vehicle operation, and construction and maintenance of vehicles and roads. Environmental impact points measure how much the environmental impacts exceed legal limits.

Results

Most (21 out of 26) biofuels reduced greenhouse-gas emissions by more than 30% compared to gasoline (Fig.1). But nearly half (12 out of 26) of the biofuels, including the economically most important ones, namely U.S. corn ethanol, Brazilian sugarcane ethanol and soy diesel, and Malaysian palm-oil diesel, have greater aggregate environmental impacts than do fossil fuels. Biofuels produced from residual products such as biowaste or recycled cooking oil fare best.

The steps within the processing chain that incur greenhouse-gas emissions (left) and total environmental impacts (right) are shown in Figure 2. Although highly variable, the greatest emissions and environmental impacts occur during agricultural cultivation through the use of machinery, fertilizers, and or pesticides, and due to soil acidification, nutrient leaching, and biodiversity loss particularly in tropical regions. The fuel production itself is second highest sources of greenhouse gases. Fuel transport to the Swiss gas stations contributes little (< 10%) to emissions and environmental impacts.

Conclusions

Not all biofuels are beneficial when their full environmental impacts are assessed. Some of the most important such as those produced from corn, sugarcane, and soy, perform poorly in many contexts. We need to consider more than just energy and greenhouse-gas emissions when evaluating different biofuels and to pursue new biofuel crops and technologies. Governments should be far more selective about which biofuel crops they support through subsidies and tax benefits.

Further reading

- Scharlemann, J. P. W. & Laurance, W. F. (2008) How Green Are Biofuels? *Science*, **319**, 43-44.
- Zah, R., Böni, H., Gauch, M., Hirschler, R., Lehmann, M. & Wäger, P. (2007) Ökobilanz von Energieprodukten: Ökologische Bewertung von Biotreibstoffen. Empa, St. Gallen, Switzerland.

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