Climate Forcing of Bioenergy Feedstocks: Insights From Carbon and Energy Flux Measurements

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Background/Objective

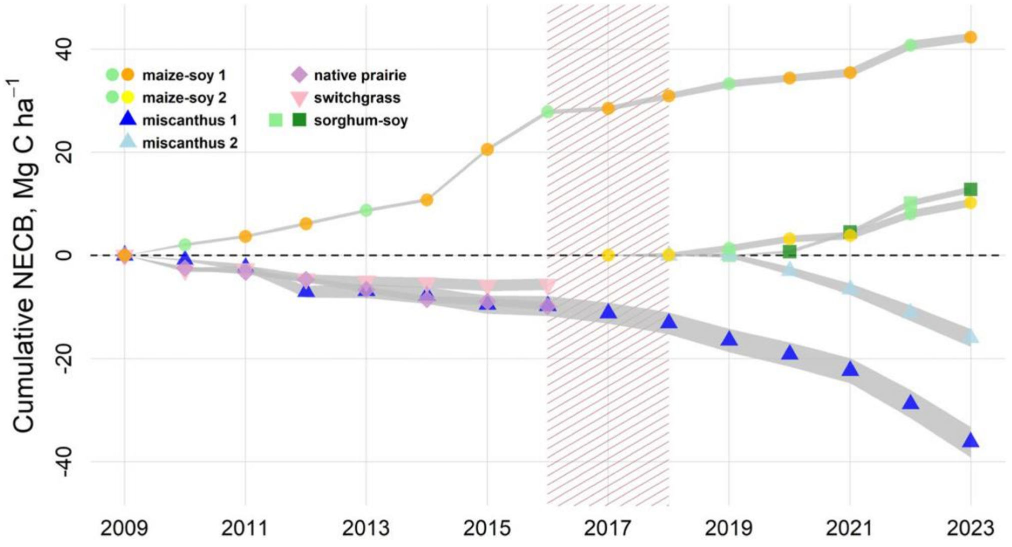
Bioenergy from biofuels has the potential to slow the increase of atmospheric CO_2 by reducing fossil fuel use. However, growing bioenergy feedstocks is land-intensive, and the expansion of maize bioethanol in the U.S. has come with environmental costs. Several alternative bioenergy feedstocks, selected in part for traits associated with ecosystem services, may provide opportunities for environmental benefits beyond fossil fuel displacement. This work tests the hypothesis that these bioenergy ecosystems will provide direct climatic cooling via their influence on carbon (C) and radiative energy flux.

Approach

We assessed the potential cooling effect of three perennial (miscanthus, switchgrass, prairie) and two annual (maize-soy, sorghum-soy) bioenergy cropping systems using multi-year records from eddy covariance towers.

Results

Perennial feedstocks were C sinks with annual mean net ecosystem C balance (NECB) of -2.7 ± 2.1 Mg C ha^{-1} for miscanthus, -0.8 ± 1.1 Mg C ha^{-1} for switchgrass, and -1.4 ± 0.7 Mg C ha^{-1} for prairie. In contrast, annual rotations were generally C sources, with annual mean NECB of 2.6 ± 2.4 Mg C ha-1 for maize-soy and 3.2 ± 2.1 Mg C ha^{-1} for sorghum-soy. Using maize-soy as a baseline, conversion to alternative feedstocks increased albedo, inducing further cooling.



Cumulative Net Ecosystem Carbon Balance (NECB) for each feedstock, including C loss from harvest. Negative values indicate C storage. Light green markers indicate soy years. Hatching indicates transition years where equipment changes prevented the collection of full years of data at some sites.

Significance/Impacts

This work highlights the impact of feedstock choice on ecosystem processes as an element of bioenergy land conversion strategies.

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