Why growing crops for food rather than energy in the Midwest can help mitigate climate change

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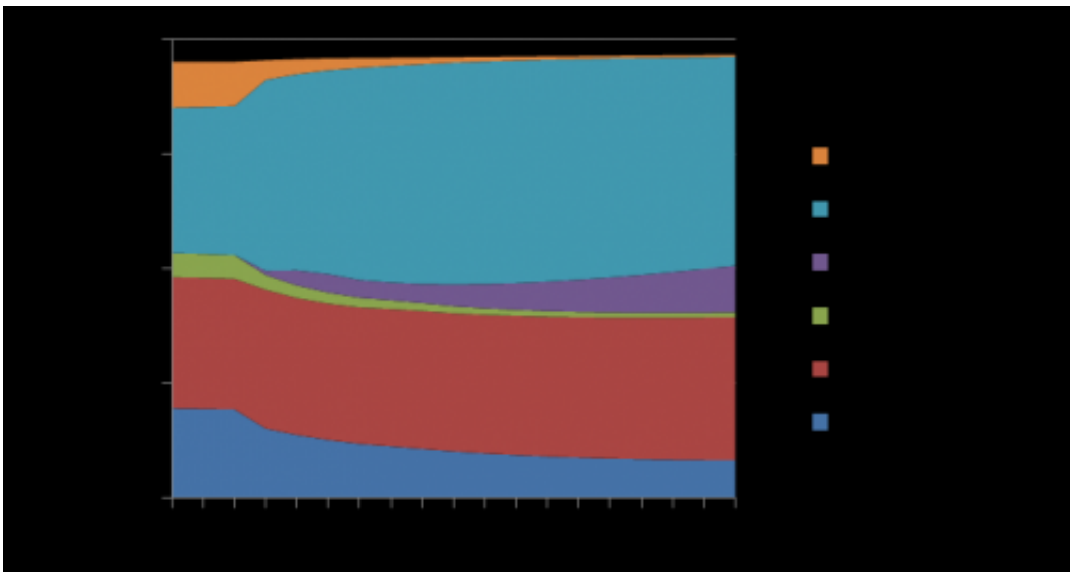

Land use change (in hectares) for 14 U.S. Midwest states under a climate mitigation policy in a global integrated model. In their study, PNNL scientists determined that many agricultural management technologies can contribute to climate mitigation.

To examine agricultural and land use practices and their climate mitigation potential in a 14-state portion of the U.S. Midwest, PNNL scientists at the Joint Global Change Research Institute nested a high-resolution agricultural model, EPIC (Environmental Policy Integrated Climate), within PNNL's flagship integrated assessment model, GCAM

(Global Change Assessment Model). Then, they used the combined system to analyze three alternative futures: one with no policy about climate change and two with different levels of climate mitigation policies. The results show that the ability of different regions to contribute to global climate change mitigation depends, in part, on the distinct biophysical characteristics of the land in each region. Nesting EPIC in GCAM also helped to show how different land use practices—for example, growing bioenergy crops or using alternative crop management practices—might contribute to climate change mitigation in a specific and globally important agricultural production region: the U.S. Midwest. Even in the future scenario with vigorous climate change mitigation policies, GCAM projects that the U.S. Midwest will remain an essential food crop production region, with limited adoption of bioenergy crops.

One of the biggest questions about climate change policies is how various regions will be affected by different global policy actions, such as how a price on carbon would influence biofuel production and greenhouse gas emissions. In this study, the simulations show that intensification of food and feed crop production is the most effective contribution to climate mitigation for land in the U.S. Midwest. Other regions of the world, where food and feed may be less inherently profitable, are better suited to afforestation for carbon storage or production of bioenergy crops, from a climate mitigation perspective. By understanding these tradeoffs, policy makers can make more informed and sustainable agricultural and land use decisions. Furthermore, this work illustrates the viability and value of nesting models with higher spatial and technology resolution inside larger-scale models to examine regional responses to global climate mitigation policies and economic conditions.

To examine the possible future land use changes in the U.S. Midwest region resulting from global climate mitigation policies, the researchers

acquired high-resolution data, involving land cover and agricultural production, crop management, and detailed soil profiles, to calibrate GCAM. The EPIC model also was used to simulate diverse crops and crop management practices to provide potential food and bioenergy crop yields for the GCAM calibration. Many crops and crop management practices were simulated, including major crops grown in rotation, no-tillage, and residue removal for bioenergy practices. Three climate scenarios were run: no policy, a mid-level climate forcing scenario, and an intensive mitigation policy designed to stabilize atmospheric radiative forcing at or below current values. To execute the approximately six million individual EPIC model runs across the 14-state region and multiple crop management scenarios, the researchers used a parallel computing framework processed via a supercomputing cluster (Evergreen).

This work is one of several efforts to add spatial and temporal detail to GCAM and link it with detailed models of natural and human systems, which is a key goal of PNNL's Platform for Regional Integrated Modeling and Analysis (PRIMA) Initiative. The GCAM scenario results from this study can be downscaled for further use in many different vegetation, land surface, and climate models, as well as to re-run the EPIC model for future years to further analyze environmental impacts of a GCAM-projected land use change for the U.S. Midwest. In addition, EPIC can be run using future climate change projections to simulate the impacts of temperature and precipitation on crop yield and carbon storage. Thus, the system applied here also could be used to examine the interactions of climate impacts on crop production and economic drivers for climate mitigation from land use changes.

More information: Thomson AM, GP Kyle, X Zhang, V Bandaru, TO West, MA Wise, RC Izaurralde, and KV Calvin. In press. "The contribution of future agricultural trends in the US Midwest to global climate change mitigation." *Global Environmental Change.* Available

online, Dec. 19, 2013. DOI: 10.1016/j.gloenvcha.2013.11.019.

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