Researchers challenge the CRP status quo to mitigate fossil fuels

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Luoye Chen (pictured) is a Ph.D. student at the University of Illinois Urbana-Champaign in CABBI Sustainability Theme Leader Madhu Khanna's lab group. Alongside the research team, Chen worked to develop an integrated modeling approach for assessing the economic and environmental feasibility of transitioning land enrolled in the Conservation Reserve Program (CRP) to bioenergy agriculture. This swap, while economically advantageous for landowners and the government, also promises significant fossil fuel mitigation in the long term. Credit: CABBI communications staff

Researchers at the Center for Advanced Bioenergy and Bioproducts Innovation (CABBI) found that transitioning land enrolled in the Conservation Reserve Program (CRP) to bioenergy agriculture can be advantageous for American landowners, the government, and the environment.

Land enrolled in the CRP cannot currently be used for bioenergy crop production, wherein high-yielding plants (like miscanthus and switchgrass) are harvested for conversion into marketable bioproducts that displace fossil fuel- and coal-based energy. Established by the U.S. Department of Agriculture in 1985, the CRP incentivizes landowners to retire environmentally degraded cropland, exchanging agricultural productivity for native habitats and accepting annual government payments in return.

As the world warms and its population explosively expands, global demand for food production is at odds with the decreased agricultural productivity threatened by extreme climate conditions. Therefore, allocating CRP land for high-yielding energy biomass might eliminate the need for bioenergy crops and food crops to vie for space.

A team led by CABBI Sustainability Theme Leader Madhu Khanna and Ph.D. student Luoye Chen developed an integrated modeling approach to assess the viability of transitioning CRP land in the eastern U.S. to perennial bioenergy crops. Their paper, published in *Environmental Science & Technology* in January 2021, confirmed that the land-use transition is indeed viable provided that certain key conditions are met.

"As proponents of a safer, more sustainable bioeconomy, we must prioritize displacing fossil fuels," said Khanna, who is also Acting Director of the Institute for Sustainability, Energy, and Environment (iSEE) at the University of Illinois Urbana-Champaign. "As scientists, it is our responsibility to take a thoughtful, innovative approach to mitigating greenhouse gases in a way that will prove beneficial in the long term.

"The transportation and electricity sectors are looking to expand bioenergy production, and it is imperative that the agricultural sector do the same. This necessitates a program wherein bioenergy cropland and food cropland coexist rather than compete."

The CABBI team takes an integrated approach to weighing the costs and benefits of swapping the CRP status quo—uncultivated acreage—for bioenergy, combining the Biofuel and Environmental Policy Analysis Model (BEPAM) with the biogeochemical model DayCent (Daily Time Step Version of the Century Model).

BEPAM assesses net profitability, answering the key question: What precise economic conditions will incentivize CRP landowners to make the switch to bioenergy cropland? An environmental counterpoint to BEPAM, DayCent simulates the full ecosystem effects of the transition on a given county, providing a "sneak peek" into the future and shedding light on how this land-use change might affect factors like crop yield, nutrient exchange, and soil carbon sequestration.

A key component of this study aggregates data from both models to formulate a greenhouse gas (GHG) life-cycle assessment, which calculates the total GHGs mitigated by the process as a whole—from the physical act of planting to the introduction of clean energy into the bioeconomy.

"The full life-cycle assessment really is key to understanding the big-picture results of our research," Chen said. "We take everything into account—the process of actually growing and harvesting the feedstocks, the carbon sequestered in the soil, and the fact that ultimately, we will be displacing fossil fuels with biofuels, and coal-based electricity with bioelectricity.

"Keeping that end result in mind anchors everything else to the ultimate goal of a net positive environmental impact."

The team concluded that converting 3.4 million hectares of CRP land to bioenergy from 2016 to 2030 is economically and environmentally viable—under certain conditions.

Economically speaking, all systems are "go" if the market price of biomass is high and the government continues to distribute appropriate CRP land rental payments. These factors can ideally function as counterweights: If biomass prices decrease, substantial land rental payments may alleviate financial stress from farmers and encourage their continued commitment to bioenergy; alternatively, soaring biomass prices would rationalize relaxed government support, saving taxpayers money. The team identified two ideal pairings: 1) landowners receive 100 percent of their original government payments and sell biomass at $75/metric ton; or 2) landowners receive 75 percent of their original payment and sell biomass for $100/metric ton. Ideally, both parties benefit.

Converting CRP land to bioenergy can also result in substantial GHG savings. Previous studies show that a large "soil carbon debt" is liable to accrue at the outset of the venture, during the planting years of miscanthus and switchgrass. However, taking into account the full life-cycle assessment mentioned above, the research team determined that the long-term effects of displacing fossil fuel- and coal-based energy with bioproducts would more than make up for this temporary loss.

Considering landowner income from biomass sales, savings in government payments to maintain existing CRP enrollment, and the monetized benefits of GHG mitigation through displacing fossil fuels (quantified using the "social cost of carbon"), the total net value of converting CRP land to bioenergy could be as high as $28 billion to $125 billion over the 2016-2030 period.

More information: Luoye Chen et al, Assessing the Returns to Land and Greenhouse Gas Savings from Producing Energy Crops on Conservation Reserve Program Land, *Environmental Science & Technology* (2021). DOI: 10.1021/acs.est.0c06133

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