Empirical measures of effects of bioenergy policy on land-use change

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Abstract

Understanding the land-use change (LUC) implications of bioenergy feedstock production is crucial to assessing the sustainability of bioenergy systems. Global or regional economic models simplify or omit regional and temporal mechanisms that can determine how bioenergy policy affects LUC. Appropriate data for validating models are scarce, but data from Iowa and the U.S. suggest that recent bioenergy development primarily involved land that had been in rotation between cropland and grassland/pasture for decades. The data further suggest that urban development, often ignored by models, is nearly irreversible and continued to contribute to net LUC. Improved datasets are needed to better test hypotheses and to develop and validate improved LUC models that incorporate regional mechanisms.

Model assumptions drive LUC results

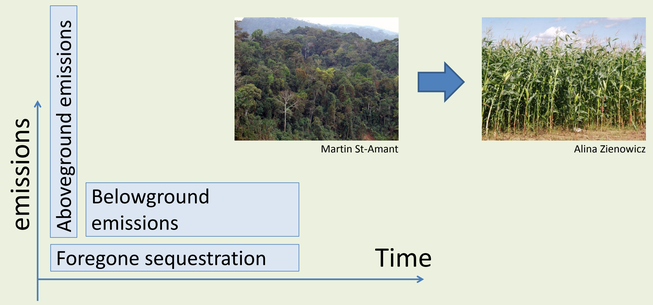

Fig. 1a. (adapted from Martin et al., 2011) Conceptual model of GHG emissions from bioenergy production, assuming high C-sequestering land uses (e.g., mature forest) are replaced by low C-sequestering land uses (e.g., row crops).

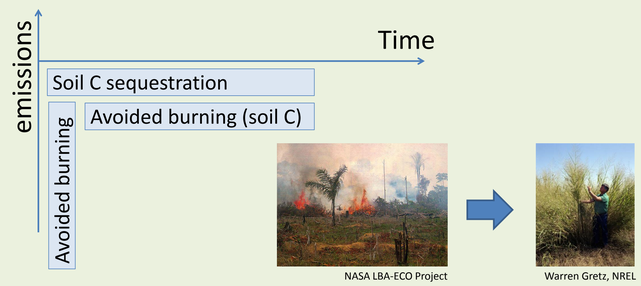

Fig. 1b. As above, but assuming C-emitting land uses (e.g., nonproductive repeated burning) are replaced by C-sequestering land use (e.g., perennial crops).

Simplified LUC models employ crucial assumptions that contradict empirical evidence, e.g., that land is either fully utilized or in a stable, natural state (Kline et al. 2011). Under this assumption, biofuels must displace high-carbon land covers as in Fig. 1a. In reality, there is ample opportunity to improve management on previously cleared land, as in Fig. 1b.

Net trends in cropland and production

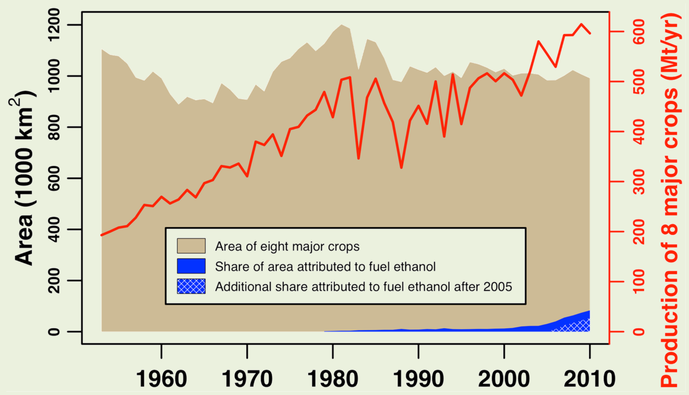

Fig. 2. US land used for fuel ethanol and land area and production for 8 major crops, based on NASS data. Ethanol land use assumes 35% co-product credit. (Calculations also based on numbers from Renewable Fuels Assoc., Schlicher [2008], and Perrin *et al.* [2009].)

As seen in Fig. 2, US land planted to crops has been relatively steady while production has increased. Land used for fuel ethanol production is relatively small and gradually increasing. No major shift in prior trends is visible for cropland area with the introduction of fuel ethanol production. Therefore, if biofuel policies had a large effect on cropland, then cropland area or yields would have decreased in the absence of those policies. In such a scenario, cropland might otherwise have been allocated as in the past (Fig. 3a, below-zero parts of "Cropland" bars).

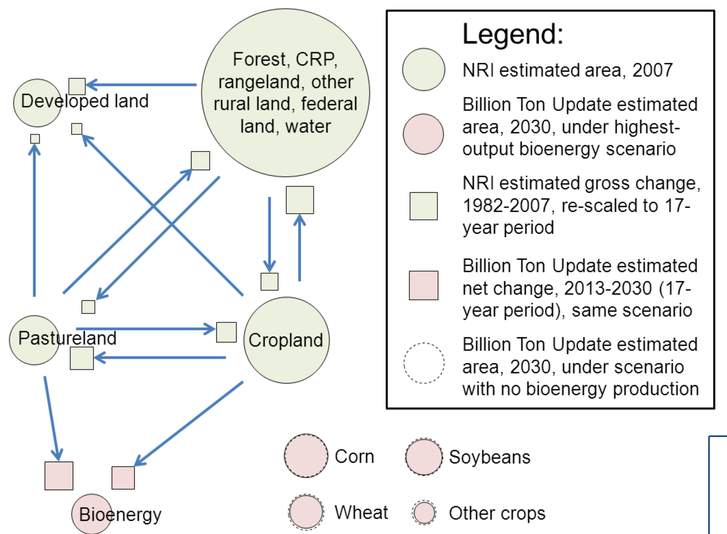

Fig. 4. US land-use change from 1982-2007 (NRI) in the context of Billion Ton Update forecasts for 2013-2030. As shown by dotted circles, bioenergy is forecast to have little effect on crop area, even under the scenario with highest demand and annual yield growth.

Gross land change analysis

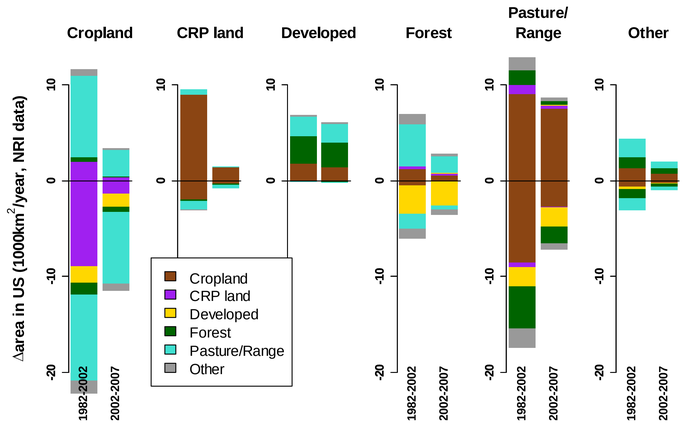

Fig. 3a. Gross changes in US to (above) and from (below) each of six land classes, based on NRI data.

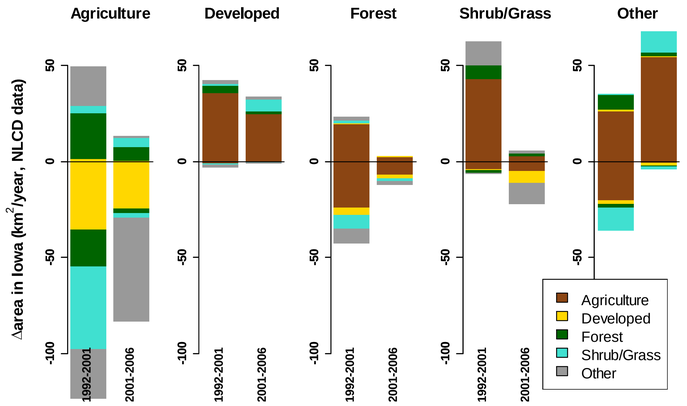

Fig. 3b. Gross changes in Iowa to (above) and from (below) each of five land classes, based on NLCD data.

According to Nickerson *et al.* (2011), "Once converted to an urban use … land rarely transitions back to a less intensive agricultural use." This effect is clear in Figs. 3 and 4. As shown in these figures, it appears plausible that in the absence of biofuel policies, more cropland would have been developed or would have continued to cycle among other uses.

Future directions

Existing data sets answer questions for which they were designed but have limited suitability for LUC studies. Our team is working toward a spatially explicit, high-resolution, consistent time series based on MODIS data, as well as a new model design to assess causality.

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