Modeling and Mapping Land Management and Net Carbon Emissions: Decision Support for Biofuels and Carbon Management on U.S. Agricultural Lands

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Abstract

The Energy Independence and Security Act (EISA) of 2007 calls for 36 billion gallons of biofuels by 2025. Of this amount, 16 billion gallons is to be generated from lignocellulosic feedstocks. Lignocellulosic feedstocks include dedicated energy crops (e.g., switchgrass, miscanthus, willow, and poplar) and residues from forest and crop commodities. A carbon accounting framework that includes all known carbon sources and sinks from US agricultural production has been developed. Current and future bioenergy feedstocks will be incorporated into this carbon accounting framework to estimate current and future changes in net carbon exchange. Mapping of these feedstocks using remote sensing products is essential for analyses of soil carbon, soil erosion, water quality, and biorefinery siting.

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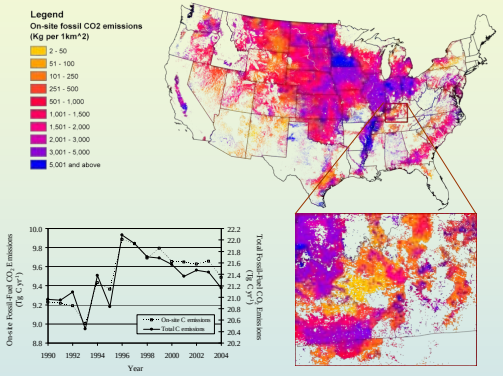
Figure 1

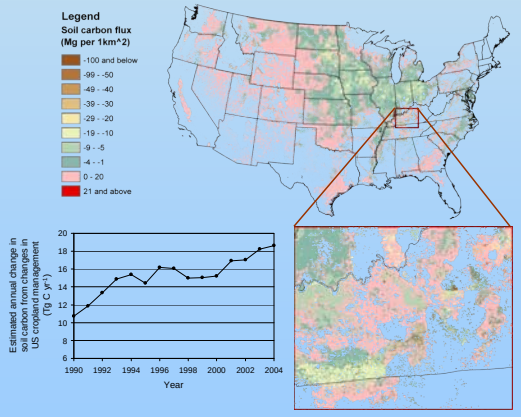
On-site Fossil-fuel CO_2 Emissions from US Cropland Production



On-site fossil-fuel emissions include machinery with combustion engines used in crop production. The combination of machinery used varies for crop, crop management, and region. Total fossil-fuel emissions include off-site CO_2 emissions generated during the production and transport of cropland inputs (e.g., fertilizers, pesticides, seeds). Trends in fossil-fuel CO_2 emissions are closely associated with annual weather events and with national farm policies and incentives.

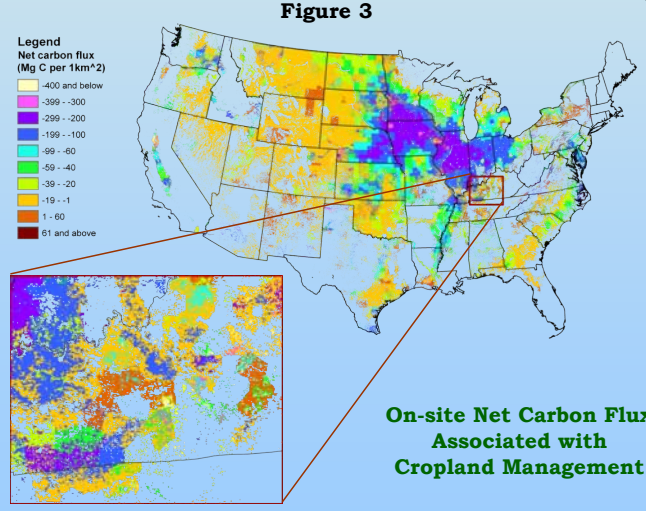
Figure 2

Annual Changes in Soil Carbon



Annual changes in soil carbon associated with changes in US cropland management are estimated here using a combination of national inventory data, soil carbon accounting methods (West et al. 2008), and MODIS land cover data.

Figure 3

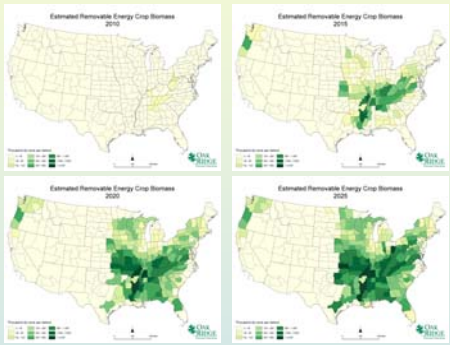


On-site Net Carbon Flux Associated with Cropland Management

On-site net carbon flux is defined here as all on-site carbon sources and sinks. Sources and sinks are estimated in our carbon accounting framework, and include (a) carbon uptake by crops, (b) decomposition of below-ground biomass and crop residue, (c) soil carbon accumulation, (d) fossil-fuel CO_2 emissions, (e) and soil CO_2 emissions associated with the application of agricultural lime. On-site net carbon flux does not include carbon harvested and transported off-site, which explains the largely negative values.

Figure 4

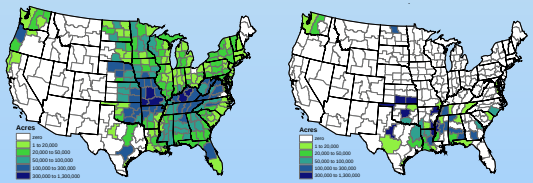
Estimated Adoption and Removal of Dedicated Biomass Feedstocks



Dedicated biomass feedstocks are defined here as switchgrass, sweet sorghum, poplar, and willow. Dedicated feedstocks do not include residues generated by traditional agronomic practices (e.g., corn stover, sorghum stubble, wheat straw). These projections were generated using the POLYSYS agricultural economic model, in conjunction with estimates of residue that can be sustainably removed without exceeding the tolerable soil loss.

Figure 5

Displacement of Croplands by Dedicated Biomass Feedstocks



Projected Acreage Converted from **Pasture** to Dedicated Crop Production, 2025

Projected Acreage Converted from **Cropland** to Dedicated Crop Production, 2025

The adoption of dedicated energy crops (e.g., switchgrass, miscanthus, poplar) are estimated annually to 2025. Estimates are based on the POLYSYS agricultural economic model that endogenously determines cellulosic prices to meet the new EISA 2007 legislation; prices stabilized around $50 per dry ton. Current estimates indicate that most dedicated feedstocks will displace pasture in the US, while a smaller amount will displace croplands in the southern US. Estimating future adoption of biomass feedstocks and future changes in land management allows for the mapping of future land use with current land-use data (e.g., MODIS) and allows for projected estimates of net carbon emissions, carbon sequestration, and net carbon exchange.