The purpose of this research is to estimate carbon sources and sinks associated with crop production in the US. We specifically looked at biotic carbon that is taken up by crops and then released onsite through decomposition or off-site through the consumption of crop commodities. We compiled data from numerous national inventories on crop production, processing, consumption, storage, import and export, and developed the first ever crop carbon budget for the US. Data were compiled at the county level. These data can be used to monitor the ultimate use of crop-derived carbon and the CO2 fluxes associated with this use. These data can also be used for comparison by humans and livestock.

Carbon fixed by agricultural crops in the US creates regional CO2 sinks where it is harvested and regional CO2 sources where it is released back to the atmosphere. The quantity and location of these fluxes differ depending on the annual supply and demand of crop commodities. Data on the harvest of crop biomass, storage, import and export, and on the use of biomass for food, feed, fiber, and fuel were compiled to estimate an annual crop carbon budget for 2000 to 2008. With respect to US Farm Resource Regions, net sources of CO2 associated with the consumption of crop commodities occurred in the Eastern Uplands, Southern Seaboard, and Fruitful Rim regions. Net sinks associated with the production of crop commodities occurred in the Heartland, Northern Crescent, Northern Great Plains, and Mississippi Portal regions. The national crop carbon budget was balanced to within 93 to 99% yr⁻¹ of total carbon uptake during the period of this analysis.

This budget represents the movement of annual crop carbon into, out of, and within the US for the year 2008. Double arrows represent inputs to the annual crop carbon stock that are available for food, feed, fiber, and fuel; single arrows represent flows of carbon that lessen the available crop carbon stock; dashed arrows represent initial photosynthetic production of crop carbon and estimated net soil carbon accumulation. Ellipses represent end uses of crop carbon. All units are in Tg C yr⁻¹. Balancing the budget allows for greater confidence in the individual components of the budget and allows us to track the ultimate use of crop commodities and release of CO2 associated with this use. Vertical fluxes, relevant to atmospheric inversion modeling, are dominated by NPP, decomposition, and consumption of food and feed by humans and livestock.

Figure 1. This budget represents the movement of annual crop carbon into, out of, and within the US for the year 2008. Double arrows represent inputs to the annual crop carbon stock that are available for food, feed, fiber, and fuel; single arrows represent flows of carbon that lessen the available crop carbon stock; dashed arrows represent initial photosynthetic production of crop carbon and estimated net soil carbon accumulation. Ellipses represent end uses of crop carbon. All units are in Tg C yr⁻¹. Balancing the budget allows for greater confidence in the individual components of the budget and allows us to track the ultimate use of crop commodities and release of CO2 associated with this use. Vertical fluxes, relevant to atmospheric inversion modeling, are dominated by NPP, decomposition, and consumption of food and feed by humans and livestock.

Figure 2. Some components of the US crop carbon budget are shown here to illustrate where prominent changes in the budget have occurred between 2000 and 2008. Harvested crop carbon varied by about 70 Tg C yr⁻¹ over this period. Carryover grain reserves fluctuate based on annual yields and post-harvest use. Carryover grain acts as a buffer for crop production and consumption. As biomass diverted to corn grain ethanol has increased, there have been decreases in carryover grain reserves and livestock feed, and increases in exported biomass. These changes impact the time and location of CO2 release from the consumption of crop commodities.

Figure 3. Harvested biomass, approximate release of biomass carbon by humans and livestock, and the geographic net exchange of crop carbon for 2008. Data are illustrated as mass carbon per county per year (a,b,c,e,g) and as mass carbon per unit area per year (b,d,f,h). Harvested biomass (a,b) is removed from the field and released as CO2 by livestock and humans (c,d,e,f). Net exchange of crop carbon (g,h) is the sum of net carbon uptake by crops, net change in soil carbon, and the geographic location of crop carbon release. Carbon uptake and release is estimated at the county level and can be aggregated by Farm Resource Regions. Farm Resource Regions are defined by US Department of Agriculture to represent geographic specialization in production of US farm commodities.

Data availability
http://cdiac.ornl.gov/carbonmanagement/cropcarbon
http://cdiac.ornl.gov/carbonmanagement/weststockemissions
http://cdiac.ornl.gov/carbonmanagement/humanemissions
http://cdiac.ornl.gov/carbonmanagement/soilcarbonchange

Citation

Acknowledgments
We gratefully acknowledge the National Aeronautics and Space Agency, Earth Sciences Division for support through the North American Carbon Program, Mid-Continent Intensive Campaign (Agreement No. NN08AAX88G) and the US Department of Energy, Integrated Assessment Research Program.