Measuring land use change impacts on carbon dynamics in the western Great Plains: The Curtis Ranch Land Use Change Experiment

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Summary:
With funding from the National Institute for Climate Change Research (NICCR) we are investigating how land use change in the western Great Plains impacts ecosystem function and interaction with the regional atmosphere. We measure fluxes of CO₂ and water vapor between the land surface and atmosphere as a way to understand how grazing and dry-land agriculture change the productivity and water balance of semi-natural grasslands in the shortgrass steppe region of eastern Colorado. We chose to work in Conservation Reserve Program (CRP) land because of the importance of this USDA program in the Great Plains region, and to understand how ecosystem processes change when CRP is returned to grazing or to dry-land agriculture. Moderate grazing by cattle has relatively subtle effects on both carbon and water dynamics in these grasslands in the short term, but differences between grazed and ungrazed systems become more apparent through time. We hypothesized that grazed grassland may be more sensitive to wet/dry years than ungrazed grassland, and this is seen in the third (dry year) at the site.

Conversion of grassland to a wheat-millet rotation resulted in a large loss of carbon to the atmosphere during conversion (~600 g m⁻² CO₂ = ~165 g m⁻² C). This land use change loss is only partially offset during subsequent crop growth. If all the CRP land in Colorado (~800,000 Ha) were transformed back to dry-land agriculture the resulting loss in perennial grass biomass could release as much as 1.3 Tg Carbon (4.8 Tg CO₂).

In the next phase we will begin restoration of the crop site during which the site will be re-sown to a grass and forb mixture typical of the shortgrass steppe. We will monitor site recovery with anticipated C sink over several years, matching in magnitude, but not speed, the rapid loss when the site was ploughed. We are developing new physiological modules for the DayCent model to simulate hourly fluxes of carbon and water, to provide coupled growth, biochemical and biophysical models. New very accurate measurements of atmospheric CO₂ concentration have been installed to provide data for regional boundary layer inversions and verify regional model estimates.

The trio of flux towers that form the Curtis Ranch Land Use Change Experiment represent some of the most important land uses of the western Great Plains region. These, coupled with modeling and inversion of atmospheric [CO₂] measurements, are providing vital information on short-term (hourly to seasonal) and long-term (seasonal-multi-annual) carbon dynamics of the Central Great Plains region.

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Fig. 1. Curtis Ranch Location and Treatment Design

Fig. 2. Three years of monthly diurnal mean fluxes (H, LE, F_{CO₂}) and [CO₂] in the graze treatment

Fig. 3. Land use impacts on monthly NEE of CO₂, water flux, and cumulative carbon and water fluxes, for three treatments at the Curtis Ranch eddy flux site