

Carbon dynamics (2000—2006) over the northern Great Plains grasslands

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Key words : eddy covariance, flux tower, gross primary production, net ecosystem exchange

Introduction The grassland ecosystem in the U.S. Great Plains occupies was about 1.5 million km². However, the contribution of the grasslands to local and regional carbon budgets remains uncertain due to the lack of carbon flux data for the expansive grassland ecosystems under various land managements, land uses, and climate variability. An understanding of carbon fluxes across the ecosystem is essential for developing carbon budget models at regional, national, and global scales.

Materials and methods A remote sensing-based empirical model, piecewise regression model (Wylie et al., 2007; Zhang et al., 2007), was modified to estimate the grassland carbon fluxes in the U.S. northern Great Plains. The model explored the empirical relationship between environmental variables and tower-based measurements collected from six grassland flux towers and extrapolated the tower-measured data to the entire grassland ecosystem. We used this model to estimate the spatio-temporal carbon fluxes across the study area. Net ecosystem exchange (NEE) between land and atmosphere were measured using eddy covariance and Bowen-Ratio techniques. We partitioned 30-minute CO₂ fluxes into total ecosystem respiration and gross primary production (GPP) using the light response curve analysis (Gilmanov et al., 2005). The predictors include the MODIS normalized difference vegetation index (NDVI), precipitation, temperature, photosynthetic active radiation, and phenological metrics. We also incorporated the actual vegetation evapotranspiration data derived from a vegetation evapotranspiration (VegET) model (Senay and Henebry, 2007), which takes into account soil moisture and land surface phenology.

Results and discussion In the northern Great Plains grasslands, we estimated a 13 percent reduction of GPP in the dry year 2002 compared to the average GPP for years 2000-2006, which resulted in an anomalous net source of carbon dioxide (-19 gC/m²/year) to the atmosphere. The carbon budgets depend, to a great extent, upon precipitation and its distribution in this region. Specifically, the 2006 NEE map (Figure 1) shows carbon sources in drier western regions and carbon sinks in wetter eastern and southern regions, which was in line with the east-west gradient of annual precipitation across this region. The annual NEE varied from -28 g C/m²/year (source) in 2006 to 37 g C/m²/year (sink) in 2001, with sources in 2002, 2004, and 2006, and sinks in other years (Figure 2).

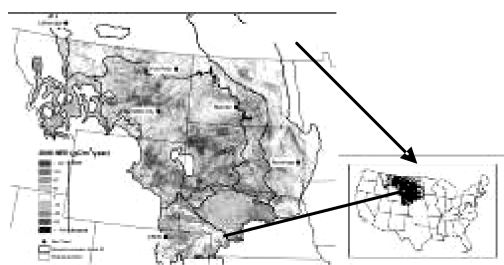


Figure 1 Spatial distribution of annual NEE for 2006.

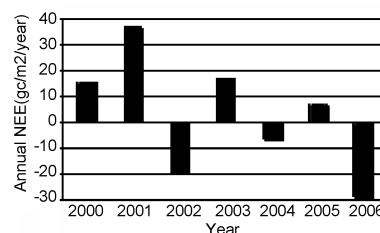


Figure 2 Estimated annual NEE for 2000-2006.

Conclusions The CO₂ exchanges over the northern Great Plains grasslands are highly variable in space and time. The annual NEE transits from sinks to sources in the dry years of 2002, 2004, and 2006. If the climate becomes drier in the future, the ecosystems may change to larger carbon sources.

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