Carbon Dynamics (2000-2006) over the Northern Great Plains Grasslands

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The 21st International Grassland Congress / 8th International Rangeland Congress took place in Hohhot, China from June 29 through July 5, 2008.

Proceedings edited by Organizing Committee of 2008 IGC/IRC Conference

Published by Guangdong People's Publishing House

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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 km^2 . 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 CO_2 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/m^2 / 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/m^2 /year (source) in 2006 to 37 g C/m^2 /year (sink) in 2001 , with sources in 2002 , 2004 , and 2006 , and sinks in other years (Figure 2) .

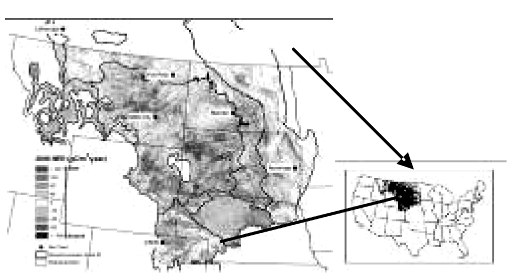

Figure 1 *Spatial distribution of annual NEE for 2006 .*

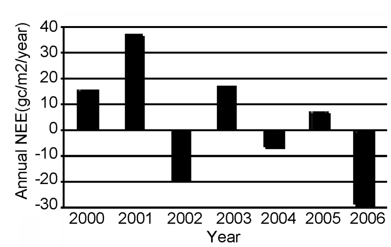

Figure 2 *Estimated annual NEE for 2000 -2006 .*

Conclusions The CO_2 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 .

References

Gilmanov , T .G . , Tieszen , L .L . , Wylie , B .K . , Flanagan , L .B . , Frank , A .B . , Haferkamp , M .R . , Meyers , T .P . , Morgan J .A . , 2005 . Integration of CO_2 flux and remotely sensed data for primary production and ecosystem respiration analyses in the Northern Great Plains : Potential for quantitative spatial extrapolation . *Global Ecology and Biogeography* 14 (3) : 271-292 .

Senay , G .B . , Henebry , G . , 2007 . Evaluating vegetation evapotranspiration (VegET) modeling results in South Dakota . In : Proceedings of the Eastern South Dakota Water Conference . October 29-31 , Sioux Falls , South Dakota .

Wylie , B .K . , Fosnight , E .A . , Gilmanov , T .G . , Frank , A .B . , Morgan , J .A . , Haferkamp , M .R . , Meyers , T .P . , 2007 . Adaptive data-driven models for estimating carbon fluxes in the Northern Great Plains . *Remote Sensing of Environment* 106 : 399-413 .

Zhang , L . , Wylie , B .K . , Loveland , T . , Fosnight , E .A . , Tieszen , L .L . , Ji , L . , 2007 . Evaluation and comparison of gross primary production estimates for the northern Great Plains grasslands . *Remote Sensing of Environment* 106 : 173-189 .