Modeling and Mapping of Carbon Fluxes in Rangeland Ecosystems

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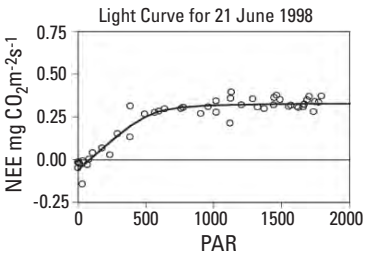
Robust, accurate, precise and interpretable regional carbon flux models are needed to understand the influence of climate and management on rangeland ecosystems. Direct measurements of CO_2 fluxes at towers allow regional models based on satellite data to be built and calibrated.

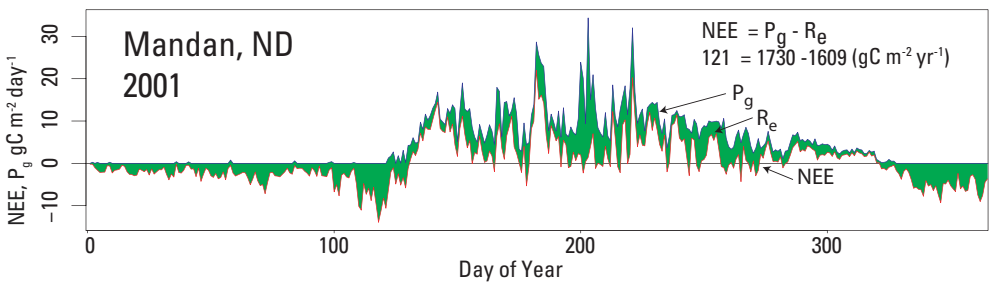
Methods

Flux towers provide detailed but very localized measurements of CO_2 fluxes or Net Ecosystem Exchange (NEE) between the atmosphere and the land surface every 20 minutes. Total ecosystem respiration (R_e) at the tower is the sum of day-time respiration (R_d), derived from a light curve equation, plus night-time respiration (R_n).

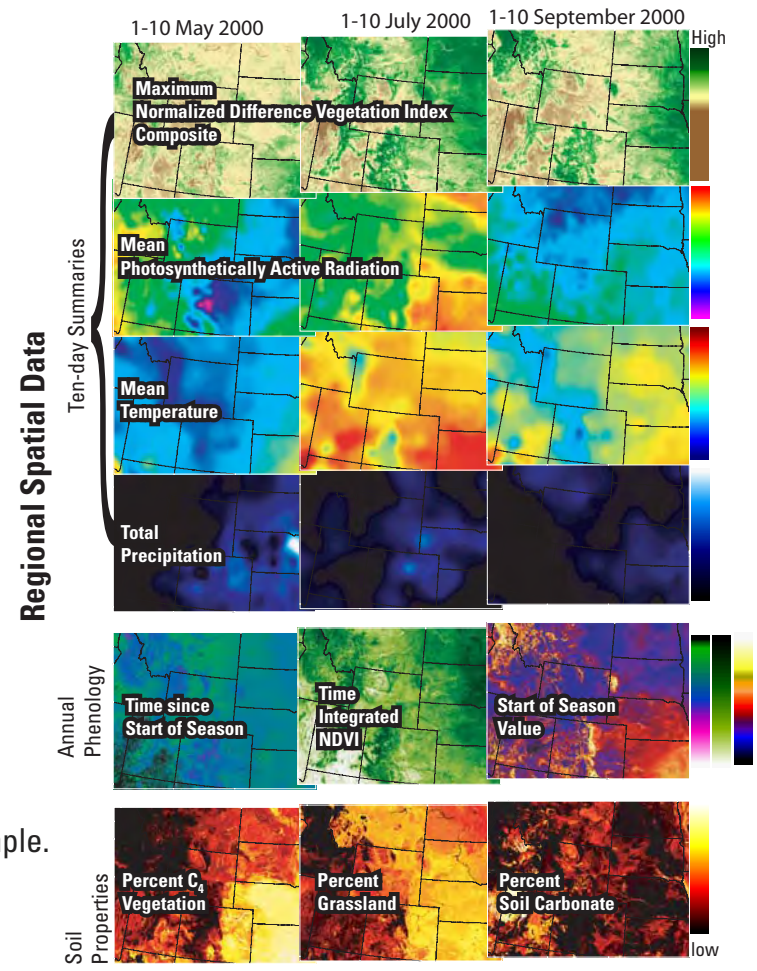


A rangeland flux tower.

Gross Primary Production (P_g) is the amount of carbon taken up in photosynthesis. If production exceeds respiration, then a net Carbon sink exists for the period measured. In 2001, the rangeland at the Mandan, ND flux tower was a small carbon sink with a net exchange of 121 gC m^{-2} yr^{-1}.



Flux tower measurements are scaled to regions using regional spatial data that contribute toward explaining the variation of flux tower measurements in a regression tree analysis.



Regression tree models, consisting of a set of stratified regression equations, are developed to predict NEE, Re and Pg at 10-day time steps for all rangeland grid

A regression tree example.

Rule 1:
if
NDVI <= 140, PAR <= 82
then
Pg = -5.05212 + 0.104 NDVI - 0.058 sosn + 0.0114 PAR - 0.0012 ssost - 0.003 c4pct + 0.001 temp

Rule 2:
if
NDVI <= 140, PAR > 82, sosn > 124
then
Pg = -10.201 + 0.354 NDVI - 0.304 sosn + 0.052 c4pct - 0.008 ssost + 0.018 temp + 0.0025 PAR

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Please visit http://edc.usgs.gov/carbon_cycle/FluxesResearchActivities.html or http://edc.usgs.gov/calval/, or contact Bruce Wylie at wylie@usgs.gov for more information.

U.S. Department of the Interior
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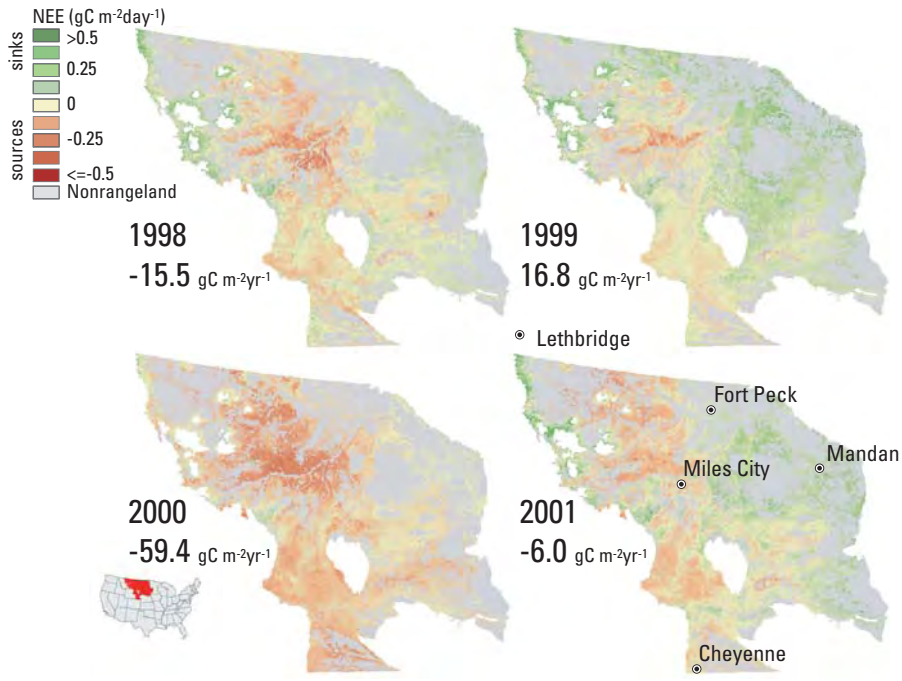
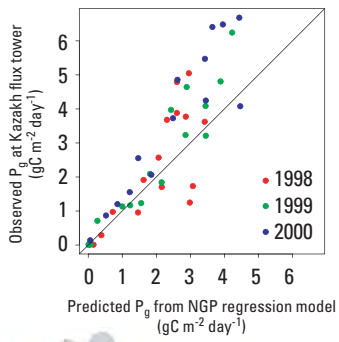
Results

Regression tree models were developed from multiple year data at five flux towers in the Northern Great Plains and two towers in the Sagebrush Steppes of North America, and one tower in the Kazakh Steppes of Central Asia.

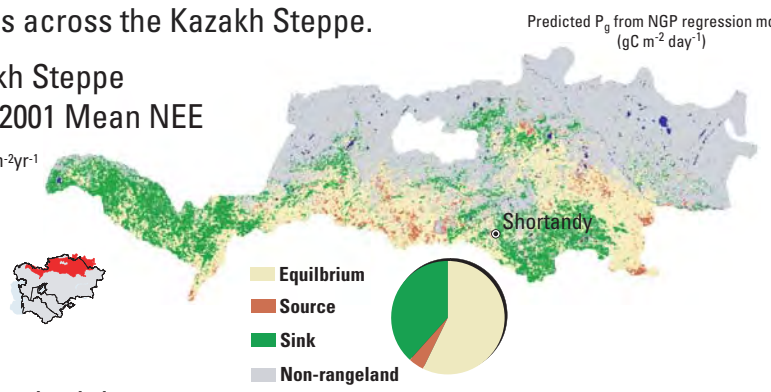
The estimates of NEE vary substantial among the years and across the rangelands of the Northern Great Plains. The Northern Great Plains was a small source in 1998, 2000, and 2001, and was a small sink in 1999.



The Northern Great Plains regression tree model applied to the Kazakh Steppe, in Central Asia indicated these rangelands were functionally similar. The pooled Northern Great Plains and Kazakh Steppe flux tower data better represent the range of ecological conditions across the Kazakh Steppe.

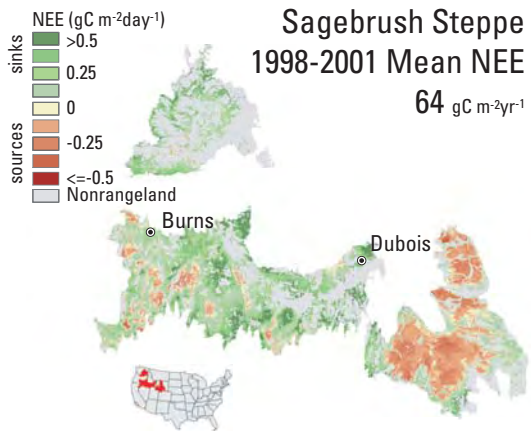


Kazakh Steppe
1998-2001 Mean NEE
21 gC $m^{-2}$$yr^{-1}$



The methodology was extended to the rangelands in the sagebrush steppes of the western United States. For the period 1998 and 2001, the rangelands in the east tended to be weak sources of Carbon, while the rangelands in the west were weak sinks. Overall the ecosystem was a weak carbon sink.

Sagebrush Steppe
1998-2001 Mean NEE
64 gC $m^{-2}$$yr^{-1}$



Conclusion

Regression tree models are effective tools for creating regional maps of carbon fluxes given regional spatial data and flux tower measurements for calibration. Between 1998 and 2001, the Kazakh steppes and the Sagebrush Steppes sequestered 73, and 64 gC $m^{-2}$$yr^{-1}$ respectively, while the Northern Great Plains released 28 gC $m^{-2}$$yr^{-1}$.