Scaling up of site carbon dynamics to predict the carbon dynamics in Kazakhstan, Central Asia

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Introduction Climate and management determine whether rangelands are net carbon sources or carbon sinks. Regional carbon dynamics of the Kazakh Steppe has not previously been documented. The objective of this study is to quantify the regional carbon flux dynamics of these extensive steppes.

Materials and methods Carbon flux towers measure the net flux of carbon dioxide (CO_2) between the ecosystem and the atmosphere. Detailed light curve analysis partitions these net fluxes into ecosystem respiration (R_e) and photosynthesis (gross primary production, P_g). A positive flux of carbon represents movement from the atmosphere to the land surface. We combined values at flux tower locations from the spatial and temporal data sets of photosynthetically active radiation (PAR), temperature, precipitation, Normalized Difference Vegetation Index (NDVI), and NDVI derived metrics with flux tower derived gross primary production (P_g) and ecosystem respiration (R_e) into a 10-day time step training database. Regression tree models were parameterized using training databases from Northern Great Plains and Kazakh Steppe flux towers. These regression tree models were then applied across the Kazakh Steppe to map growing season 10-day P_g and R_e. Annual fluxes were estimated using gap filled winter fluxes from the winter of 2001-2002 based on methods used by Gilmanov et al. (2004). Refinement in regional estimation of winter fluxes in the Kazakh Steppe would improve the annual NEE maps. Inter-annual and spatial variability of annual net ecosystem exchange (NEE) were investigated using inter-annual statistics and spatial moving window statistics.

Results Regression trees used for mapping of growing season 10-day P_g and R_e were robust and accurate (Table 1). The Kazakhstan winter flux estimate (1.25 g CO_2/m^2 per day) was used with growing season NEE to estimate annual NEE for each year from1998 to 2001. The area associated with inter-annual carbon sinks were fifty five times larger than inter-annual carbon source area. Carbon sources are seen surrounding wetland areas within Kazakhstan and may be attributable to wetland dynamics not being adequately captured by the MODIS land cover. The annual average NEE for the Kazakh Steppe was relatively stable with the greatest value occurring in 2000. This resulted in a increase in CO_2 across the four years as seen in Figure 1. The local variance images identified areas with lower NEE surrounding some urban areas. Although this was not common, it may identify overgrazed areas with reduced carbon sequestration and potential for improvement.

Table 1 Kazakh Steppe Regression Tree Accuracies

	R^2	Standard Error
P_g (g CO_2 m^{-2} day^{-1})		
Jackknife Years	0,81	3,24
All Training	0,83	1,77
R_e (g CO_2 m^{-2} day^{-1})		
Jackknife Years	0,63	2,70
All Training	0,77	1,33

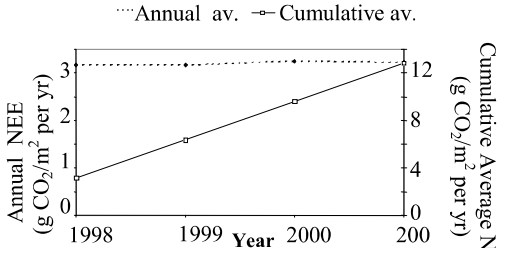

Figure 1 Annual and Cumulative NEE average

Conclusion The results of this study show that regression tree algorithms were effective when applied regionally to the Kazakh Steppe. This approach maximized the utility of intercontinental flux towers for regional mapping. The Kazakh Steppe has more average cumulative sinks than sources. Land use changes from soil carbon depleting spring wheat to grassland represent carbon sequestration opportunities.

References

Gilmanov, T.G., D.A. Johnson, N.Z. Saliendra, T.J. Svejcar, R.F. Angell, & K.L. Clawson (2004). Winter CO_2 fluxes above sagebrush-steppe ecosystems in Idaho and Oregon. Agricultural and Forest Meteorology, (in press).