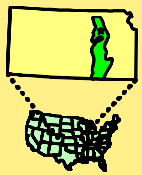
Carbon Fluxes in Grazed and Ungrazed Tallgrass Prairie

Clenton E. Owensby, Jay M. Ham, and Lisa M. Auen, Department of Agronomy Kansas State University

Rationale and Objectives

Grazing is ubiquitous on the world's grasslands. In order to determine the contributions of grasslands to the global carbon balance, estimates of their source or sink status are needed. Atmospheric flux measurements using eddy correlation techniques offer an opportunity to measure source/sink status of grassland ecosystems. These measurements must be taken on grazed grasslands. The addition of an ungrazed treatment allows for interpretation of the mechanisms affecting carbon dynamics. Our objectives were to:

- Measure carbon, water vapor, and energy fluxes on tallgrass prairie with no grazing, grazed moderately, and grazed heavily.
- Partition fluxes into net ecosystem flux and net ecosystem respiration.
- Determine a yearly carbon balance.

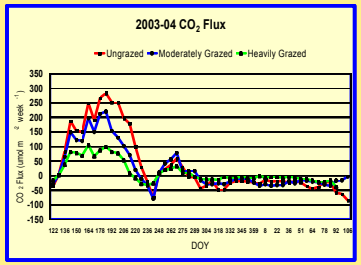


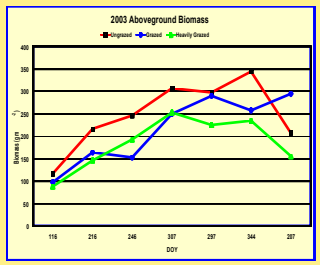
Experimental Site

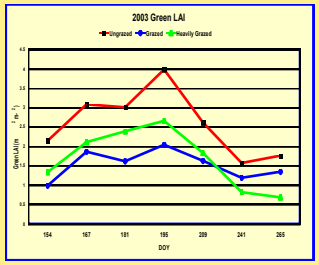
- Rannells Flint Hills Prairie
- Tallgrass Prairie – Dominated by C4 grasses, big bluestem and indiangrass.
- Peak Aboveground Biomass 425 g m^{-2}, 35 g m^{-2} is from forbs.
- Precipitation - 840 mm, with 520 mm occurring during the growing season.
- Burned annually in late April.
- Carbon year is from burn to burn.

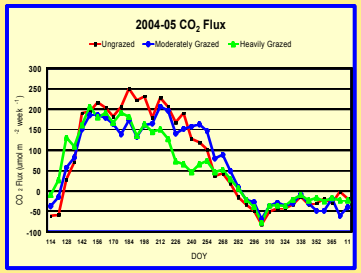
Impact of Grazing

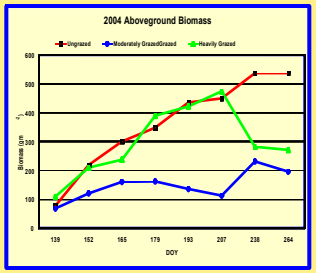
We used eddy correlation to determine CO_2 flux, water vapor flux, and energy fluxes on three pastures grazed moderately (MG) and not grazed (UG) tallgrass prairie from 1998 to 2005 and grazed heavily (HG) from 2004 to 2005. Fluxes of CO_2 were measured almost continuously (24 hr) from immediately following burning through the burn date the following year (365 d). Aboveground biomass and leaf area were determined by clipping biweekly during the growing season. Carbon lost due to burning was estimated by clipping immediately prior to burning, and cattle C export determined by weight gain of the steers. Soil CO_2 flux was measured every two hours using automatic sampling chambers. Steers were stocked at twice the normal season-long stocking rate (0.81 ha $steer^{-1}$) for the first half of the grazing season (~May 1 to July 15) for MG and at 0.81 ha $steer^{-1}$ season long for HG. During the early growing season, grazing reduced net carbon exchange relative to the reduction in green leaf area, but as the growing season progressed on both the grazed areas, regrowth produced a more open canopy and younger leaves that had an apparent higher photosynthetic efficiency. Despite a substantially greater green leaf area on the ungrazed area, greater positive net carbon flux per unit of leaf area occurred on the grazed areas during the late season. Nighttime carbon losses were greater on the ungrazed area in the early season, but were greater on the grazed area late in the season. During the peak growth period, an amount equivalent to 80-85% of the carbon fixed on a clear day was lost each day through soil CO_2 flux and plant respiration. Both MG and UG tallgrass prairie appeared to be carbon storage neutral for the six years of data collection. Under HG in 2003, the carbon balance showed a loss of 92 g m^{-2}.

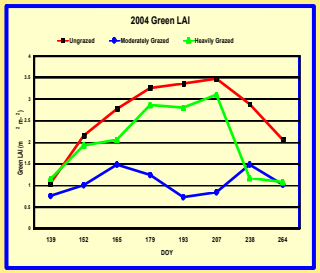


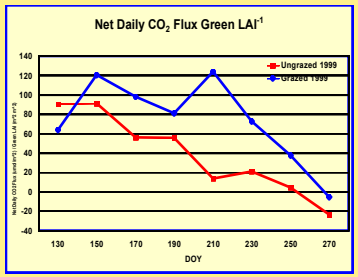








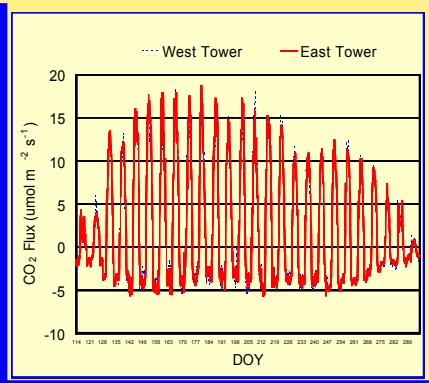




Carbon Balance			
	Ungrazed	Moderately Grazed	Heavily Grazed
Carbon Balance Year	g C m^{-2}	g C m^{-2}	g C m^{-2}
1998-99	-31	-5	
1999-00	-40	-11	
2000-01	+66	0	
2002-03	-82	-4	
2003-04	+37	+33	-92
5-yr Sum	-60	+13	

Conclusions

- Tallgrass Prairie grazed at rates above that recommended is likely losing carbon to the atmosphere.
- Grazing invokes a compensatory response whereby late in the season grazed areas have a more positive net carbon exchange than ungrazed.
- The primary loss of carbon from the ecosystem to the atmosphere is from soil respiratory processes.
- Paired flux systems on the same area show that treatment comparisons are likely legitimate.
- Ungrazed and moderately grazed tallgrass prairie ecosystems are likely carbon neutral, neither gaining or losing carbon.



Acknowledgements

This research was supported by the Biological and Environmental Research Program (BER), U.S. Department of Energy, through the Great Plains Regional Center of the National Institute for Global Environmental Change (NIGEC) under Cooperative Agreement No. DE-FC03-90ER61010 and by the Biological and Environmental Research Program (BER), U.S. Department of Energy, Grant No. FG03-99ER62863/A002.

This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, Under Agreement No. 2001-38700-11092.

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

Partial funding and land resources for this research were provided by the Hilas Bay and Emma Browning Rannells Flint Hills Prairie Preserve.

Emily Benson, Fred Caldwell, Jamey Duesterhaus, Grant Good, John Murphy, and David Graham contributed greatly to this work.