Experimental warming and ecosystem CO_2 exchange in a northern Great Plains grassland: Analysis of automatic chamber measurements

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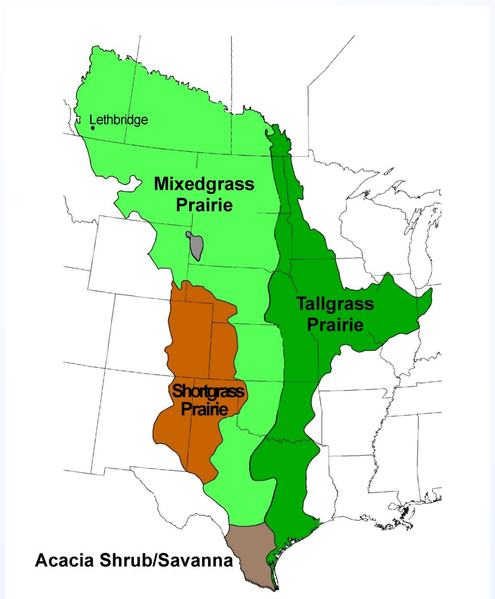
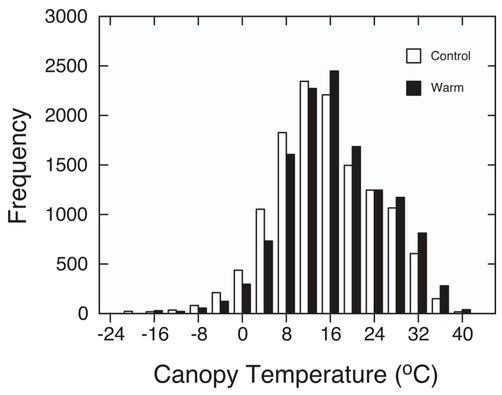


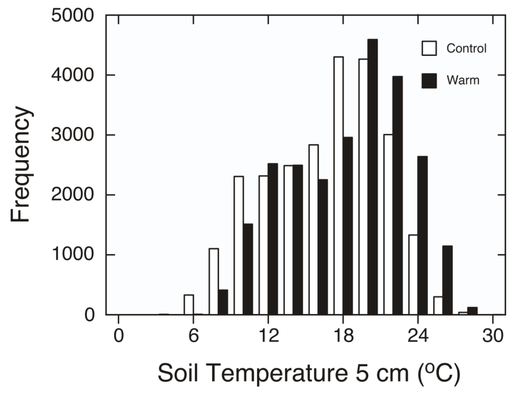
Grasslands of the Great Plains (Ostlie *et al.* 1997)

Summary

- Experimental plots were heated using T-FACE technology with target warming of 1.5/2.0 °C during day/night
- Warmed plots had lower average soil water contents than control plots, but soil moisture was non-limiting because of higher than normal precipitation in 2013
- Ecosystem CO_2 exchange rates were measured with an automatic chamber system (n=3 per treatment)
- Both the (i) peak season CO_2 exchange rates and (ii) the pattern of seasonal variation in CO_2 flux rates were very similar in control and warmed plots
- There was no significant difference between the control and warmed treatments for growing season integrated net ecosystem productivity or biomass production

Treatment Effects on Canopy and Soil Temperature



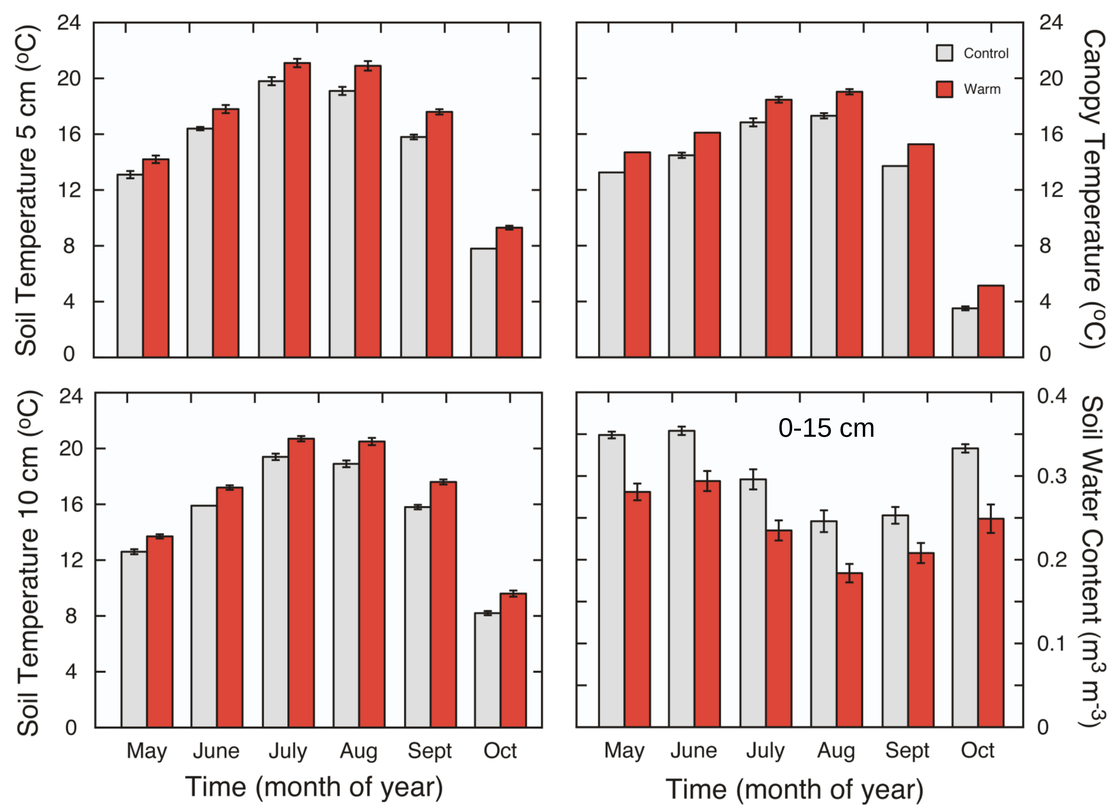


We used T-FACE technology to increase canopy temperature in experimental plots above that of control plots with a target of 1.5 °C warming during the day and 2.0 °C warming during the night.

Average ± SD for measurements made either hourly (canopy, n=12816) or half-hourly (soil, n=24624) during May to October, 2013 for three replicates per treatment.

	Control	Warm	Difference
Canopy Temperature (°C)	13.2 ± 9.2	14.8 ± 9.0	1.6
Soil Temperature 5 cm (°C)	15.7 ± 4.6	17.2 ± 4.6	1.5

Seasonal Variation in Monthly Average Temperature and Soil Moisture in the Treatment Plots

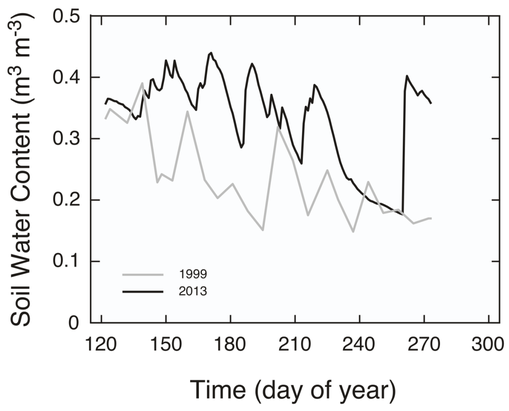


Canopy and soil temperatures were consistently higher (by 1.4 to 1.6°C) in the warm treatment plots relative to the control plots during the growing season months (May-October) in 2013. Values represent monthly average temperatures (±SE, n=3).

Volumetric soil water content was consistently lower (on average by 0.064 m^3 m^{-3}) in the warm treatment plots relative to the control plots during the growing season months (May-October) in 2013. Values represent monthly average soil moistures (±SE, n=3).

Soil moisture contents were relatively high, even in the warm treatment plots, because of the greater than normal precipitation inputs that occurred during May-October in 2013.

The 2013 Growing Season was Wetter than Normal



	Precipitation (mm) May-October
Normal ± SD	268 ± 93
1999	240
2013	337

Normal = Average during 1971-2000

Temperature Free-Air Controlled Enhancement (T-FACE)

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Infrared heater arrays for warming ecosystem field plots

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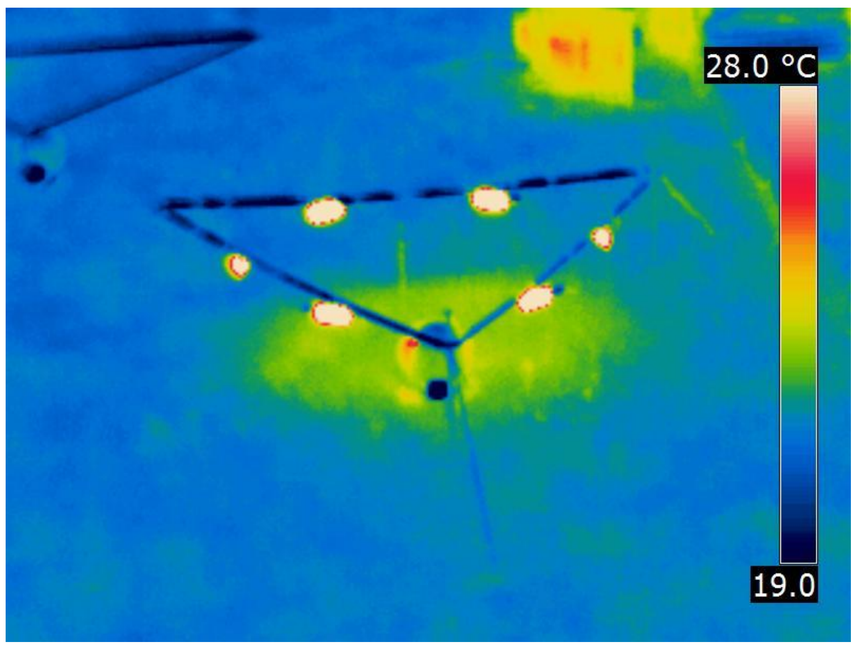
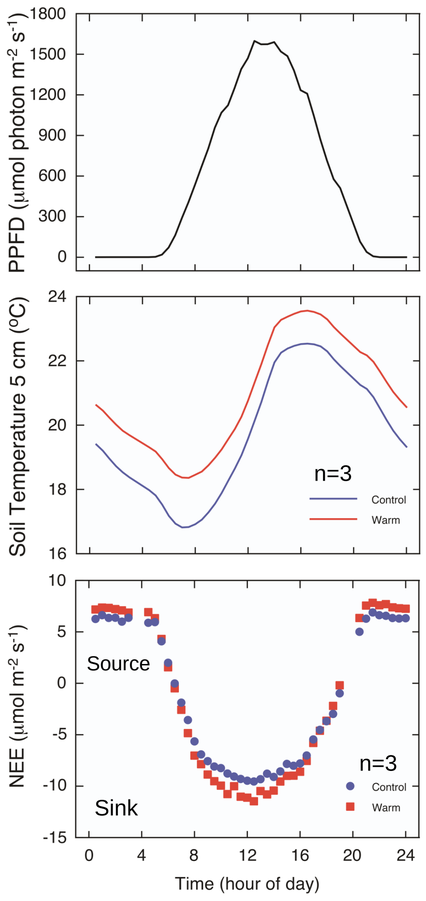
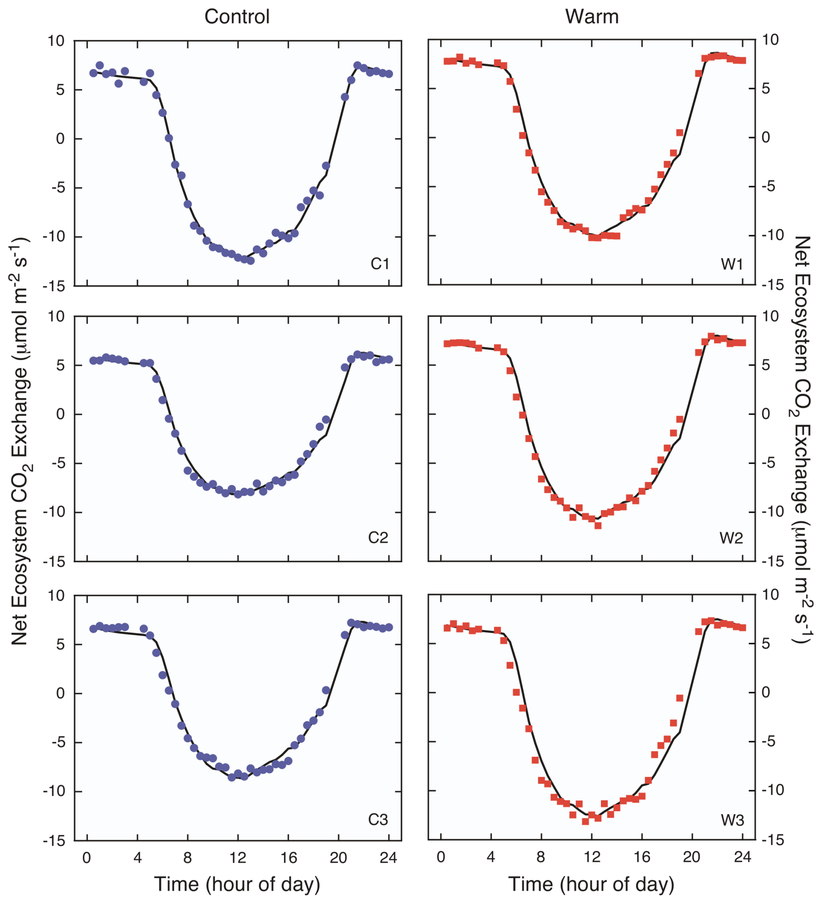


Automatic Net Ecosystem CO_2 Exchange Chambers with Sand-Ring Collar

Average Diurnal Pattern (July 1-15) for Net Ecosystem CO_2 Exchange (NEE) and Environmental Conditions





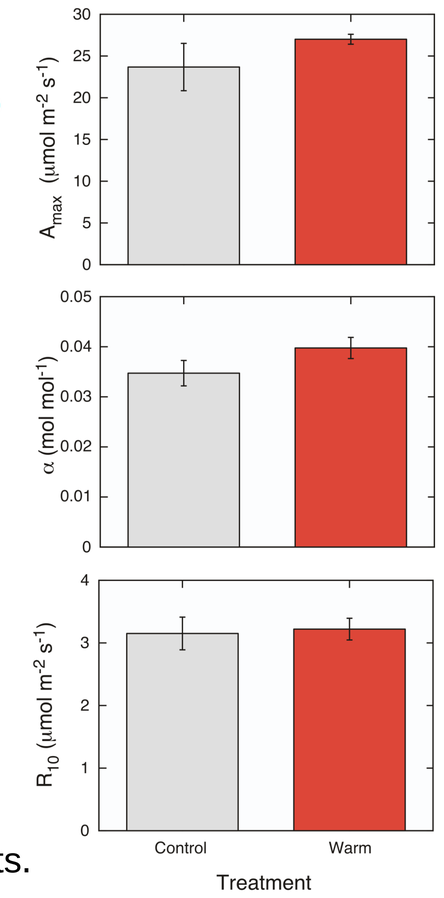
Calculated Photosynthetic (A_{max}, α) and Respiratory Capacity (R_{10})

$$NEE = -\frac{A_{max}\alpha PPFD}{A_{max} + \alpha PPFD} + R_{10}Q_{10}^{\left(\frac{T-10}{10}\right)}$$

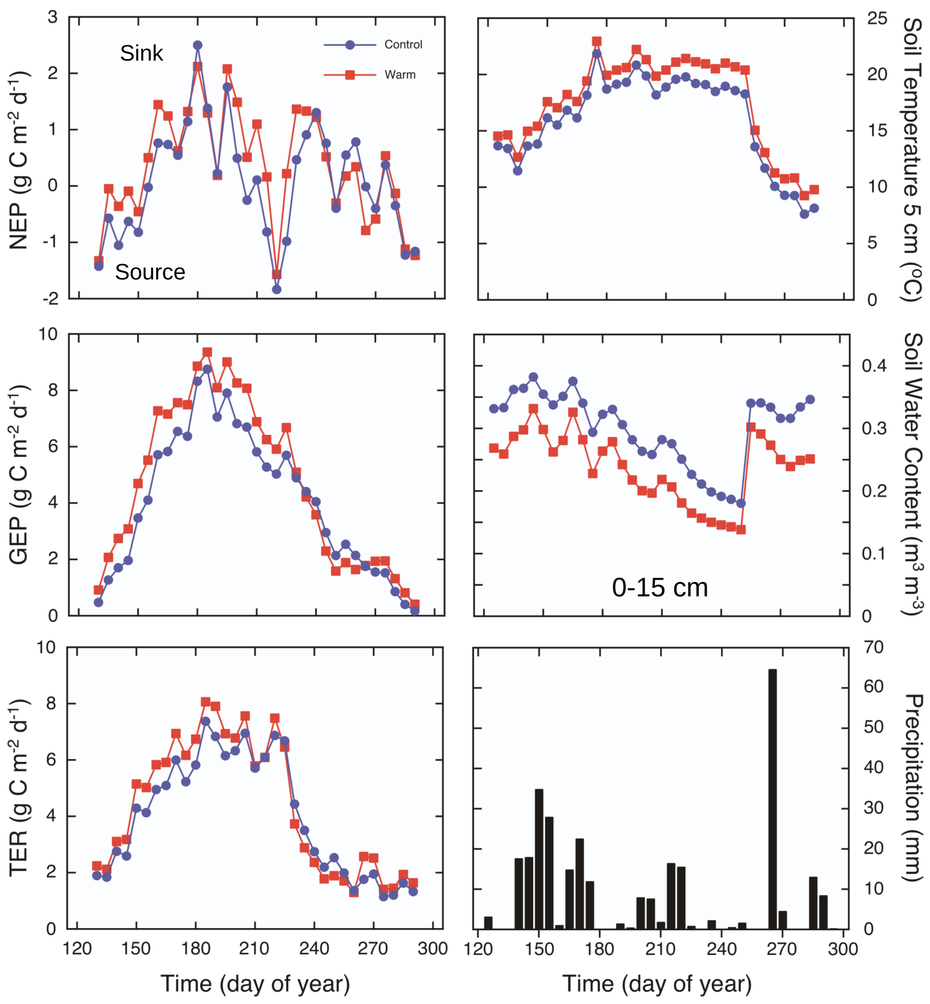
The equation shown above was fitted to the average diurnal NEE data for all plots (n=3 per treatment).
A_{max}, α, R_{10} were calculated using non-linear regression.

A_{max} = photosynthetic capacity
α = apparent quantum yield
R_{10} = respiratory capacity at 10°C
Q_{10} = temperature sensitivity coefficient (1.8 to 2.2)
T = soil temperature 5 cm depth
PPFD = incident radiation (PAR)

There were no significant differences between treatments.

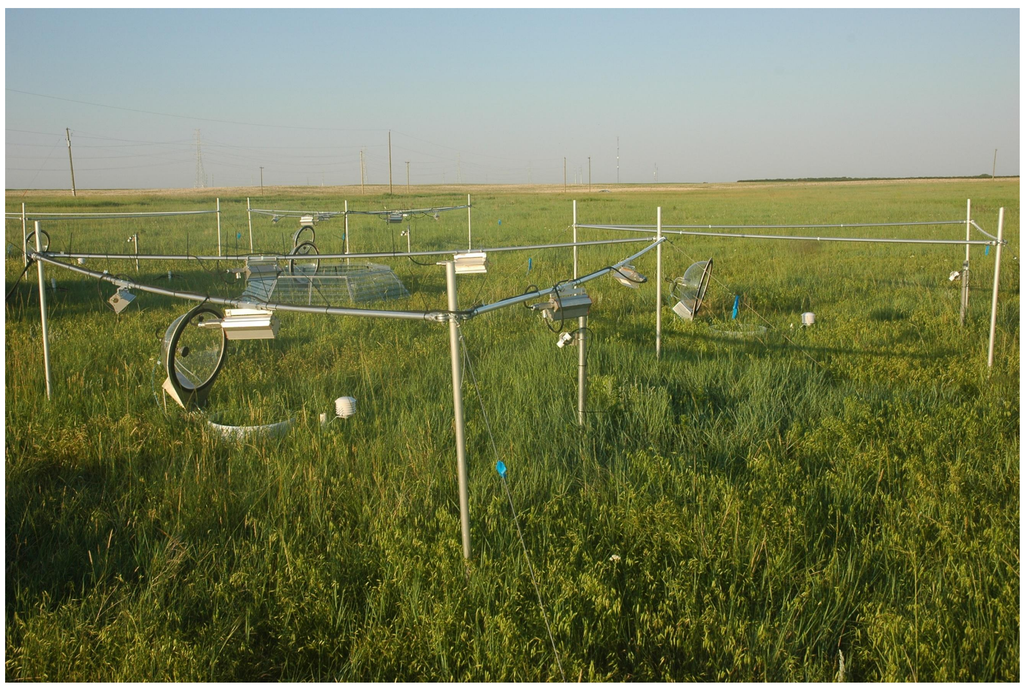


Seasonal Variation in CO_2 Flux and Environmental Conditions

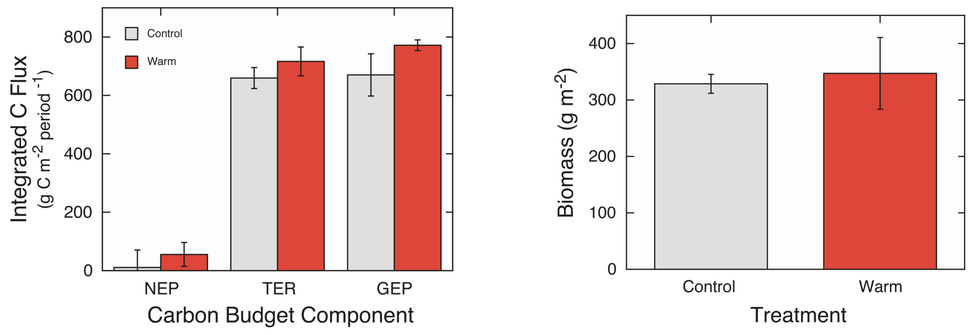


Despite the warmer and drier soil conditions in the heated treatment, there was no significant difference in the seasonal pattern of variation in net ecosystem production (NEP), gross ecosystem photosynthesis (GEP) or total ecosystem respiration (TER) during the first year of the experiment (2013).
The values represent 5-day averages (n=3).
NEP = GEP – TER, positive NEP = net uptake (sink)

NEE Chambers in IR Heated and Control Plots



Integrated CO_2 Flux and Above-ground Biomass



Warming had no significant effect on integrated CO_2 exchange (May-October) or peak above-ground biomass (August 6) in the first year of the experiment (2013). n = 3, NEP = GEP - TER