4.4 IMPACTS OF OVERGRAZING ON CARBON DIOXIDE FLUX ON A SOUTHERN MIXED-GRASS PRAIRIE

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1. INTRODUCTION

Global atmospheric CO_2 levels continue to rise unabated. CO_2 concentrations have increased because of changes in land use and burning of fossil fuels (Watson et al.,1996). Rangelands are the dominant terrestrial ecosystems that comprises more than 50 percent of the world land area. Rangelands dominate the world's landscape, however, their role in the global C budget has not been adequately documented. Because of their vastness, these temperate terrestrial ecosystems play a role in the balance of global carbon. Some have claimed the rangeland dominated North American temperate region may be a C sink and if quantified, could contribute to balancing the global C budget (Fan et al., 1998; Keeling et al., 1996; Schimel, 1995; Ciais et al., 1995; Rastetter et al., 1992; Gifford, 1994). The objective of this study was to determine the impact of moderate and heavy grazing intensities on CO_2 flux on a Southern Plains mixed-grass prairie.

2. METHODS

Two rangeland sites, grazed historically at about 53 to 60 AUD ha^{-1} and in similar ecological condition, were selected on the Southern Plains Experimental Range, Woodward, OK (latitude 36E36' N, longitude 99E35' W, elevation 630 m). The moderate grazing treatment, considered to be a sustainable management system (Sims and Gillen, 1999), was continued on one site while the other was subjected to markedly heavier grazing at about 90 AUD ha^{-1} beginning in 1999. CO_2 flux was measured in 1998, 1999, 2000, and 2001 on each site using Bowen ratio/energy balance (BREB) instrumentation. Twenty-minute above-canopy CO_2 fluxes were calculated according to the procedures of Dugas (1993). Such data have been shown to be similar to those from other methods of measuring CO_2 flux (Dugas et al., 2001). In the field testing of a closed chamber system, Angell and Svejcar (1999) found close agreement between the closed chamber and BREB measurements.

Plant biomass, including root biomass, leaf area, and plant height was measured. Biomass sampling coincided with the growing season when about two-thirds of the annual rainfall of about 571 mm occurred. The herbaceous material was separated by categories: warm season grass, cool season grass, forbs, and previous years' growth.

3. RESULTS AND DISCUSSION

Total growing season CO_2 flux ranged from net gains of 82 to 712 g CO_2 m^{-2} on the moderately grazed prairie compared to 60 to 325 g CO_2 m^{-2} on the heavily grazed site (Table 1). Estimates of the annual CO_2 flux ranged from a loss of 80 to a gain of 181 g CO_2 m^{-2} yr^{-1} for the moderately grazed site compared to a net loss of 76 to 542 g CO_2 m^{-2} yr^{-1} for the heavily grazed mixed-grass prairie (Table 2). The data from the moderately grazed treatment are consistent with that reported for this same site from 1995 to 1998 (Sims and Bradford, 2001; Frank et al., 2000).

Growing season daily fluxes averaged -2.9 and -1.8 g CO_2 m^{-2} d^{-1}, respectively, for the moderate and heavy grazing treatments (Table 1). Daily CO_2 flux averaged across years for the moderate treatment was about -0.02 g CO_2 m^{-2} d^{-1} compared to 1.0 g CO_2 m^{-2} d^{-1} for the heavy grazing treatment (Table 2). Both the net and daily fluxes follow the growing conditions. Annual precipitation averaged 645 mm during this study and was 582, 802, 742, and 453 mm for 1998, 1999, 2000, and 2001, respectively. Growing season precipitation was generally lower than normal, about 60 rather than 70% of the annual rainfall. This was especially so in 1998 and 2001 when growing season rainfall was less than 50% of the total.

Table 1. Growing season CO_2 flux[1] on moderately and heavily grazed Southern Plains mixed-grass prairie.

Grazing treatment	Year	d	Net flux (g CO_2 m^{-2})	Daily flux (g CO_2 m^{-2} d^{-1})
Moderate	1998	153-244	-82	-0.9
	1999	105-244	-712	-5.1
	2000	120-245	-525	-3.7
	2001	125-248	-193	-1.9
Heavy	1998	153-244	-200	-2.5
	1999	105-244	-325	-2.3
	2000	120-245	-240	-1.7
	2001	125-248	-60	-0.8

[1] Positive and negative numbers are upward and downward CO2 fluxes, respectively.

By 2001, the third year of this study, the average standing crop of herbage ranged from 48 g m^{-2} in May to peak of 228 g m^{-2} on the moderately grazed site compared to a range from 43 to 158 g m^{-2} on the heavily grazed site (Figure 1).

4. CONCLUSIONS

Overgrazing of a southern mixed-grass prairie can release significant amounts of C from this soil-plant system. With a moderate grazing treatment, some net C is sequestered by this prairie. The moderate stocking rate used in this study was developed during a twenty-year study to determine the carrying capacity (Sims and Gillen, 1999) of these rangelands that are widespread in

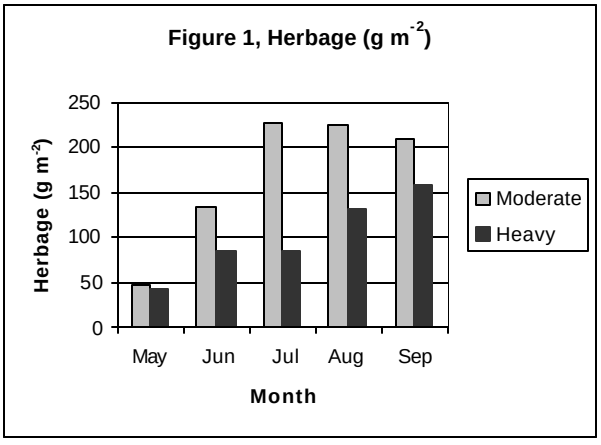
the Southern and Central Plains.

Table 2. Annual CO_2 flux on moderately and heavily grazed Southern Plains mixed-grass prairie.

Grazing treatment	Year	d	Net flux ($g\ CO_2\ m^{-2}$)	Daily flux ($g\ CO_2\ m^{-2} d^{-1}$)
Moderate	1998	108-	30[1]	-.08
	1999	90-365	181[1]	0.5
	2000	1-365	-6	-0.02
	2001	1-365	-80	-0.3
Heavy	1998	-[2]	-[2]	-[2]
	1999	87-365	-480[1]	-1.3
	2000	1-365	-542	-1.5
	2001	1-365	-76	-0.3

[1] Estimated from the days sampled.
[2] Equipment moved to new location.

Earlier studies indicated that these Southern Plains mixed-grass prairie communities have the potential to sequester C (Frank et al., 2000). However, differences in vegetation structure affect the patterns of CO_2 flux. Grazing, especially abusive grazing, also affects the direction and magnitude of CO_2 flux. Grazing impacts the seasonality of leaf production and LAI patterns as well, and would also alter CO_2 flux patterns (Sims and Bradford, 2001).



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