Photosynthesis and soil respiration from a mixed-grass prairie : effects of grazing and drought

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Introduction Current objectives of rangeland management include not only concerns of forage production , but also for environmental impacts . The effects of animal grazing on the physiology of rangeland plants have been studied at different spatial-temporal scales and have varied results . In leaf-level studies , it is not easy to account for the spatial-temporal heterogeneity of main ecophysiological parameters . In farm-level studies , it is not easy to manipulate key environmental drivers (such as drought or temperature) . We conducted a field-plot scale study of photosynthesis and respiration of a rangeland considering the effects of both cattle grazing and drought .

Materials and methods The field measurements were superimposed on pastures of a long-term grazing intensity study since 1989 (Patton et al . , 2007) and a study of the effects of drought on rangeland production (Ryan et al . , 2004) . Two pastures with moderate and heavy grazing plus a non-grazing exclosure were used . Within each pasture , three plots of 3m 6m each were chosen from an representative upland area and assigned with natural rainfall , average rainfall and 75% of average rainfall (drought) treatment , respectively , using six automated rain-out-shelters . Drought treatment (Ryan et al . , 2004) was applied from 2003 to 2004 , while ecophysiological measurements were conducted from 2004 (effect of drought) and 2005 (post-drought recovery) . Daily photosynthesis was calculated from measured canopy photosynthesis-light response curves (using a transparent chamber of 44 .5 cm × 44 .5 cm × 60 cm in dimension attached to LI-6400) and hourly solar radiation data . Daily accumulated ecosystem respiration was calculated from measured soil respiration rate (using a 6400-09 soil respiration chamber) and soil water and temperature data . The field measurements were made on 25 clear days from May to Sep .

Results and discussion In both 2004 and 2005 , canopy photosynthesis and net ecosystem CO_2 exchange rates peaked in June . The average daily net CO_2 exchange for 2004 and 2005 is 0 .23 mol CO_2 m^{-2} day^{-1} and 0 .07 mol CO_2 m^{-2} day^{-1} , respectively , similar to the daily rate for a low LAI canopy (Thornley , 1998) . In 2004 , the drought plots had a daily CO_2 exchange rate of 0 .14 mol CO_2 m^{-2} day^{-1} , which was 58% lower than the data for the average rainfall treatment . In 2005 , with the removal of drought treatment , the rangeland recovered accordingly (in terms of ecosystem net CO_2 exchange) . The main effect of grazing intensity on ecosystem CO_2 exchange was not significant for the whole grazing season . However , in June , when the grassland plants were most active in physiology , the moderately grazed grassland showed a more positive net gain than did the idled land .

Conclusions (1) The net ecosystem CO_2 exchange on mixed-grass prairie in North Dakota responded sensitively to drought stress without prolonged post-drought recovery . (2) The benefits of moderate grazing on ecosystem CO_2 exchange were more on the net exchange than on canopy photosynthesis alone .

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