Dynamics of long-term carbon sequestration on rangelands in the western USA

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Introduction Rangelands in the USA occupy 161 million hectares of land. Worldwide, rangelands occupy about half of the land area and account for more than 1/3 of the world's terrestrial carbon (C) reserves. Because of their large land area, rangelands have the potential to sequester a significant amount of additional atmospheric C. Schuman et al. (2001) estimate that rangelands and marginal croplands restored to grasslands in the USA can sequester 64 million metric tonnes C/ha/yr if properly managed. The objective of this research was to evaluate the long-term effects of grazing on soil C storage in a northern mixed-grass prairie (NMP).

Materials and methods Organic C dynamics were assessed on NMP paddocks that were grazed season-long at light (CL) and heavy stocking rates (CH) and on non-grazed exclosures (EX) after 10 and 20 years following initiation of grazing in 1983. Soil organic C and aboveground C components were assessed on one permanent 50 m transects established in each of two replicate paddocks. Soil were sampled in 1993 and 2003 at 10 m intervals on each transect for C measurements and samples were also collected at the 10 and 30 m locations for bulk density determination to enable calculation of C mass.

Results Grazing increased soil organic C storage after 10 years, Table 1. Grazing enhanced plant residue decomposition and early season photosynthesis resulting in increased soil C storage compared to the EX. No differences were evident between CL and CH grazing after 10 years. However, significant soil C was lost from the soil profile between 1993 and 2003 under CH grazing compared to CL and EX. The nearly 30% loss in soil organic C indicates that CH grazing can have significant negative impacts on C cycling during extended periods (2000-2003) of drought that occurred during the second 10 year period. This loss of C is supported by Morgan *et al.* (2004) who reported lower net system CO_2 assimilation, using CO_2 flux measurement technology, in a short-grass prairie ecosystem with CH grazing during the drought years of 2002 and 2003 compared to moderately grazed systems and EX. Continuous, heavy season-long grazing has resulted in a major shift in plant community composition and decreased above-ground biomass. Whereas, C_3 perennial grasses predominate in the CL treatment, C_4 perennial grasses dominate in CH, and C_3 perennial grasses and forbs co-dominate in the EX.

Table 1 Soil organic C mass (kg C/ha x 10^2) under various grazing treatments on northern mixed-grass prairie in Wyoming USA

Soil Depth	1993			2003			Change (%) From 1993 to 2003		
(cm)	EX	CL	CH	EX	CL	CH	EX	CL	CH
0-15	282b	351a	359a	273a	320a	260a	-3	-9	-28*
0-30	479b	580a	583a	473b	542a	425b	-1	-7	-27*
0-60	881b	919ab	1013a	805b	925a	705b	-9	+1	-30*

Different lower case letters indicate significant differences between grazing treatments (within a year and soil depth), $P \leq 0.10$. Asterisks indicate a significant difference in C mass between years, $P \leq 0.10$.

Conclusions This study demonstrates that proper grazing management under normal precipitation can enhance C sequestration in NMP rangelands compared to no grazing (or exclusion of grazing) over a 20 year period. In addition, heavy season-long grazing resulted in plant community shifts, lowered production, and loss of SOC from the soil profile during extended drought periods. Therefore, proper grazing management is paramount to ensure sustainable long-term production and C sequestration by these ecosystems.

References

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