Modeling the Impact of Grazing on Water Budgets

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Introduction Land management is important for heat and water transfer by altering plant and soil functions. It is essential to quantify and predict management effects on these processes in order to assess their consequences for plant production and the environment. Many studies have focused on the effects of land management on soil hydraulic properties. However, few studies have dealt with the consequences of these practices on water budgets, especially in the semi-arid grassland. In this paper, *in situ* measurements of hydro-meteorological and energy elements from the project MAGIM" (*Matter fluxes in grasslands of Inner Mongolia as influenced by stocking rate*) were used to parameterise the hydrological model HYDRUS-1D (Šimůnek et al., 1998) to simulate water fluxes as a function of grazing intensity.

Materials and methods This study was performed on long-term experimental sites of Inner Mongolia Grassland Ecosystem Research Station (IMGERS, 43°37′50″N, 116°42′18″E). Four plots with different grazing intensities were investigated. Two plots were protected from grazing since 1979 (UG 79, 24 ha) and 1999 (UG 99, 35 ha). The other two plots were grazed: one was grazed only during winter time with 0.5 sheep units (ewe and lamb) ha^{-1} yr^{-1} (WG, 40 ha) and the other was heavily grazed with 2 sheep units ha^{-1} yr^{-1} (HG, 100 ha) during the whole year. In each plot, soil moisture was measured by Theta-probes in three soil depths at 5, 20 and 40 cm. The automatic micrometeorological stations recorded the precipitation and other weather variables. To determine the root length density, root samples were taken up to 100 cm depth. In addition, undisturbed soil samples were taken at four depths of 4～8, 18～22, 30～34 and 40～44 cm to determine the water retention characteristics and hydraulic conductivity. Modeling of soil water flow was performed with HYDRUS-1D for a growing period of 153 d from 1st May to 30th September, 2004-2006. The initial condition was set based on measured water contents. An atmospheric boundary condition and free drainage condition was imposed at the soil surface and bottom boundary of the flow domain, respectively.

Results In general, the simulated water contents agree well with the measurements in all four plots. This is exemplified by the treatment UG 79 during the growing period in 2006 (Figure 1). The increases in water content at 5 cm and 20 cm depth after rainfall were predicted reasonably well. However, the model underestimated the water contents at 40 cm depth. After model calibration and validation, water household components for the four plots were calculated (Table 1). In comparison with the two ungrazed sites, winter grazing did not show clear effects on the water household components, while heavy grazing remarkably decreased soil water storage by 25%～45%, interception by 50%～55% and transpiration by 20%～30%, and increased evaporation by 25%～40%, runoff by 100%～300% and drainage by 100%～200%.

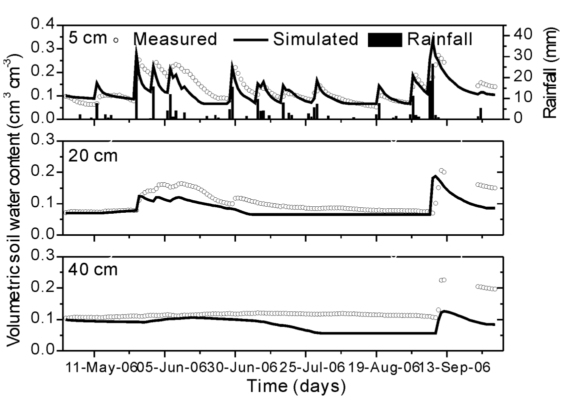

Figure 1 *Comparison of simulated and measured soil moisture in UG 79 during the growing period in 2006.*

Table 1 *Water household components during the growing periods in 2004-2006 simulated with Hydrus-1D (in mm; P: Precipitation, I: Interception, T: transpiration, E: Evaporation, S: Water storage change, D: Drainage, and R: Runoff).*

Year	Treatment	I	T	E	S	D	R	errors
2004	UG79	16.3	171.0	106.0	-23.6	1.1	1.7	2.5
	UG99	15.2	166.0	113.2	-20.1	3.2	1.6	-4.1
(P=275	WG	14.7	154.0	115.3	-18.0	4.0	4.1	0.9
mm)	HG	7.1	131.2	141.8	-21.1	6.5	5.5	4.0
2005	UG79	14.8	90.4	73.8	-29.5	1.3	0.3	-4.1
	UG99	14.4	82.4	75.6	-23.4	1.7	0.2	-3.9
(P=147	WG	13.2	79.7	86.1	-29.2	1.3	0.2	-4.3
mm)	HG	6.6	65.3	104.6	-33.6	5.7	0.4	-2.0
2006	UG79	18.3	131.4	110.8	-19.5	1.8	1.0	-1.8
	UG99	17.4	117.5	109.3	-3.3	1.5	0.7	-1.1
(P=242	WG	16.3	103.6	116.2	5.9	0	1.7	-1.7
mm)	HG	8.2	71.9	157.7	1.8	1.0	5.1	-3.7

Conclusions HYDRUS-1D model revealed the impact of grazing on water budgets. We conclude that intense grazing increased soil evaporation and reduced plant available water, consequently reduced grassland productivity.

Reference

Šimůnek, J., Sejna, M., van Genuchten, M.Th., 1998. The HYDRUS-1D software package for simulating the one dimensional movement of water, heat, and multiple solutes in variably-saturated media. Version2.0. IGWMC-TPS-70. Int. Ground Water Modeling Center, Colorado School of Mines, Golden.