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Influence of grazing exclosure on vegetation biomass and soil quality☆

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ABSTRACT

This study investigated the influence of sixteen years exclosure from unmanaged grazing on aboveground vegetation biomass, soil organic matter (SOM), soil aggregation and nitrogen (N) mineralization in arid shrubland of Baluchistan, Pakistan. Sampling was carried out from three sites along the chronosequence of secondary succession. One site was located at open-for-grazing area (grazed site) and the other two sites were located in the area that is protected since 1998. One of the protected site is more remote from grazing (protected site 1) where the land is less disturbed and has thick vegetation than the other protected site (protected site 2). Results showed a significant difference for aboveground vegetation biomass across sites and was in the order of protected site 1 > protected site 2 > grazed site. Soil organic matter was 53% and 46% higher in protected sites than grazed site. Aggregates larger than 2 mm size were not detected in soil from grazed site but represented 4.5% and 3% of the sample soil profile at the protected site 1 and protected site 2, respectively. Rate of N mineralization was lower in soils at the grazed site as compared to soils at the protected sites. Soil moisture contents were significantly lower at grazed site and showed a strong positive correlation with aboveground vegetation biomass. This study demonstrates that unmanaged grazing severely affected aboveground vegetation biomass, soil organic matter, large-sized soil aggregates, nitrogen mineralization and soil moisture contents. Short term exclosure from grazing (~16 years) can enhance aboveground vegetation biomass and soil quality in terms of soil organic matter accumulation, soil aggregation, retention of soil moisture and nitrogen mineralization in this arid rangeland.

1. Introduction

Rangelands are predominantly arid and semi-arid regions of tropical, subtropical, temperate, desert, alpine and tundra biomes (Bartley et al., 2006; Lund, 2007; Stoddart, Smith, & Box, 1975; Weber & Horst, 2011). Rangelands cover around 41% of the terrestrial area of the world (Middleton, Stringer, Goudie, & Thomas, 2011). In many urban and rural populations, people depend on rangelands for their sustenance and these ecosystems provide livelihoods for approximately 2 billion people of the world (Middleton et al., 2011).

Heavy grazing and un-managed utilization along with climate change-associated factors (e.g. e.g. change in temperature and rainfall pattern and frequency) have resulted in approximately 20% degradation/desertification of rangelands worldwide (MES (Millennium Ecosystem Assessment) 2005; Wehrden et al., 2012). Degradation of rangelands refers to change in plant cover, biomass, species composition and soil quality (Irwin & Ranganathan, 2007). Rangeland degradation can cause severe socio-economic hardships associated with the environmental consequences (Bedunah & Angerer, 2012; Brunson, 2014). Reduced aboveground biomass with rangeland degradation influences soil attributes by limiting litter recruitment and organic contributions to soil and plant biomass-induced hydrological lifts of water table (Irwin & Ranganathan, 2007; Snyman & Preez, 2005). Reduced soil organic matter affects soil aggregation, infiltration,

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Table 1
Rangeland types, years of protection from free grazing, aboveground vegetation biomass (or % cover) and soil organic matter (or carbon) at protected and non-protected sites.

Rangeland type	Livestock grazing exclusion (years)	Aboveground vegetation Biomass (g m^{-2}) or % cover		Soil organic matter/carbon (g kg^{-1} soil)		Soil depth (cm)	Reference
		Protected site	Non-protected site	Protected site	Non-protected site		
Semi-arid rangeland of Inner Mongolia, China	12	–	–	5.31	2.98*	0–10	Chen et al. (2012)
alpine meadows in Nagqu Prefecture, northern Tibetan, China	6	165.3	97.8*	50	30*	0–5	Xiong et al. (2014)
Horqin semi-arid sandy land, Inner Mongolia, China	8	–	–	5.9	3.8*	0–10	Li et al. (2015)
Semi-arid rangeland, Changling county, Jilin province, China	5	254	70	6.92	6.20*	0–10	Li, Dong, Wen, Wang, and Wu (2014)
Arid steppe in El Gonna, Tunisia	12	1.75	0.512	13.4	6.0*	0–20	Jeddi and Chaieb (2010)
Semi-arid Dega Temben Woreda, Tigray, Ethiopia	10	43 (% cover)	4 (% cover)*	24	15*	0–15	Mekuria et al. (2007)
Semi-arid Imam Kandi basin, West Azerbaijan province, Iran	14	–	–	17.1	11.7*	0–30	Mofidi, Jafari, Tavili, Rashtbari, and Alijanpour (2013)
Semi-arid, Njemps Flats, Kenya	≤10	–	–	5.60	3.91*	0–20	Mureithi et al. (2014)
Semi-arid woody rangeland, Iran	> 20	–	–	15.5	13.2*	0–15	Raiesi and Riahi (2014)
Desert steppe, Altai region, northwest China	8	32.2	11.3*	28.4*	17.1*	0–10	Rong, Yuan, and Ma (2014)
Semi-arid sagebrush steppe region of Fremont County, Wyoming, USA	~40	–	–	22.7	19.4	0–15	Shrestha and Stahl (2008)
Semi-arid, Horqin sandy Grassland of Northern China	5	59.3	13.6*	2.79	2.10*	0–15	Yong-Zhong, Yu-Lin, Jian-Yuan, and Wen-Zhi (2005)

Values followed by * are significantly different at $P < 0.05$