ISSN: 2251-824X (E)

INTERNATIONAL JOURNAL OF
FOREST, SOIL AND EROSION

Vol 11 No. 4 (2021)

Impact of Grazing on Productivity of Grasslands of Kashmir Himalaya

Helal A. Lone[*], Mukhtar A. Bhat[*] and G. H. Rather[**]

[*]Corresponding author: helallone@gmail.com

[*]Department of Botany, Amar Singh College, Cluster University Srinagar-190 008, (J & K).
[**]Department of Botany, Islamia College of Science and Commerce Srinagar-190 006, (J & K).

Abstract

Grasslands form an important component of forests in Kashmir Himalaya and form subsistence basis for the local as well as nomadic farm families. They support livestock species which in turn play very important economic and socio-cultural roles for the wellbeing of rural households in the form of food, income, asset saving, transport, and sustainable agricultural production. However, overgrazing coupled with improper management of grasslands is gradually impairing their regenerative potential. The overgrazing in grasslands results in a deleterious change in floristic composition, productivity, and palatability. We investigated the effect of grazing on the productivity of herbaceous vegetation in grasslands of Kashmir Himalaya by a comparative analysis of protected and unprotected plots. The plant species occurring in the study area were listed and their biomass (above-ground and below-ground) was estimated by clippings. The study revealed low values for biomass in unprotected plots and vice-versa was true for protected plots. The low biomass is attributed to the removal of an appreciable quantity of herbage cover by grazing animals. The species richness and the floristic composition modified significantly with grazing intensification.

Keywords: Grasslands, Productivity, Regenerative potential, Herbaceous Vegetation, Rural Households, Sustainable Agriculture.

Introduction

Grasslands are highly dynamic ecosystems encompassing all natural and semi-natural pastures, woodlands, scrub, and steppe formations dominated by grasses and grass-like plants (Blair *et al*., 2014). The grasslands cover approximately 40% of the Earth's land surface (Le Cain *et al*., 2002; Wang and Fang, 2009) and provide livelihoods for nearly 800 million people, as well as forage for livestock, wildlife habitat, valuable ecosystem services and locations for recreation and tourism (White *et al*., 2000; Zhang, 2006; Stromberg *et al*., 2013). Grassland ecosystems serve important economic and ecological functions, such as material production, climate regulation, soil and water conservation, sand stabilization, soil improvement and biodiversity preservation (Liu *et al*., 2011; Abdalla *et al*., 2016; Trepekli *et al*., 2016). However, grassland ecosystems are easily susceptible to disturbances and highly vulnerable to climate change and human activities (Li *et al*., 2007; Yan *et al*., 2013; Davis *et al*., 2014; Eichelmann *et al*., 2016). The major disturbances in the grassland ecosystem include grazing, fire, drought, invasion, fragmentation, and encroachment.

Grazing is a key disturbance and plays an important role in shaping the structure and function of grassland ecosystems (Mc Naughton 1985; Anderson *et al*., 2006). The livestock grazing is the major driving force affecting vegetation dynamics, species distribution and landscape-scale biodiversity in addition to forage quantity and quality (Henkin *et al*., 2010). Structurally, grazing modifies the species composition, richness, vertical profiles, plant traits, soil water infiltration and availability of nutrient to plants and a number of other attributes of grasslands (Noy-Meir *et al*. 1989; Yates, 2000; Mc Intyre and Lavorel 2001; Rodrıguez *et al*. 2003). Functionally, grazing alters the flow of energy and the cycling of materials, both directly, through defoliation, trampling, and dung and urine depositions, and indirectly, through modification of species composition and species interactions (Schlesinger *et al*. 1990; Aguiar *et al*. 1996; Hobbs *et al*., 1996; Cui *et al*., 2005; Jeddi and Chaieb, 2010; Tefera *et al*., 2010). Accordingly, species composition and biomass production may be influenced through the direct effects of defoliation and trampling, and the indirect effects of nutrient enrichment and depletion (Snyman, 1998; Fernandez-Gimenez and Allen-Diaz, 2001).
In the present study, an attempt has been made to assess the impact of grazing on the grasslands of Kashmir Himalaya as these forms the subsistence base for the livelihood of the majority of the rural population the area.

Material and Methods

The grasslands of Langate Forests Division were selected as representatives of the Kashmir Himalaya. The Forest Division falls in the north-western part of the Kashmir valley between 34° 15' and 34° 45´ N latitude and 73° 45' and 74° 45' E longitude. The forests extend over an area of 360.60 km^{-2} and occupy north-eastern slopes of Kazinag and Shamsabri ranges. The altitudinal zonation varies from 1590-4093 m a.s.l. The entire area is divided into four territorial ranges viz., Rafiabad, Mawar, Rajwar, and Magam. These four forest ranges selected to represent the four different sites (Sites-I, II, III and IV) respectively for the present investigation (Fig. 1).

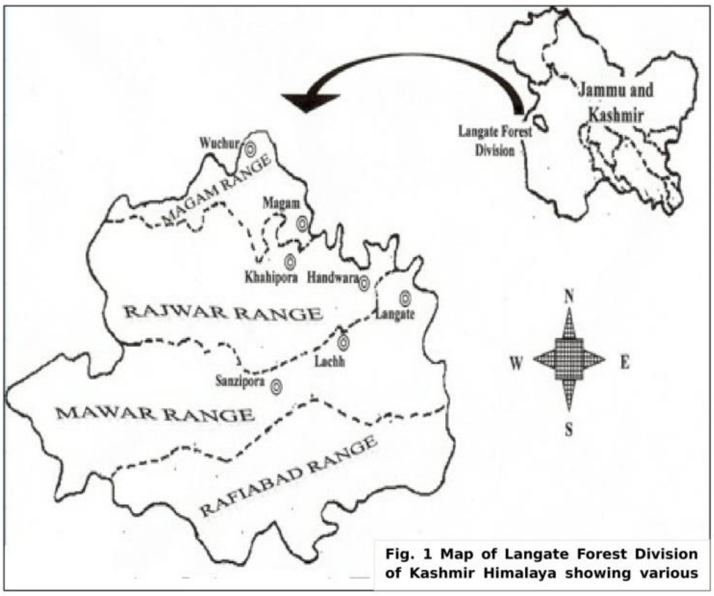

Fig. 1 Map of Langate Forest Division of Kashmir Himalaya showing various

The climate of the area is in general conformity with the climate of Kashmir valley, being the sub-Mediterranean type with marked seasonality having four distinct seasons- spring, summer, autumn, and winter. The type of climate, the division enjoys, is characterized by both seasonal and diurnal extremes of temperature. July is the hottest month of the year with a maximum temperature record of 32 ^{o}C. The autumn starts in September and ends in November. Both photo- and nycto-temperatures start falling from October onwards till a minimum of -4 ^{o}C is obtained in December. The frost is experienced in November on upper altitudes, while lower down it is mostly bright. The winter onsets in December and lasts till April. The annual precipitation is around 108.4 cm, one-third of which is received in the form of snow during winter.
The estimation of primary productivity and the intensity of grazing were determined by biomass analysis of grazed and ungrazed plots. For this purpose, the quadrats of definite size (40x40 cm^2) were laid randomly at ungrazed and grazed plots of the grasslands in each of the four territorial ranges monthly during the growing season from April to November of 2016. From each quadrat, the above-ground parts (live and standing dead) of all the plants were clipped by using scissors. The belowground plant material was harvested from the same quadrats. The monoliths of different sizes were dug out to a depth of 50 cm on the same date, washed under a fine jet of water and brought to the laboratory. The aboveground, as well as belowground parts, were collected in separate polyethylene bags from ungrazed and grazed areas. Each fraction was dried to constant weight at 85°C (Newbould, 1967) and thereafter its dry weight per unit area was calculated. The above- and below-ground net productivity and the net primary productivity were computed using the 'trough peak analysis' by summation of positive changes in live biomass for protected and grazed areas (Singh *et al.*, 1975). The difference in productivity values are explained on the grounds of the effect of grazing (biotic factor) in the areas under study.

Results

The present study on productivity estimates of herbaceous vegetation of grasslands of Langate Forest of Kashmir Himalaya depicted discernible variations both in time and space as a result of animal grazing (Fig. 2 & 3). An insight into the data showed that the aboveground biomass at unprotected areas varied between 63.10 g m^{-2} and 398.10 g m^{-2} as compared to protected areas where it ranged from 87.9 g m^{-2} at Site-III in April to 694.50 g m^{-2} at Site-I in September .on the other hand below-ground biomass for protected areas fluctuated between 313.30 g m^{-2} again at Site-III in May and1015.50 g m^{-2} at Site-II in November and between 290.50 g m^{-2} at Site-III in May and 754.60 g m^{-2} at Site-I in November. The above-ground

and below-ground net primary productivity also showed similar trends and depicted higher values for protected areas. The above-ground net primary productivity varied from 229.70 g m^{-2} yr^{-1} at Site-III to 498.30 g m^{-2} yr^{-1} at Site-I for protected areas and from 155.40 g m^{-2} yr^{-1} again at Site-III to 316.60 g m^{-2} yr^{-1} at Site-II for unprotected areas, while as below-ground net primary productivity varied between 315.70 g m^{-2} yr^{-1} at Site-IV and 555.00 g m^{-2} yr^{-1} at Site-II and between 230.20 g m^{-2} yr^{-1} at Site-III and 320.20 g m^{-2} yr^{-1} at Site-II respectively.
The overall net primary productivity recorded was greater (645.00 g m^{-2} yr^{-1} at Site-IV to 968.90 g m^{-2} yr^{-1} at Site-I) for the protected area than the unprotected area (385.60 g m^{-2} yr^{-1} at Site-III 637.60 g m^{-2} yr^{-1} at Site-II). In general, the protected areas depicted higher values both for above-ground and below-ground biomass as well as productivity. While as above-ground biomass depicted gradual increase from April to September at most of the study sites, the below-ground biomass depicted a slight decrease in May and June during the early growing season, being followed by a gradual increase till November.

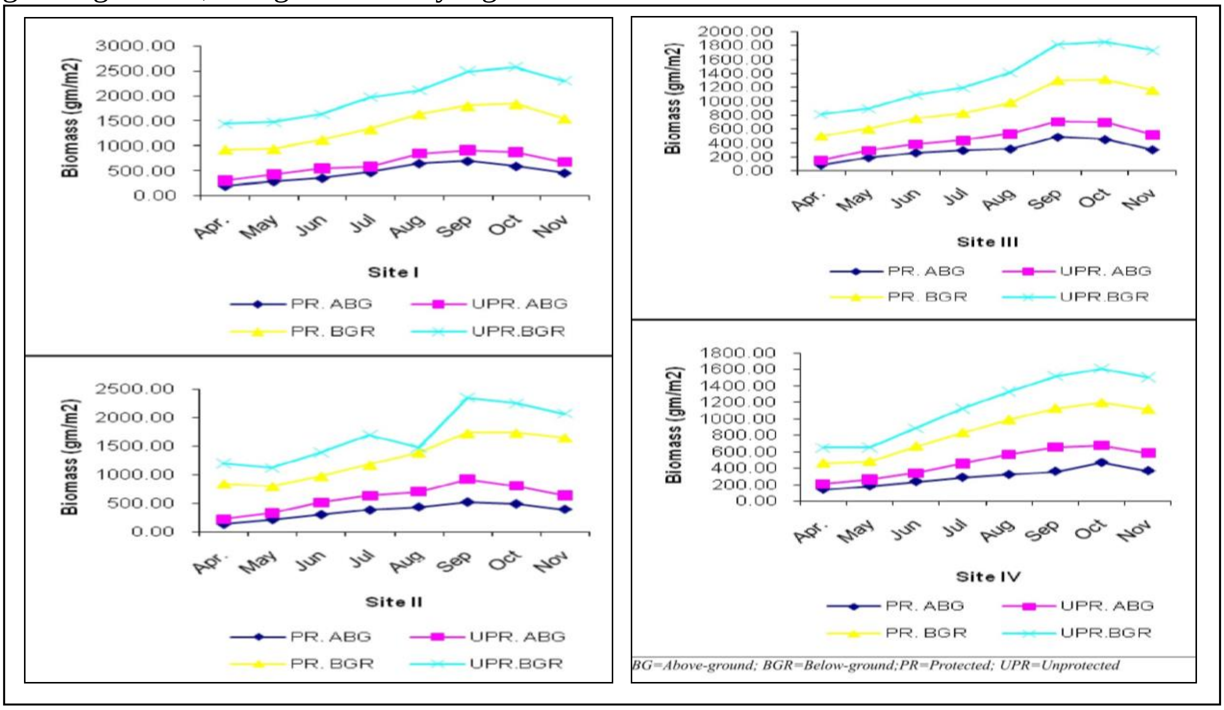

Fig. 2. Monthly variations in the above and below-ground biomass of herbaceous vegetation of unprotected and protected areas at various selected sites of Langate Forest Division.

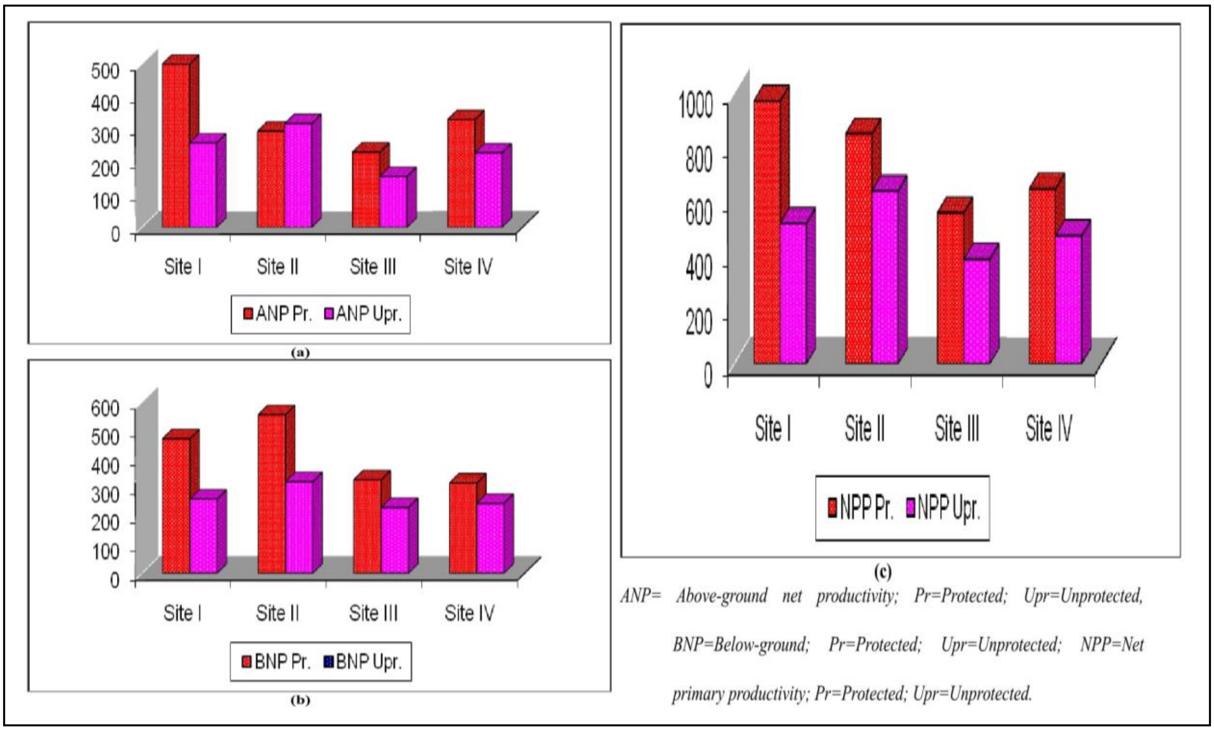

Fig. 3. Variations in the (a) above-ground, (b) below-ground and (c) net primary productivity (gm/m^2/year) of herbaceous vegetation at protected and unprotected areas at various study sites of Langate Forest Division.

Discussion

The plant biomass (both above-and below-ground) varied considerably through different months in both protected and unprotected areas. The highest values of biomass during the months of July, August and September are due to the presence of more number of species which could further be attributed to the fact that more hospitable situations were created facilitating their phenotypic development and thus increasing their population. The above-ground net production ranged from 229.70 g m^{-2} yr^{-1} to 498.30 g m^{-2} yr^{-1} at protected sites against the values recorded at unprotected sites which ranged between 155.40 g m^{-2} yr^{-1} and 316.60 g m^{-2} yr^{-1}. The low values in unprotected areas revealed the consumption of foliage by grazing animals and the illicit cutting of grass and illegal extraction of medicinal herbs by the inhabitants and the smugglers. The adverse effects of grazing were compounded by the fact that grazers were found to consume not only the leaves and stems but also the inflorescence of all the palatable species, thus decreasing the viability capacity of the species (Fig. 4a-d).

The trampling by grazing animals and humans creates a characteristic plant community dominated by species whose morphology gives them a certain tolerance to bruising, compression and other physical abuse. The removal of herbage biomass and trampling by the hooves of stock appear more damaging leading to disintegration of humus and organic matter, thus, altering edaphic changes like high bulk density, lower infiltration and increased run-off and consequently the vegetal changes at the grazed sites. The above findings are further corroborated by the works of other investigators while studying the effect of grazing on the structure and productivity of vegetation (Lewis, 1970; Kumar and Joshi, 1972;

Shankarnarayan, 1977; Mwendra and Mohamed Salem, 1997; Sharma and Upadhaya, 2002 and Lone and Pandit, 2007). Heavy grazing increased therophytes and decreased the proportion of chamaeophytes and geophytes. Chamaeophytes and geophytes are especially susceptible to trampling, while matted and rosette hemicryptophytes and therophytes are relatively tolerant of trampling (Cole, 1995).

Fig. 4. (a-d). Overgrazing of the ground layer vegetation by buffaloes, cattle, sheep and horses disturbing the biodiversity.

The below-ground production in the protected areas was higher than that in the unprotected ones, but was in general higher than the above-ground net production in both the areas as has also been reported by Gupta and Saxena (1971), Sims and Singh (1971), Kumar and Joshi (1972) and Misra and Misra (1986). The higher below-ground net productivity is attributed to the enhanced downward translocation of assimilates on account of the dense foliage at protected sites with lower respiratory loss. This is also due to the fact that the presence of the perennial root-stocks has resulted in increased below-ground biomass.
The results of the present study indicate that the multitude of ecological stresses has disturbed the forest ecosystem as reflected by changes in soil characteristics and phyto-sociological features. The mild disturbances increase the plant species diversity, richness, and evenness while as severe disturbances lead to a decrease in these variables for all types of vegetal zones. On the other hand, the reduction in vegetation cover due to various factors not only makes the soils prone to erosion but also lead to the reduction of major plant nutrients due to leaching. Thus, the growing anthropogenic pressures are responsible for modifying the natural forest ecosystem in terms of its structural and functional attributes which not only modify the nature of soil both in its composition and texture but also reduce the rich biodiversity of plants

vis-à-vis their productivity. The present study contributes to a better understanding of grazing effects on grassland productivity and provides data to support the management of grassland ecosystems.

References

Abdalla, K., Chivenge, P., Everson, C., Mathieu, O., Thevenot, M., Chaplot, V. (2016). Long-term annual burning of grassland increases CO_2 emissions from soils. *Geoderma*, **282**: 80–86.

Aguiar, M. R., Paruelo, J. M., Sala, O. E., Lauenroth, W. K. (1996). Ecosystem responses to changes in plant functional type composition: an example from the Patagonian steppe. *J. Veget. Sci*., **7:** 381–390.

Anderson, R. H., Fuhlendorf, S. D., Engl, D. M. (2006). Soil nitrogen availability in tall grass prairie under the fire-grazing interaction. *Rangeland Ecology and Management*, **59**: 625-631.

Blair, J., Nipper, J., Briggs, J. (2014). Grassland Ecology. In: R. K. Monson (Ed.). Ecology and the Environment. The Plant Sciences, 8. DOI 10.1007/978-A. Springer.

Cole, D.N. (1995). Experimental trampling of vegetation. Predictors of resistance and resilience. *J. Applied Ecol*., **32**:215-224.

Cui, X.Y., Wang, W.F., Niu, H.S., Wu, J., Wang, S.P., Schnug, E. (2005). Effect of long-term grazing on soil organic carbon content in semiarid steppes in Inner Mongolia. *Ecol. Res*., **20**: 519-527.

Davis, S.C., Burkle, L.A., Cross, W.F., Cutting, K.A. (2014). The effects of timing of grazing on plant and arthropod communities in high-elevation grasslands. *PLoS ONE*, 9: e110460.

Eichelmann, E., Wagner-Riddle, C., Warland, J., Deen, B., Voroney, P. (2016). Evapotranspiration, water use efficiency, and energy partitioning of a mature switch-grass stand. *Agric. For. Meteorol*. **217**: 108–119.

Fernandez-Gimenez, M. E., Allen-Diaz, B. (2001). Vegetation change along gradients from water sources in three grazed Mongolian ecosystems. *Plant Ecology*, **157**: 101–118.

Gupta, R. K., Saxena, S. K. (1971). Ecological studies in the protected and grazed lands in arid zone of Western Rajasthan. *J. Indian. Bot. Soc*., **50**:289-300.

Henkin, Z., Perevolotsky, A., Sternberg, M. (2010). Vulnerability of Mediterranean grasslands to climate change: What can we learn from a long-term experiment? *Options Mediterr. Ser. A Sem. Mediterr*., **92**: 167–174.

Hobbs, N. T., Baker D. L., Bear G.D., Bowden D. C. (1996). Ungulate grazing in sagebrush grassland: mechanisms of resource competition. *Ecol. Appl*., **6**: 200–217.

Jeddi, K., Chaieb, M. (2010). Changes in soil properties and vegetation following livestock grazing exclusion in degraded arid environments of South Tunisia-*Flora*, **205**: 184–189.

Kumar, A., Joshi, M.C. (1972). The effect of grazing on the structure and productivity of vegetation near Pilani, Rajasthan, India. *J. Eco*l., **60**:665-675.

Lecain, D.R., Morgan, J.A., Schuman, G.E., Reeder, J.D., Hart, R.H. (2002). Carbon exchange and species composition of grazed pastures and exclosures in the short grass steppe of Colorado. *Agriculture Ecosystems and Environment*, **93**: 421–435.

Lewis, J.K. (1970). Primary producers in grassland ecosystems. Pp.241-247. In: Dix, R.L. and Beigleman, R.G. (eds.). *The grassland Ecosystem*: A Supplement. Range Sci. Dept. USDA.

Li, S.-G., Asanuma, J., Kotani, A.; Davaa, G., Oyunbaatar, D. (2007). Evapotranspiration from a Mongolian steppe under grazing and its environmental constraints. *J. Hydrol*., **333**: 133–143.

Liu, X.Y., Long, R.J., Shang, Z. (2011). Evaluation method of ecological services function and their value for grassland ecosystems. *ActaPratacult. Sin*. **20**: 167–174.

Lone, H. A., Pandit, A. K. (2007). Impact of grazing on community features and biomass of herbaceous species in Langate Forest Division of Kashmir. I*nd. For.*, **133 (1)**:93-100.

Mc Intyre, S., Lavorel, S. (2001). Livestock grazing in subtropical pastures: steps in the analysis of attribute response and plant functional types. *Journal of Ecology*, **89**: 209-226.

Mc Naughton, S. J. (1983a). Serengeti grassland ecology: the role of composite environmental factors and contingency in community organization. *Ecological Monographs*, **53**: 291-320.

Mc Naughton, S. J. (1985). Ecology of a grazing ecosystem: The Serengeti. *Ecological Monographs*. **55**: 259-295.

Misra, M.K., Misra, B.N. (1986). Net primary production and diversity in the grasslands of Behrampur, Orissa. *Indian J. Fores*.,**9**: 146-150.

Moyo, S., Swanepoel, F. J. C. (2010). Multifuncionality of livestock in developing communities. In: The Role of Livestock in Developing Communities: Enhancing Multifunctionality, edited by FransSwanepoel, Aldo Stroebel and SibonisoMoyo, Co-published by The Technical Centre for Agricultural and Rural Cooperation (CTA) and University of the Free State.

Mwendera, E.J., Mohamad Salem, M.A. (1997). Infiltration, surface runoff and soil loss as influenced by grazing pressure in the Ethiopian highlands. *Soil Use and Management*, **13**:29-35.

Newbould, P.J. (1967). *Methods for estimating the primary production of forests*. IBP Handbook 2. Blackwells, Oxford.

Noy-Meir, I., Gutman, M., Kaplan, Y. (1989). Responses of Mediterranean grassland plants to grazing and protection. *Journal of Ecology*, **77**: 290-310.

Rodriguez, C., Leoni, E., Lezama, F., Altesor A. (2003).Temporal trends in species composition and plant traits in natural grasslands of Uruguay. *J. Veget. Sci*., 14: 433–440.

Schlesinger W.H., Reynolds J.F., Cunningham G.L.,Huenneke L.F., Jarrell W.M., Virginia R.A., Whitford,W.G. (1990). Biological feedbacks in global desertification. *Science*, **247**: 1043–1048.

Shankarnarayan, K.A. 1977. Impact of overgrazing on the grasslands. *Annals of Arid Zone*, **16**(3): 349-359.

Sharma, K.P., Upadhayaya, B.P. (2002). Phytosociology, primary production and nutrient retention in herbaceous vegetation of the forestry arboretum on the Aravalli hills at Jaipur.*Trop. Ecol*., **43**(2):325-335.

Sims, P.L., Singh, J.S. (1971). Herbage dynamics and net primary production in certain ungrazed and grazed grasslands in North America. pp.59-124. In: French, N.R. (eds.)

Preliminary analysis of structure and function in grasslands. Range Sci., Dep. Sci. Ser. No. 10. Colorado State Univ.,Fort Collins.

Singh, J.S., Leurenoth, W.K., Steinhorst, R.K. (1975). Review and assessment of various techniques for estimating net aerial primary production in grassland from harvest data. *Botanical Review*, **41**: 181-232.

Singh, J.S., Yadava, P.S. (1974). Seasonal variation in composition of plant biomass and net primary productivity of tropical grasslands at Kurukshetra, India. *Ecol. Monogr*., **44**:351-376.

Stromberg, C. A. E., Dunn, R. E., Madden, R. H., Kohn, M. J., Carlini, A. A. (2013). Decoupling the spread of grasslands from the evolution of grazer-type herbivores in South America. *Nature Communications*, **4**: 1478.

Tefera, S., Dlamini, B. J., Dlamini, A. M. (2010). Changes in soil characteristics and grass layer condition in relation to land management systems in the semi-arid savannas of Swaziland. *J. Arid Environ*.,**74**: 675-684.

Trepekli, A., Loupa, G., Rapsomanikis, S. (2016). Seasonal evapotranspiration, energy fluxes and turbulence variance characteristics of a Mediterranean coastal grassland. *Agric. For. Meteorol*.,**226**: 13–27.

Wang, W., Fang, J.Y. (2009). Soil respiration and human effects on global grasslands. *Global and Planetary Change*, **67**: 20–28.

White, R.P., Murray, S., Rohweder, M. (2000). Pilot Analysis of Global Ecosystems: Grassland Ecostems. World Resources Institute, Washington DC., 69 pp.

Yan, L.; Zhou, G.S., Zhang, F. (2013). Effects of different grazing intensities on grassland production in China: A meta-analysis. *PLoS ONE*, **8**: e81466.

Yates, C. J., Norton, D. A., Hobbs, R. J. (2000). Grazing effects on plantcover, soil and microclimate in fragmented woodlands in south-westernAustralia; Implications for Restoration. *Austral Ecology*, **25**: 36-47.

Zhang, J. T. (2006). Grassland degradation and our strategies: a case from Shanxi Province, China. *Rangelands*, **28**:37-43.