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Above-ground and Below-ground Biomass situation of Milke-Jaljale Rangeland at Different Altitudinal Gradient

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Abstract
Rangeland conservation has been increasingly interested for carbon reduction and mitigation of climate change, because of carbon storage. Thus, biomass of the rangeland remains pivotal regarding carbon sequestration on rangeland. Present study was conducted in high altitude rangeland at Jaljale (4000 m), Gorujure (3500 m) and Milke (3000 m) on September, 2010 with an objective to estimate rangeland biomass following the total harvesting method. Result revealed that biomass of high altitude rangeland has relatively high value (1.50 t/ha for both above ground biomass and 43.48 t/ha for below ground biomass) compared to low altitude rangeland (0.35 t/ha for above ground biomass and 16.93 t/ha for below ground biomass). Similarly, monocot plant density play crucial role for biomass contribution of rangeland.

***Key words*: Rangeland, biomass, carbon sequestration, high altitude.**

Introduction

Rangelands represent the largest and most diverse land resource in the world. More than half of the world's land surface is grazed. Nearly 100 of the world's countries have at least one-half and 130 countries have at least one-third of their agricultural land area in grazing lands. Rangelands include 1.8 million hectors of land in Nepal, 12% of total land (LMP, 1993). Most of the rangelands fall under High Mountain (50.3%) followed by high hill (29%) and mid hill (16.7%) (MOPE, 2002). High altitude rangelands are home to a unique assemblage of flora and fauna (Yonzon and Heinen, 1997). About 131 endemic plant species are found in the high altitude rangelands (Shrestha, 1997). It is repository of medicinal plants, world's most threatened and endemic species and provider of ecosystem goods and service to local people. The rangeland provides 36% of the total feed requirement for livestock in the country and livestock share 47.3% income of high altitude Nepalese household economy (Tulachan and Neupane, 1999). Over the centuries, the indigenous rangeland management system has been the base for sustained livestock production in Nepal. Despite the importance of local management of rangelands in bringing about economic betterment of the people of the northern areas of Nepal, the subject has remained largely unexplored (Rai and Thapa, 1993).

It is also a great pool of carbon. Rangelands have a large potential to sequester C because they occupy about half of the world's land area and store greater than 10% of terrestrial biomass C and 10 to 30% of global soil organic carbon (SOC)

(Schlesinger, 1997; Scurlock and Hall, 1998). It is estimated that rangelands globally sequester C in soil at a rate of 0.5 Pg C yr-1 (Schlesinger, 1997; Scurlock and Hall, 1998). This implies that modest changes in C storage in rangeland ecosystems have the potential to modify the global C cycle and indirectly influence climate (Schimel *et al*., 1990; Ojima *et al*., 1993; Conant *et al*., 2001).

Because of global concern with climate change, it is expected that carbon markets will develop more rapidly and with deeper financial backing than other markets for ecosystem services. In the short-term, it is more likely that charismatic rangeland carbon assets that can contribute to purchaser's corporate public image would be of interest to the voluntary market.

The rangeland areas are highly degraded and overexploited. Owing to rangeland degradation its productivity and carbon pool is declining day by day. As a consequence, its negative impact is affecting the whole ecosystem. The main causes of degradation are over-grazing, poor management and low priority in government programme. Rangeland has high potentiality to uplift socio-economic condition of pastoralist; it can contribute to mitigate climate change through carbon sequestration in soil and help to promote tourism industries.

Plant biomass measurement is a fundamental procedure for grassland management and grassland field studies. It is important biophysical parameters of vegetation; vegetation biomass estimation not only is necessary for studying productivity, carbon circles, and nutrition allocation in terrestrial ecosystem but also important to the natural resources management since the amount of vegetation biomass directly influences human utilization patterns of surface vegetation and affects other biophysical parameters.

The objective of this paper is to compare above and below ground biomass of the plants of the three selected areas. The other objective is to determine whether the average biomass of the plants below the ground and above the ground of the selected sites can be considered statistically significant or not.

Materials and methods

Study area

Milke-Jaljale Mountain ridge lies as political border of Taplejung and Sankhuwasabha districts of eastern Nepal. Its geographical position is 27°17′35″ to 27°30′28″N latitude, 87°31′09″ to 87°38 ′14″ E longitude, extended from 3000 to 4500 msl altitude. Its climatic condition is average temperature 10-15°C and average annual rainfall 1650 mm. The area is under heavy human and livestock (yak, cattle, buffaloes, sheep and goats) pressures (Oli, 2002). It serves as habitat corridor between Makalu-Barun Conservation Area towards northwest and Kanchenjunga Conservation Area towards north-east, both of which touch the Qomolongma Biosphere Reserve in Tibet (Koirala, 2002).

The mountain ridges across Milke-Jaljale are the natural niches for dozens of *Rhododendron* species. This is the capital of *Rhododendron* of Nepal and home to 27 species of *Rhododendron*.

Experimental design

The research work was carried out at three different altitudinal sites (3000 msl, 3500 msl and 4000 msl) on September, 2010. At each altitudinal study site, five 30 × 30 cm^2 15 cm deep quadrates were taken using completely randomized design, for the study. The biomass of the quadrates was estimated with total harvesting method. To estimate the above-ground biomass whole plants of the sampled quadrate were cut at ground level and packed separately in nylon bags and was made sun dry. Similarly, to estimate the below-ground biomass plants' root was excavated and washed with water jet in a 2 mm sieve. Washed plant roots were transferred to a spread plastic and impurities like sand and stones were removed. The sun-dried biomass was made oven dry at 70°C for 48 hr till constant weight attained. Density was calculated by following Mention standard literature (Misra, 1968).

Data analysis

Initially, the descriptive statistics (mean, variance, range, standard error etc.) of the biomass were obtained for different sites. The variability in the biomass content in different sites were analyzed using one way ANOVA, since, the design of the experiment was completely randomized. Data were analyzed using SPSS 13. Above ground biomass and below ground biomass of the different sites were considered significant if p-values were less than or equal to 0.05 ($p \leq 0.05$). In case of statistically significant result observed from ANOVA, a post hoc test, least significant difference (LSD) test was used for further identification of the significant mean difference.

Result and discussion

Biomass is depending upon major factors like temperature, moisture content, soil texture, photosynthesis, microbial activity, and available nutrients. Biomass productivity of grassland/rangeland has been reported variable on different places. In this study, both Above Ground Biomass (AGB) and Below Ground Biomass (BGB) depicted large spatial variations (Tab. 1). The range of the AGB was from 0.35 t/ha to 1.50 t/ha and similarly BGB were from 16.93 t/ha to 43.48 t/ha. The largest AGB and BGB occurred in Jalajale rangeland at altitude 4000 msl. The high altitude rangeland showed high biomass productivity in both AGB and BGB. AGB and BGB of Jaljale at the altitude of 4000 msl were 1.02 t/ha and 41.62 t/ha respectively whereas AGB and BGB of Milke at the altitude of 3000 msl were 0.62 t/ha and 22.314 t/ha respectively. Both AGB and BGB of the studied rangelands showed increasing trend with altitudinal rise. A mean biomass of Suklaphant grassland at 250 msl reported 249.72 g/m^2 (Pant and Lekhak, 2008). Similarly, the maximum biomass (39.75 t/ha) was found at 3650 msl whereas the minimum biomass (23.03 t/ha) was found at 3450 msl in upper Mustang rangeland (Maharjan, 2010) and 50 – 1020 g/m^2 above ground biomass reported from the grassland of Annapurna Conservation Area in Manang district at 3500 msl (Bhattarai et al, 2004).

Both aboveground biomass (AGB) and belowground biomass (BGB) of the Jaljale-Gorujure and Jaljale-Milke rangelands found to be significantly ($p<0.05$) different, while performing analysis of variance (ANOVA).Further on performing Post-Hoc test of LSD test both AGB and BGB were found to be non-significantly ($p>0.05$) different in Gorujure and Milke (Tabs. 2, 3).

The high altitude rangeland (Jaljale) has high amount of aboveground biomass because as lesser number of grazing animals can access it compared to low altitude

Table 1. Descriptive statistics of AGB and BGB of study sites.

Sites (altitude m)	No	AGB (t/ha)			BGB (t/ha)		
		Mean	SD	Range	Mean	SD	Range
Milke (3000)	5	0.62±0.104	0.234	0.35-0.87	22.314±2.66	5.949	16.93-32.09
Gorujure (3500)	5	0.62±0.071	0.159	0.48-0.82	29.168±3.84	8.606	19.74-43.01
Jalajale (4000)	5	1.02±0.139	0.311	0.74-1.50	41.620±0.92	2.065	39.20-43.48

Table 2. Least Significant Difference (LSD) test for identification of the significant mean difference of aboveground biomass.

Sites (altitude m)	Sites (altitude m)	Mean difference	Std. error	Significance
Milke (3000)	Gorujure (3500)	0.0024	0.153	0.988
Milke (3000)	Jaljale (4000)	0.3984(*)	0.153	0.024
Jaljale (4000)	Gorujure (3500)	0.3960(*)	0.153	0.024

* The mean difference is significant at the 0.05 level.

Table 3. Least Significant Difference (LSD) test for identification of the significant mean difference of belowground biomass.

Sites (altitude m)	Sites (altitude m)	Mean difference	Std. error	Significance
Milke (3000)	Gorujure (3500)	6.8540	3.894	0.104
Milke (3000)	Jaljale (4000)	19.3051(*)	3.894	0.000
Jaljale (4000)	Gorujure (3500)	12.4511(*)	3.894	0.008

* The mean difference is significant at the 0.05 level.

rangeland (Milke). Aboveground biomass was relatively found less than belowground biomass because high intensity of grazing in the study area. There were large number of monocot plant species in high altitude rangeland where in lower rangeland, it is very low. The rangeland area is predominated with monocot plants *Carex* sp. and *Agrostis pilosula* species. Thus, monocot plant forms profusely its root at upper layer of soil and contributes large belowground biomass on rangeland.

This study showed that plant density influenced the biomass of plant on rangeland. Further, monocot plant density play crucial role for biomass contribution of rangeland, table 4 depicted that density percentage of monocot plant revealed increasing order from low altitude, Milke (5966 plant/m^2), to high altitude rangeland, Jaljale (13844 plant/m^2).

Table 4. Density of plant at study sites.

SN	Sites (altitude m)	Plant density (Individual/m^2)	
		Dicot	Monocot
1	Jaljale (4000)	1411	13844
2	Gorujure (3500)	1688	7233
3	Milke (3000)	3444	5966

In conclusion, both the above ground and below ground biomass of forage on high altitude rangelands are in increasing order with elevation gradient; it influenced the composition of monocot and dicot plant vegetation on rangeland too.

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