



Variation in plant biomass of Oak and Pine forest grazinglands in temperate Central Himalaya, India

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Abstract

The assessment of plant biomass in *Quercus leucotrichophora* and *Pinus roxburghii* forest dominated grazinglands was made in grazed and ungrazed forest. The study area is located between 29° 22' and 29° 23' N latitude and 79° 28' and 79° 29' E longitude at an elevation of 1700 – 2000 m in the Kumaun Central Himalaya, India. The forest grazing land identified as grazed, based on continuously grazed by domestic animals for last several years and large number of grazing trails and dung remains. Ungrazed forest, the grazing animals were hardly reached or least grazing incidence was detected and away from human settlements. The aboveground biomass extracted in 1x1 m quadrat and belowground in 25x25x30 cm monolith. The biomass varies from 176.9 to 385.9 gm⁻² in oak forest grazingland and was higher 134.79 to 267.96 gm⁻² as compare to pine forest grazingland. The mean total aboveground biomass in grazed was 583.00±1.25 gm⁻² and 1031.5±1.78 gm⁻² in ungrazed oak forest. The mean below ground biomass was 373.93±0.68 gm⁻² in grazed and 591.73±2.66 gm⁻² in ungrazed oak forest. The mean total aboveground biomass of grazed was 450.2±2.05 gm⁻² and 731.5±1.84 gm⁻² in ungrazed pine forest. The mean belowground biomass was 194.23±0.33 gm⁻² in grazed and 260.37±0.18 gm⁻² in ungrazed pine forest. The anthropogenic disturbance and disturbances including climatic change is adversely affects the biomass of these forests. Thus, the conservation and management of these temperate forest grazingland is an urgent need to the people living in this zone for their livelihood.

Keywords: Biomass, Grazingland, Himalaya, Oak forest, Pine forest

Introduction

Himalayan mountain ecosystems usually have unique topography and climatic features and reflect a high level of endemism in biological communities. Himalaya is diverse with a variety of forest covers due to variation in elevation and climate as the vegetation community had a direct relationship with altitude. The Himalayan forest cover plays a significant role in providing many ecological services to the human population and their live stocks. Forest in Central Himalaya have been exposed to heavy biotic pressure including lopping, litter collection, fodder and fire-wood collection, animal grazing, surface burning and deforestation (Kumar & Ram 2005; Singh *et al.* 2014) [14, 42].

The mid to high elevation forest of the Uttarakhand Himalaya are mainly dominated by *Quercus leucotrichophora* and *Pinus roxburghii* tree species. The lesser Himalayan region is colonized by subtropical broad leaved forest is dominated by Chir-pine (*Pinus roxburghii*) and Oak (*Quercus leucotrichophora*) species (Kharkwal & Rawat 2010) [13]. Pine forests are found all along the Himalaya with the exception of Kashmir valley between altitudes of 1000-1800 m and are classified as low montane needle leaf forest with concentrated summer leaf drop, while oak forest covers extensive area between 1500-3000 m elevations and are classified as low to mid montane Hemi-sclerophyllous broadleaf forest with concentrated summer leaf drop (Singh & Singh 1992) [40]. These species are intricately associated not only with agro ecosystem but also within the life support system of the inhabitant of the hills in this area (Singh 1981) [39].

Plant biomass is regarded as the characterization of an

ecosystem, since it reflects the ecosystem capacity during a certain time span in accumulating organic matter (Miao & Li 2007) [21]. Among the biotic factors, grazing is having a profound effect that influences the vegetation at a local scale (Yagil *et al.* 2002) [47]. Although many plant species are not resilient to grazing, there are reports of plants responding to herbivory with increased growth compared with that of ungrazed plants (Manseau *et al.* 1996; Uniyal *et al.* 2005) [18, 45]. The effects of grazing on forest ecosystem have been investigated mainly to regard to aboveground vegetation. Grazing alters species composition of both tree and herb communities (Rooney 2009) [32], changes soil chemical properties and soil structure (Binkley *et al.* 2003) [3], disturb soil surface (Nomiya *et al.* 2003) [24], damage low shrub layer and tree shoot (Pepin *et al.* 2006) and prevents growth of trees sapling and thus, forest regeneration in general (Gomez *et al.* 2003) [9]. Among the most significant effects of overgrazing on aboveground vegetation is the reduction of shrub and herb biomass in general (Mirrill *et al.* 2003; Joys *et al.* 2004; Chaideftou *et al.* 2009; Bergmeir *et al.* 2010) [20, 12, 4, 2] and reduction of herbs in particular (Gomez *et al.* 2003; Stocklon *et al.* 2005) [9, 43].

Increasing anthropogenic pressure on forest over the few decades has led to vast exploitation of natural flora in Uttarakhand Himalaya. (Ram *et al.* 2005) [14]. Due to anthropogenic pressure several changes seen in floral and faunal diversity, habitat, landscape, soil degradation in forests (Rathore 1993) [30]. Rikhari & Palni (1999) [31] investigated affect of forest fire on ground vegetation in Central Himalaya. Several study have been made on the anthropogenic pressure

and livestock grazing in the Himalaya (Silori 2001; Silori & Mishra 2001; Chhetri 2004; Nautiyal *et al.* 2004; Kumar & Ram 2005) [14, 35, 36, 5, 22] conducted a detailed study on anthropogenic disturbance and plant biodiversity in certain forests of Central Himalaya of Uttarakhand. Biomass estimation is essential for determining the status and flux of biological materials in an ecosystem as well as for the understanding of its dynamics (Anderson 1970) [1]. Leith and Whittaker (1975) [16] pointed out that forest biomass, if measured and analysed in its proper context as part of production, gives an overall picture of ecosystem functioning. Swank and Schreuder (1974) [44] described that tree biomass quantity per unit area of land constitutes the primary inventory data that needed to understand the flow of materials and water in the forest ecosystems. The increase in human pressure and disturbances in oak and pine forest is responsible for formation of forest gap (patchy vegetation). The gaps are continuously widening due to the consistent grazing and other disturbances. These forest gaps used as livestock grazing and collection of grasses for stallfed animals. Thus, the present study deals with the assessment of the biomass in oak and pine forest dominated grazinglands in central Himalayan and comparison of biomass in grazed and ungrazed forest.

Materials and Methods

The study area is located between 29° 22' and 29° 23' N latitude and 79° 28' and 79° 29' E longitude at an elevation of 1700–2000 m in the Kumaun Central Himalaya, India. After a through survey, two forest grazingland were identified in the area i.e. the Banj-oak (*Quercus leucotrichophora* A. camus) and Chir-Pine (*Pinus roxburghii* Roxb.) dominated forest grazingland. The selected forests were further categorized as grazed and ungrazed forest grazingland. In each grazingland, three sites were selected and, a total of 12 sites were identified and selected for the detail study.

The climate of the entire study area is influenced by monsoon pattern of rainfall. There are three main season, winter (December to February) is usually very cold with light rain; summer (April to mid-June) is warm and dry and a rainy season is warm and humid (mid-June to mid-September). The average rainfall is about 1352 mm and average humidity is about 55%. The mean annual temperature is 18.5°C. The soil of the area represents meadow soil, brown forest soil (Singh *et al.* 2015) [38].

The forest grazingland identified as grazed, based on continuously grazed by domestic animals for last several years and large number of grazing trails and dung remains. Ungrazed forest, the grazing animals were hardly reached or least grazing incidence were detected and away from human settlements. Herbaceous biomass was assessed across all the sites of oak and pine dominated forest grazingland. The seasonal variation (winter, summer, rainy) assessed by placing three samples (quadrats) of 1x1 m, harvested as close, to the ground as possible for aboveground biomass. The aboveground herbaceous biomass was packed in polyethylene bags and brought to the laboratory. The samples were separated into live shoots and dead shoots. The ground material was also collected as litter including wood litter. All other unidentified material considered as miscellaneous. After removal of aboveground material, a 25x25x30 cm monolith

was excavated from each sample harvested for belowground material. All the available material packed in polyethylene bags and brought to the laboratory. Roots were washed with water to remove soil and other foreign materials. The aboveground and belowground materials were dried in oven at 60°C till constant weight and weighted. The weight was measured by using digital electronic balance with accuracy of 0.001 mg.

Result

Oak forest Grazingland: Across the study sites, the mean total aboveground biomass varied from 557.8±2.28 to 596.9±2.60 gm⁻² in grazed forest and 890.9±2.14 to 1053.0±2.54 gm⁻² in ungrazed. The mean live shoot biomass varied from 263.8±2.74 to 279.5±0.60 gm⁻², dead shoot varied from 127.0±0.28 to 146.0±1.11 gm⁻² and litter biomass varied from 167.0±0.29 to 188.1±0.64 gm⁻² in grazed forest. In ungrazed forest, the mean live shoot biomass varied from 463.7±6.98 to 517.6±3.14 gm⁻², dead shoot varied from 203.5±2.94 to 229.5±3.18 gm⁻² and litter biomass varied from 304.3±1.64 to 323.7±5.87 gm⁻² (Fig. 1).

The mean belowground biomass varied from 360.8±3.55 to 383.6±4.21 gm⁻² in grazed forest and 540.7±1.38 to 630.4±2.21 gm⁻² in ungrazed forest. Across the sites, the miscellaneous biomass varied from 161.3±0.06 to 171.0±0.95 gm⁻² grazed forest and 301.8±0.79 to 313.9±0.48 gm⁻² in ungrazed forest (Fig. 1).

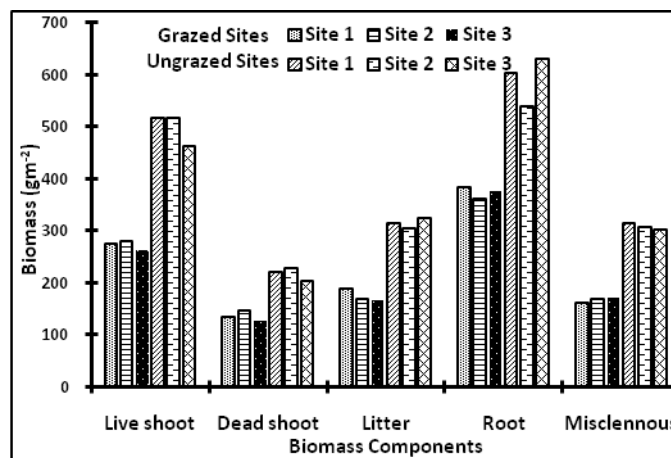


Fig. 1: Variation in aboveground and belowground biomass (gm⁻²) in Oak grazed and ungrazed forest sites

Pine forest Grazingland: Across the study sites, the mean total aboveground biomass varied from 444.4±2.33 to 456.2±1.50 gm⁻² in grazed forest and 701.0±2.29 to 751.2±2.15 gm⁻² in ungrazed forest. The mean live shoot biomass varied from 229.7±0.18 to 248.2±0.50 gm⁻², dead shoot varied from 80.3±1.43 to 89.6±3.45 gm⁻² and litter biomass varied from 118.4±1.79 to 128.8±0.97 gm⁻² in grazed forest. In ungrazed forest, the mean live shoot biomass varied from 280.6±0.79 to 324.1±2.75 gm⁻², dead shoot varied from 167.1±3.29 to 210.8±1.27 gm⁻² and litter biomass varied from 248.0±1.55 to 260.0±2.78 gm⁻² (Fig. 2).

The mean belowground biomass varied from 181.2±4.15 to 201.1±3.93 gm⁻² in grazed forest and 258.1±1.02 to 264.0±1.25 gm⁻² in ungrazed forest. Across the sites, the

miscellaneous biomass varied from 99.4±1.49 to 105.2±0.64 gm⁻² in grazed forest 173.1±0.89 to 183.1±0.23 gm⁻² in ungrazed forest (Fig. 2).

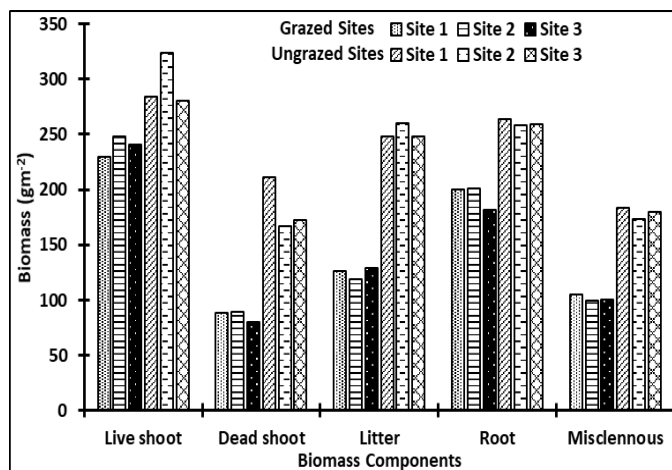


Fig. 2: Variation in aboveground and belowground biomass (gm⁻²) in Pine grazed and ungrazed forest sites.

The mean total aboveground biomass in grazed oak forest was 583.00±1.25 gm⁻² and 1031.5±1.78 gm⁻² in ungrazed oak forest. The mean belowground biomass was 373.93±0.68 gm⁻² in grazed oak forest and 591.73±2.66 gm⁻² in ungrazed oak forest. The miscellaneous biomass was 166.77±0.29 gm⁻² in grazed oak forest and 307.70±0.35 gm⁻² in ungrazed oak forest (Fig. 3). The mean total aboveground biomass of grazed pine

forest was 450.2±2.05 gm⁻² and 731.5±1.84 gm⁻² in ungrazed pine forest. The mean belowground biomass was 194.23±0.33 gm⁻² in grazed pine forest and 260.37±0.18 gm⁻² in ungrazed pine forest. The miscellaneous biomass was 101.73±0.21 gm⁻² in grazed pine forest and 178.58±0.29 gm⁻² in ungrazed pine forest (Fig. 3).

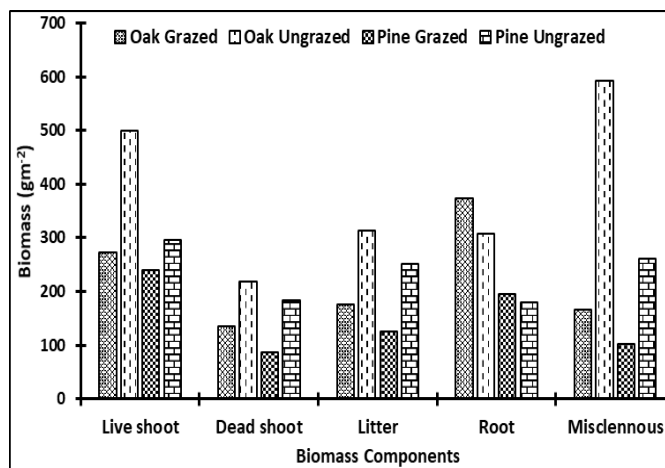


Fig. 3: Variation in aboveground and belowground biomass (gm⁻²) in Oak and Pine grazed and ungrazed forest.

ANOVA showed that the aboveground biomass (live shoot, dead shoot and litter), belowground biomass and miscellaneous components varied significantly across forests as well as grazed and ungrazed forests (Table 1).

Table 1: Analysis of variance (ANOVA) for different treatments and components

Source of variation	Live Shoot	Dead Shoot	Litter	Root	Miscellaneous
Forest	11.34*	4.68*	6.48*	68.91*	17.94*
Grazingland	17.79*	27.78*	64.37*	12.68*	24.40*
Sites	0.211 NS	0.278 NS	0.024 NS	0.117 NS	0.008 NS

= Significant at 1% (P<0.01), NS = Non Significant

Discussion

Large-scale tree felling for timber and other industrial raw materials during the pre British period to the 1960s and 1970s was the major cause of deforestation in the Uttaranchal Himalaya (Kumar & Ram 2005) [14]. Two important factors are responsible for the high anthropogenic impact on these forests: (i) easy approach, and (ii) high plant biodiversity like in mixed broadleaf forests. The day-to-day needs of the people are animal fodder, leaf litter, grazing and fuel wood, and the periodical needs are timber, industrial raw materials and non-timber forest products. Fire is used for the growth and establishment of grass, and grass is used for grazing as well as for off season animal stall-feeding. In recent years, the increasing human pressure in form of collection of forest produce, grazing and trampling by animal are common in oak and pine forest. These pressure increase disturbances in forest as a result the dense oak and pine forest have open canopy, poor regeneration, absence of sapling and poor soil nutrient and fertility. The periodic removal of forest resources and anthropogenic disturbances lead the chronic form of disturbances, a small amount of resources removed periodically, adversely impacted these forests. The global

climate change phenomenon may also influence the growth and development of these forests grazingland. The biomass is one of the major resources of these forests for the human beings. In the grazingland, biomass used in the form of collection of grasses for stallfed, grazing of animal and collection of medicinal and aromatic grass and herbs which are extracted from these forest grazinglands. In the present study, the biomass varies from (176.97 to 385.97 gm⁻²) in oak forest grazingland and was higher (134.79 to 267.96 gm⁻²) as compare to pine forest grazingland (Fig. 4). This may be due to presence of deep soil, occasional fire and moisture, support the growth of herbaceous vegetation in oak forest. Pine forest witnesses the recurrent fire, soil erosion and other disturbance activities leading to low biomass. Saxena and Singh (1980) [34] also found that the herbaceous biomass range between 20 to 724 gm⁻² under *Q. leucotrichophora* forest in Nainital area. The aboveground biomass in the present study ranged 134.79 and 385.97 gm⁻². The biomass reported 51-679 gm⁻² in North temperate American grasslands (Sims & Singh 1978; Singh *et al.* 1983) [37, 41] which is higher than reported in the present study. Similarly, Kumar & Joshi (2016) [15] reported aboveground biomass between 187-800 gm⁻² and

belowground 401-996 gm⁻² in a grassland of Rajasthan. Generally villagers are used fire in these grazingland especially in winter and summer season, for better sprouting of grasses in rainy season. Fire regimes play an important role in biomass allocation patterns. The forest fire has been emerging as the most common disaster in pine forest and one of the main reason for minimizing the biomass. In fire-prone ecosystems, total plant biomass, growth rates, and distribution of biomass between roots and shoots are influenced by fire intensity and frequency (Pare & Bergeron 1995; de Vinas & Ayanz 2000; Dijkstra *et al.* 2002; Day *et al.* 2006; Mack *et al.* 2008) [25, 7, 8, 6, 17]. The biomass of ungrazed forest grazingland was maximum than the grazed forest grazingland in the present study. Nautiyal *et al.* (2001) [23] have reported that the highly grazed areas shown low aboveground biomass. Thus, these grazed forest showed high grazing pressure indicating the low above and belowground biomass. May & Webber (1982) [19] have reported that the patterns of aboveground

standing crop, belowground biomass, and above and belowground ratio are controlled by water availability, length of growing season, exposure and soil stability. The existence of a species in a particular habitat depends not only upon its ecological adaptations but also on the associated species and the abiotic environment (Vijay & Negi 2004) [46]. Ram *et al.* (1988) [29] reported aboveground biomass between 1020 and 1105 gm⁻² a protected grassland at Gopeshwar, Chamoli, a temperate grassland, while Ram *et al.* (1989) [27] the aboveground biomass reported 282-409 gm⁻² and belowground 540-3630 gm⁻² in an alpine grassland of Rudranath. Sah *et al.* (1994) [33] reported 116-305 gm⁻² belowground biomass in a temperate grassland of Ranichauri, India. Joshi (2011) [10] reported 235 gm⁻² aboveground biomass and 56-195 gm⁻² belowground biomass in Nainital region and also reported in belowground biomass 84-33 gm⁻² in Nainital region (Joshi 2012) [11]. These results are comparable to the present study (Table 2).

Table 2: Comparison of biomass in different grasslands

Biomass of different forest sites	Aboveground biomass (gm ⁻²)	Belowground biomass (gm ⁻²)	Reference
Gopeshwar, India	1020 – 1105	-	Ram <i>et al.</i> 1988 [29]
Rudranath alpine, India	382-409	540-3630	Ram <i>et al.</i> 1989 [27]
Ranichauri, India	-	116 -305	Sah <i>et al.</i> 1994 [33]
Nainital, India	235	56-195	Joshi, 2011 [10]
Nainital, India	-	84-233	Joshi, 2012 [11]
Rajasthan (Pilani), India	187-800	401-996	Kumar and Joshi, 2016 [15]
Nainital, India	444- 596	181-383	Present Study

Now a days, the forest of Kumaun Himalayan region are facing a huge pressure from forest fire, uncontrolled grazing and other anthropogenic disturbances. The disturbances responsible for the decreasing forest cover, through, poor regeneration, decrease soil fertility, soil erosion and recurrent fire. The climate change phenomena is also influences the biomass structure of these grazinglands. Thus, the conservation and management of these temperate forest grazingland is an urgent need to the people living in this zone for their livelihood.

Acknowledgement

Authors are thankful to Department of Forestry and Environmental Science, Kumaun University, Nainital for providing necessary facilities and encouragement.

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