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Biomass and Productivity of Different Forest Grazing Lands in Central Himalaya

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This study emphasizes biomass, net primary productivity and dry matter cycling of grazing land vegetation under sal (*Shorea robusta*), chir pine (*Pinus roxburghii*) mixed broadleaf, chir pine, banj oak (*Quercus leucotrichophora*)-chir pine, rianj oak (*Quercus lanuginosa*) and tilonj oak (*Quercus floribunda*) forests from January 1982 to December 1982 at an elevation of 300-2200 m in Central Himalaya. Peak values of live shoot and belowground biomass occurred in September during the monsoon period. Peak net accumulation rate increased with increasing elevation and it was recorded maximum in September for lower elevation (below 1350 m), in July for middle elevation (1750-1850m) and in August for higher elevation (above 2000 m) grazing lands. Dead shoot biomass was minimum in September and maximum in November. The annual aboveground production was slightly lower by summation of positive live shoot biomass compared to the summation of peak live weights of individual species and was lower in mid-elevational grazinglands where carbon/nitrogen ratio was higher compared to other grazinglands. The annual belowground production was 70-114 g m^{-2} yr^{-1} and increased with increasing elevation. Of the total annual net production, 87-92 % was disappeared.

Key Words: Central Himalaya, Grazing lands, Biomass, Primary productivity

Introduction

The forested area accounting for 29% of the total Central Himalayan geographical area also constitutes the grazing land from where herbaceous ground vegetation is grazed and collected for stall feeding of animals throughout the year, regardless of the amount present. Inspite of close linkages between man and forests through livestock little information is available (Chaturvedi et al. 1988) on the dry matter production of forested grazing lands.

The present study deals with biomass, net primary production and dry matter flow in the grazing land vegetation under sal (*Shorea robusta*), chir pine (*Pinus roxburghii*) mixed broadleaf, chir pine, banj oak (*Quercus leucotrichophora*) - chir pine, rianj oak (*Quercus lanuginosa*) and tilonj oak (*Quercus floribunda*) forests along an elevational gradient of 300-2200m in Central Himalaya. These selected forest types represent the major vegetation below 2400 m elevation in Central Himalaya and are main source of fodder and herbage for livestock.

Material and Methods

The study area lies (29° 0′-29°48′ N and 79° 15′-79° 45′ E) between 300-2200m elevations. The sites selected were subjected to minimal biotic disturbances in terms of grazing or herbage removal. The various forest types, and their important tree species and above ground tree and shrub biomass are given in table 1.

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Site-to-site variations due to the elevational changes are evident (table 1). More than 75 % of the total annual rainfall occurs in rainy season (mid-June to mid-September) which is preceeded by a dry and warm summer (April to mid-June) and followed by dry and cool winter (October to March). The sites tend to become increasingly mesic with increasing elevation which is indicated by precipitation-effectiveness (P-E) index (table 1). The soil is sandy loam in all the forests, excepting sal forest, where it is loamy sand with acidic in nature. The soil is rich in nitrogen and organic carbon (table 1).

Methods

The shoot biomass (grasses, forbs, and seedling of trees and shrubs) was harvested from five randomly selected 1 m^2 plots at 30-days intervals from January 1982 to December 1982. Care was taken not to harvest a plot more than once. Five 0.25 × 0.25 × 0.30 m plots were harvested for belowground parts. Thereafter aboveground component was fractioned into live species- wise and dead shoots. Litter was collected as per suggested by Sims and Singh (1978). Roots were washed with water. Fresh weight of harvested samples was taken in the field. Subsamples for different components were brought to the laboratory and oven dried to constant weight at 80° C. The fresh: dry weight factor was used to determine biomass. Biomass totalled across different species furnished the biomass of entire herbaceous vegetation for each of the forests.

Peak net accumulation rate was calculated by $W_2 - W_1/t_2-t_1$ where W_1 an W_2 are total live shoot biomass at time t_1 and t_2.

Table 1 *Certain characteristics of the study sites. 1 mean annual temperature(°C), 2 total rainfall (cm), 3 elevation (m), 4 ph, 5 nitrogen (%), 6 organic carbon (%), 7 C:N ratio, 8 P-E index, 9 total aboveground shrub and tree biomass*

Forest type/ dominant species*	1	2	3	4	5	6	7	8	9
Sal *Shorea robusta*	23.0	207.6	300	6.8	0.15	1.1	7.3	71.3	570
Chir pine mixed broadleaf *Pinus roxburghii, Quercus leucotrichophora Lyonia ovalifolia, Q. glauca, Rhododendron arboreum*	21.1	200.0	1350	6.7	0.30	3.5	11.6	92.9	158
Chir pine *P. roxburghii*	15.8	218.5	1750	6.2	0.26	3.7	14.2	97.2	163
Banj oak-chir pine *Q. leucotrichophora, P. roxburghii*	15.8	131.3	1850	6.3	0.33	3.5	10.6	57.2	326
Rianj oak *Q. lanuginosa*	14.9	248.8	2150	6.0	0.46	4.2	9.1	119.4	463
Tilonj oak *Q. floribunda*	14.9	248.8	2200	6.3	0.40	4.0	10.0	119.4	640

*forest types were named on the basis of dominant species

Aboveground net primary production(ANP) was determined by (i) summation of live shoot biomass increase and dead shoot biomass increase if any, and (ii) by summation of peak live weights of individual species. These methods are improvement over the estimates obtained from peak community biomass because all species in the community may not reach their peak standing crop at any one time and senescence may occur concurrently with growth (Singh et al. 1975). Belowground net primary production (BNP) was sum of the significant increments in total root biomass, which may be underestimation (Newbould 1968). It was practically not possible to separate live from dead roots in each samples, at each sampling date and since live: dead root ratio vary with time. Total net primary production (TNP) was sum of the ANP and BNP, translocation between above and belowground parts were not taken into account.

Rates of transfer of dry matter to the dead standing compartment and to the litter compartment, and rates of litter disappearance, root disappearance and total disappearance were calculated following Singh & Yadava (1974) and Ram et al. (1989).

Results and Discussion

Periodic changes in different components are shown in figure 1. Analysis of variance indicated significant differences (in all cases $P < 0.01$) between months.

In sal, chir pine mixed broadleaf, chir pine, banj oak- chir pine, rianj oak and tilonj oak forests, minimum live shoot biomass was in January and maximum in September, which are markedly higher compared to oak forests (49-50g m^{-2})(Rawat 1983) and lower compared to chir pine forest (130g m^{-2}) (Chaturvedi et al. 1988).

The live shoot biomass during growth period (January to September) was positively related to monthly rainfall ($r = 0.649$-0.807; $P < 0.05$-0.01) and temperature ($r = 0.743$- 0.866; $P < 0.01$).

The peak net accumulation rate (an index of net photosynthetic efficiency of the vegetation under given environmental conditions, and indication of optimum growing conditions at different sites) (Sims & Singh 1978) in this study was far lower compared to tropical grasslands of India, which is as high as 14- 15 g m^{-2} d^{-1} towards end of rainy season (Singh & Yadava 1974, Gupta & Singh 1982).

Table 2 *Peak net accumulation rate ($g\ m^{-2}\ d^{-1}$) (a), net primary production ($g\ m^{-2}\ yr^{-1}$) (b), total herbaceous biomass across the year (live shoot + dead attached + litter) ($g\ m^{-2}$) (c), and root : shoot ratio(d) for different forest grazing lands*

Forest type	a		b			c	d
	Rate	Month	ANP 1*	ANP 2*	BNP		
Sal	0.77	September	101	91	70	1374	0.90
Chir pine mixed broadleaf	0.43	September	73	77	80	1395	1.16
Chir pine	0.45	July	59	61	87	1057	1.57
Banj oak-chir pine	0.60	July	85	87	81	1701	1.62
Rianj oak	0.66	August	105	110	100	1576	1.43
Tilonj oak	0.69	August	89	93	114	1576	1.43

*1 is by first method and 2 is by second method

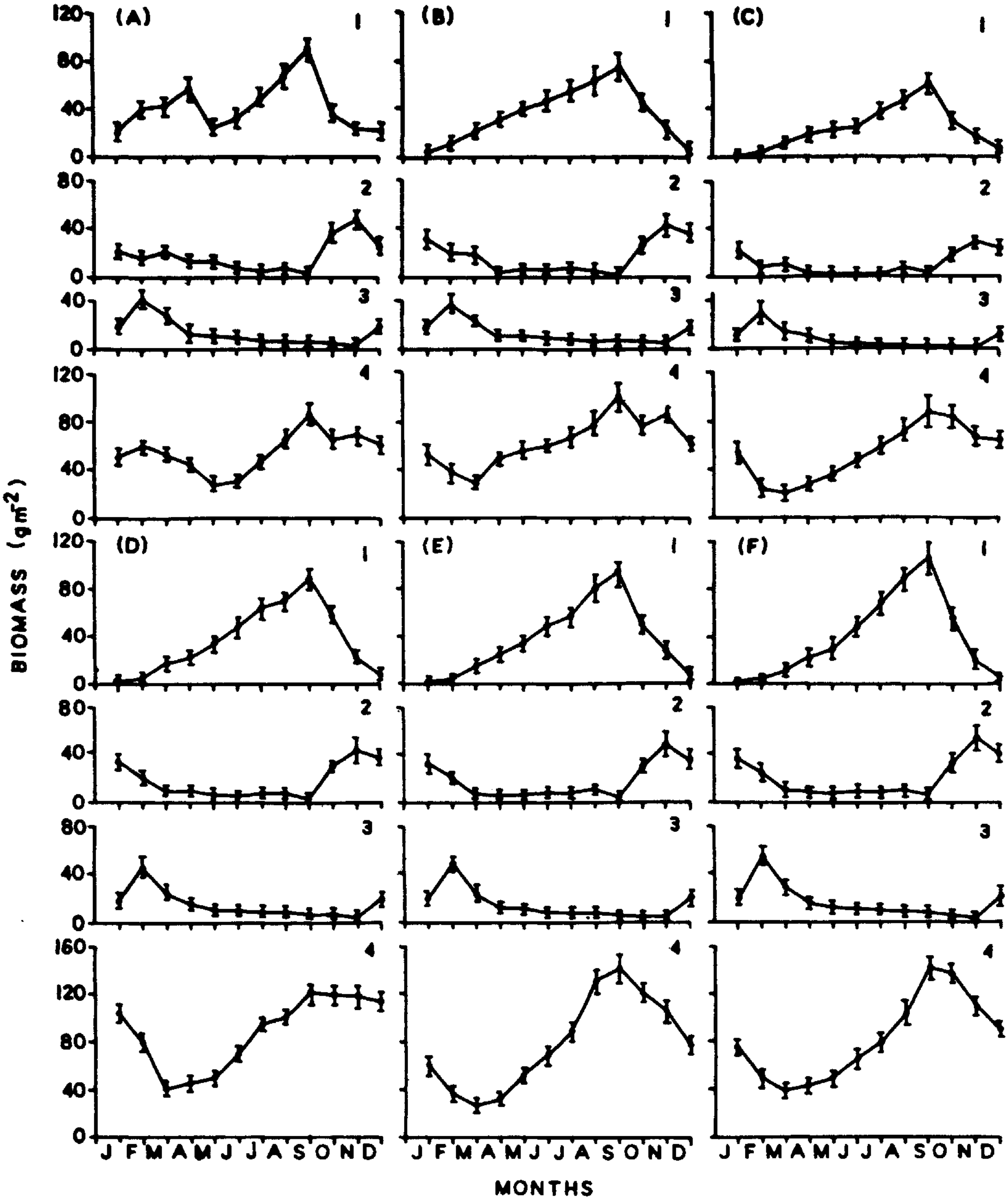

Figure 1 Periodical changes in biomass of various primary producer compartments (vertical bars represent ± SE). A, B, C, D, E, and F represent sal (*Shorea robusta*), chir pine (*Pinus roxburghii*) mixed broadleaf, chir pine banj oak (*Quercus leucotrichophora*)- chir pine, rianj oak (*Q. lanuginosa*) and tilonj oak (*Q. floribunda*) forests, respectively while 1, 2, 3 and 4 represent live shoot, dead attached shoot, litter and belowground

Dead shoot biomass was highest in November and lowest in September, reflecting the fast growth of herbaceous vegetation during the rainy season triggered by warm temperatures and abundant rainfall, and the massive transfer of live shoots into the standing dead compartment in the postmonsoon period following the maturity of herbage at the onset of cool, xeric conditions in the annual cycle.

The herbaceous litter mass was highest in February, thereafter it decreased continuously and reached minimum in November. The decrease is due to low input and quick disappearance of litter.

The belowground biomass declined from September to March, whereafter it increased. The dynamics of root biomass mirrored that of the live shoot biomass.

Total herbaceous biomass (live + dead attached shoots + roots) (table 2) were slightly lower than the value (1751g m^{-2}) reported by Chaturvedi et al. (1988) for chir pine forest grazing land. Variation in total biomass occurs due to increase or decrease in aboveground biomass. Variation in root: shoot ratio (table 2) was related to climatic factors and the type of dominant species (Chaturvedi et al. 1988), which indicates drier growing conditions of chir pine and banj oak- chir pine forest sites (Rikhari et al. 1992).

ANP calculated by both the methods was in the range of values 2- 216 g m^{-2} yr^{-1} (Ford & Newbould 1977, Bazzaz & Bliss 1971 Chaturvedi et al. 1988) for grazing land forest ecosystems. Barring sal forest site, ANP- estimates from sum of species peaks was slightly higher compared to positive increment method, in which values were under estimated. Sims & Singh (1978) argued that grasslands with greater species diversity may have a tendency to overestimate species occuring in small amounts by positive increment summation method. In this study, the herb species with lower amount of biomass and seedlings of woody plants were pooled. That is why the values obtained by positive increments were less than that of species peak biomass summation. In addition to the afore said situation, the time separation of peak biomass may also be one of the relative causes for underestimated values.

BNP values (table 2) of this study were comparable to the value reported for chir pine forest grazing land of Central Himalaya (Chaturvedi et al. 1988). The precise estimate of BNP is having many difficulties (Lauenroth et al. 1986) due to problems associated with techniques, unaccounted losses of organic root secretion, sloughing of root hairs and root caps, translocation of organic material to fungal components of mycorrhizal roots and to freshly sprouting shoots, consumption of fine roots by soil animal, cumulation of random errors, and quantity of dead roots (Singh et al. 1984).

Total net primary production was 153-205g m^{-2} yr^{-1} by first method and 139- 207g m^{-2} yr^{-1} by second method.

Dry matter dynamics in a compartmental model is given in figure 2. Of the total net production, an assimilate pool about 44 to 59 % was channeled to shoots and 41 to 56 % to roots. Transfer of live shoots into dead shoot compartment and that of dead shoots into litter compartment was almost 100 % within the year. The rate of disappearance of litter was almost 100 % and that of belowground was 84 to 91%. Thus the total output was almost similar to the total input, indicating that various grazing lands are in equilibrium as shown by climax communities (Chaturvedi et al. 1988, Ram et al. 1989).

In nut shell, it can be concluded that biomass and net primary productivity varied from one grazing lands to other due to variety of factors, viz., altitude, temperature, soil nitrogen and organic carbon, carbon/nitrogen ratio, and dominant tree species and ground vegetation. The peak net

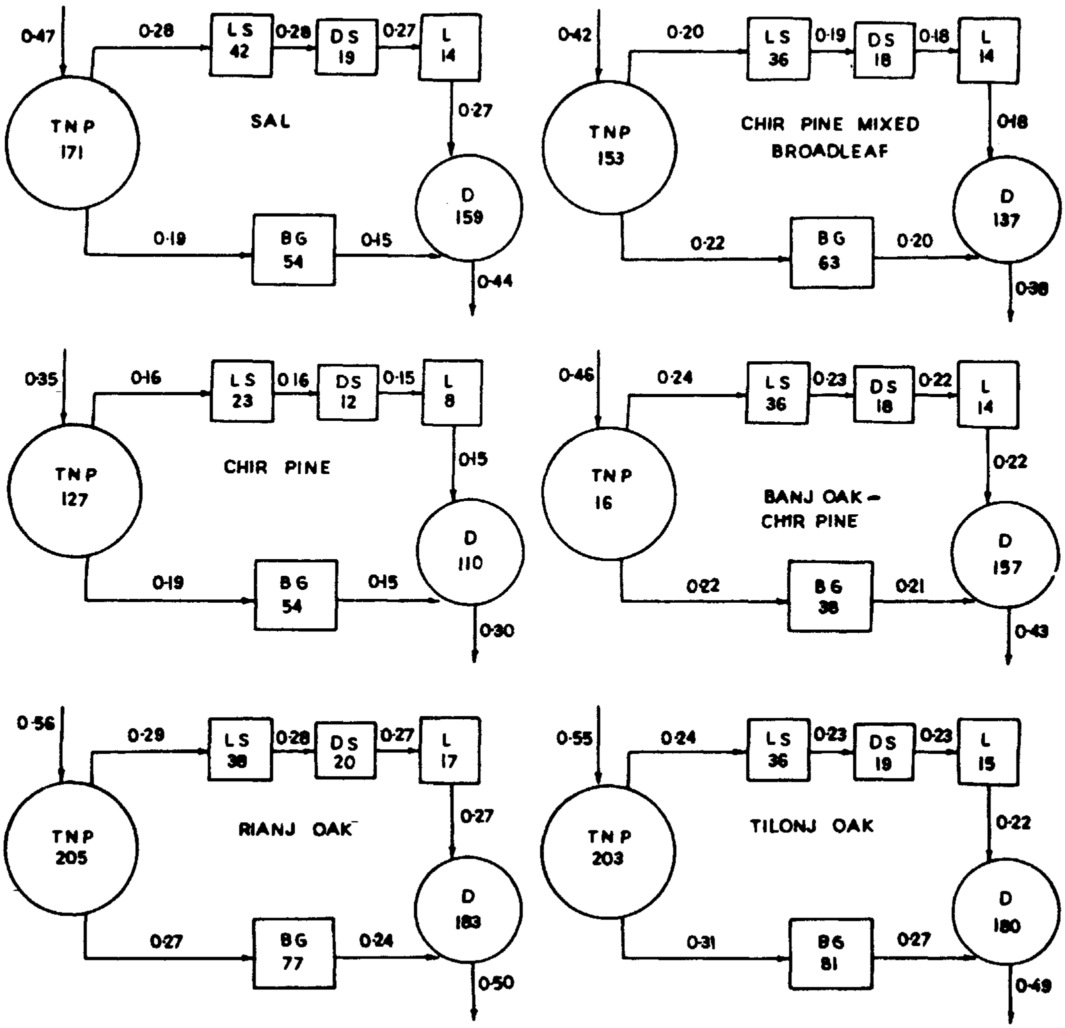

Figure 2 Annual dry matter flow through the primary producer compartments. Values in the compartments are mean standing crop (g m^{-2}) while on arrows are net flux rate (g m^{-2} d^{-1}). TNP = Total net primary production; LS = Live shoot; DS = Dead shoot; L = Litter; D = Disappearance; BG = Belowground

accumulation rate, which increased with increasing elevation and ANP were lower for mid-elevational grazing lands where carbon/nitrogen ratio was higher. BNP values increased with increasing elevation due to increase in soil nitrogen and carbon. Of the total annual production, 87-92% diasappeared annually.

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