



Dry Matter Dynamics of Capillipedium Community of Garhwal Himalaya

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Abstract

Present study deals net primary production and dry matter structure in *Capillipedium- Pinus* community of temperate grazingland of Garhwal Himalaya. Five sites were selected for the study, in which four were open, and one site is protected, located on south-east, east-north, east-south, north-west aspects. Four sites were subjected to biotic interference treated as grazing-land and one site is used as agriculture land (Protected site). Mostly grasses paid highest green biomass contribution on all sites. ANP ranged from 83.82 gm⁻²yr⁻¹ to 542.08 gm⁻² yr⁻¹ while BNP ranged from 128 gm⁻²yr⁻¹ to 474g m⁻² yr⁻¹ on all sites. Winter season was severe and long with food accumulation in belowground parts that is utilized in next growing season. The objective of the present study was to determine the net primary production, its annual transfer dynamics and the system transfer functions of the inter-compartmental changes in a temperate grazingland dominated by *Capillipedium parviflorum*.

Keywords: ANP, BNP, NPP, System transfer function, *Capillipedium parviflorum*.

Introduction

Plant growth and development is influenced by many environmental factors such as rainfall, temperature, relative humidity, topography, latitude, longitude and locality (Singh. *et al.*, 2000). The structure of biomass provides useful information about the quantity of organic matter products in a given time under given climatic conditions. Biomass based subsistence economy has been an age-old mode of dependence on forest for food, fuel, fodder and timber. However, indiscriminate cutting and burning of these forests and also over grazing within them, inevitably leads to alteration in both the structure and function of forest ecosystem (Dakwale and Lull, 1981; Wayne, 1984). Productivity of green plants is one of the most important functional attributes of the ecosystem. Biomass provides a useful comparison of the actual quantities of plant material that can be harvested at a given time for the livestock. In agriculture, composition and productivity responses to altered precipitation regimes are important, because they influence the capacity of grasslands to

support livestock production (Fay. *et al.*, 2000).

Pine dominated temperate grazingland in Himalaya are major source of livestock grazing as well as fodder for stock feeding especially in garhwal Himalaya. *Capillipedium parviflorum* is dominant grass of many such grazingland and found mostly on the floor of *Pinus* experiences by heavy firing during summer. However, there are no reports on dry matter dynamics of *Capillipedium parviflorum* community in garhwal himalaya. In this study, the data presented are concerned with the net primary production, its annual transfer dynamics and the system transfer functions of the inter-compartmental changes in a temperate grazingland dominated by *Capillipedium parviflorum*

A number of studies have been carried out on biomass and productivity in different forest and grassland ecosystems. Some important workers include (Odum, 1971); (Van Dyne. *et al.*, 1963; Laurenroth and Whitman, 1977), and

(Mc Naughton, 1983, 1985). In India, structure, biomass dynamics, species diversity and primary production was studied by (Singh and Joshi, 1979; Tiwari, 1986; Chaturvedi and Singh, 1987; Ram, 1988; Joshi. *et al.*, 1988; Sah and Ram, 1989; Sah and Saxena, 1990; and Sah. *et al.*, 1994; Dhaulakhandi and Rajwar, 2007; Joshi. *et al.*, 2012; Rai. *et al.*, 2020).

Study Site

Temperate grazingland dominated by *Pinus roxburghii* canopy was selected in Badiyargarh (Tehri Garhwal) area 25 km north of Srinagar Garhwal extending from 1000-1500 m above msl. Five sites were selected of which four were open for grazing and remaining one was protected site. These sites were named as Site A (Nagdev I), Site B (Nagdev II), Site C (Navgarh), Site D (Sendri), and Site E (Badiyargarh). Table 1 shows possible ecological parameters and its status in all study site

Table 1: Ecological parameters and its status in all study site

Parameter	Site A	Site B	Site C	Site D	Site E
Local name	Nagdev I	NagDev II	Navgarh	Sendri	Badiyargarh
Latitude	30° 22' - 30° 14'	30° 22' - 30° 14'	30° 22' - 30° 14'	30° 22' - 30° 14'	30° 22' - 30° 14'
Longitude	78° 56' - 78° 47'	78° 56' - 78° 47'	78° 56' - 78° 47'	78° 56' - 78° 47'	78° 56' - 78° 47'
Altitude(mt)	1400	1400	1300	1100	1300
Slope	Moderate	Moderate	Moderate	Moderate	Moderate
Angle	25° -40°	25° -40°	25° -40°	25° -40°	25° -40°
Aspect	South-east	East- north	East-south	North-west	East-south
Soil Color	Dark grayish brown	Dark brown	Dark brown	Brown	Brown
Soil Texture	Sandy- clayey	Sandy- clayey	Sandy- clayey	Sandy- clayey	Sandy- clayey
Soil Temp.	23 °C	23 °C	28°C	27°C	23°C
Soil pH	6.62	6.68	6.58	6.78	6.83
WHC %	74.48 ± 9.69	79.42 ± 12.86	94.32± 7.33	75.82 ± 10.63	79.63 ± 1.52
Moisture %	25.95 ± 2.56	28.89 ± 8.40	26.22 ± 4.30	34.89 ± 5.48	17.71 ± 1.32
Org. Carbon %	1.03 ± 0.19	1.05± 0.19	0.93 ± 0.26	1.04 ± 0.26	1.03±0.18
Nitrogen %	0.051	0.053	0.046	0.052	0.051
Phosphorus (Kg/hc)	31.8 ± 12.9	31.8 ± 12.9	31.9 ± 7.4	31.9 ± 9.0	31.1 ± 9.7
Potassium (kg/hc)	355.6 ± 84.9	362.5± 63.86	316.6± 45.01	349.4 ± 47.13	363.01± 73.55

Methods

Vegetation of all stands was analysed for aboveground and belowground standing crop following short-term method (Odum, 1960). The samples were taken seasonally. On each sampling date 10 quadrats of 50 x 50cm² size were laid down at random in the field. In the present investigation the aboveground net primary production (ANP) and belowground net primary production (BNP) was computed

by following (Singh and Yadava, 1974; Singh. *et al.*, 1975; and Sims. *et al.*, 1978).

Storage, Net Accumulation and Disappearance Rates

Values on storage of dry matter production are based on average standing crop during investigation period. In the present investigation the respiration rate could not be estimated. Odum (1969) reported a value of .30 as the median ratio of respiration to net

production. Considering this view, in the present investigation the total net production was multiplied by .30 to get the amount of dry matter used in respiration (R) during the study period. This amount of respiration was further summed with the value of total net production to obtain gross primary production (GP). Different transfer rates of dry matter between the compartments root and litter disappearance rates were computed following the balance sheet approach (Singh and Yadava, 1974).

System Transfer Functions

The system transfer function is the quantity by which the system block multiplies the input to generate the output (Grodins, 1963; Golley, 1965) and reflects the orientation of the functioning of an ecosystem in space and time (Sims and Singh, 1971).

Results

For the estimation of net primary production, the sum totals of species-wise positive increase in aboveground live biomass was added to sum totals of positive increase in standing dead and sum totals of positive increase in belowground biomass through the year . Table 1 represents the resulting estimate of the net primary production of all sites.

Table 1: Net Primary Production of *Capillipedium* Community (gm⁻² day⁻¹)

Sites	ANP	BNP	TNP
Site I	542.08	465.57	1007.65
Site II	297.6	309.32	606.92
Site III	83.82	128	211.82
Site IV	404.44	474	878.44
Site V	390.07	474	630.07

Table 2: Transfer of Dry Matter in Different Compartments for *Capillipedium* Community

Compartment	I	II	III	IV	V
Aboveground net primary productivity					
Initial green biomass	155.56	95.4	170.84	13.24	205.7
ANP	542.08	297.6	83.82	404.44	390.07
Total input into the system	697.64	393	254.66	417.68	595.77
Transfer to standing dead	267.8	45.08	-54.58	201.88	307.19
Green biomass at the end of season	429.84	347.92	309.24	215.8	288.64
Total output	697.64	393	254.66	417.68	595.77
Unaccounted	Nil	Nil	Nil	Nil	Nil
Standing dead					
Initial SD	80.8	56.48	68.2	33.36	*
Production of SD	267.8	45.08	-54.58	201.88	307.19
Total input	348.6	101.56	13.62	235.24	307.19
Transfer to litter	258.72	55.12	-129.21	162.64	216.39
SD at the end of season	89.88	46.44	142.84	72.6	90.8
Total output	348.6	101.56	13.62	235.24	307.19
Unaccounted	Nil	Nil	Nil	Nil	Nil
Litter					
Initial amount	200	120	160	160	100
Production of litter	258.72	55.12	-129.22	162.64	216.39
Total input	458.72	175.12	30.78	322.64	316.39
Litter disappearance	98.72	19.12	-219.22	130.64	166.39
Litter at the end	360	156	250	192	150

Total output	458.72	175.12	30.78	322.64	316.39
Unaccounted	Nil	Nil	Nil	Nil	Nil
Belowground					
Initial belowground	254.28	344	304	156	40
Belowground net production	465.57	309.32	128	474	240
Total input into the system	719.85	653.32	432.00	630	280
Disappearance of BNP	215.85	113.32	2.00	50	80
belowground at the end of season	504	540	430.00	580	200
Total output	719.85	653.32	432	630	280
Unaccounted	Nil	Nil	Nil	Nil	Nil

Dry Matter Dynamics

The ratio of input and output of dry matter in different compartment was calculated as per balance sheet approach as suggested by (Singh and Yadava, 1974) and is presented in Table-2 and 3. Gross primary production of all five study sites (A,B, C, D and E) was 1309.945 g m⁻² yr⁻¹ ,788.996 g m⁻² yr⁻¹ , 275.37 g m⁻² yr⁻¹ ,1141.97 g m⁻² yr⁻¹ ,818.994 g m⁻² yr⁻¹ of which 302.295 g m⁻² yr⁻¹ , 182.076 g m⁻² yr⁻¹ ,63.55 g m⁻² yr⁻¹ ,263.532 g m⁻² yr⁻¹ ,188.997 g m⁻² yr⁻¹ was lost by plants in respiration respectively.

Total net production amounted to be 1007.65 g m⁻² yr⁻¹(Site A), 606.92 g m⁻² yr⁻¹(Site B), 211.82 g m⁻² yr⁻¹(Site C), 878.44 g m⁻² yr⁻¹(Site D), 629.44 g m⁻² yr⁻¹ (Site E) of which 465.57 g m⁻² yr⁻¹,309.32 g m⁻² yr⁻¹,128 g m⁻² yr⁻¹,474 g m⁻² yr⁻¹,240 g m⁻² yr⁻¹ was directed to ANP and remaining 542.08 g m⁻² yr⁻¹, 297.6 g m⁻² yr⁻¹, 83.82 g m⁻² yr⁻¹,404.44 g m⁻² yr⁻¹, 390.07 g m⁻² yr⁻¹ to BNP respectively. The transfer of dry matter from ANP to SD was estimated as

267.8 g m⁻² yr⁻¹, 45.08 g m⁻² yr⁻¹, -54.58 g m⁻² yr⁻¹, 201.88 g m⁻² yr⁻¹, 307.19 g m⁻² yr⁻¹ in all five sites. The amount for the transfer of SD to litter was calculated for all sites as 258.72 g m⁻² yr⁻¹, 55.12 g m⁻² yr⁻¹, -129.22 g m⁻² yr⁻¹, 130.64 g m⁻² yr⁻¹, 166.39 g m⁻² yr⁻¹. The values of 98.72 g m⁻² yr⁻¹(Site A), 19.12 g m⁻² yr⁻¹(Site B), -219.22 g m⁻² yr⁻¹ (Site C), 130.64 g m⁻² yr⁻¹(Site D) ,166.39 g m⁻² yr⁻¹(Site E) were recorded for litter disappearance.

In belowground compartment the transfer function of BNP to BD was 314.57g m⁻²yr⁻¹, 215.85 g m⁻² yr⁻¹,113.32 g m⁻² yr⁻¹, 2.00 g m⁻² yr⁻¹, 50 g m⁻² yr⁻¹. The transfer from TNP to TD was 314.57, 132.44,-217.22, 180.64 and 246.39 g m⁻² yr⁻¹ found in all five study sites.

There was net accumulation of 693.08 g m⁻² yr⁻¹(Site A), 474.08 g m⁻² yr⁻¹(Site B), 429.08 g m⁻² yr⁻¹(Site C), 697.8 g m⁻² yr⁻¹(Site D), and 38.6 g m⁻² yr⁻¹ (Site E) in biomass during the year.

Table 3: Dry Matter Dynamics of *Capillipedium* Community

Compartment	I	II	III	IV	V
GP	1309.95	788.996	275.37	1141.97	818.994
R	302.295	182.076	63.55	263.532	188.997
TNP	1007.65	606.92	211.82	878.44	629.99
TNP-ANP	465.57	309.32	128	474	240
TNP-BNP	542.08	297.6	83.82	404.44	390.07
ANP-SD	267.8	45.08	-54.58	201.88	307.19
SD-L	258.72	55.12	-129.22	162.64	216.39
L-LD	98.72	19.12	-219.22	130.64	166.39
BNP-BD	215.85	113.32	2.00	50	80
TD	314.57	132.44	-217.22	180.64	246.39
Net accumulation in Biomass	693.08	474.08	429.04	697.8	383.6

System Transfer Function

In the present study, system transfer functions between different compartments have been estimated to study of the intrinsic behaviour of each compartment (Table 4). The values indicated that annually the transfer functions of TNP to ANP ranged between 39 to 62% with the maximum at site E and minimum at C. However, the total net production accumulated underground was found to be 46, 51, 61, 54 and 38% on sites A, B, C, D and E, respectively. The transfer function of ANP-SD was highest at site E (78.7%) and minimum at C (-65%). Sites A, B and D showed 49%, 15.1% and 53% transfer function of ANP-SD. Moreover 47.7, 18.5, -15.4, 40.2,

55.4% of ANP was transferred to litter compartment. System transfer function of SD to litter was observed to be minimum on site E being 70.4% only while maximum value was estimated on Site C amounting 236.7%. The values for litter to litter disappearance were recorded very low on site B (34.68%), A (38.15), E (76.8%). On Site C and D the amount were observed as 169.64% and 80.32%, respectively. Belowground disappearance ranged between 1.56% (site C) to 46% (site A). Total disappearance values were observed amounting to 31.21, 21.82, -102.5, 20.56, and 39.11% on site A, B, C, D and E respectively.

Table 4: System Transfer Function

Compartments	Site I	Site II	Site III	Site IV	Site V
TNP-ANP	0.54	0.49	0.40	0.46	0.62
TNP-BNP	0.46	0.51	0.60	0.54	0.38
ANP-SD	0.49	0.15	-0.65	0.50	0.79
SD-L	0.97	1.22	2.37	0.81	0.70
ANP-L	0.48	0.19	-1.54	0.40	0.55
L-LD	0.38	0.35	1.70	0.80	0.77
BNP-BD	0.46	0.37	0.02	0.11	0.33
TNP-TD	0.31	0.22	-1.03	0.21	0.39

Discussion

Most grassland have a unimodal pattern of increase and decrease in green biomass (Sims, *et al.*, 1978), the peak occurring earlier in the growing season in sites dominated by cool season species and later on grasslands dominated by warm season species. Year to year variations in peak green biomass depend more on amount of precipitation during the growing season than on other environmental factors (Smoliak, 1956; Ricklefs, 1973). The presence of dead shoots in the canopy is a function of the rate of production and of senescence of the green shoots. In a natural ecosystem (Pine Forest) the needle litter has been estimated at 6076 Kg ha⁻¹ year⁻¹, with a carbon content of 534.6 g kg⁻¹ of pine needles (Singh and Bhatnagar, 1997). Besides the pine needles, other forms of vegetation also contribute to the mineralization process in the pine forest. Net primary production in any ecosystem represents the integration of all the effects of abiotic factors on primary producers

as well as the genetics of the various plant species (Lauenroth and Whitman, 1977). The net primary productivity varies from season to season in both aboveground and belowground parts and is greatly influenced by abiotic and biotic factors. Maximum ANP was observed at site A. Belowground net production was maximum at site D due to translocation of food material from aboveground to belowground. Belowground production was recorded higher than aboveground production in all the study sites. It might be due to the translocation of photosynthates to root which forms the storage organs as sites is represented by many underground perrenating organs bearing plants. Fluctuations in underground biomass during the season are a function of losses that result from decomposition and root exudates, as well as translocation of photosynthates back and forth to shoots. The climate and intensity of biotic interference are the most important determinants of the structure and function of the vegetation. The great-

er herbage yield under *Pinus roxburghii* forest as compared to other forest may partly be due to the annual or periodic fires which characterize the pine habitat. The difference in productivity across different grazinglands, within similar rainfall conditions, can be attributed to the difference in species composition, physiographic conditions and soil moisture storage (Sah. *et al.*, 1994).

Net Accumulation and transfer rates are presented in Block Arrow Model (Fig 1). The figures show that there was higher accumulation of organic matter in root compartment than shoot compartment during the growing year. Root organic accumulation was higher on site D ($1.30 \text{ gm}^{-2} \text{ day}^{-1}$) and E followed by site A ($1.28 \text{ gm}^{-1} \text{ day}^{-1}$), B ($.85 \text{ gm}^{-1} \text{ day}^{-1}$) and C ($.35 \text{ gm}^{-1} \text{ day}^{-1}$), as reported by Rawat (1990) in Oak forests of Garhwal Himalaya.

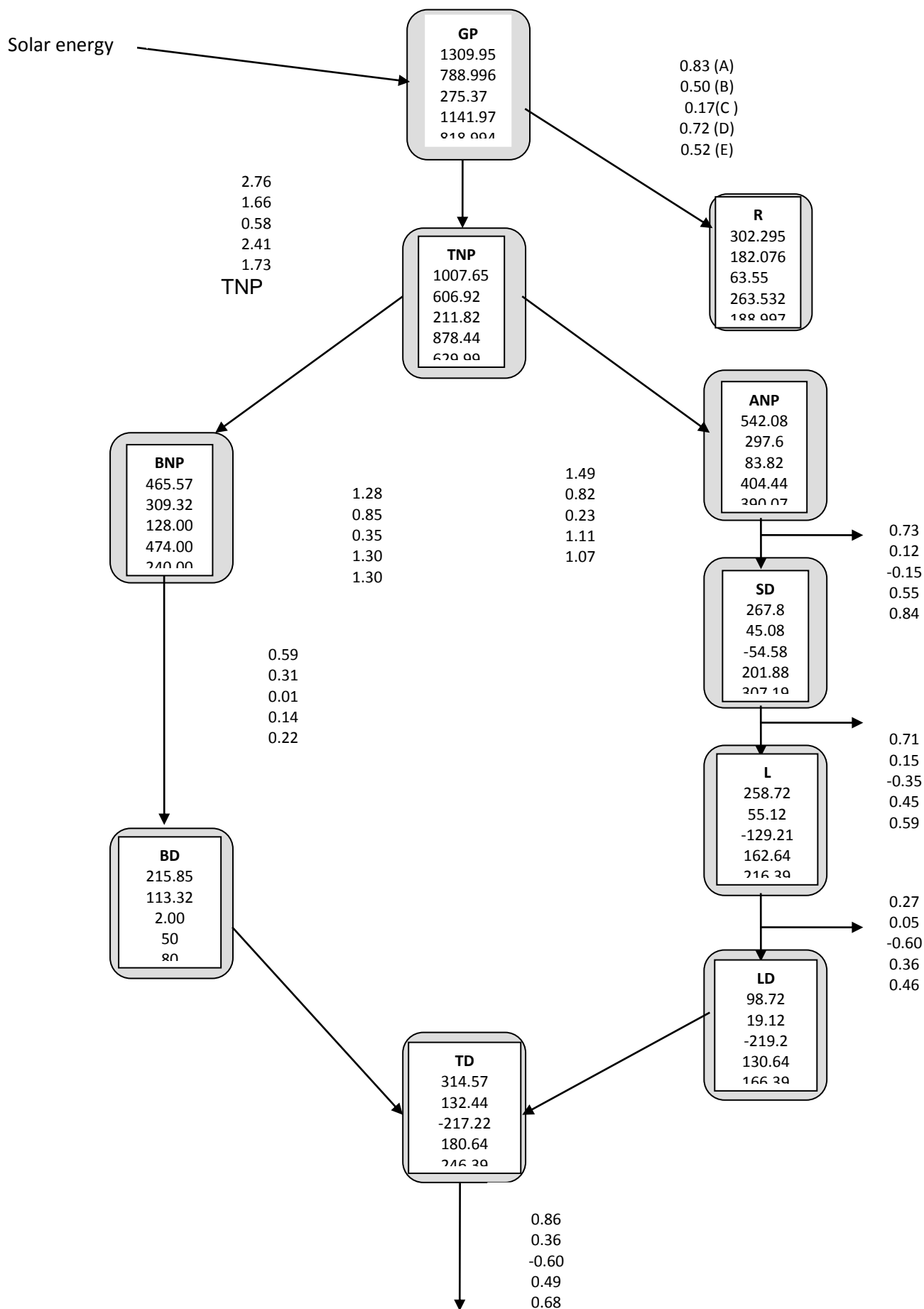


Fig 1: Net primary production, accumulation rates and disappearance rates at all sites.

GP- Gross production

TNP- Total net primary production

ANP- Aboveground net primary production

SD- Production of standing dead

L- Litter production, **LD-** Litter disappearance

BNP- Below ground net production

BD- Belowground disappearance

TD- total disappearance

Compartments- gm-2

Accumulation and disappearance rates= gm-2 day-1

Lowest accumulation of organic matter in belowground biomass appears due to the adverse effect of grazing on biomass accumulation in belowground parts (Bhandari, 1996). Higher accumulation of organic matter in the shoot compartment depicts that burning increased the transfer of organic matter to shoot compartment. It has been assumed in the present study that the only source of transfer of organic matter from live shoots is through dead shoot to litter to litter disappearance following the view of Singh and Yadava, (1974) and the organic matter of roots from root decomposition. The maximum rate of litter decomposition at site E ($.46 \text{ gm}^{-2} \text{ day}^{-1}$) followed by site D ($.36 \text{ gm}^{-2} \text{ day}^{-1}$), A ($.27 \text{ gm}^{-2} \text{ day}^{-1}$), B ($05 \text{ gm}^{-2} \text{ day}^{-1}$) and site C ($-.60 \text{ gm}^{-2} \text{ day}^{-1}$). Higher rates of litter decomposition due to fire or other factors in the montane forests of Garhwal Himalaya was also reported by (Tiwari, 1980; and Rawat, 1990). Lower accumulation and rate of disappearance of organic matter in litter compartment was due to grazing which decreases litter production through the removal of dead shoots during herbivory and ultimately affecting the rate of litter disappearance.

The net accumulation of dry matter amounting 693.08 (site A), 474.48 (site B), 429.04 (site C), 697.8 (site D) and 383.6 (site E). This accumulation was removed from the system either through wind, runoff or through local tribes.

The system transfer function values calculated for present grazing land show that 39-61%

TNP changed into ANP. 38- 60% TNP was transferred to BNP. Sims and Singh (1971) observed the values in the range of 35% to 76% and 24.65 % in belowground and aboveground compartment, respectively, in temperate grasslands of North America which are similar to our findings. Sims and Singh (1971) pointed out that higher transfer function BNP-BD probably indicates stability of grasslands. The higher total disappearance in the present study was due to active efficiency of micro-organisms in the study site.

Conclusion

The climate and intensity of biotic interference are the most important determinants of the structure and function of the vegetation. The greater herbage yield under *Pinus roxburghii* forest as compared to other forest may partly be due to the annual or periodic fires which characterize the pine habitat. Higher accumulation of organic matter in the shoot compartment depicts that burning increased the transfer of organic matter to shoot compartment. It has been assumed in the present study that the only source of transfer of organic matter from live shoots is through dead shoot to litter to litter disappearance and the organic matter of roots from root decomposition. Lower accumulation and rate of disappearance of organic matter in litter compartment was due to grazing which decreases litter production through the removal of dead shoots during herbivory and ultimately affecting the rate of litter disappearance. Higher transfer function BNP-BD probably indicates the stability of grasslands

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