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ECOLOGICAL STATUS AND IMPACT OF DISTURBANCE IN AN ALPINE PASTURE OF GARHWAL HIMALAYA, INDIA

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Abstract: The alpine area in Garhwal Himalaya is highly fragile and is known for its beautiful flora and fauna. The study area was located just below the Gangotri glacier which is the origin of Bhagirathi, a holy river of India. Pilgrimage, tourism, adventure activities and mules are the factors responsible for causing disturbance in this area. There is a remarkable variation in the values of diversity, species richness, dominance, density IVI and biomass production at Bhojbasa Protected (BP) and Bhojbasa Disturbed (BD) sites. The value of liveshoot biomass was highest in August (444 g m^{-2} on BP and 80 g m^{-2} on BD sites). Belowground biomass was also recorded highest for BP site and lowest for BD site. The ANP value at BP site was 363 g m^{-2} y^{-1} and 26 g m^{-2} y^{-1} at BD site.

This area has shown decrease in diversity and productivity, and heavy soil erosion that indicate the consequence of increasing human activities due to pilgrimage, tourism and camping and frequent movement of mules carrying goods. Therefore, this area requires strict measures for biodiversity conservation and disaster mitigation.

Key words: alpine pasture, biomass, primary productivity, compartmental transfer

Introduction

Phytosociological studies incorporate mainly the description of plant composition, floristic communities and the functional aspects. Plants in nature occur in repeating groups of associated plants called communities. The structure of a community is determined mainly by the dominating plant species and not by other characteristics [ODUM, 1971]. The increase in diversity of species in a community shows that the adaptational potential is greater to changing condition of an environment.

The alpine pastures of the Himalaya located above treeline (timberline) are regarded as herbaceous formation governed by many climatic factors [BILLINGS, 1973]. The structure and functioning of the vegetation of any area is affected by the interaction of various factors. The climate and biotic conditions have a remarkable effect on live, standing dead and litter biomass [SIMS and SINGH, 1978a], [MC NAUGHTON, 1985]. Biomass is regarded as the total dry weight of vegetation at any time for a unit area in an ecosystem.

Himalayan alpine vegetation regarding biomass, productivity, conservation, structure, phenology, phytosociology has been studied by Sundriyal & al. (1987), Joshi & al. (1988), Ram & al. (1989), Sundriyal (1992), Rajwar & Dhaulakhandi (1994), Dhaulakhandi & al. (2000), Kala & al. (2002), Kala (2004) and others during last two decades.

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Material and methods

Study area

Two study sites, one protected and other disturbed, were selected at Bhojbasa located four km. down Gangotri glacier in Uttarkashi district of Garhwal Himalaya at an altitude of 3800 m. Protected site was fenced by barbed wire to inhibit any kind of disturbance. The BD site showed disturbance by grazing and trampling by mules used in the transport system and by local people and tourists.

Phytosociology

Data on climate were collected from the Observatory of National Institute of Hydrology, Roorkee at Bhojbasa. Phytosociological analysis was done using 50 x 50 cm quadrats during July and August. On each sampling date 10 randomly placed quadrats were laid down. Basal cover was quantified by selecting ten stems of different sizes for each species. The basal cover was calculated by the method described by Misra (1968).

Plant biomass

Aboveground plant biomass was collected through randomly placed 50 x 50 cm quadrats by harvesting them at ground level. Sampling was done in the concluding week of each month from May to October. Belowground biomass was taken from 3 soil monoliths (25 x 25 x 30 cm depth). The aboveground plants were separated into live shoot, dead shoot and litter, and weighed separately. Belowground monoliths were washed carefully and dried completely at $80^{o}C$ until constant weight.

Net primary productivity

Aboveground net primary production (ANP) was determined as the sum of positive changes in biomass in successive months plus mortality [SINGH & YADAVA, 1974]. Belowground primary production (BNP) was estimated as the sum of positive increments in belowground biomass (DAHLMAN & KUCERA, 1965). In the present study, the production estimation was made by summing up positive changes in live biomass and mortality [SINGH *et al*., 1975].

Compartmental transfer

The net accumulation and disappearance rates were calculated following the methods given by Singh & Yadava (1974) and Sims and Singh (1978a, b). System transfer function is the quantity by which the system block multiplies the input to generate the output [Golley, 1965].

Accumulation and disappearance rates

Net accumulation and disappearance rates were calculated only for the six month period. The rates were calculated following Singh & Yadava (1974); Sims & Singh (1978 b).

Results

Phytosociological analysis

In the month of August grasses dominated the BP site. Among most dominant four species, *Calamogrostis decora* had the highest importance value index (IVI) of 41.74, followed by *Trisetum clarkei* (28.87), *Stipa roylei* (18.77) and *Poa phagophilla* (18.46). *Potentilla argyrophylla* was dominant among non-graminoids with an IVI of 16.33. The least dominant species was *Astragalus chlorostachys* (Fig. 1).

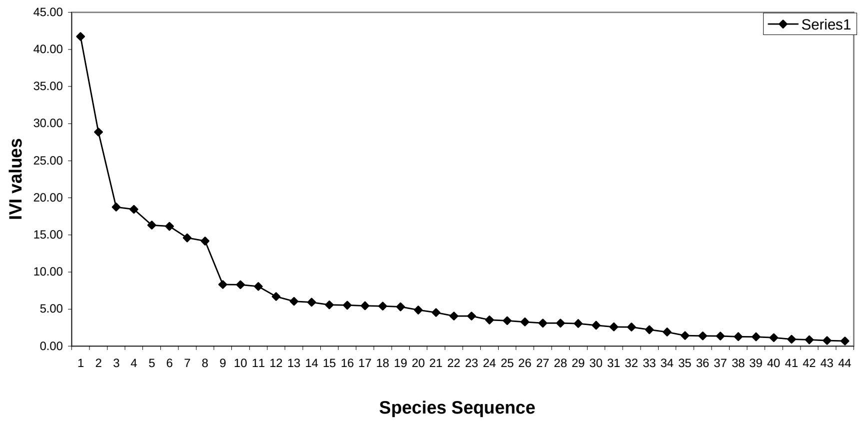


Fig. 1. Dominance-Diversity Curve for August on Bhojbasa Protected site

On BD site, in the month of August *Sibbaldia parviflora* and *Geranium pratense* were recorded as dominant and co-dominant species with IVI values of 34.08 and 28.33 respectively, and with a density of 8.15 and 10.8 plants m^{-2} respectively. Dominant six herb species were non-graminoids, while *Trisetum clarkei* was dominant species among grasses. A total of 28 species was recorded on this site. Total density value was 121.6 plants m^{-2} and total basal cover (TBC) amounted 3.26 cm^2 m^{-2} (Fig. 2). Table 1 depicts comparative data on number of species, density and total basal cover for both the sites.

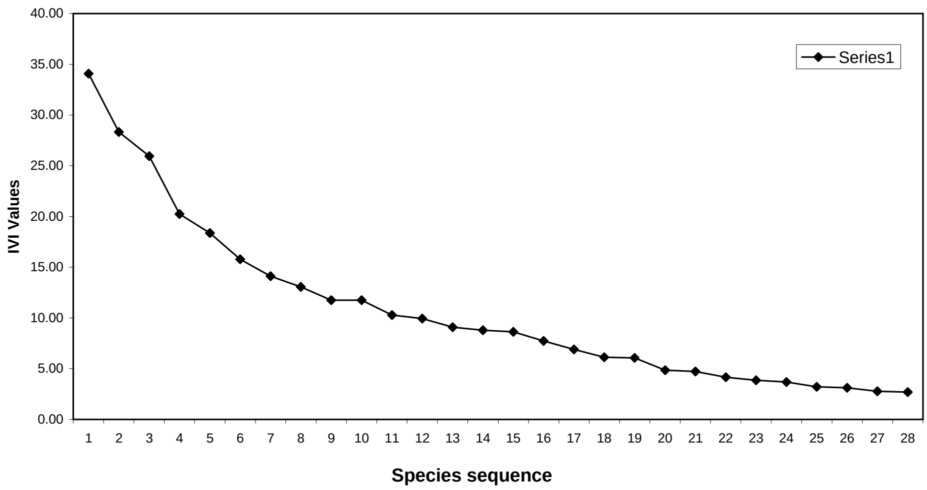


Fig. 2. Dominance-Diversity Curve for August on Bhojbasa Disturbed site

Biomass

On protected site, the maximum liveshoot biomass was recorded in August (444 g m^{-2}) (Fig. 3) and the maximum belowground biomass was observed in May (2101 g m^{-2}) and thereafter, it showed a decreasing trend until August showing least value and then started increasing (Fig. 5). Highest litterfall and standing dead biomass were recorded in October, which have been caused by severe cold (Fig. 4). The liveshoot biomass showed a positive correlationship with temperature and rainfall (r = +0.7198 and +0.4144 respectively).

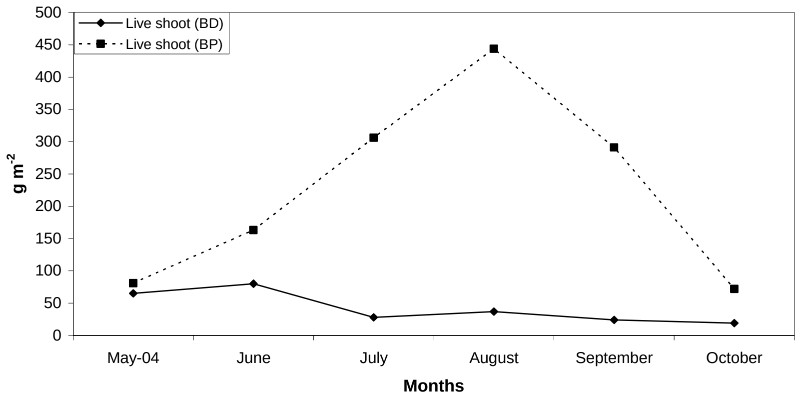


Fig. 3. Liveshoot Biomass Production (g m^{-2}) on BD and BP sites

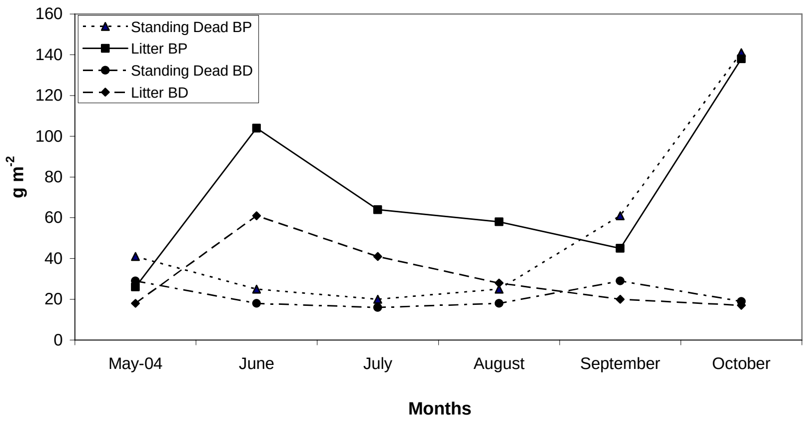


Fig. 4. Standing dead and Litter Production (g m^{-2}) on BD and BP sites

On disturbed site at Bhojbasa the liveshoot biomass decreased continuously from June (80 g m^{-2}) to October (19 g m^{-2}) (Fig. 3). July and August constituted favourable period for the vegetative growth of plants due to favourable conditions of temperature and moisture on this site but the biotic disturbance caused the least production of biomass.

Lowest values for liveshoot, standing dead and litterfall were observed in the month of October (Fig. 3 & 4). Maximum belowground biomass was recorded in October (1160 g m^{-2}) and a decreasing pattern was observed in belowground biomass from May onwards. A positive correlationship was found between mean temperature with liveshoot, standing dead and litter (r = + 0.2041, + 0.4819 and + 0.4658 respectively). Standing dead and litter showed positive correlationship with rainfall (r = + 0.7280 and + 0.0199 respectively).

Productivity

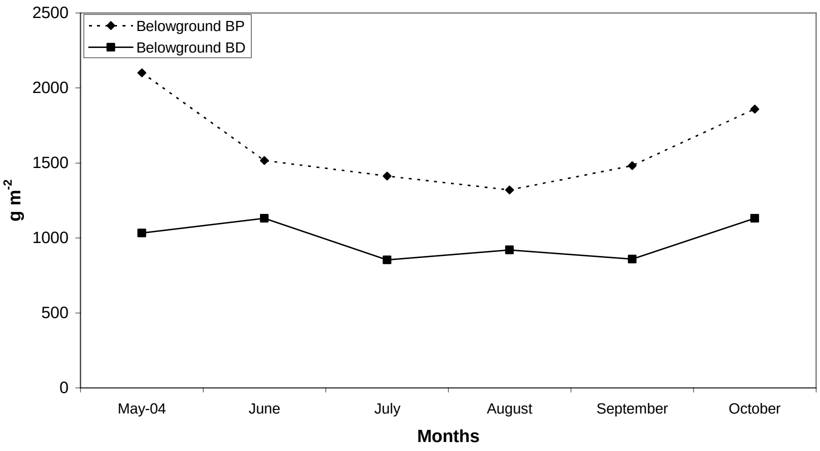


Fig. 5. Belowground Biomass Production (g m^{-2}) on BD and BP sites

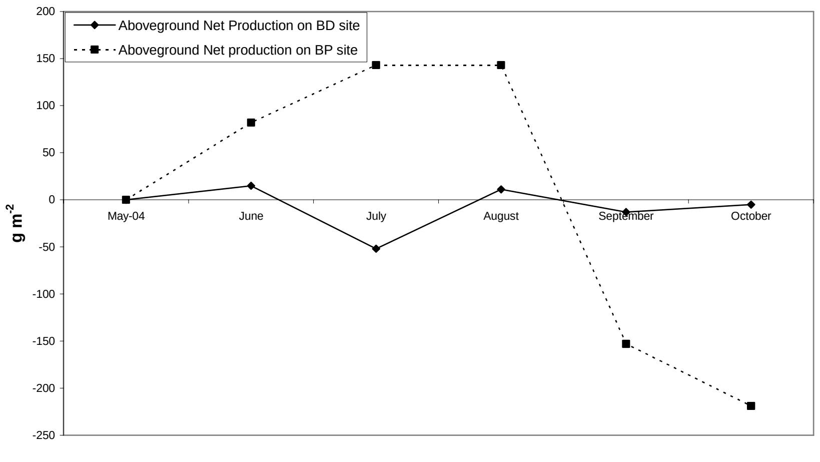


Fig. 6. Aboveground Net Production (g m^{-2}) on BD and BP sites

On Bhojbasa protected site aboveground net production (ANP) was 368 g m^{-2}. Positive values were observed consecutively for three months from June to August.

Maximum value was recorded in July (Fig. 6). On Bhojbasa disturbed site annual net aboveground production was 26 g m^{-2}, while highest value was observed as 15 g m^{-2} in June.

On Bhojbasa protected and Bhojbasa disturbed sites the values of belowground net production were 640 and 466 g m^{-2} respectively (Fig. 7).The TNP is the sum of aboveground and belowground net production (Figs. 8 to 9).

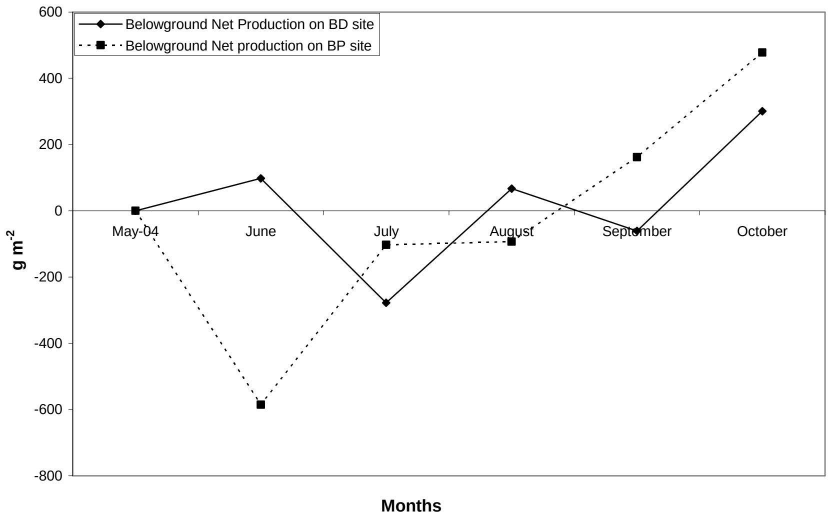


Fig. 7. Belowground Net Production (g m^{-2}) on BD and BP sites

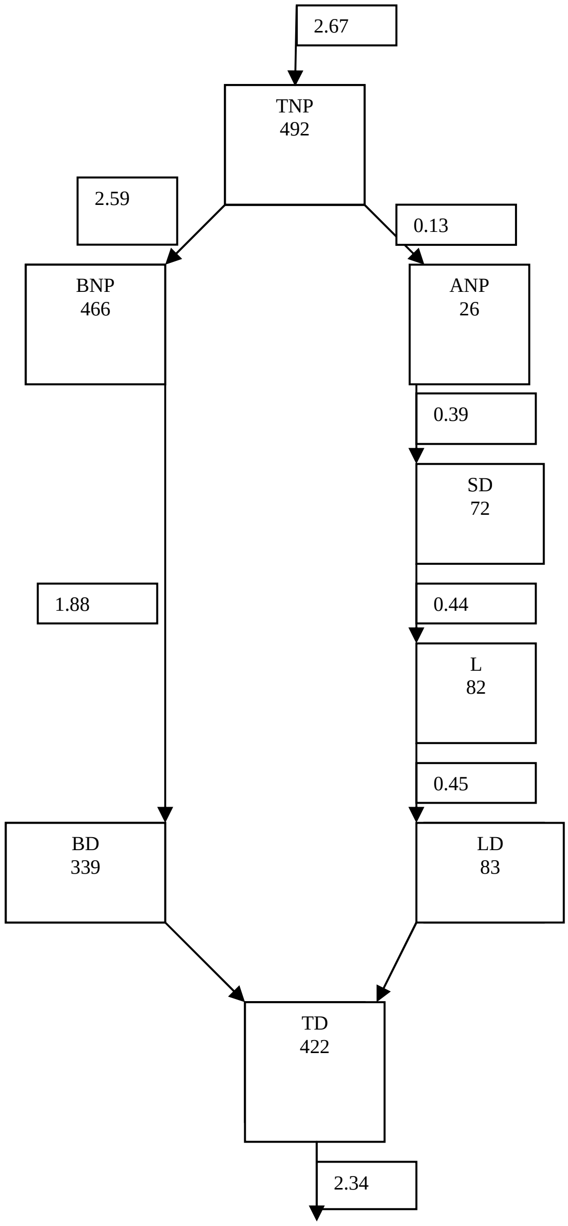
Tab. 1. Comparison of different parameters of Bhojbasa Protected (BP) and Bhojbasa Disturbed (BD) sites at Bhojbasa

Months	**No. of species**		**Total density (plants m^{-2})**		**Total basal cover (cm^2 m^{-2})**	
	BP	BD	BP	BD	BP	BD
May	17	7	206.4	56.7	3.21	0.96
June	28	17	316.9	6.5	4.61	1.11
July	36	21	456.5	72.1	6.29	1.23
August	44	28	358.0	121.6	7.65	3.26
September	26	18	293.7	83.3	5.32	2.0
October	13	9	131.1	46.3	2.79	1.56

Tab. 2. System Transfer Functions on BP and BD sites

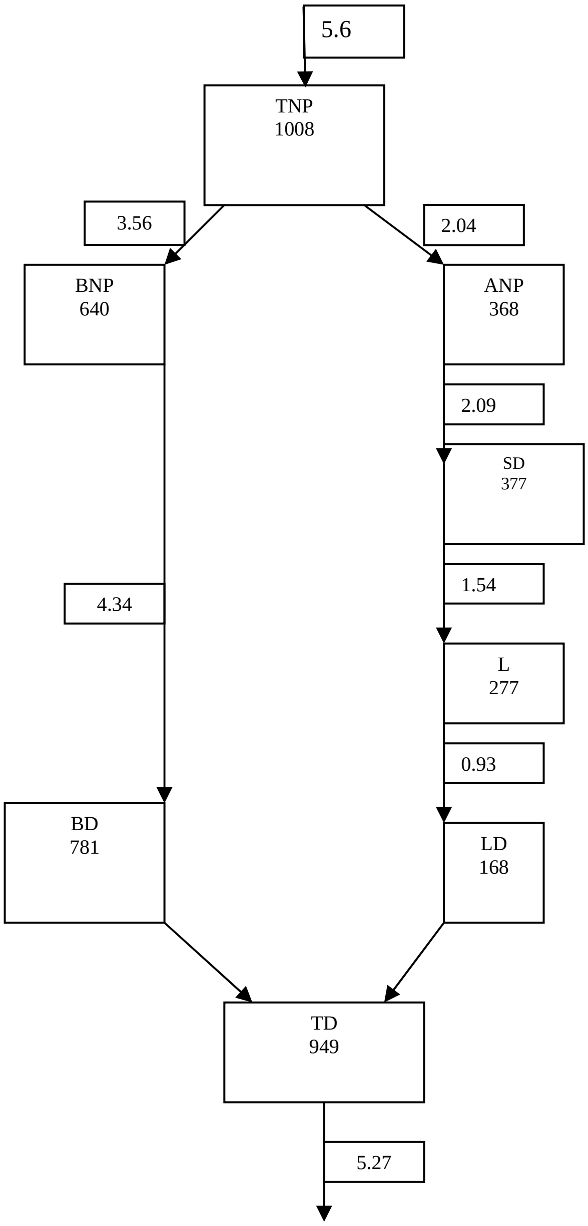
System transfer	**BP**	**BD**
TNP-ANP	0.365	0.053
TNP- BNP	0.635	0.947
ANP-SD	0.024	2.690
SD-L –	0.735	1.139
ANP-L	0.735	3.150
L-LD	0.606	1.012
BNP-BD	0.122	0.727
TNP-TD	0.941	0.858

The Figs. 8 and 9 show a balanced ecological status. The input rate in BP was 5.6 g m^{-2} d^{-1} and the rate of disappearance was 5.27 g m^{-2} d^{-1}. The values for BD sites (Fig. 9) showed input value 2.67 and 2.34 g m^{-2} d^{-1}. The values are comparatively showed low production and accumulation rates than BP site. The system transfer functions for the present study sites have been given in Tab. 2.



Compartments g m^{-2}
Accumulation and Disappearance g m^{-2} d^{-1}

Fig. 8. Net primary production, accumulation and disappearance rates on BD site for 180 days



Compartments g m^{-2}
Accumulation and Disappearance g m^{-2} d^{-1}

Fig. 9. Net primary production, accumulation and disappearance rates onBP site for 180 days

Discussion and conclusion

Plant growth in alpine region starts with onset of summer and snow melting. The growth activity increases with increase in temperature and moisture. Grazing affects the frequency and density of species [SUNDRIYAL et al., 1987, 1992; SUNDRIYAL et al., 1988]. It has been reported that the values of belowground and aboveground biomass also varied with grazing activity. It reduced the green cover over the ground and synthesized low carbohydrate which ultimately assimilated in the belowground parts.

In Bhojbasa on both BP and BD sites a sharp distinction was observed in values of total density and total basal cover. In the month of July and August, on BP site total density values were 456.45 and 358.05 plants m^{-2} respectively, while on BD site these values were 72.1 and 121.6 plants m^{-2} respectively. Similar pattern was observed for TBC on BP site with the values of 6.3 and 7.6 cm^2 m^{-2} in July and August respectively, while on BD site these values were 1.22 (July) and 3.26 cm^2 m^{-2} (August) (Tab. 1).

The structure of biomass of an ecosystem is mainly controlled by climatic conditions and edaphic characteristics, which are closely related to phenology and floristic diversity. The uniformity in increase in biomass showed the favourable conditions of climate from May to August in Bhojbasa disturbed site. During rainy season the biomass was observed less in comparison to the summer season. This season should have shown higher biomass because of favourable growth, but the frequent and unrestricted grazing by animals caused a decrease in these values. At the same time during the rainy season the tourism and pilgrimage activities were at its lowest. In the month of October sharp decline in biomass was recorded due to severe cold in the high altitudes.

On protected site the biomass increased with increasing precipitation. Biomass was highest in August and the total density in July. A sharp decline in temperature after September caused senescence in vegetative parts causing sharp decline in biomass production and number of species. On disturbed site May-June was peak period for herbaceous growth. Due to low pilgrimage and tourism activities in this period the production was low in July and August. Root biomass decreased significantly in grazed site, similar findings were recorded by Vickery (1972) and Weilgolaski (1976).

Billings *& al*. (1977) have reported that roots of tundra plants grow at low temperature below 5^{o}C and can resume active elongation even after being temporarily frozen. However biomass accumulation in belowground component could be due to retranslocation of organic matter and nutrients from shoot and the accumulation of dead root. Billings (1973) found that several major graminoids of tundra continue primary root elongation throughout the growing season. As the food storage is a prime function of underground part, it seems that high root–shoot ratios are needed just to maintain enough carbohydrate for the early spring shoot growth [BILLINGS, 1973].

On the Bhojbasa disturbed site the peak values were observed in the months of June and July because in late June or early July the pilgrimage and tourism pressure reduced and the animals were free to graze randomly.

Accumulation is the rate of production of dry matter and its transfer through various compartments. Ultimate disappearance from the system for different plots is shown in Figs. 8 to 9. Net rate of accumulation of organic matter in different compartments of the block diagrams was calculated by dividing the production value by the number of days (for present study the days were 180).

A limited amount of dry matter remains after annual cycle which may be required simply to buffer the effect of year to year fluctuations in the environment [RAM &

al., 1988]. The situation is differing from the successional tropical grassland where there is accumulation of surplus organic matter which could result in the advancement of the seral grassland to woodland conditions [GUPTA & SINGH, 1982b].

System transfer function is the quantity by which the system block multiplies the input to generate the output and reflected the orientation of the functioning of an ecosystem in space and time [SIMS & SINGH, 1971c].

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