# PRODUCTION AND COMPARTMENT TRANSFER OF DRY-MATTER IN A TROPICAL GRASSLAND COMMUNITY

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Production and compartment transfer studies of a protected *Dichanthium annulatum* (Forsk.) Stapf. dominated grassland community were undertaken from June 1971 through May 1972. The various compartments and the transfer occurring in each were summarised, and system transfer functions were calculated. Net aboveground production was considerably greater than their temperate counterparts, which may be due to basic differences in the mechanism of carbon fixation (Hatch and Slack Pathway). The fluctuation in belowground biomass and production may partly be due to carbohydrate translocation during various periods of the growth phase of aboveground live (green) parts. In all about 59 .7 per cent of organic matter disappeared annually (through litter and root disappearance) from the total net production of 989 $g/m^2$/year or 9.89 mt/ha/year.

## INTRODUCTION

Production and compartment transfer studies are important for a better understanding of the structure and function of ecosystems. Productivity, as a functional attribute of a community (Odum 1960, 1962), has attracted much attention during recent years. Primary production is defined as the gain in weight of organic matter generated by photosynthesis in a specified time interval.

In a multispecies community (present investigation) the time of maximum biomass may not be coincident with the same stage in phenological development of all species. Thus maximum biomass of the community tends to be an underestimate of net primary production. Hence, in the present investigation sums of positive biomass increment of individual species were considered as net production following the short-term harvest method as described by Odum (1960). All measurements were made in an exclosed *Dichanthium annulatum* (Forsk.) Stapf. dominated grassland community at Ujjain (23° 11′ N and 75° 44′ E).

## MATERIALS AND METHODS

The minimal size of the quadrat was determined to be 5,000 sq. cm. (Goodall 1952 and Oosting 1956). This area was cast in a rectangular shape of 50 × 100 cm in accordance with the suggestions of Green (1959), VanDyne *et al.* (1963) and Pearson (1965). Eight quadrates were sampled randomly at monthly intervals from June, 1971 through May, 1972.

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The cut vegetation was transported to the laboratory in polythene bags and was sorted species-wise into green and non-green components. Surface litter was collected for dry weight determination. For the estimate of belowground biomass three replicates of the size 50 × 50 cm were dug to a depth of 50 cm (Dahlman and Kucera 1965). Roots and subterranean parts were removed from the soil core using a jet of water in a mesh. All the plant materials were oven dried at 80°C for 24 hr and weighed.

Such observations were made at the end of each month and the data were averaged to express the standing crop above and belowground in terms of dry weight (biomass) per metre square. Sums of positive biomass increment of individual species were considered for aboveground net production. Belowground production was evaluated by summing the positive increment of biomass through the successive sampling period. The transfer or accumulation rates between different compartments and system transfer functions were calculated (cf. Sims and Singh 1971). The estimates of net aboveground primary productivity (ANP) in the present study have been arrived at by the summation of positive live (green) biomass change of individual species throughout the year. Similarly the standing dead (SD) production and litter production (L) was calculated from the sum of positive differences of individual species in standing dead and total in litter through the successive sampling dates for a year. Litter disappearance (LD) was arrived at by the method of Golley (1965).

Belowground net production (BNP) or the annual increment has been estimated by summing the positive change in biomass through the successive sampling intervals and root disappearance (RD) was calculated from the difference between peak belowground biomass and the succeeding minimum belowground biomass. Total net primary production (TNP) is the sum of aboveground net production (ANP) of live (green) and belowground net production (BNP) and the total disappearance (TD) is the sum of litter disappearance (LD) and root disappearance (RD).

Net rate of accumulation of material in different compartments of the block diagram was calculated by dividing the respective values by 365 days and are shown on the arrows in the block diagram. System transfer functions for the different compartments were also calculated (Table I).

TABLE I

*System transfer functions of dry matter dynamics*

| Compartments | System transfer functions |
|---|---|
| Total net primary production to aboveground net primary production | 0.57 |
| Total net primary production to belowground net primary production | 0.42 |
| Aboveground net primary production to standing dead | 0.74 |
| Standing dead to litter | 0.82 |
| Litter to litter disappearance | 0.62 |
| Belowground net primary production to root disappearance | 0.88 |

## Results and Discussion

Fig. 1 shows that great variation occurs in average monthly values of biomass in different primary producer compartments [viz. live (green), standing dead, litter and belowground] of the community. It is apparent that the trend of change in biomass of live (green) is reverse to that of belowground. The peak biomass of standing dead was found in the same month when the peak of belowground was obtained. Litter increases gradually from the month of September onwards. The productivity values along with the transfer occurring in each compartment are indicated in Fig. 2.

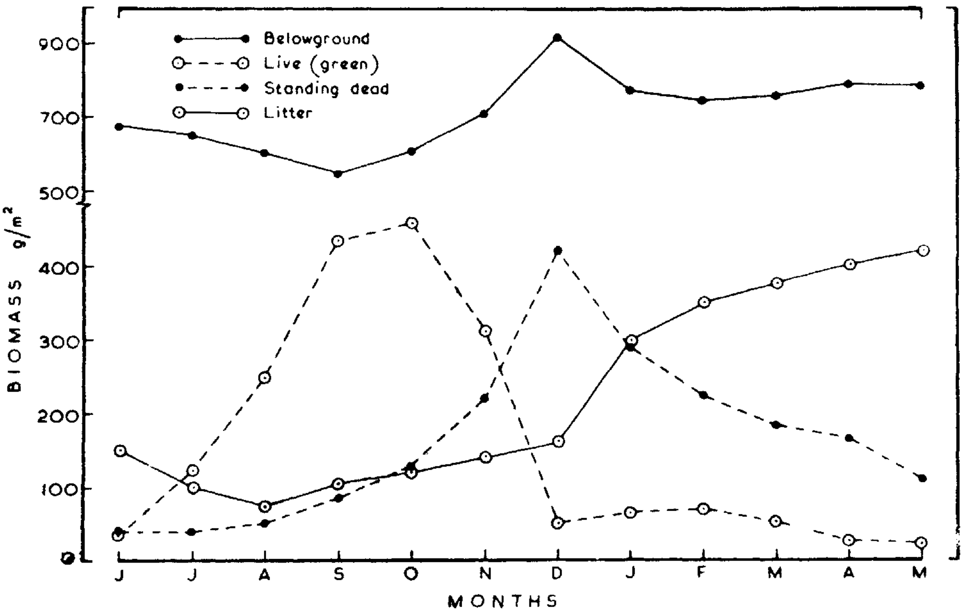


FIG. 1. Standing biomass in various primary producer compartments [viz. live (green), standing dead, litter and belowground].

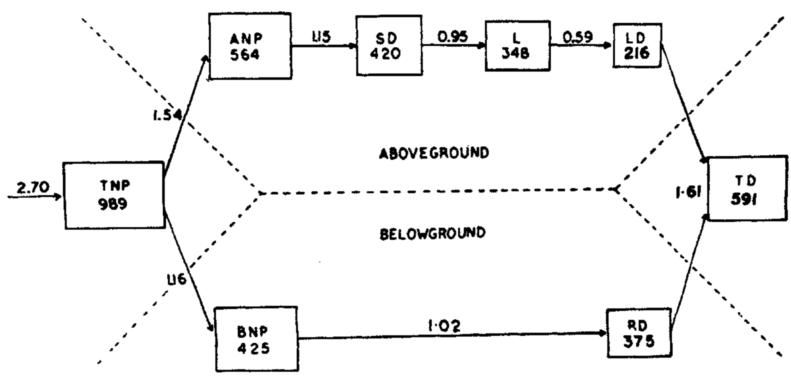


FIG. 2. Compartment transfer of dry matter. Compartments (block)—g/m²/year. Accumulation rates (arrow)—g/m²/day. *TNP*, Total net production; *ANP*, Aboveground net production; *SD*, Standing dead production; *L*, Litter production; *LD*, Litter disappearance; *BNP*, Belowground net production *RD*, Root disappearance; *TD*, Total disappearance.

On account of marked differences in the climatic conditions prevalent in different seasons and the phenological behaviour of the species, great variation occurs in the standing crop of dry matter (Fig. 1). The different behaviour of species with regard to the increase and subsequent decrease in the live (green) biomass and production on the study site reflects the effect of precipitation and subsequent dryness in the atmosphere and soil. During the rainy season (monsoon), grasses and legumes grow rapidly and after reaching a peak in September and October they dry fast in response to the dry climatic conditions. In case of *Dichanthium annulatum* and *Cymbopogon martinii* the growth of tillers again increases standing crop of green in January and February, due to the light winter showers causing sprouting of the new tillers. It is generally accepted that naturally growing plants attain maximum rate of photosynthesis at light intensity below full sunlight (Kramer and Clark 1947). During the rainy season (July through October), higher production was obtained when light is interrupted (cut off) by the clouds and on the other hand moisture is also abundant.

Net aboveground production in this grassland community is considerably greater than its temperate counterparts (Misra 1969). This fundamental difference may be due to basic differences in the mechanism of carbon fixation in the tropical and temperate plants. Many tropical grasses and forbs fix carbon by the Hatch and Slack pathway and not through the Calvin cycle which is more common in temperate plants (Hatch and Slack 1966; Laetsch 1969; Downton and Treguna 1968; Treharne and Cooper 1969 and Tieszen 1970).

The standing dead vegetation is the transitional stage between live (green) biomass and litter, as the weight of live biomass declines during winter and summer seasons, the weight of standing dead increases. The monthly and seasonal variations of standing dead production vary considerably. The maximum was obtained in the month of December, when most of the species dried up after attaining their peaks, hence, the green part of the vegetation converted into standing dead.

The litter compartment has two input sources, the standing dead from previous years and the annual input from green vegetation (Golley 1965). During the wettest months, i.e., July and August, value for ground litter decreases, probably due to high decomposition rate and also due to negligible addition to this category from the standing dead.

The fluctuation in belowground biomass and production may partly be attributed to carbohydrate translocation. The soluble carbohydrate reserves are used during periods of rapid growth (McCarty 1935). The plant, during periods of rapid growth, has a greater capacity to deplete carbohydrate reserves than to add to them. Consequently, the concentration of soluble carbohydrates in the roots during the early period of vegetative growth is lowered, which affects the dry weight and production of belowground parts.

The net community production 989.0 g/m$^2$/year or 9.89 mt/ha/year indicates that net production of grasslands and forests of tropical regions are equal. The reasons for equality of grassland and forest net production have not been fully explored, probably, the special physiology of certain species of tropical grasses (the Hatch-Slack carbon pathway in photosynthesis) and the fact that grass is replaced by forest in the sere are the two important factors (Golley 1972). The Hatch-Slack pathway permits photosynthesis at high light intensities with lower losses to respiration than is normal for trees and other plants.

It is evident from Fig. 2 that the community synthesizes total net organic matter at a rate of 2.70 $g/m^2/day$ out of which 1.54 $g/m^2/day$ are directed for aboveground growth and 1.16 $g/m^2/day$ accumulated belowground. About 57 per cent of the total net production is reflected in the aboveground net production (ANP) and 42 per cent is encountered in belowground net production (BNP). Rate of litter disappearance is slower than root disappearance, however, the rate of total disappearance was 1.16 $g/m^2/day$. In all about 59.7 per cent organic matter disappeared annually, through litter and root disappearance, from the total net production of 989.0 $g/m^2/year$. The system transfer function is the quantity by which the system block multiplies the input to generate the output (Grodins 1963) and is the ratio of output to input. Singh and Yadav (1972) working with a tropical grassland found these quantities to be a good measure to express the change in the ecosystem functioning in wet and dry periods of the year. The system transfer functions obtained in the present investigation indicate that more production is directed aboveground as compared to belowground . The rate of transfer from aboveground net primary production to standing dead and from standing dead to litter increases. However, the disappearance rate of belowground is more as compared to litter disappearance.

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*Original not seen.