SECTION - VII
GENERAL DISCUSSION AND CONCLUSION

In the preceding chapters at the end, a specific discussion has already been given regarding the structural and various functional aspects of the community studied. An idea of the whole picture can be made on the basis of present investigation and the studies of other workers. Present chapter deals with the synthesis of such informations and an effort has been made to give an idea of structural and functional aspects of the grassland studied. Odum (1962) was of the opinion that structural and functional study could be helpful in understanding and controlling nature.

The study area situated in the region can be characterized by long, hot and dry summer season, low precipitation and small winter season. Ombrothermic diagram of the area revealed four wet months and eight dry months. According to Thornthwaite and Mather (1955) on the basis of moisture index value (-18.75) the study area can be classified as dry sub-humid (C_1) with the ecoclimatic formula as C_1 A_3 b_1 s.

Variation in species composition showing prominent seasonal changes (Table 4) and species diversity are recorded in this protected study area. The importance of soil moisture in species diversity has also been explained by Daubenmire (1959)
and Trivedi (1976). The soil moisture and protection against grazing seem to be the chief factors responsible for species diversity in the study area. Golley and Gentry (1965), Gupta et al. (1972), Naik (1973), Srivastava (1980) and Srivastava (1987) have also noted higher number of species in protected communities.

With the onset of monsoon a flush of species appear, the annuals complete their span of life usually upto winter and then disappear leaving perennials to survive in dry and unfavourable period. According to Pandeya et al. (1977), the periodic climate is manifested in phenological diversity. Total number of species occurred was 46 out of which 44 species enlisted in rainy season. Abundance of therophytes in this area indicates therophytic phytoclimatic as well as greater biotic disturbances. Bharucha and Dave (1944), Pandeya (1953), Srivastava (1980) and Srivastava (1987) have also reported higher number of therophytes in Indian grasslands.

The percentage of species in the five frequency classes showed that $A < B > C > D < E$ for study area indicating a greater floristic heterogeneity of vegetation. It is also interesting to note that frequency classes was quite different to that of normal frequency spectrum of Raunkiaer's.

*Iseiloma laxum* showed its maximum I.V.I. in all the seasons in this study site (Table 8a, b & c). *D. annulatum* achieved
second highest I.V.I. in all the three seasons. A. monilifer also secured third rank in winter and summer season. So I. laxum and D. annulatum can be designated as dominant and sub-dominant species respectively. Greater I.V.I. of dominant, sub-dominant and other perennial species during summer season may be ascribed as absence of other associates in the community (Misra, 1973; Asthana, 1974; Trivedi, 1976 and Srivastava, 1980).

In grassland communities, changes in the phytomass values at short intervals are attributed to the marked variations in the ombrothermic and soil conditions to which the phenology of herbaceous species is strongly adapted and adjusted (Singh, 1978). Standing crop phytomass showed great variation according to seasonal conditions. In present study above ground part exhibited maximum value in December (Table 11) probably due to the lush growth of various species continued with the onset of monsoon upto winter. A clear decline in phytomass occurred after December due to death and shattering of annual species as well as seasonal tillers of perennial grasses following maturity. Maximum phytomass value for community as well as for all the compartments (D. annulatum, I. laxum, A. monilifer and 'other species') except litter was observed in September and the second peak of highest phytomass value in December. Pandeya et al. (1977) also emphasized that the changes in the above ground phytomass varied from locality to locality depending upon the
ecoclimatic. Major portion of the above ground phytomass was contributed by dominant and sub-dominant species. According to Jankowska (1968) the protection allowed better growth of grasses and thus contribution made by grasses increased with an increase in protection.

Maximum value of above ground phytomass is compared with the values of other tropical grasslands (Table 15). The value of study area is higher to that of Sagar (Jain, 1971), Jhansi (Gupta, 1976), Srivastava (1987) but lower than that of Kurukshetra (Singh and Yadav, 1974) and Orai (Srivastava, 1980).

The relation of above ground phytomass with that of density reveals positive relation ($r=0.36$, $P=N.S$), similarly basal cover is also directly related to above ground phytomass with $r=0.53$, $P=N.S$ (Fig. 8A and B). Both these statistical relations reveal that with an increase in the density and basal cover of species the phytomass increased, which is in conformity with the observation of Gupta (1978), Srivastava (1980) and Srivastava (1987).

Below ground phytomass, in this study showed higher accumulation of organic matter during rainy season, as has also been reported by Billeore (1978) and Srivastava (1980). A decreasing trend observed in below ground during winter and
summer seasons, which may be explained due to cessation of
growth and death of the root system under hot and dry conditions
and/or due to disappearance of root system during pre-monsoon
period, as new tillers appear from March to June at the expense
of the root phytomass.

Comparative account of below ground phytomass with
other studies (Table 15) reveals that the value is quite high
to that of Choudhary (1967), Billore (1973), Naik and Misra
(1974) and Srivastava (1980) and lower to that of Jain (1971),

Below ground and above ground phytomass ratio (B.G/ A.G) showed maximum value in August and minimum in winter season.
Summer season revealed higher to winter season. According to
Pandeya et al., the ratio of B.G/A.G. phytomass varied and
increased under semi-arid condition. He was of opinion that
accumulation of above ground and below ground organic matter
depends on ecoclimate, totality of soil characters and phenology.
When B.G/A.G. ratio was compared to other findings it is observed
that ratio is lower to Choudhary (1972), Dakwale (1975) and
Agnihotri (1979) and higher to Jain (1971), Singh and Yadav

Thus regarding the growth of total phytomass in dry
months it was not nil but negligible as compared to respiratory
loss, drying and weathering of old growth because of extreme
hot and dry conditions.

Rainfall influenced the annual primary productivity
in grassland. According to Whyte (1975) higher rainfall in
tropics increases the productivity. Due to complete protection
present grassland community showed higher A.N.P. When the value
of A.N.P. was compared to other communities (Table 21) revealed
that the value in present study is very much near to the
observations of Varanasi (Maurya, 1970), Jhansi (Gupta, 1976)
Ujjain (Billore, 1978) and Orai (Srivastava, 1987).

Below ground net production (B.N.P.) also showed
higher value in comparison to other places as Varanasi
(Choudhary, 1972), Delhi (Varshney, 1972), Jhansi (Gupta, 1976),
Ujjain (Billore, 1978) Mandala (Agnihotri, 1979) and Orai
(Srivastava, 1980) and lower to Sagar (Jain, 1971), Jhansi
(Trivedi, 1976) and Rajkot (Pandey et al., 1977). According to
Singh and Yadav (1974) higher B.N.P. is probably due to xeric
condition which faces deep root penetration.

Total net production (T.N.P.) of present *Iseilema-
Dichanthium* dominated community when compared to other
communities (Table 21) exhibited close relation with the
*Bothriochloa* (Naik, 1973; Ambikapur), *Dichanthium* (Billore, 1978;
Ujjain) communities. It has higher value in comparison to
Varanasi (Singh, 1972), Delhi (Varshney, 1972), Sagar (Dakwale, 1975), Jhansi (Gupta, 1976) and Mandala (Agnihotri, 1979) grasslands and lower to Sagar (Jain, 1971), Varanasi (Singh, 1972), Jhansi (Trivedi, 1976), Rajkot (Pandey et al., 1977) and Orai (Srivastava, 1980) grasslands.

Thus the present investigation revealed that this protected grassland is very near in its productivity to the grasslands of Sagar (Jain, 1971), Kurukshetra (Singh and Yadav, 1972) and Orai (Srivastava, 1980) and showed higher value than that of grassland of Varanasi (Ambasht et al., 1972), Delhi (Varshney, 1972), Ratlam (Billore, 1973), Dhakarwara (Trivedi, 1976) and Orai (Srivastava, 1987). It also showed lower value to Varanasi grassland (Ambasht et al., 1972). This difference may be due to the difference in the mechanism of carbon fixation in the tropical and temperate plants. Many tropical grasses and forbs fix carbon by C_{4} path way and not through the C_{3} path way, which is more common in temperate plants (Singh, 1978).

Relationship amongst species diversity, dominance, stability and net production revealed (Fig. 9A, B, C & D) that net production is inversely related to dominance index and directly related to diversity index. These observations support the findings of Patten (1963), Singh and Misra (1969), Singh and Ambasht (1975) and Srivastava (1987). So it is concluded
that species diversity increases productivity efficiency of
the system while dominance makes the system stable, though
less efficient for production.

Maximum rate of litter disappearance was recorded
in rainy season. This high rate of disappearance in rainy season
was probably due to warm temperature and high moisture content,
which favours to increase the growth of micro-organisms and
their activities.

Comparison of organic matter dynamics to other
communities revealed that annual production and disappearance
of organic matter of study stand is quite comparable to the
findings of Bille (1978, Ujjain) and Srivastava (1987, Orai)
(Table 23). The values are lower to the grassland of Kurukshetra
(Singh and Yadav, 1974). Thus it is evident that rate of
production and disappearance depends on the climatic conditions
of the area and other local conditions.

In Indian grasslands generally systematic analysis
showed the values of T.N.P. to A.N.P. between 39% to 69% and
this transfer function usually more than T.N.P. to B.N.P.
(Misra, 1973; Bille, 1973; Singh and Yadav, 1974; Trivedi, 1976;
Agnihotri, 1979 and Srivastava, 1987), except few grasslands
where T.N.P. to A.N.P. is less than T.N.P. to B.N.P. The same
trend also occurred in present investigation i.e. T.N.P. to A.N.P
59% and T.N.P. to B.N.P. 0.40%. Amount of loss of litter was found 1.52% which is nearer to Sims and Singh (1971) and Gupta (1976). Total value of loss of organic matter (0.32%) is much nearer to that of Srivastava (1980) at Orai (41%). Thus it is concluded by aforesaid observation that variation in different components of system transfer function may be due to the differences in climatic, edaphic and floristic characters.

Nutritive value of plant based upon its chemical composition and developmental stages. According to Lander (1937) and Patel et al. (1950) as the maturity advanced, the nutritive value of forage progressively decreased. Sen (1957) observed good protein content in young stage. Shankar Narayan et al. (1971) also reported 6.0% protein in July and 1.7% in June in Heteropogon contortus at Jhansi.

In present investigation the protein content was found maximum in July and minimum in May. A decline pattern was observed in protein content from July (rainy) to May (summer). The findings, regarding the protein content of Chakravarty et al. (1970), Mall et al. (1973), Dogra et al. (1979) and Srivastava (1987) also support present observation.

Fat is helpful to resist the temperature. So the maximum percentage of fat is accumulated in winter (January). Mall et al. (1973) were of opinion that low temperature may
cause much accumulation of fat in forage. Like the findings of Mall et al. (1973), in present study also maximum fat content occurred in January and minimum in June. Srivastava (1987) also observed maximum fat content in January and minimum in June while studying the nutritive value of grasses, legumes and forbs of grassland community at Orai.

The range of crude fibre percentage obtained in present investigation was 35.34 to 42.78% which was found within the range recorded by Sen (1957) i.e. 27.23 to 43.62%. According to Whyte (1964) the crude fibre content increases as the maturity attained by the forage. The same trend is observed in present study as the maximum fibre content occurred in May (Maturity period) and minimum in July (growing period).

Ash percentage revealed that maximum percentage was found in May and minimum in July. This observation is also confirmatory with the findings of Pandey (1978) and Srivastava (1987).

Carbohydrate content showed decreasing trend towards maturity in this investigation. The findings of Srivastava (1987) is also in support of present observation. The range of carbohydrate content occurred as 44.99% to 49.72% which was very much near to the range i.e. 45.32% to 53.81% reported by Gupta (1974).
Thus it is evident by earlier mentioned observations that protein and carbohydrate accumulated in the growing period (rainy season) with maximum values in July. As the plant attained maturity (summer season) protein and carbohydrate were utilised and the values declined showing minimum in May. Fibre and ash showed a regular pattern with maximum value in May and minimum in July. These two attributes were revealed contrast relation with protein & carbohydrate in respect of maximum and minimum values. Fat the richest source of energy is only organic matter which showed maximum storage during winter season (January) and enable the forage to resist with low temperature.

The caloric value of plant material depends upon the quality and quantity of reserve food in it. Further, the energy content of a plant or its components are governed by its fat content or nutritive status, and also its genetic constitution; and stage of life history. Energy storage constituents in plants are carbohydrates, proteins and lipids.

In the present investigation caloric value on dry weight and ash free dry weight basis was recorded. Latter seems more accurate in comparison to former because of free from all types of contamination. *Dannulatum, I.laxum, A. monilifer* and 'other species' showed maximum caloric value in January (winter) and litter showed in February on per gram dry
weight as well as ash free dry weight basis. Community also showed maximum caloric value in winter. Thus it is obvious that low temperature favours synthesis of fat, which is richest component for energy. The findings may be compared with Choudhary (1967), Singh (1972) and Srivastava (1980). Increasing trend in caloric value shown in rainy season (due to vegetation growth) reaches to highest in winter (due to highest fat content). In summer (drier months) it showed decreasing trend, due to reduction of fat content and advancement of age of the plants. These observations were also supported by Dwivedi (1970).

Accumulation of energy significantly depends on the climatic conditions and the response of the plants. In the present investigation maximum energy accumulation was occurred by all the compartments as well as community as a whole in December (winter). Above ground part showed higher energy value than below ground part. Gradual fall in the average energy value from standing live to standing dead and to litter was due to weathering and decay of organic matter. The same finding was also observed by Ovington and Heitkamp (1960), Golley (1965), Choudhary (1967), Jain (1971), Das (1974), Trivedi (1976), Srivastava (1980) and Bawa and Singh (1991). The energy stored in the plant material was transferred to the floor through litter fall as a result of death of annuals and gradual drying of perennials. The energy thus transferred through litter fall was released
to the soil by the decay and decomposition of litter due to the activity of microbes inhabiting the soil.

The overall average caloric value obtained in the present investigation is well within the range of other tropical grassland communities. The value is very similar to Varanasi, Gorakhpur and Pauri grasslands (Table 38). Mc Nair (1945) also observed variation in average caloric value in different communities.

The high value of energy conserving efficiency (E.C.E.) i.e. 4.35% was found in the present investigation, indicating that the grassland community of this region has high potential for capturing solar radiation.

*D. annulatum*, *I. laxum*, *A. monilifer*, 'other species' and litter as well as community showed seasonal fluctuation in E.C.E. Energy conserving efficiency exhibited same trend as observed in net dry matter production, because former is calculated on the basis of latter. Above ground part of the plant showed higher E.C.E. than the below ground part. This trend was also observed by Singh and Misra (1968), Singh and Yadav (1974) and Srivastava (1980).

The E.C.E. of present investigation is much greater than in the temperate and some tropical grasslands. It is very much similar to that of meadow steppe (West Siberia) and Varanasi (Table 39).
In tropical grasslands, like present grassland, year long growing season, abundant precipitation, high light intensity and preponderence of C$_4$ plants perhaps favour greater efficiency of energy conserving.
SUMMARY

In the present investigation the seasonal variation in primary productivity, nutritive value and energy conserving efficiency of three forage species namely Dichanthium annulatum (Forssk) Stapf., Iseilema laxum Hack. and Alysicarpus monilifer (W & A) has been estimated. Rest species grouped as 'other species' also has been evaluated for the study of community as a whole.

A grassland community, selected for above cited problem, was situated in I.T.I. Campus, Orai at lat. 25°59' N, long. 79°37' E and about 125 metres above mean sea level in Bundelkhand Region, Uttar Pradesh. The study area was given full & fresh protection from all the type of biotic interferences.

Computation of water balance of the study area was made following the method proposed by Thornthwait and Mather (1955) and the ecoclimatic formula obtained as $C_{1}A_{3}b_{1}s$ indicated a dry sub-humid climate of the study area.

Floristic composition of the study stand reveals that the area under investigation is dominated by Iseilema laxum Hack and Dichanthium annulatum (Forssk) Stapf. Total number of species enlisted during study period (July, 1987–June, 1988) was 46 including grasses (17), legumes (10) and forbs (19). The maximum number of species (44) was recorded in rainy season.
and minimum (17) in summer season.

Phenological study of the vegetation revealed that most of the species had flowering fruiting and seed formation in rainy, winter and summer seasons respectively. Life form classes indicate a Therophytic nature of the stand.

Total vegetation frequency, density, abundance, basal cover, relative frequency, relative density, relative dominance and importance value index (I.V.I.) of individuals of the species have been worked out. The percentage species in the five frequency classes showed heterogeneity in the grassland studied.

On the basis of I.V.I. *Iseilema* and *Dichanthium* ranked as dominant and sub-dominant species. Both the species showed their maximum I.V.I. in ascending manner in rainy (105.56 & 89.02) winter (117.96 & 102.02) and summer (124.46 & 106.52) seasons respectively. Seasonally *Alysicarpus* showed its I.V.I. as 5.13, 8.59 and 10.27 in the same manner as above.

Total above ground phytomass for *D.annulatum*, *I.laxum* and 'other species' showed their maximum value in December i.e. 361.93, 445.25 and 525.10 g/m². *A.monilifer* obtained its maximum value in September (91.00 g/m²). Minimum value for *D.annulatum*, *I.laxum*, *A.monilifer* and 'other species' was observed in June i.e. 155.35, 171.33, 5.70 and 225.67 g/m² respectively. For
community maximum (1574.61 g/m²) and minimum (727.50 g/m²) values were found in December and July respectively.

Total below ground phytomass showed maximum value for D. annulatum, I. laxum and A. monilifer in August (309.50, 321.9 and 34.50 g/m² respectively) and for the 'other species' in September (423.62 g/m²). The minimum value was 126.24, 150.34, 1.10 and 176.26 g/m² respectively in the month of June for all the cases. For community maximum (1049.10 g/m²) and minimum (453.94 g/m²) values were observed in August and June respectively.

Total phytomass varies considerably in different months. Maximum value for community(2397.38 g/m²) was obtained in September followed by December, the second peak (2296.48 g/m²) and minimum value of 1237.84 g/m² in June. The same trend was exhibited by all the components except the litter. Maximum percentage contribution of Dichanthium, Iseilema, Alysicarpus 'other species' and litter was found 28.11, 32.21, 4.70, 38.50 and 18.24% in the months of August, July, September, September and June respectively.

Below ground/above ground (B.G./A.G.) ratio remained always less than one except in August (1.07).

Above ground net production (A.N.P.) was obtained as 1186.46 g/m²/yr and below ground net production (B.N.P.) as 820.00 g/m²/yr. Total net production (T.N.P.) worked out was 2006.46 g/m²/yr.
In A.N.P. (1186.46), the share of *D. annulatum*, *I. laxum*, *A. monilifer*, 'other species' and litter was 261.49, 312.20, 92.14, 401.83 and 118.80 g/m² respectively at the rate of 0.72, 0.86, 0.25, 1.10 and 0.32 g/m²/day respectively. Percentage contributions observed were 22.03, 26.31, 7.77, 33.87 and 10.01% for above mentioned compartments respectively. Seasonally all the three species, 'other species' and litter showed maximum A.N.P. in rainy season and minimum (Zero) in summer season with an intermediate value in winter season.

In B.N.P. the share of *Dichanthium*, *Iseilema*, *Alysicarpus* and 'other species' was found as 211.24, 293.75, 7.64 and 307.37 g/m² with the rate of 0.58, 0.80, 0.02 and 0.84 g/m²/day respectively. Percentage contribution exhibited by these compartments was 25.76, 35.82, 0.93 and 37.48% respectively. Seasonally maximum B.N.P. for *Dichanthium*, *Iseilema* and 'other species' was noted in rainy season while for *Alysicarpus* in winter. Minimum value for *Iseilema*, *Alysicarpus* and 'other species' was observed in summer season while *Dichanthium* showed in winter. Percent contribution of A.N.P. and B.N.P. to T.N.P. was found 59.13 and 40.86% respectively.

The annual net production is comparable with that of some other tropical grasslands. The study stand (community) seemed to be highly productive (20.06 ton/ha/yr).
Statistical relationship between structural and functional aspects revealed a negative relationship between diversity index and dominance index, net production and stability and dominance index and net production, while a positive relationship was found between dominance index and stability.

Organic matter dynamics so exhibited revealed that the present grassland community synthesized 2006.46 g/m²/yr at the rate of 5.49 g/m²/day. Out of this amount 1186.46 g/m²/yr was reflected in the net growth of above ground parts at the rate of 3.25 g/m²/day and 820.00 g/m²/yr in the below ground parts at the rate of 2.24 g/m²/day.

Total loss from the community was found to be 650.44 g/m²/yr at the rate of 1.78 g/m²/day which is 32.41% of T.N.P. The resultant values indicated that litter accumulates at faster speed than its decomposition but root loss occur at faster speed than accumulation. Thus amount of remains behind as the litter did not include roots in the ecosystem over annual cycle.

Nutritive value, which is based on protein, fat, fibre and carbohydrate of three forage species, 'other species' and litter in different components varies considerably in different months.

Protein, the major building material for the body of animals and plants was maximum (5.32%) in July and minimum (3.70%)
in May. Among the compartments **A. monilifera** (legume) showed higher value (4.45-6.17%) than 'other species' (3.96-5.76%), **D. annulatum** (3.52-5.18%), **I. laxum** (3.41-5.12%) and litter component (3.20-4.50%).

Fat, the energy rich material and very useful component of diet was observed as maximum in January (2.43%) and minimum in June (2.08%). Compartments can be arranged in decreasing manner of fat as **D. annulatum** (2.26-2.65%), **I. laxum** (2.23-2.64%), 'other species' (2.02-2.33%) and **A. monilifera** (1.83-2.22%). In litter component the fat value ranged as 2.03-2.33%.

Fibre which is less nutritive but essential part of the diet attained its maximum (42-78%) and minimum (35.34%) value in the months of May and July respectively. **I. seiloma** achieved higher values (37.90-49.02%) in comparison to **Dichanthium** (37.19-48.51%). Litter component (34.69-39.65%), 'other species' (32.58-38.38%) and **Alysicarpus** (34.36-38.36%).

Ash consisting mineral nutrients essential for body was noted for maximum value (10.29%) in May and minimum (7.43%) in July. **I. seiloma** showed high ash content (8.22-11.33%) as compared to **Dichanthium** (8.24-11.31%), litter (6.20-9.96%), 'other species' (7.43-9.58%) and **Alysicarpus** (6.93-9.50%). Ash showed same trend as found in fibre content.

Carbohydrate, is very useful to produce heat, energy and fat in the body of animals. It also forms the basis of fat
and sugar in milk. It ranged from a minimum of 41.07% in the month of May to a maximum of 49.72% in the month of July. When the values are expressed on the basis of compartments, it was greater in litter component (45.32-52.34%) and lesser in 'other species' (45.98-52.28%), Alysicarpus (45.75-50.70%), Dichanthium (34.36-46.94%) and Islecloma (33.97-46.33%).

Thus on the basis of account given above the present grassland can be called as medium type in nutritive value.

Energy studies of present investigation showed high caloric values on per gram dry weight as well as ash free dry weight basis in winter season. Increasing trend in energy shown from rainy season to winter declined in summer season.

There was a gradual decline in the energy storage from standing live to standing dead, and litter component. Maximum energy accumulated in above ground part during winter (December). Community showed higher energy storage in above ground (5649.5 K.cal/m²) than below ground (3350.1 K.cal/m²).

In present investigation high value (4.35%) of energy conserving efficiency indicated that the grassland community has a high potential for capturing solar radiation. E.C.E. exhibited monthly and seasonal fluctuation trend in D. annulatum, I. laxum, A. monilifer, 'other species' and litter as well as in total vegetation. For community, only five months namely,
July, August, September, October and December showed positive values of E.C.E., out of them the month of September was noted for highest value (3.878%). Based on descending order of E.C.E. the four compartments and the litter component have been arranged as follows; 'other species', *I.laxum*, *D.annulatum*, *A.monilifer* and litter.