CHAPTER I
CHAPTER I

Introduction; Site description, Analytical methods.

Grasslands have been regarded something like a "natural bank, from which unlimited supply of capital could be drawn, without deposits being ever made", and have been used as such in the past unmindful of the serious consequences the future generations may have to face (Dabadghao 1951). Ecologically, these are considered as a type of vegetation, that comes up naturally with rains, afford grazing to the cattle for a brief period and then die out. In the light of researches, carried out in different parts of the world, grasses are now being considered as a pivotal material in the planning of a sound national agricultural policy.

Grasslands occupy approximately 45.0 million square kilo-metres area throughout the world in tropics, temperate and alpine regions (Misra 1974), approximately three fourth of which lies in tropical and sub-tropical regions. In India grasslands occupy about 8.1 % (62,879,000 acres) of the total land surface (Naik 1973). These are mainly seral in nature, for there are no examples of temperate or sub-tropical climax grasslands in this sub-continent (Bor 1942, Puri 1960, Champion and Seth 1968).
The relatively more stable grassland communities developed under the influence of fire and grazing, constitute a biotic climax or in Clementsian terminology a 'disclimax'. The other important factors responsible for the origin of grasslands are cutting and lopping of the forests and shifting of cultivation (Whyte 1964).

Ecological researches in natural grasslands, during past two decades, were mainly concerned with the floristic composition, phytosociology and succession, in relation to climatic, edaphic and biotic factors. But in the light of the unprecedented additions, during the recent years to the study of grassland ecology, the grasslands are seen as a vast natural ecosystem providing food and fodder for man and his cattle.

A very exhaustive review of work done on grasslands till 1950 has been given by Hanson (1950). Structural and functional aspects of natural grasslands and pastures were paid attention by Carpenter (1940), Har-lon (1956), Brougham (1960), Coupland (1961), Ratliff and Heady (1962), Cooke et al. (1965), McNaughton (1967), Higgs and James (1969) and Lewis (1969, 1970). Lewis (1970) has given an exhaustive account of the primary
production of the temperate grassland ecosystem.

Changes in net primary productivity and species diversity, during the course of succession, in grassland community, has been investigated by Odum (1960). Golley (1960, 1965) studied the structure, function and energy dynamics of an old field Broomsedge community. The seasonal changes in standing crop and net primary production of Kirigamine grasslands in Japan have been estimated by Iwaki et al. (1964). A comparative study of prairie, savanna, oakwood and maize field ecosystems by Ovington et al. (1963), led them to suggest a method, for estimation of net primary production, by difference method. However, Porter (1967) emphasized that the methods established in temperate regions are not applicable in prairies, where green material never becomes zero and production takes place throughout the year.

Ecological studies on grazed and protected grasslands and rangelands have been carried out by Anthony and Peterson (1955), Pearson (1967), and Ellison (1960). Other notable contributions in the field of grassland ecology are that of Bray et al.
Investigations on below-ground plant parts were not given the deserved attention because of difficulties in its sampling under field conditions, in the absence of proper technique/facilities in the early years. However, recent studies in America, Eurasia, and Soviet Union have greatly increased the amount of information on below-ground production (Bray 1963, Coupland and Johnson 1965, Troughton 1957, 1960, Wilson 1970). Importance of root/shoot ratio have been indicated by Monk (1966). While Dahlman and Kucera (1965), and Kucera et al. (1967) have investigated net production and turn over value of the underground plant parts in prairie. Other earlier workers, who studied below-ground production, are Weaver and Zink (1946), Weaver and Darland (1949), Weaver (1958, 58 a, 58 b) and Bray (1963).

Community energetics of old field terrestrial ecosystems have been studied by Golley (1960, 1961, 1965, 1969), Odum et al. (1962), Bliss (1962), Kickehfer (1962), Wiegart and Evans (1964), Wiegart (1965), Kucera et al. (1967), and Menninick (1967).

In India Hole (1911-13) is supposed to be the pioneer worker in the field of grassland ecology. Beginning of the thirties of this century emerged with

Studies on grassland productivity at Varanasi were initiated by Singh (1967-1968). Choudhary (1967) worked out productivity and energetics of Dichanthium annulatum community, at Varanasi. On the basis of these findings Singh and Misra (1969) indicated that efficiency of energy capture of tropical grasslands is greater than their temperate counterparts, and have further emphasized that in tropical grasslands, productivity increases with diversity, while dominance increases community stability at the expense of production. Ambasht and Maurya (1968), Dwivedi (1970), Ambasht et al. (1971) are other contributors from Varanasi, in this field.
Gupta et al. (1971-72), Singh and Yadav (1972), Varshney (1972), Vyas et al. (1972) have investigated productive aspect of grassland ecosystem.

In Madhya Pradesh Jain (1971), Billore (1973), Misra (1973), Naik (1973), Agarwal (1973) and Dass (1974) have worked out the productivity, energetics and mineral cycling, in different grasslands communities.

Grasslands flourishing on 'Bhata Soil' of Bilaspur were not studied from this angle. Thus under the present investigation data were collected on the physical environment and community structure and function at two sites. Since grazing by cattle viz. cow, buffalow, and goats is a normal feature of this area, one of the two sites selected in this study, was open to all sorts of biotic stress. This helped in evaluating the impact of grazing on the structure and function of these communities.

LOCATION: The present study was carried out at Mohanbhati village, approximately 25 Km. north of Bilaspur town (Fig. 1.3). Bilaspur is situated, in the eastern part of Madhya Pradesh, between 20° 5' N latitude and 82° 12' E longitude and lies almost in the centre of Chhattisgarh plains (Fig. 1.1). It stands over a plain surface, with an average height, of approximately 292.3
MAP OF INDIA

FIG. 1.1 - SHOWING POSITION OF M. P.
metres above m.s.l. According to district statistical handbook (1972) forests occupy about 18% of the total area of the district. On fallow land, unsuitable for cultivation (2.3% area of the district) grasslands have developed. The grassland near Mohambhata village was open land till 1969, when the Directorate of Forest Research, Madhya Pradesh selected the site for plantation. Approximately 40 acres were fenced and in 2/3 area Eucalyptus sp, Dalbergia sissoo, Acacia arabica, and Agave americana, were planted by the forest department. The remaining 1/3 area remained almost undisturbed for about three years and supported grassland community. Just outside the fenced area, a vast unprotected patch of the grazing land was under heavy pressure of grazing by cattle of adjoining villages. The present study has been carried out both in protected and grazed grassland communities.

CLIMATE: In Thornthwaite system of classification of climate, Bilaspur falls in tropical sub-humid region. The year is divisible into three distinct seasons viz. rainy (July to October), winter (November to February), and summer (March to June). The climatic conditions of Bilaspur, during study period (1972-1973) are recorded in table 1.1.
<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature</th>
<th>Relative Humidity</th>
<th>Solar Radiation</th>
<th>Rainfall</th>
<th>Clouds</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>34.0°C</td>
<td>41.4%</td>
<td>60.1 mWh/m²/day</td>
<td>3.0 cm</td>
<td>28 days</td>
</tr>
<tr>
<td>July</td>
<td>35.6°C</td>
<td>40.2%</td>
<td>59.8 mWh/m²/day</td>
<td>3.0 cm</td>
<td>26 days</td>
</tr>
<tr>
<td>August</td>
<td>37.3°C</td>
<td>38.9%</td>
<td>59.5 mWh/m²/day</td>
<td>2.5 cm</td>
<td>24 days</td>
</tr>
<tr>
<td>September</td>
<td>34.8°C</td>
<td>37.6%</td>
<td>59.2 mWh/m²/day</td>
<td>2.0 cm</td>
<td>22 days</td>
</tr>
<tr>
<td>October</td>
<td>32.5°C</td>
<td>36.3%</td>
<td>58.9 mWh/m²/day</td>
<td>1.5 cm</td>
<td>20 days</td>
</tr>
<tr>
<td>November</td>
<td>29.1°C</td>
<td>35.0%</td>
<td>58.6 mWh/m²/day</td>
<td>1.0 cm</td>
<td>18 days</td>
</tr>
<tr>
<td>December</td>
<td>25.7°C</td>
<td>33.7%</td>
<td>58.3 mWh/m²/day</td>
<td>0.5 cm</td>
<td>16 days</td>
</tr>
<tr>
<td>January</td>
<td>22.3°C</td>
<td>32.4%</td>
<td>58.0 mWh/m²/day</td>
<td>0.0 cm</td>
<td>14 days</td>
</tr>
<tr>
<td>February</td>
<td>19.0°C</td>
<td>31.1%</td>
<td>57.7 mWh/m²/day</td>
<td>0.0 cm</td>
<td>12 days</td>
</tr>
<tr>
<td>March</td>
<td>15.7°C</td>
<td>29.8%</td>
<td>57.4 mWh/m²/day</td>
<td>0.0 cm</td>
<td>10 days</td>
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</table>

**Climate Record of Bilaspur**

Total: 875.10 cm
The average annual rainfall at Bilaspur is 1327.8 mm. (Appendix -1). However, the study year was relatively dry with only 875.10 mm. rainfall.

Fig. 1.4 depicts monthly variation in rainfall, temperature and humidity at Bilaspur during July 1972 to June 1973. July, August and September were the wettest months of the year, with rainfall exceeding 100 mm. From middle of June to October when average daily temperature is low in relation of the amount of precipitation, humid period prevails. During this time relative humidity remains high, which offers favourable opportunities for growth. The unfavourable season (dotted area) caused by water shortage, is prevalent for most part of the year. High average daily temperature without rainfall is the characteristic feature of summer season, whereas winter is distinguished by low daily temperature and scanty rainfall restricted in the month of February. These constitute the unfavourable period for growth.

The solar radiation data was procured from Nagpur, the nearest meteorological station (about 408 Km. from Bilaspur) situated almost on the same latitude. The lowest value 327 cal/cm²/day was recorded during the rainy season, (August), and highest in summer 556 Cal/cm²/day (May). It ranges from 404 to 460 cal/cm²/day in winter.
FIG 1.4 A - PRECIPITATION-TEMPERATURE VARIATIONS DURING 1972-73.

FIG 1.4 B - TEMPERATURE-HUMIDITY VARIATION DURING 1972-73
**G O L O G Y:** The most conspicuous feature of Chhatisgarh plains are lower Vindhyan rocks, consisting of shales and lime stones with subordinate sand stone. The formation of Bilaspur district could be classified into three systems viz, Gondawana, Cuddapah and Dharwars with Archeans. Western half of the district is covered by Archeans and Dharwars and the eastern half by Gondwana. The Archeans are exposed in the north-western part of the district and have given a rugged topography to this region.

**G O I L:** Bilaspur soils belong to Cuddapah and Vindhyan formations. These systems constitute an ancient formation and therefore soils derived, are all highly mature and silicious in nature. In the soil map of Madhya Pradesh (Kumar 1972) Chhatisgarh has been put under red and yellow soils. These soils occupy most of the eastern district of the state and are classified into the following four groups:

1. **Kanhar soils:** deep heavy clay soil 50-55% clay with abundant lime concretions.

2. **Dorsa soils:** contain 40-45% clay.

3. **Matasi soils:** 30-35% clay, shallow and coarse textured.

4. **Bhata soils:** very shallow and almost free from lime concretions.
1. ALLUVIAL SOIL
2. DARK BLACK SOIL
3. SIMPLE BLACK SOIL
4. SHALLOW BLACK SOIL
5. RED & BLACK SOIL
6. RED & YELLOW SOIL
7. OTHER TYPES

FIG. 12 — SOIL MAP OF MADHYAPRADESH
The soil of the sites selected for the present investigation falls under 'Bhata' soil of the above classification. Bhata is local vernacular name given to the red coloured soils. It is a complex of diverse types of soils, occurring in this region. 'Bhata' is considered to be an infertile soil. It consists of a slight sprinkling of sandy soil over gravel. The 'Bhata' soils vary from place to place in their characteristics like colour, texture and soil reaction. Soil full of stones and ferruginous gravel, which impart red colour to it, is known as 'Red Bhata'. If formed from the shales, these are called as 'Pathar Bhata', and when developed on ferruginous gravel without the characteristics red colour, is known as 'Kankar Bhata', although the soil is reddish in colour at the surface and at various depths.

Mechanical composition of 'Bhata Soil' and its textural classification, based on Alexander (1952), is incorporated, in the table 1.2. In the protected area soil down to 30 c.m. depth is constituted by 41.0% clay, while in grazed area, the deeper soil layers no doubt show a moderate amount of clay (23%), contain 34.2% sand. One possibility for the difference in clay content may be, that the leaching and run off
<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Sandy Clay Loam</th>
<th>Sandy Clay</th>
<th>Clay Loam</th>
<th>Sandy Loam</th>
<th>Loamy Sand</th>
<th>Loamy Sand</th>
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<tbody>
<tr>
<td>0-10</td>
<td>23.00</td>
<td>32.40</td>
<td>41.00</td>
<td>34.20</td>
<td>36.70</td>
<td>30.30</td>
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<td>10-20</td>
<td>26.00</td>
<td>6.00</td>
<td>0.00</td>
<td>6.00</td>
<td>19.45</td>
<td>8.55</td>
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<tr>
<td>20-30</td>
<td>30.00</td>
<td>32.50</td>
<td>19.45</td>
<td>42.50</td>
<td>16.12</td>
<td>13.38</td>
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<td>30-40</td>
<td>9.00</td>
<td>14.40</td>
<td>14.00</td>
<td>40.30</td>
<td>18.10</td>
<td>11.40</td>
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<tr>
<td>40-50</td>
<td>14.40</td>
<td>6.05</td>
<td>18.10</td>
<td>12.50</td>
<td>62.25</td>
<td>2.40</td>
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**Mechanical Analysis of Soil Samples from Different Depths at Protected and Grazed Site**

*Table E-1*
losses of finer particles are relatively less at protected site on account of good vegetal cover. Whereas soils of grazed area, being devoid of a good amount of plant cover, get subjected to quick leaching and thereby tend to be sandy.

Temperature, moisture content and pH of soils at both the sites are recorded in table 1.3. The soil moisture shows seasonal variation at both the sites. In general lower temperature is recorded in winter and higher in summer at all the three depths at two sites. It was observed that temperature generally falls as the depth increases. When the two sites are compared, the protected site show low temperature at all the depth during three seasons as compared to grazed one. Obviously this difference may be attributed to differences in vegetal cover and moisture content at two sites.

Soil moisture content vary in different seasons and at different depths at both sites (Fig.1.5). In general, moisture content was high during rainy season and low in summer. Also with increasing depth, there is marked increase, in the moisture content at both sites. Comparison of the sites reveal that at the protected site, values are higher than grazed site,
<table>
<thead>
<tr>
<th>Month</th>
<th>1° Soil Temp. °C</th>
<th>2° Moisture Percent</th>
<th>3° Soil pH</th>
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** Moisture and Grazed Sites**

Monthly variation in soil temperature, moisture content, and pH at 1.5 ft - 1.3
FIG. 1.5 - SEASONAL & DEPTH WISE VARIATION IN SOIL MOISTURE CONTENT AT PROTECTED & GRAZED SITES.

FIG. 1.6 - SEASONAL & DEPTH WISE VARIATION IN SOIL-PH AT PROTECTED & GRAZED SITES.
during all the three seasons and depths.

The pH of soil was minimum (6.4-6.8) during rainy season and maximum (7.0 to 8.0) during summer at both the sites (Fig. 1.6). However, its value was relatively low at protected site. During rainy and winter seasons pH value at protected site was low as compared to grazed site. On the other hand pH of grazed site gradually increases from 6.8 (rainy) to 7.9 (summer). In all the seasons there was increase in pH with increasing depth.

BIOTIC ENVIRONMENT: - Grazed site was open to all types of biotic disturbances. The area was under constant stress of intensive grazing by village cattle predominated by cows. Besides, buffalo and goats were other large herbivores, which graze at this site. It was observed that the grazing intensity was high during rainy season with an average daily duration of 6 to 8 hours. Frequency of grazing, slows down after cessation of monsoon and in summer season it reaches its lowest ebb, as all the above ground plant parts die out due to prevailing high temperature and low soil moisture.

The following are the methods adopted to study the species structure, biomass, net primary
productivity, and energetics of the plant community and to determine certain physical and chemical properties of the soil.

COMMUNITY STUDIES :- The analytical characters viz, frequency, density and dominance of plant species were determined by quadrat method (Misra, 1968). A circular quadrat of 50 c.m. area was used for this purpose (Van Dyne et al. 1963, Pearson 1965). The quadrat size was predetermined by the species-area-curve method (Goodall 1952, Oosting 1955). Every month ten randomly distributed quadrats were studied for determination of the above mentioned analytical characters, on each of the protected and grazed sites, from July 1972 to April 1973.

From these data the relative values of frequency, density and dominance for all the species were calculated and finally the importance value index (IVI) of each species was determined by adding these values. (Misra 1968).

Phenology of plant species at both the sites was also recorded during the study period. This has been shown through phenograms (Singh 1968, Agarwal 1973). Index of species diversity at each site was
calculated according to the following formula of Golley and Gentry (1966).

\[
\text{Diversity index} = \frac{\text{Total number of species}}{\text{Number of species per square meter}}.
\]

Indices of species similarity and dissimilarity at two sites has been calculated according to the following formula of Sorensen (1948)

\[
S = \frac{2 \cdot C}{A + B}
\]

where \(S\) - Species similarity based on number of species in two samples.
- \(A\) - Number of species in sample A (protected site)
- \(B\) - Number of species in sample B (grazed site)
- \(C\) - Number of species common to both sites.

Species dissimilarity = 1 - \(S\)

**PLANT BIOMASS**: Data on standing crop biomass of live and dead plant material of the above ground and underground plant parts were collected for seven months i.e. July, August, September, October (rainy season), December, February (winter season), and April (summer season). Due to complete drying up of vegetation in hot summer data for May and June were not recorded. Sampling was done in ten randomly
located quadrats of 25 x 25 cm. size in last week of each month.

Clipping of the above ground plant parts with scissors, in each quadrat was done as close to the ground level as possible. The clipped samples of each quadrat were kept separately in polyethylene bags. The litter present on the soil surface was also collected quadrat wise. The dead plant parts which fell on the soil while cutting the plants were included in the litter. These samples were then brought to the laboratory and species wise green and non-green components were separated. After keeping all the samples in separate paper bags these were dried in oven at 80°C for 24 hours and weighed.

For below ground biomass determination three monoliths, of 10 x 10 x 30 cm. size were dug out each month from both the sites. The monoliths were taken from the places where clipping of above ground parts was done. Floatation method (McKell et al. 1961) was applied for separation of roots from the soil. The monoliths were kept within large earthen pots filled with water. After twelve hours, when the soil became sufficiently wet, aggregates of soil were broken to loosen the roots. The
suspension was then transferred to a bucket and stirred vigorously. This enabled the lighter to come up near the water surface, leaving the heavy soil particles in the bottom. The suspension was poured on a sieve to collect the root material. This process was repeated several times till no root was left in suspension. Roots were finally washed thoroughly with running water to remove the finer soil particles adhering to the surface. These were then kept in paper bags and transferred to a hot air oven, for drying at 80°C for 24 hours and weighed afterwards.

**NET PRIMARY PRODUCTION** :- The apparent net above ground primary productivity was calculated by summation of positive increase in the total above ground standing crop biomass. The latter is the sum of above ground live biomass, standing dead and litter. Similarly below ground productivity, has been calculated by summing positive changes, occurring during sampling period (Grassland Biom, IBP 1972). Net primary production was calculated on seasonal basis. Since May and June are the hottest and driest months of the year, the entire area remains barren for these two months, hence the values of the plant biomass recorded...
In last week of April has been taken as initial biomass to compute the productivity for the month of July.

Turn over value is expressed as the ratio of annual increment to maximum biomass (Dahiman and Kucera 1965). The transfer or accumulation rates of dry matter between different compartment and system transfer function were calculated according to the method suggested by Golley (1965), Sims and Singh (1971) and Singh and Yadav (1972).

Litter disappearance (LD) was calculated from the peak litter biomass and succeeding minimum biomass of litter. Similarly root disappearance (RD) was calculated from the difference between peak below ground biomass and the succeeding minimum below ground biomass (Misra 1973).

**Caloric Value:** Dried plant parts were powdered with the help of hand mortar and pestle and a homogeneous powder was obtained, by passing it through 0.5 mm sieve. Pellets were prepared with the powdered material and dried for two hours at 100° C. Thereafter, these were transferred to a dessicator. After cooling down,
individual pellet was weighed accurately up to the fourth decimal place. These were then used for bomb calorimetry. Three pellets were ignited for each sample. Due corrections were made for fuse wire and for the acid formed, during combustion. The caloric value was calculated according to the following formula (Lieth 1968):

\[
V = \frac{W \Delta t - \Sigma c}{G}
\]

where
- \(V\) - Calorific value (cal)
- \(W\) - Volume of water (mL)
- \(\Delta t\) - corrected temperature (°C) difference in reading of Beckman thermometer before and after burning.
- \(\Sigma c\) - Correction value for the ignition wire
- \(G\) - sample dry weight (g)

Caloric value have been expressed both on per gram dry weight and ash free dry weight basis.

Ash content of the plants was determined by igniting known amount of oven dried powdered samples, in muffle furnace at 500 - 550 °C for 3 to 5 hours till residue was obtained (Peach and Tracey 1956).

Efficiency of energy capture has been
calculated by the following formula (Misra 1974):

\[
\% \text{ Energy conserving efficiency} = \frac{\text{Net production} \times \text{Energy per gram ash free dry weight}}{\frac{1}{2} \text{ solar radiation}} \times 100
\]

**SOIL ANALYSIS** :- Certain physical and chemical properties such as temperature, moisture content and pH of the soil samples collected from three depths viz. 0-10, 10-20, 20-30 cm at both the sites was studied during experimental period.

Mechanical analysis of soil was done by international pipetting method of Piper (1944). Soil temperature in different months was recorded at all the three depths by ordinary thermometer. Triplicate readings were taken for each depth. Moisture content of soil samples, from three depths, was determined by drying it in oven at 105°C for 24 hours (Misra et al. 1970). Soil pH was determined with the help of an electrically operated pH meter. Statistical calculations were done as suggested by Snedecor and Cochran (1967).