STUDY AREA AND METHODS

Study area

Nokrek Biosphere Reserve (NBR), where this study was carried out, is spread over an area of 820 sq. km covering parts of East Garo Hills, West Garo Hills and South Garo Hills districts in Meghalaya. It lies between 90°13’ E and 90°35’ E longitudes and 25°20’ N and 25°29’N latitudes (Fig 1.1a). It is situated on hilly terrain of Tura ranges of mountain system with altitude ranging from 200 m to 1415 m asl. The highest peak of this ridge called Nokrek Peak (1415 m asl) lies within the Core Zone of the NBR. The core zone of the NBR, which is also designated as Nokrek National Park, covers 47.48 sq. km area of the ridge of Nokrek Hills, spread in east-west direction. The northern aspect of the National Park is comparatively of gentle slope while the southern flank consists of hills with very steep to moderate slopes. The core zone of the BR has the distinctive virgin vegetation of Meghalaya. The major rivers of the Garo Hills viz., Simsang, Dedari, Dareng and Ganol, originate from the Nokrek BR. The area surrounding the core zone is the buffer zone, covering 772.52 sq. km area of the BR.
Fig. 1.1a  Map showing the location of study sites in the Nokrek Biosphere Reserve in Meghalaya.
Fig. 1.1b  Map showing the locations of the study sites within the northern sector of the Nokrek BR (● - sites studied, M- montane forests, R- riverain forests, J₁,₃,₆,₁₂ - jhum fallows of different ages, B- bamboo groves, O- orchards).
Fig. 1.1c Map showing the locations of the study sites within the southern sector of the Nokrek BR (● - sites studied, ○ - villages with coalmines, L- lowland forests, CM- coal mining affected area).
Climate

The area enjoys tropical climate with high rainfall, high humidity, mild summers and moderately cold winters. Monsoon rains are received from April to October with occasional rainfall during November to March. It has three seasons of which summer corresponds to the months from March to April, rainy season from May to October and winter from November to February.

NBR receives highest rainfall during the months of June to August. The average annual rainfall recorded at Sangsanggre, Tura during last three years (1999-2001) was 3012 mm (Fig 1.2), which was spread over 117 days.

Temperature varies from place to place depending on aspect, altitude and vegetation. The southern part of the BR is slightly warmer than the northern part. The northern aspect of the BR is the coldest area of the Garo Hills. The average temperature during the study period ranged from 33.4 °C to 14.8 °C. The highest temperature recorded was 39°C (April) and the lowest was 10 °C (Jan-Feb)(Fig 1.2).

The mean minimum and mean maximum relative humidity for the same period was 23 % and 98 %, respectively.

Geology and soil

The Garo Hills region of the Meghalaya Plateau is an extensively dissected tract formed of gneissic rocks with old inlier, and rocks of Sela group. Some patches in the northern and southern parts are formed of recent alluvium and Jaintia Series/ Simsang Series of rocks, respectively. The basement of Gneissic Complex covering an area of about 60 % of the Garo Hills of Pre-
Cambrian age is the oldest litho unit exposed in central and northern parts of Garo Hills and is composed of gneissic, granulites, migmatites, amphibolites and Bonded Iron-Formation (BIF) intruded by basic and ultra basic bodies. Over the Pre-Cambrian crest localized patchy occurrences of sedimentary rocks belonging to the Gondwana group are found comprising of pebble bed, sandstone and carboniferous shells with streak and lenses of coal. Occurrences of basaltic trap rock and rhyolitic crystals tuff as detached sheet lenses, are indicative of Cretaceous- Paleocene volcanic activity in West Garo Hills districts. Sediments of tertiary age occur extensively around Siju, Adugre, Baghmara, Rongram and many other localities towards southern part of Garo Hills. The Shella formation is composed of sandstone, lithomargic clay, shells and coal seams. The important minerals found in the region are coal, limestone, pyrite, phosphorite gypsum, glass sand, clay and iron. A strip of vast coal deposit occurs in the southern part of the Garo Hills districts. This coal is of Lower Eocene geological horizon. The concerned rocks belong to the Jaintia Series. In the entire Garo hills districts the total reserve of coal has been estimated to be 39500 million tonnes and West Darenggre area has more than 35 % of it. A considerable portion of this deposit falls under the Nokrek Biosphere Reserve, and lies in the southern and eastern buffer zone of the BR. Because of the ecological setting, peculiar land holding systems and lack of infrastructure, unscientific extraction of coal in unorganized sector is going on and the area affected by coal mining is increasing day by day.
Soil is sandy to loamy sand, and red, brown to dark brown in colour. It is acidic in nature throughout the core zone. Within the buffer zone pH of the soil was lowest in the coalmine areas (4.02) and highest in the limestone mining areas where the soil reaction was alkaline (8.08). The core zone soils are rich in organic matter and nutrients (N, P, K) compared with the buffer zone soils. Within the buffer zone itself the soil properties varied significantly from site to site (Table 1.1).

### Table 3.1: The physico-chemical characteristics of soil in different sites in Nokrek Biosphere Reserve.

<table>
<thead>
<tr>
<th>Site</th>
<th>Texture</th>
<th>Moisture content (%)</th>
<th>pH</th>
<th>N (%)</th>
<th>P (µg/g)</th>
<th>K (µg/g)</th>
<th>SOM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Loamy sand</td>
<td>22.91 ± 1.83</td>
<td>5.78 ± 0.12</td>
<td>0.57 ± 0.11</td>
<td>4.1 ± 0.56</td>
<td>225.00 ± 45.00</td>
<td>6.70 ± 0.42</td>
</tr>
<tr>
<td></td>
<td>Sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>Loamy sand</td>
<td>14.60 ± 0.46</td>
<td>5.79 ± 0.02</td>
<td>0.26 ± 0.03</td>
<td>3.3 ± 0.1</td>
<td>60.00 ± 3.0</td>
<td>5.14 ± 0.23</td>
</tr>
<tr>
<td></td>
<td>Loamy sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>Loamy sand</td>
<td>28.87 ± 0.44</td>
<td>5.79 ± 0.16</td>
<td>0.69 ± 0.06</td>
<td>2.5 ± 0.3</td>
<td>65.00 ± 5.0</td>
<td>6.68 ± 0.22</td>
</tr>
<tr>
<td></td>
<td>Loamy sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J12</td>
<td>Sandy loam</td>
<td>20.86 ± 1.70</td>
<td>5.56 ± 0.06</td>
<td>0.54 ± 0.04</td>
<td>4.3 ± 0.05</td>
<td>160.00 ± 30.00</td>
<td>5.80 ± 0.32</td>
</tr>
<tr>
<td></td>
<td>Sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J6</td>
<td>Sandy loam</td>
<td>21.27 ± 1.68</td>
<td>5.98 ± 0.11</td>
<td>0.53 ± 0.10</td>
<td>2.6 ± 0.20</td>
<td>150.00 ± 20.00</td>
<td>5.12 ± 0.34</td>
</tr>
<tr>
<td></td>
<td>Sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J3</td>
<td>Loamy sand</td>
<td>24.99 ± 1.05</td>
<td>5.99 ± 0.13</td>
<td>0.38 ± 0.01</td>
<td>2.6 ± 0.2</td>
<td>75.00 ± 15.00</td>
<td>5.62 ± 0.41</td>
</tr>
<tr>
<td></td>
<td>Sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J1</td>
<td>Sandy loam</td>
<td>21.27 ± 2.83</td>
<td>5.95 ± 0.17</td>
<td>0.56 ± 0.06</td>
<td>3.3 ± 0.6</td>
<td>205.00 ± 45.00</td>
<td>5.68 ± 0.19</td>
</tr>
<tr>
<td></td>
<td>Sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Sandy loam</td>
<td>28.11</td>
<td>6.03</td>
<td>0.43</td>
<td>2.35</td>
<td>55.00</td>
<td>4.50</td>
</tr>
</tbody>
</table>

39
<table>
<thead>
<tr>
<th></th>
<th>Sandy clay</th>
<th>Sandy</th>
<th>Sandy clay-loam/</th>
<th>Sandy clay-loam/</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>± 0.54</td>
<td>± 0.03</td>
<td>± 0.06</td>
<td>± 0.15</td>
</tr>
<tr>
<td></td>
<td>34.04</td>
<td>5.63</td>
<td>0.48</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>± 1.46</td>
<td>± 0.06</td>
<td>± 0.056</td>
<td>± 0.4</td>
</tr>
<tr>
<td>CM</td>
<td>Sandy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>± 0.72</td>
<td>4.02</td>
<td>0.20</td>
<td>2.95</td>
</tr>
<tr>
<td></td>
<td>± 0.44</td>
<td>± 0.065</td>
<td>± 0.35</td>
<td>± 0.50</td>
</tr>
<tr>
<td>LM</td>
<td>Sandy clay-loam/</td>
<td>7.14</td>
<td>8.08</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>± 1.90</td>
<td>± 0.18</td>
<td>± 0.030</td>
<td>± 0.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>± 0.12</td>
<td>± 45.00</td>
</tr>
</tbody>
</table>

M- Montane forest (Core zone), L- Lowland forest, R- Riverain forests, J$_{12}$, J$_{6}$, J$_{3}$, J$_{1}$- Jhum falls of different ages (10-12 years, 6-8 years, 3-4 years and 1-year old respectively), B- Bamboo groves, O- Orchards, CM- Coal mining affected ecosystems, LM- Limestone mining affected ecosystems.

Vegetation

On the basis of altitude, the climax vegetation of the area can be grouped into tropical and subtropical moist hill forests.

i) Tropical evergreen forest (altitude 200-1000 m) - This type of forest is found in the southern ridge of the core zone of the BR. It covers 137.71 sq. km area, which is 16.79 % of the total area of the BR. The forests in this zone are characterised by the presence of species like Vitex peduncularis, Cyanometra polyantha, Aporusa wallichii, Ficus spp. etc. Woody climbers and twiners are also abundant.

ii) Tropical semievergreen forest (altitude 200-1000 m) – This type of vegetation is restricted to certain rocky areas and steep slopes. The areas affected by coal mining show this type of vegetation. The deciduous trees like Shorea robusta, Dillenia pentagyna, Albizia spp., Parkia roxburghii,
*Rhus javanica* are commonly seen. It covers 109.25 sq. km (i.e. 13.52 %) of the total area of the BR.

iii) Tropical moist deciduous forest (altitude 200-1000 m) – Major part of the forested vegetation type is represented by the moist deciduous forests, which are confined to the buffer zone. These forests are mostly dominated by deciduous species especially *Shorea robusta.*

iv) Riverain forests (riparian fringing forests) – These forests are found in the vicinity and along the course of the rivers. The vegetation is dominated by trees like *Drimycarpus racemosa, Aesculus assamica, Sapium baccatum, Ficus* spp., etc. The presence of a variety of epiphytes, ferns and lianas makes these forests physiognomically similar to those mentioned above. These riparian fringing forests are the continuous stretches of the core area vegetation but lie outside the boundary of the core area and are affected by the disturbance to some extent due to the shifting agricultural activities in the adjoining areas.

v) Bamboo groves – The patches of bamboo are found scattered with other types of vegetation on the areas of moderate slopes mostly along the streamlets. They are spread over 15.66 sq. km and constitute 1.91 % of the total area of the BR. These are the seral stages of the above vegetation types and mainly comprise *Melocana* sp., *Dendrocalamus hamiltonii,* etc.

vi) Subtropical broad-leaved hill forest (altitude 1000-1412 m) – This forest type is confined to the core zone. Major part of the core area (63%) is covered by this forest type, which is spread over 30.54 sq. km (i.e. 3.7 %
of the entire BR). The dominant tree species in this zone are *Helicia robusta*, *Callophyllum polyanthum*, *Gynocardia odorata*, *Elaeocarpus rugosus*, *Castanopsis armata*, *Castanopsis tribuloides*, and *Engelhardtia spicata*.

In spite of the occurrence of deciduous elements, the vegetation can be described as subtropical evergreen forest, since majority of the tree species in the canopy layer is evergreen. The ground vegetation is dominated by *Impatiens* spp., *Polygonum* spp., *Ophiorrhiza* sp., *Globba clarkei*, *Hedychium* spp., *Costos specious* etc. Ground ferns and other pteridophytes are common on the forest floor. The tree trunks and branches are covered with profuse growth of mosses, ferns and other epiphytes.

**Fauna**

The area is also rich in faunal diversity. The NBR and its surrounding area harbour a variety of mammals, birds, fishes, reptiles, amphibians and invertebrates as well. The mammals found in the BR area are tiger, Indian elephant, Indian bison, leopard, leopard cat, sambar, barking deer, Indian wolf, common fox, wild pig, Malay bear, black bear, capped langur, Assamese macaque, pig tailed macaque, stump tailed macaque, Rhesus macaque, giant squirrel, binturong, slow loris, pangolin, flying squirrel, civet, five striped palm squirrel, hare, Indian porcupine, mongoose, golden cat, hog badger, ferret badger etc.
Among the birds crested serpent eagle, great pied hornbill, Indian pied hornbill, forest eagle owl, Barn owl, scops Owl, cuckoo shrike, Indian three-toed forest kingfisher, crow pheasant, Himalayan golden back woodpecker and Indian forest night jars are the important birds. Besides, there are many varieties of ducks, parakeets, pigeons, doves, swifts, swallows, bee-eaters, wagtails, mynahs, barbets etc. A variety of lizards, snakes and other reptiles are also found in the BR.

Though this area supports a wide variety of animals, their numbers are small and thus many of these species may be under rare, endangered and threatened categories. According to one report (Anonymous, 2000), census of animals inhabiting the BR needs to be done on an urgent basis.

**Demographic features**

In total, 129 villages are located within the buffer zone of the NBR. The majority of the population consists of Garo tribe. The total human population within the BR is 39,432 with average density of 48.08 persons per sq. km. Population per village ranges from 20 to 2200. Ratio of female population to the male population is 1.106. The population of the children below 15 years age is 15,591.

The local population residing within the BR is mainly the Garos. The tribe is divided into exogamous divisions called “chatchis” viz. Sangma, Marak, Momin, Areng and Shira. Most of the Garos are Christians by faith and only a small population (10%) still follows the original Garo religion. Garo society is
matrilineal and have certain institutions to control the cohesive structure of family kinship and social relationships among the clans within their respective territorial jurisdictions called "A'khings". The major means of subsistence is shifting cultivation, whereas some families also have orchards, paddy fields or tea gardens as the source of subsidiary earnings.
Methodology

1. Characterisation of human activities and identification of various ecosystem types in the BR

Characterisation of human activities

Various human activities having important role in altering the vegetation of the BR were identified as follows-

1. The practice of shifting cultivation
2. Coal and lime stone mining
3. Permanent agricultural and horticultural practices (viz., paddy cultivation in permanent paddy fields, planting of orchards and tea gardens etc.)

An attempt has been made to determine the relative importance of these activities causing disturbance in the BR by studying spatial pattern of disturbance i.e. proportion of area under different disturbance types caused due to human activities. This has been attempted by mapping selected sites as well as collecting secondary data from different sources with the help of questionnaires and semi-structured interviews and GIS imagery.

The above-mentioned parameters were studied through extensive field visits for characterisation of human activities.

Identification of different ecosystem types

Based on the field observations, different ecosystems were identified within the BR. Different natural ecosystem types were identified based on environmental gradients i.e. along the altitudinal gradients and dominant
vegetation types. Besides these, various other undisturbed ecosystems, and man-
damaged and man-managed ecosystems based on the type of human activities
operating within them were also identified. These ecosystem types have been
discussed in detail in Chapter IV.

Site selection for detailed study

The attempt was made to select the sites as widely as possible to represent
variation among all the identified ecosystems in the northern as well as the
southern region of the BR (Fig. 1.1b and 1.1c). Two sites selected from the core
area of the BR, (C-a at 1412m altitude and C-b at 1300m altitude) were from the
northern region. In southern region, two sites in the lowland forests (L-a 708m
altitude and L-b 314m altitude) were selected from buffer zone. Similarly,
two sites R-a (altitude 915m) and R-b (altitude 968m) were selected from the
riverain forests associated with two major rivers viz., Simsang and Dedari,
respectively. These riparian fringing forests are the continuous stretches of the
core area vegetation but lie outside the boundary of the core area and are
affected to some extent by shifting agricultural activities in the adjoining areas.

All these sites constituted undisturbed ecosystems. The shifting cultivation
fallows of different ages, which were of common occurrence in the northern
region of the buffer zone of the BR, were grouped under four age groups; 10-12
year old, 6-8 year old, 3-4 year old and 1 year old fallows. Each of these four
groups was studied by selecting two sites each (J12a-b, J6a-b, J3a-b, J1a-b).
Similarly, two sites were selected from each of the two, orchards (O-a, O-b) and
bamboo groves (B-a, B-b). In the southern region, from coal mining areas two sites (CM-a, CM-b) whereas from limestone mining area only one site (LM) were selected.

Table 3.2 List of the selected sites representing different ecosystems within the BR along with their altitudes.

<table>
<thead>
<tr>
<th>Ecosystems</th>
<th>Sites</th>
<th>Altitude (m)</th>
<th>Sampled area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montane forest in core zone</td>
<td>M-a</td>
<td>1412</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>M-b</td>
<td>1300</td>
<td>0.1</td>
</tr>
<tr>
<td>Low land forest in buffer zone</td>
<td>L-a</td>
<td>708</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>L-b</td>
<td>314</td>
<td>0.1</td>
</tr>
<tr>
<td>Riverain forest in buffer zone</td>
<td>R-a</td>
<td>915</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>R-b</td>
<td>968</td>
<td>0.1</td>
</tr>
<tr>
<td>Jhum fallows (12-yr. old)</td>
<td>J12-a</td>
<td>1100</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>J12-b</td>
<td>1228</td>
<td>0.1</td>
</tr>
<tr>
<td>Jhum fallows (6-yr. old)</td>
<td>J6-a</td>
<td>1078</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>J6-b</td>
<td>1133</td>
<td>0.1</td>
</tr>
<tr>
<td>Jhum fallows (3-yr. old)</td>
<td>J3-a</td>
<td>1226</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>J3-b</td>
<td>1005</td>
<td>0.1</td>
</tr>
<tr>
<td>Jhum fallows (1-yr. old)</td>
<td>J1-a</td>
<td>1120</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>J1-b</td>
<td>1291</td>
<td>0.1</td>
</tr>
<tr>
<td>Bamboo groves</td>
<td>B-a</td>
<td>920</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>B-b</td>
<td>828</td>
<td>0.1</td>
</tr>
<tr>
<td>Orchards</td>
<td>O-a</td>
<td>938</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>O-b</td>
<td>831</td>
<td>0.1</td>
</tr>
<tr>
<td>Coal mine spoils</td>
<td>CM-a</td>
<td>250</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>CM-b</td>
<td>314</td>
<td>0.1</td>
</tr>
<tr>
<td>Limestone mine spoils</td>
<td>LM</td>
<td>149</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>2.2</strong></td>
</tr>
</tbody>
</table>
In each of these sites ten quadrats of 10m x 10m were laid randomly for all the woody individuals including trees and lianas with CBH ≥ 5 cm were enumerated. The height of the trees was measured using a calibrated bamboo stick as well as a clinometer, wherever suitable and circumference at breast height (CBH) of each individual was recorded at 1.37 m from the ground level. Shrub species were enumerated separately from these quadrats. Similarly, for the ground cover twenty quadrats of 1m x 1m were studied randomly in each site in two different seasons (dry and wet seasons).

**Identification of plant species**

The voucher specimens were collected from all the quadrats and identified with the help of local florae (Kanjilal et al. 1997, Haridasan and Rao 1985-87, Balkrishnan 1981-83). Tentative identifications were confirmed by matching the specimens with the herbarium sheets in BSI Herbarium, North-Eastern Circle, Shillong, Herbarium of Department of Botany, NEHU, Shillong and CNH, Howrah. All the identified species were recorded along with their habit and habitat details. Besides the quadrats, the plant samples were randomly collected to inventorise the plant biodiversity and were recorded under different ecosystem types identified within the study area.

**Analysis of biodiversity**

The analysis of biodiversity was carried out by calculating Shannon Diversity Index ($H'$), Simpson Dominance Index (D) and Pielou Evenness Index
These indices were adopted for their low sensitivity to the sample size (Magurran 1988).

Shannon Diversity Index ($H'$)  
$$- \sum p_i \ln p_i$$  
i.e.  
$$- \sum \frac{n_i}{N} \ln \left( \frac{n_i}{N} \right)$$

Where, $n_i$ = importance value of the $i^{th}$ species  
$N$ = Importance value of all the species

Simpson’s Index of dominance ($D$)  
$$\sum p_i^2$$  
i.e.  
$$\sum \left( \frac{n_i}{N} \right)^2$$

Where, $n_i$ = importance value of the $i^{th}$ species  
$N$ = Importance value of all the species

Pielou Evenness Index ($E$)  
$$H' / \ln S$$

Where, $H'$ = Shannon Diversity Index

$S$ = Total number of species

$\alpha$ diversity ($D$) was calculated according to Whittaker(1960)

$$D = \frac{S}{\log N}$$

Where, $S$ = Total number of species in the sample  
$N$= Total number of individuals in the sample

$\beta$ diversity ($\beta_w$) was calculated according to Whittaker(1960)

$$\beta_w = \left( \frac{S}{\alpha} \right) - 1$$

Where, $S$ = Total number of species in a system

$\alpha$= The mean species richness
Enumeration of endemic, rare, threatened and medicinal plants of the BR


Data on medicinal plants occurring in the BR were collected from primary as well as secondary sources. The techniques such as participatory observations, semi-structured interviews were used to collect the primary data regarding medicinal plants used by the local Garo people inhabiting the BR. Four local herbal practitioners (locally known as oza) were interviewed and relevant information about the medicinal plants viz., their local names, habitat, parts used and their different uses were documented. The voucher specimens were collected and identified with the help of local florae as well as the herbaria in the Botany department, NEHU, BSI, North-Eastern Circle, Shillong and CNH, Howrah.

An extensive literature survey was carried out to record all the well-known medicinal plants occurring in the BR. The plants were collected, identified and their uses were noted down with the help of available literature (Dymok et al. 1890, Kirtikar and Basu 1933, Rao 1981, Rao and Shanpru 1981, Bentley and Trimen 1983, Neogi et al. 1989, Warrier et al. 1993).
Analysis of community structure

Kershaw (1973) distinguishes three components of vegetation structure:

a) Quantitative structure (i.e. abundance of each species in the community)

b) Horizontal structure (spatial distribution)

c) Vertical structure (distribution into different layers/strata)

a) Quantitative structure was studied by determining density, frequency, basal cover and IVI of each species in the selected communities following the methods given by Miieller-Dombois and Ellenberg (1974).

Frequency indicates number of sampling units in which a given species occurs and thus expresses the distribution or dispersion of various species in a community. It was calculated using the following formula:

\[
\% \text{ Frequency} = \frac{\text{Number of sampling units in which the species occurred}}{\text{Total number of sampling units studied}} \times 100
\]

All the species are then classified into five frequency classes as follows,

A 1-20 %
B 21-40 %
C 41-60 %
D 61-80 %
E 81-100%

The normal distribution according to Raunkiaer’s law of frequency class is A>B>C D<E. The proportion of the species in different frequency classes gives the homogeneity or heterogeneity of the community. The higher the value of class E, the more is the homogeneity.
Density and abundance represent the numerical strength of species in the community.

Density is expressed as the number of individuals of a species per unit area and is calculated as follows:

\[
\text{Density (number of plants per sample unit) = } \frac{\text{Total number of individuals of a species in all the sample units}}{\text{Total number of sample units studied}}
\]

Abundance is expressed as the number of individuals per quadrat of occurrence and is calculated as follows:

\[
\text{Abundance = } \frac{\text{Total no of individuals of a species}}{\text{Number of quadrats of occurrence of the species}}
\]

Basal cover refers to the area of ground penetrated by the stem and is measured as,

\[
\text{Basal cover} = \frac{(CBH)^2}{4\pi}
\]

Dominance is the function of density and basal cover which is given as,

\[
\text{Dominance = Mean basal area per individual x Total number of individuals in a species}
\]

Relative density, relative frequency, relative dominance and Importance Value Index (IVI) were calculated from above data. IVI was calculated as,

\[
\text{IVI (trees) = Relative frequency + Relative Density + Relative Dominance}
\]

and
IVI (shrubs and herbs) = Relative frequency + Relative Density

b) Horizontal structure of selected communities was analysed by the formula outlined by Whitford (1948)

\[
\text{Whitford’s Index} = \frac{\text{Abundance}}{\text{Frequency}}
\]

\[
\text{A/F ratio} =
\begin{array}{ll}
< 0.025 & \text{(Regular distribution)} \\
0.025 - 0.05 & \text{(Random distribution)} \\
> 0.05 & \text{(Clumped distribution)} \\
\end{array}
\]

c) Vertical structure of selected communities was analysed with the help of life form spectra and profile diagrams.

**Life forms**

Life forms provide description of the vegetation on physiognomic basis. The species are classified on the basis of the position of perennating organs/buds, which provide an indication of the manner in which the plant survives the unfavourable season.

All the species encountered in the study area were identified and classified under different life forms as per the Raunkiaer’s classification (1934).

- **Phanerophytes**
  - Trees and shrubs having perennating buds above 0.3 m
- **Chamaephytes**
  - Herbs or low woody plants having perennating buds just above the ground level up to 0.3 m
- **Hemicryptophytes**
  - Perennating buds borne close to ground/ half hidden in soil
Cryptophytes Perennating buds below soil/ water surface

Therophytes Annuals, which survive unfavourable season through seeds or spores.

Lianas Woody climbers

Pseudo-lianas plants, which germinate on other plants and establish (Hemi-epiphytes) their roots in the ground, or germinate on the ground and grow on other trees disconnecting from the soil.

Epiphytes Plants germinating and rooting on other plants

Profile diagrams

Profile diagrams of the selected communities dominated by tree components (core zone communities, jhum fallows, and mining areas) were prepared to illustrate the details in vertical spacing of the species. A transect of 30 m-60 m x 5.0 m was established in each of these stands. The dominant individuals were drawn to the scale on a graph paper indicating their position, height, bole height and crown cover.

Comparison of stands

The qualitative comparison between the pair of sites representing same or different communities was carried out by calculating Sorensen Index (Magurran 1988)

\[
Sorensen \text{ Index} = \frac{2j}{(a + b)} \times 100
\]
where, \( j \) = the number of species common to both sites
\( a \) = the number of species in site A, and
\( b \) = the number of species in site B.

The quantitative similarity between the stands representing different ecosystems has been worked out following Morisita-Horn index \( (C_{\text{MH}}) \),

\[
C_{\text{MH}} = \frac{2 \sum (a_n \times b_n)}{(d_a + d_b) \times a_N \times b_N}
\]

where,
\( a_N \) = the number of individuals in site A
\( b_N \) = the number of individuals in site B
\( a_{n_i} \) = the number of individuals in the \( i^{th} \) species in site A
\( b_{n_i} \) = the number of individuals in the \( i^{th} \) species in site B

\[
da = \frac{\sum a_{n_i}^2}{a_N^2}, \quad \text{and} \quad db = \frac{\sum b_{n_i}^2}{b_N^2}
\]