GENERAL DISCUSSION
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GENERAL PATTERN OF FOREST DISTRIBUTION:

The present study deals with vegetation analysis of the natural forest of Hastinapur region. Three sites were selected for the present study (Hillock, Block-1 and Block-2). Hastinapur is located in Western part of Uttar Pradesh (Upper Gangetic plain). Dry hot summer and dry cold winter characterize the climate of this zone. Rainfall is usually less than 70 cm. The soil of the wide area except cultivated land is saline. Dry deciduous and shrubby forests are common in this part. Vegetation is of open type, consisting of small trees and thorny or spiny shrubs of stunted growth. There is luxuriant growth of ephemeral herbs and grasses during the rainy season.

Murty and Singh (1961) during their study on ‘Flora of Hastinapur’ concluded that forest of Hastinapur is tropical dry deciduous type, with average annual rainfall of 30 to 35 inches. Maximum temperature varied up to 45° C and minimum 2° C in cold frosty nights of January. During present study, it was observed that the mean annual maximum and minimum temperature for the year 2005 and 2006 were 30.32° C and 18.08° C, 30.97° C and 18.36° C respectively. The pattern of annual rainfall recorded for the year 2005 and 2006 were 710.2 and 525.14 (in mm). (Table 1.1 & 1.2).

According to Champion and Seth (1968) in northern tropical dry deciduous forest type mean annual temperature ranged between 24° C to 27° C and mean annual rainfall ranged from 900 to 1,150 (mm). Recorded values of temperature and rainfall in the present study were higher; in comparison to the previously observed values, these high values indicated that there is development of tropical dry deciduous forest in to tropical dry thorny scrub forest. This is clearly reflected specially in vegetation of Hillock forest. Changed climatic factors and biotic as well as anthropogenic interferences had major influence on the vegetation of the present study sites.
Table 5.1 (a): Mean values of Total Tree Basal Area, Total Tree Density in different study sites (Values averaged across the individuals)

<table>
<thead>
<tr>
<th>Site</th>
<th>Total Tree Basal Area (cm² 100⁻²)</th>
<th>Total Tree Density (Trees 100 m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hillock</td>
<td>3713.49</td>
<td>8.3</td>
</tr>
<tr>
<td>Block-1</td>
<td>4354.83</td>
<td>9.5</td>
</tr>
<tr>
<td>Block-2</td>
<td>6095.35</td>
<td>9.9</td>
</tr>
</tbody>
</table>

Table 5.1 (b): Mean values of Seedling, Sapling and Shrub Density (Values averaged across the individuals)

<table>
<thead>
<tr>
<th>Site</th>
<th>Seedling density (Ind 100 m⁻²)</th>
<th>Sapling density (Ind 100 m⁻²)</th>
<th>Shrub density (Ind 100 m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hillock</td>
<td>2.4</td>
<td>5.3</td>
<td>6.24</td>
</tr>
<tr>
<td>Block-1</td>
<td>5.5</td>
<td>4.4</td>
<td>3.26</td>
</tr>
<tr>
<td>Block-2</td>
<td>7.0</td>
<td>6.9</td>
<td>4.04</td>
</tr>
</tbody>
</table>
getting open in Hillock, and the data analyzed about density of trees and shrubs
also support more shrub undergrowth. This inverse relationship between shrub
and tree indicated that the shade caste by the canopy restrict shrub undergrowth
at other two study sites which have low shrub density in comparison to Hillock.

The total tree density was lowest in Hillock forest (8.3 tree 100 m$^2$) than in
the Block-2 forest (9.9 tree 100 m$^2$) which showed higher tree density among the
study sites.

**REGENERATION OF SPECIES:**

On the basis of size class structure (inclusive of seedling, i.e. individuals <
30 cm height, sapling i.e. > 30 cm in height and Cbh 31.5 cm or less and trees
i.e. individuals > 31.5 cm Cbh) the various tree species encountered in the study
sites can be arbitrarily categorized as under-

1. **Expanding and stable:** i.e., with a population structure exhibiting broad base
tapering toward the peak.

2. **Declining:** i.e., with an inverted pyramidal shape or with a bulged middle
tapering towards both ends.

3. **Interrupted:** i.e., with intermittent absence of size classes, suggesting gap
phase type regeneration.

4. **Youthful:** i.e., with all individuals confined to seedling or sapling size classes,

5. **Accidental:** i.e., individuals being limited to one or two older size classes.

On the basis of population structure it is easy to foretell that Bauhinia
racemosa, Tectona grandis, Acacia farnesiana, Acacia catechu and Prosopis
juliflora would perpetuate as dominant in study forest sites.

In all the study forest sites having different number of species and those
having bio-edaphic disturbances, irrespective of species number it was observed that only 40% individuals at Block-1 forest showed expanding population structure, it is possible that decrease in number of species an indicative of the fact that this forest are approaching the late successional stage. The species number decrease in the ultimate formation of climax on account of dominance of few species (Clements 1905; Goodman 1975).

In Hillock, 42.85% species showed interrupted and accidental type of regeneration. It indicates disturbance and consequent reduction in survival of individuals at a given time interval or episodic or gap phase type regeneration (Jackson and Faller 1973).

In Block-2 forest the maximum proportion of individuals (56.25%) displaying expanding population structures, which clearly indicated Block-2 site is regenerating adequately this trend is followed by Hillock and Block-1 forest. Sufficient number of seedling and sapling of important tree species were present to replace younger tree in the near future.

**DIVERSITY AND SPECIES RICHNESS:**

Plant diversity is important component of ecosystem. It has been related to succession, stability and various other aspects. Species richness has been regarded as index of diversity right from the beginning. According to Whittaker (1977) species richness can be depicted at several levels for which he used the terms Alpha diversity (Within in community diversity), Beta diversity (between community diversity) and Gamma (landscape diversity) diversities.

In present study soil properties showed that soil of Hillock site holds moister than other two study sites. Moisture provides suitable condition for soil to act as growth medium and to protect trees from entering in to stressful phase. Relatively higher species richness in Hillock suggests that favorable moisture condition enhance species diversity. Among the species, which exclusively
occurred in Hillock forest, were *Acacia farnesiana*, *Prosopis juliflora* and *Acacia catechu*. During this study it was observed that this site is relatively humid having low evotranpirational rate and are also frequently subjected to burning, grazing and anthropogenic activities. At Block-1 the amount of soil Nitrogen was observed to be highest (Table-1.3) because of good number of trees of *Tectona grandis*.

**Table: 5.2**

<table>
<thead>
<tr>
<th>Site</th>
<th>Moisture level</th>
<th>Average species diversity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>On the basis of Density</td>
</tr>
<tr>
<td>Hillock</td>
<td>High</td>
<td>0.041</td>
</tr>
<tr>
<td>Block-1</td>
<td>Intermediate</td>
<td>0.054</td>
</tr>
<tr>
<td>Block-2</td>
<td>Low</td>
<td>0.005</td>
</tr>
</tbody>
</table>

According to Kenjale (1994) *Tectona grandis* releases the higher amount of available nitrogen content in soil. The maximum phosphorus in Hillock forest soil suppose to be due to Acacia species, which improve the poverty of nutrient in soil especially of phosphorus these findings are also supported by Rajwanshi *et al.* (1985). The accumulation of species richness for shrub and herbs in Hillock may be due to higher diversity of microhabitat (Grubb 1977) and/or abundance of physical environmental resources (Tilman 1982), which facilitates the establishment, and regeneration of specialized species. Shariff *et al.* (1991) however observed that species diversity is negatively correlated with soil fertility in particular with available phosphorus content of the soil. Odum (1961) suggest that species diversity increase steadily as the vegetation develop in to mature forest. Distribution of *Tectona grandis* in Hillock forest indicated that a better moisture condition is known to favor large leaved deciduous species, this result are in accordance of the study of Givinsh (1987).
Shannon Weiner's index of diversity is a statistical abstraction between two components i.e. species richness and evenness or equitability. In regard to the present study, Hillock forest showed high value of diversity index in comparison to Block-1 and Bloock-2. Results observed indicate that Hillock forest site is subjected to maximum disturbance and anthropological activities. Highest disturbance enhanced species diversity due to space invasion by new species. Pandey and Singh (1985) have also reported increasing species diversity in disturbed ecosystem of Kumaun Himalaya.

When total number of individuals was counted in study sites, it was found that there was less number of trees at Hillock, while the number of shrub and herbs were higher there in comparison to two other study sites. Due to disturbances at Hillock forest Tree canopy is getting open from close forest to scrub forest. As the canopy decreases the number of different species reduces significantly in tree and climber category, it is natural, as climber require support of tree species. However the opening of canopy leads to the increase of shrub and other weeds. The number of shrubs showed a marked increase, which is typical of weed character. It is established fact that shrubs mostly weeds occupy the blank space left by the trees. Thus there is not only the decrease in biodiversity but also the overall landscape is also affected at Hillock. When the natural landscape is fragmented overall species richness may stay the same or even increases.

Table 5.3: Total Number of Individuals in different study sites.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Site</th>
<th>Tree</th>
<th>Seedling</th>
<th>Sapling</th>
<th>Shrub</th>
<th>Herb</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hillock</td>
<td>83</td>
<td>107</td>
<td>55</td>
<td>1686</td>
<td>2070</td>
<td>4001</td>
</tr>
<tr>
<td>2.</td>
<td>Block-1</td>
<td>95</td>
<td>88</td>
<td>110</td>
<td>1021</td>
<td>2519</td>
<td>3833</td>
</tr>
<tr>
<td>3.</td>
<td>Block-2</td>
<td>99</td>
<td>139</td>
<td>144</td>
<td>1360</td>
<td>1908</td>
<td>3650</td>
</tr>
</tbody>
</table>
The average values of index of dominance (Cd) were higher in Hillock, which indicate homogenous nature of the community, in other words this community is dominated by single species. Furthermore more the homogenous nature of the community, lesser is the diversity and hence stability i.e. such habitats are subjected to renewed disturbances and are occupied by more opportunistic and environmentally flexible species with ecological amplitude.

Equitability i.e. species per log cycle index is another aspect of diversity. Several workers have used Shannon Weiner's information index in order to express the combined effect of species richness and equitability i.e. evenness among the importance value of the species and it has often been termed as synthetic index. However equitability showed stronger correlation with species richness than the diversity did with species richness. It appears that Shannon-Weiner's information index is simply another measure of equitability and fails to incorporate the component of species richness (Whittaker 1977, Tewari 1982). In relation to present study it was observed that equitability values for Tree, Seedling, Sapling and Herb layer were higher for Block-2 forest while the lower values for equitability was recorded for Hillock forest.

In present study Tree, Seedling, Sapling of Hillock furnished by typical log-normal progression of importance value, while the D-D curve for Block-1 and Block-2 and shrubs of three study sites showed intermediate form between log-normal and log curves. According to Whittaker (1972) the geometric form, is often exhibited by vascular plant communities of low diversity. The geometric series is a consequence of constant proportional decrease in importance from most to least important species. The log normal series described the portioning of realized niche space among various species and it is the consequence of the evolution of diversity in the species along the niche parameters that it exploits. Coppins and Shimwell (1971) suggested that typical geometric progression is
obtained in earlier successional stage. In middle part of successional gradient the curve approaches the log normal distribution and in final stage it reveals to geometric series owing to strong dominance of few species.

In context to this area-varying conclusion tend to emerge from various approaches. The Block-1 forest in which species number showed minimal changes from tree to sapling stage has attained stabilization. However in a stable community the dominant should have adequate number of individuals in all size classes. Species number and diversity index value were higher in highly disturbed forest (Hillock) and mean tree density decreased from high to moderate (Hillock to Block-1) and increased in low disturbance area (Block-2). The shrub density decreased from high to low disturbance. High proportional of early successional species in disturbed forest indicated that disturbance induced succession. The mean number of young individuals increasing from high to low disturbance indicates that disturbance adversely affect regeneration.

**ORDINATION:**

Ordination method may represent an improvement on vegetation description based on dominant (Dooley and Collins 1984) and perhaps reveal some of the underlying relationship between vegetation and environment. The gradient analysis examined by polar ordination technique of Bray and Curtis (1957) made several pattern apparent with regard to community characteristics and species distribution. In the present study sites Ordination technique for 30 quadrats of tree layer and 60 quadrat, each of seedling, sapling and shrub were made, rather than the distinct zonality of vegetation the present observation suggest continuous change in vegetation. According to Hanawalt and Whittaker (1976) boundaries of ecosystems are artificially imposed for the sake of classification and accounting.

In figures (16.5 a&b) the values of tree Relative Basal Area (Quadrat wise) are plotted in the ordination graph. There was lack of definite pattern, as the
quadrate with varying levels of Relative Basal area may occur side by side, for example in the middle part of the ordination graph quadrat with Relative Basal Area ranging from 1.23 to 20.41 occur. In other words, quadrats resembling in species composition may have widely different values of Relative Basal Area. Only in upper part of the graph Relative Basal Area of quadrats clearly increases with decreasing Y values, with which also parallels the decrease in the importance value of Acacia nilotica and increase in those of several broad leaved species. Relative Basal Area also varies considerably in the quadrat having substantial representation or dominance of other tree species (Quadrat 21-30) and quadrat with low to high Relative Basal Area values may resemble in species composition.

One of the reasons of this patchy pattern of distribution of vegetation in the quadrat of ordination graph is that the Hillock with a reasonably similar species composition, total tree density and tree basal cover having high species diversity and species richness values especially for shrub and herb layer.

It seems that because of more moist condition of Hillock site, a number of mesic species of trees and shrub, which are out competed by drought enduring species on drier parts, are able to successfully establish at Hillock. Variation in species diversity of forest sites is widened also by management practices, such as burning and selective removal of individuals of certain species or lack of these practices. This is the case in respect to the Hillock forest, where management practices, such as these leads to the single species dominance, but whereas such practices are employed or they are not effective, several broad leaf species are able to occupy sites (Block-1 and Block-2) resulting in high level of species diversity of trees at these sites.

To conclude several factors relating to topography, moisture, fire and stability of site have influence the species diversity in the forests of this region, confounding any straightforward relationship between climate and species diversity.
CONCLUSION:

To conclude Acacia nilotica, Tectona grandis, Eucalyptus globules, Bauhinia racemosa, Phoenix sylvestris and their varying mixture with other species constitute the vegetation of the present study forest sites. Expansion of Acacia nilotica and Prosopis juliflora at Hillock in geological past has been found to be associated with warm and moist climate phase. The present distribution of Acacia nilotica, Prosopis juliflora and Dalbergia sissoo at Hillock forest indicated that these species held more moisture than other species.

If only broad leaf species were to be considered, we find that from Hillock to Plain forest (Block-1 and Block-2), proportion of tree species with large leaves decreases. This is contradictory to the general observation that leaf size increases with increasing moisture and decreasing temperature up to a considerable extent (Givnish 1987).

In the site, Hillock where level of disturbance is high (frequent burning, grazing and other anthropogenic activities) only few species are able to occupy them, and thus tree species of this site showed low species richness. On the contrary higher diversity and richness of trees at other two study sites with in the same climate is suggestive of the fact that species diversity is not directly related to climatic gradient.

Thus with in the present study diverse communities varying in tree size, tree number, adaptation to climatic conditions, species diversity and other features occur. They also differ in size of standing crop, but all of them attain similar productivities (Singh and Singh 1987). This shows that environmental variation that occurs with in the forest leads to varied community characters without causing variation in productivity.

From last so many years natural forest have been replaced by variety of simple agricultural monoculture especially in tropical areas. Around the world biological communities that took million of years to develop are being devasted
(Sharma 2003). The current decline in diversity of plant species in study sites is largely the result of human activities from habitat destruction, over harvesting and introduction of exotic plants. The diversity of natural ecological communities has never been more valued than they are now, as they became increasingly threatened by the environmental crisis. In the past studies on biological diversity have been concentrated on high spatial scale e.g. regional and global. A great of time and expertise has been expanded but our understanding of structure and functioning of communities has been meager. The current status of ecological studies therefore is shifting from higher scale to locally manageable scale.

The present study is a modest effort focusing on a small area; large-scale studies are needed to help determine appropriate conservation and management strategies for the betterment of existing population and biodiversity of forest.