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# Natural regneration of plant species as affected by biotic disturbances in Hastinapur forest of North West Uttar Pradesh, India

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**Abstract:** In the present study various phytosociological attributes like frequency, density and abundence of woody vegetation were analysed along the disturbance gradient in tropical dry deciduous forest of Hastinapur region of North west Uttar Pradesh, India. Three sites were analysed for floristic composition, distribution pattern, species diversity and dominance (i.e. Hillock,Block-1 and Block-2)Hillock was highly disturbed, while Block-1 and Block-2 were moderately and least disturbed sites respectively. Maximum number of tree, seedlings and saplings were recorded for Block-2 and minimum for Hillock. Number of shrub species was maximum on Hillockbecause of open forest canopy due to disturbances, which provide favourable conditions for growth of shrubs and other weeds. Most of species except shrubs were regular followed by random in distribution pattern. The value of CD and H'for trees 0.01 on Block-1 to 0.035 on Hillock and 0.00 on Block-2 to 0.014 on Hillock respectively. These low values clearly indicate aridity of the area and habitat destruction. Phytosociological study of this area indicates that there is an urgent requirement of conservation practices

**Keywords:** Biotic disturbances, Plant species, Phytosociological attributes, Species diversity

## INTRODUCTION

Hastinapur region of North West Uttar Pradesh is part of the upper Gangetic plain. The total area of Hastinapur is 3364.3 Hectare from which 262.89 Hectare land come under the Hastinapur wild life sanctuary (Khan *et al.,* 2013). The vegetation in the forest of upper Gangetic plain is generally of tropical dry deciduous type. As a whole, the vegetation shows xerophytic features due to arid climate conditions. Tall trees are rare; the bushy growth is successful and occupies a greater area. The following trees are common: *Acacia nilotica, Albizzialebbek, Albizzia odoratissina, Dalbergia sissoo, Diospyros cordifolia, Phoenix sylvestris, Streburus asper.* Bushy growth of the following species is abundant: *Acacia concinna, Adhatoda vesica, Butea monosperma,Casseria tomentosa,Capparis sepiaria, Flacourtia indica.* Among major factors that influenced vegetation structure are Human disturbances, extensive grazing, trampling invasion of opportunistic species and soil erosion. Human disturbance and extensive grazing has resulted in formation of highly fragmented vegetation which in turn has critical impact on community structure (Shahid and Joshi, 2016). Species composition is one of the major or anatomical characters of plant community. Thus the species content and their ecological amplitude determine the structure and nature of plant community the number of species accommodated in a communities is an important factor from ecological point of view, since it seems to increase as community become more stable. The mosaic of species distribution in any forest are governed by various environmental factors (Bajpai *et al.,* 2012). knowledge of species composition and diversity of tree species is of utmost importance not only to understand the structure of forest community but also for planning and implementation of conservation strategy of the community (Malik *et al.,*2014: Malik and Bhatt, 2015). In 1953 when government of Uttar Pradesh started working on the colonization scheme of Hastinapur, Prof. V.Puri who had already studied the flora of Hastinapur (1961), suggested that Hastinapur should be taken first for a more intensive study as the luxuriant vegetation of this place likely to suffer much through human influence. It was feared that after some years, the physiognomy of the whole area may totally change and therefore the problem appeared to be more urgent. Now a day there appears a very different view of forest of Hastinapur as compared to the past. In the present study plant diversity assessment (mainly higher plants) and quantitative analysis of forest, vegetation was done in the forest of Hastinapur as affected by various degrees of disturbances in order to observe the effect of disturbances on plant diversity and stability.

## MATERIALS AND METHODS

**Study site:** The study was carried out in tropical dry

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forest of Hastinapur, which is situated near the river Ganga, 36.4 km North East to Meerut District. It lies at $29^0$ 1’ N latitude and $79^0$ 9’ E longitudes and has an elevation 215 mt above the sea level.The area includes a high level land the ‘Khola’ taken up for afforestation by the forest department of the Uttar Pradesh government and a low lying land of ‘ Khadar’ the old bed of river Ganges, which has now shifted towards east, most of which is under cultivation. Several temporary ravines flow across the ‘Khola.’ During the rains water descends through them in to ‘Khadar’ and ultimately meets the river Ganges. Besides, there lays more or less permanent ravines the Boodhi- Ganga about 0.4 kilometers from ‘Khola’. It is an old branch of river Ganges, which flow parallel to it for some distance and eventually merge in to it.

The whole forest area of Hastinapur is divided in 15 forest blocks, which are ‘Pandav’, Droupadi, Arjun, Yudisther, Bheem, Krishna, Nakul Sahdeva, Abhimanu, Kaurvas, Duryodhna, Karna, Bhishma, Vidur and Drauna.The three sites were selected for the quantitative vegetation study  come under ‘Kaurvas block’. One forest site selected for study was near to the road in the form of Hillock and another two were selected near Pahli Nisihia (Jain temple) and named Block-1 and Block-2 which were far from the road aside (Fig.1).

The climate of the study area is influenced by monsoon pattern of rainfall. Three sites were selected for quantitative vegetation study Named Hillock (which is situated near main road), Block-1 and Block-2 (these sites are situated 3-5 km inside from main road). Hillock is facing highest level of anthropogenic disturbances such as grazing, collection of fodder and wood, tourismetc. Which was observed in open forest canopy and patchy pattern of distribution of vegetation) while Block-1 is moderately disturbed (comparatively more number of trees then Hillock) and Block-2 is least disturbed site (Highest number of trees and saplings). Each site was surveyed at regular interval (once in 15 days) during entire study period for floristic composition of woody species, plant density, mean and total basal cover, dominance, species diversity and concentration of dominance and distribution of individual species in accordance of woody vegetation stratification.

## METHODOLOGY

The phytosociological studies of woody vegetation was carried out by lying down 10 m× 10 mquadrates for trees, while for seedlings, saplings and shrubs 60randomly placed quadrates of 2m× 2m on each site. Size and minimum number of quadrates required to be studied were determined following species area curve method (Misra; 1968). The circumference at breast height of all trees, saplings and seedlings occurring in each quadrate were measured for individual species. A shrub was Phanerophyte which branched from the base of the stem (Muller-Dombois and Ellenberg,1974).

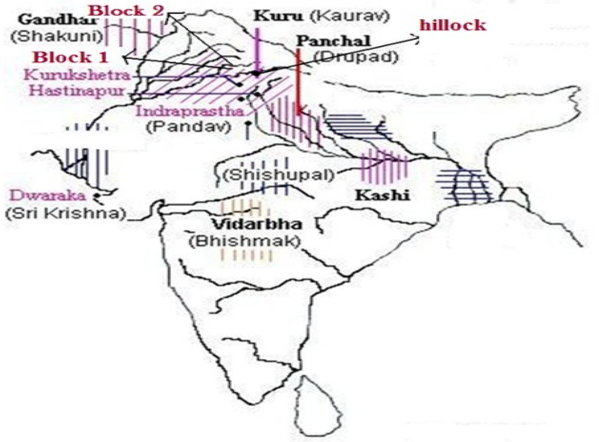


**Fig.1.** *Location Map of  Hastinapur, India showing studied sites.*

The Vegetational data were quantitatively analysed for Abundance, Density and Frequency (Curtis and McIntosh, 1950), relative frequency, relative density and relative dominance were determined following Phillips (1959) while Importance value index(IVI) was calculated following Misra (1968). The ration of abundance to frequency (A/F) for different species was determined for eliciting the distribution pattern following Curtis and Cottam (1956).

In order to express the dominance and ecological success of any species, with a single value, the concept of IVI has been developed as per Curtis and Mc Intosh (1950), Phillips (1959) and Mishra (1968). This index utilizes three characters *viz.* Relative frequency, Relative density, and Relative dominance or Basal area following Curtis (1959).

Relative Basal Area  =  Total basal area of the species/ Total basal area of all the species × 100

Relative Density  = Number of individuals of the species/ Number of individuals of all the species × 100

Relative Frequency  = Number of occurrence of the species / Number of occurrence of all the species × 100

By adding above three values IVI were calculated. The spatial distribution of species in different forest sites has been derived from Whiteford index of A/F ratio (Whiteford 1949). The A/F ratio if below 0.025 indicates regular distribution, between 0.025 - 0.05 indicates random distribution and ≥ 0.05 indicates contagious distribution (Curtis and Cottam 1956). Since the relation between frequency and abundance indicates the nature of species distribution. The distribution pattern of different species was studied using the ratio of A/F.

Species diversity (H’) was determined by Shannon and Weiner information function (Shannon and Weiner 1963).

$H=\Sigma (ni/n) \log 2 (ni/n)$

Where  n is total number of species and ni is individual of a species

The concentration of dominance values was assessed by Simpson's index (Simpson 1949) followed by Whittaker (1975).

$CD = \Sigma (ni/n)^2$ ……………..Eqn (1)

Ni and n are same as above

Beta diversity was calculated to measure the rate of species change across the sites

β diversity was calculated by formula given by Whittaker (1975).

BD = Sc/ S …………… Eqn (2)

BD = Beta (β) diversity

Where Sc is the total number of species occurring in a set of samples counting each species only once, whether or not it occur more than once and S is average number of species per individual sample.

Beside these calculations dominance diversity (DD) curve were also drawn to ascertain resource apportionment among the different species in various study sites for trees, saplings, seedlings and shrubs separately .The d-d curve was made by taking the values of IVI for each species in different stands and was plotted on the Y-axis and species sequence on the X-axis. Wherein the IVI was used as an expressive measure to the niche or species resource apportionment.

## RESULTS AND DISCUSSION

There were lowest number of trees species at Hillock (6) as compared to Block-1 (10) and Block-2 (16). Composition of tree species showed little variation, which might be due to similar climatic condition. The dominant species on Hillock, Block-1 and Block-2 was *A. nilotica* (Table1). *A. nilotica* and *A. catechu* were showing highest IVI values of 77.63,48.91, and 25.64 in studied sites respectively. There was great variation in range of basal cover in studied sites. Trees of Hillock showed higher girth classes which indicates this site is dominated by the trees of mature age and values of basal cover fall in range reported by Singh *et al.* (1981) low density of trees at Hillock(Table-1) indicates that tree canopy in getting open in Hillock due to disturbance.

The saplings ranged between 4 to 11 being minimum on Hillock and maximum in Block-2. Saplings of *A. nilotica* and *Tgrandis* were present in all the sites while sapling of *Bauhinia racemosa*, *Butea monosperma*, *Bauhinia purpurea*, *Cassia fistula*, *Pongamiapinnata* and *Phoenix sylvestris* were present in both Block -1 and Block-2.(Table-2) The seedlings ranged from 5 to 10 being minimum in Hillock and maximum in Block-2. Seedlings of *A.nilotica*, *T.grandis*were common in all the three sites, while seedlings of *B.racemosa*, *B.purpurea*, *B.monosperma* were present in both Block-1 and Block-2. Seedlings of *Prosopis*

**Table 1.** Phytosocioloical attributes of different woody species in site -1 (Hillock).

| Species | Phytosociological attributes | | |
|---|---|---|---|
| **Trees** | **Density** (Ind100m$^{-2}$) | **TBA ((cm$^2$100$^{-2}$)** | **IVI** |
| *Acacia nilotica* | 2.20 | 1055.0 | 77.63 |
| *Acacia farnesiana* | 1.60 | 718.81 | 60.07 |
| *Acacia catechu* | 1.50 | 661.35 | 54.07 |
| *Prosopis juliflora* | 1.90 | 633.04 | 58.11 |
| *Dalbergiasissoo* | 0.50 | 384.41 | 27.81 |
| *Tectonagrandis* | 0.60 | 257.41 | 23.26 |
| **Total** | 8.30 | 3710.49 | |
| **Saplings** | D | TBA | IVI |
| *Acacia nilotica* | 1.00 | 33.30 | 113.64 |
| *Acacia farnesiana* | 0.50 | 17.16 | 68.41 |
| *Prosopis juliflora* | 0.50 | 15.97 | 62.07 |
| *Tectonagrandis* | 0.40 | 14.52 | 56.95 |
| **Total** | 2.40 | 80.95 | |
| **Seedlings** | D | TBA | IVI |
| *Acacia nilotica* | 1.55 | 3.54 | 83.95 |
| *Acacia farnesiana* | 1.05 | 2.58 | 63.64 |
| *Prosopis juliflora* | 1.15 | 1.96 | 58.88 |
| *Tectonagrandis* | 0.95 | 2.55 | 56.98 |
| *Zizphyusxylopyra* | 0.65 | 1.48 | 366.48 |
| **Total** | 5.30 | 12.11 | |

**Table 2.** Phytosocioloical attributes of different woody species in site -2(Block-1)

| Species | Phytosociological attributes | | |
|---|---|---|---|
| **Trees** | **Density** (Ind100m$^{-2}$) | **TBA (cm$^2$100$^{-2}$)** | **IVI** |
| *Acacia nilotica* | 2.00 | 540.36 | 48.91 |
| *Eucalyptus globules* | 1.40 | 511.50 | 38.53 |
| *Bauhinia purpurea* | 0.90 | 526.59 | 31.92 |
| *Haplophrag-maadenophyllum* | 0.90 | 478.98 | 30.80 |
| *Butea monosperma* | 0.80 | 460.84 | 27.62 |
| *Cassia fistula* | 0.80 | 364.23 | 25.40 |
| *Tectonagrandis* | 0.80 | 315.48 | 24.08 |
| *Pongameapinnata* | 0.70 | 364.08 | 24.34 |
| *Bauhinia racemosa* | 0.60 | 396.90 | 24.04 |
| *Albizialebbek* | 0.60 | 395.87 | 25.02 |
| **Total** | 9.50 | 4354.83 | |
| **Sapling** | D | TBA | IVI |
| *Acacia nilotica* | 0.80 | 22.84 | 49.40 |
| *Bauhinia racemosa* | 0.80 | 18.10 | 44.34 |
| *Pongamiapinnata* | 0.75 | 14.96 | 39.53 |
| *Bauhinia purpurea* | 0.70 | 11.55 | 35.57 |
| *Phoenix sylvestris* | 0.65 | 15.53 | 35.71 |
| *Butea monosperma* | 0.65 | 13.50 | 34.04 |
| *Tectonagrandis* | 0.65 | 14.87 | 35.05 |
| *Cassia fistula* | 0.50 | 9.90 | 27.11 |
| **Total** | 5.50 | 21.25 | |
| **Seedlings** | D | TBA | IVI |
| *Tectonagrandis* | 0.75 | 2.21 | 53.69 |
| *Bauhinia racemosa* | 0.85 | 2.91 | 59.96 |
| *Bauhinia purpurea* | 0.75 | 1.90 | 49.46 |
| *Butea monosperma* | 0.65 | 1.67 | 45.32 |
| *Acacia nilotica* | 0.80 | 1.66 | 46.96 |
| *Cassia fistula* | 0.60 | 3.21 | 45.52 |
| **Total** | 4.40 | 13.56 | |

**Table 3.** Phytosocioloical attributes of different woody species in site -3 (Block-2).

| Species | Phytosociological attributes | | |
|---|---|---|---|
| | **Density** | **TBA** | **IVI** |
| **Trees** | (Ind100m$^{-2}$) | **(cm$^2$100$^{-2}$)** | |
| *Acacia catechu* | 0.8 | 696.60 | 25.64 |
| *Tectonagrandis* | 0.7 | 431.60 | 22.74 |
| *Cassia fistula* | 0.8 | 510.77 | 23.83 |
| *Ailanthus excelsa* | 0.9 | 416.74 | 23.44 |
| *Butea monosperma* | 0.8 | 483.38 | 23.39 |
| *Phoenix sylvestris* | 0.8 | 331.60 | 20.89 |
| *Bauhinia purpurea* | 0.8 | 346.19 | 19.87 |
| *Delbergiasissoo* | 0.7 | 366.09 | 19.21 |
| *Acacia nilotica* | 0.5 | 418.51 | 18.06 |
| *Pongamiapinnata* | 0.5 | 323.85 | 16.50 |
| *Bauhinia variegate* | 0.6 | 336.05 | 16.36 |
| *Bauhinia racemosa* | 0.5 | 340.06 | 15.53 |
| *Pithecolobium dulce* | 0.4 | 348.70 | 14.40 |
| *Albizzia lebbek* | 0.4 | 270.60 | 13.38 |
| *Eucalyptus globules* | 0.4 | 236.25 | 12.82 |
| *Diospyros cordifolia* | 0.3 | 202.31 | 10.03 |
| **Total** | 9.90 | 6059.30 | |
| **Saplings** | D | TBA | IVI |
| *Phoenix sylvestris* | 0.76 | 21.99 | 36.05 |
| *Ailanthus excelsa* | 0.80 | 18.20 | 33.24 |
| *Tectonagrandis* | 0.80 | 15.34 | 31.35 |
| *Bauhinia racemosa* | 0.55 | 11.51 | 26.26 |
| *Butea monosperma* | 0.65 | 15.19 | 28.14 |
| *Bauhinia purpurea* | 0.65 | 14.01 | 27.36 |
| *Cassia fistula* | 0.70 | 11.92 | 25.97 |
| *Pongamiapinnata* | 0.50 | 11.97 | 24.88 |
| *Dalbergiasissoo* | 0.50 | 9.19 | 21.03 |
| *Bauhinia variegata* | 0.50 | 10.78 | 22.81 |
| *Acacia nilotica* | 0.60 | 10.08 | 23.06 |
| **Total** | 7.00 | 150.18 | |
| **Seedlings** | D | TBA | IVI |
| *Phoenix sylvestris* | 0.95 | 2.18 | 41.50 |
| *Butea monosperma* | 1.00 | 2.02 | 41.20 |
| *Tectonagrandis* | 0.75 | 1.96 | 36.03 |
| *Cassia fistula* | 0.80 | 1.64 | 33.47 |
| *Acacia nilotica* | 0.60 | 0.87 | 22.76 |
| *Cassia fistula* | 0.80 | 0.90 | 24.42 |
| *Pongamiapinnata* | 0.80 | 1.03 | 24.25 |
| *Acacia catechu* | 0.60 | 0.67 | 21.73 |
| *Bauhinia racemosa* | 0.55 | 1.22 | 23.78 |
| **Total** | 6.90 | 14.32 | |

*juliflora* and *Zizhyhusxylopyra* were present only on Hillock(Table-3). As indicated in the result values of total tree density was highest at Block-2 (9.9 tree 100m$^{-2}$) and lowest at Hillock (8.3tree 100m$^{-2}$). Similarly the value of shrub density was lowest at Block-2 and Highest at Hillock (Table-4-) because there is inverse relationship between tree and shrub density. At Hillock due to open forest canopy there was availability of greater light on the ground which promote the growth of shrubs.. Higher disturbances at Hillock are the casual factor for the lower density of trees but it is favourable for the growth of shrubs so Hillock site showed maximum shrub density. Block-2 which is least affected by biotic disturbances like Recurrent human inter-vention for the collection of fuel wood,

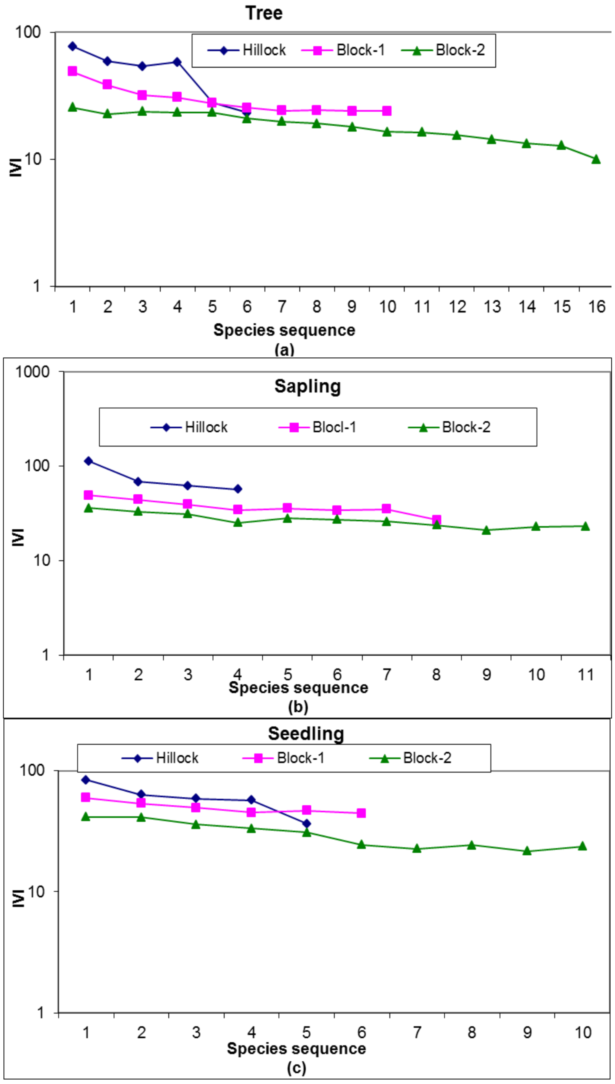


**Fig. 2.** *Comparision between D-D curves of Trees, Sapling and Seedling in different study sites*

fodder, litter and minor forest products as well as grazing, browsing and trampling can substantially alter species habitat (Shahid and Joshi2016) and showed lowest shrub density. According to Rikhari *et al.* (1997) as the tree density increases the infiltration of light to the ground decreases that affect density of lower story and ground flora.

Species diversity ranged from 0.000 to 0.814, 0.001 to 0.022 and 0.002 to 0.845 for the trees, saplings and seedlings stratum (Table-5) these values were more than 50% lower than those for tropical forest reported by Knight (1975). The possible reason for the low diversity index may be aridity of the area because of excessive temperature in summer months and low rainfall and possible habitat destruction, which leads to the less number of species and their individuals. However higher values of diversity index for Hillock can be attributed to a greater degree of repeated disturbances,

**Table 4.** Composition of shrubs in different study sites.

| **Species** | **Frequency (%)** | **Density Ind100m-2)** | **Abundence (Ind100m-2)** | **A/F Ratio** |
|---|---|---|---|---|
| **Hillock** | | | | |
| *Acacia concinna* | 70 | 10.3 | 14.71 | 0.210 |
| *Cannabis sativa* | 70 | 8.8 | 12.64 | 0.180 |
| *Flacourtiaindica* | 90 | 11.8 | 13.61 | 0.151 |
| *Abutilon ramosum* | 80 | 9.1 | 11.37 | 0.142 |
| *Adhatodavasica* | 90 | 10.3 | 11.44 | 0.127 |
| *Cissampelospareira* | 70 | 5.2 | 7.64 | 0.109 |
| *Lantana camara* | 65 | 4.6 | 7.07 | 0.108 |
| *Abutilon indicum* | 85 | 7.3 | 8.64 | 0.101 |
| *Malvestrumcoromandelianum* | 85 | 6.9 | 8.11 | 0.095 |
| *Murrayakoenigi* | 80 | 4.9 | 6.18 | 0.077 |
| *Urenalobata* | 75 | 4.2 | 5.66 | 0.075 |
| *Capparissepiaria* | 60 | 2.5 | 4.16 | 0.069 |
| *Parkinsonia aculeate* | 75 | 3.2 | 4.26 | 0.056 |
| *Indigoferatinctoria* | 70 | 2.5 | 3.57 | 0.051 |
| *Calatropisgiganata* | 65 | 2.0 | 3.07 | 0.047 |
| **Block-1** | | | | |
| *Adhatodavesica* | 75 | 3.4 | 5.66 | 0.075 |
| *Zizphusmauritiana* | 75 | 3.4 | 5.33 | 0.071 |
| *Lantana camara* | 75 | 3.4 | 5.26 | 0.070 |
| *Tinosporacordifolia* | 70 | 3.5 | 4.50 | 0.064 |
| *Durentarapens* | 75 | 3.4 | 4.60 | 0.061 |
| *Malvastrumcoromandelianum* | 75 | 3.4 | 4.60 | 0.061 |
| *Abutilon indicum* | 80 | 3.5 | 4.43 | 0.055 |
| *Zizhyphusoenopelia* | 80 | 3.5 | 4.43 | 0.055 |
| *Indigoferatinctoria* | 65 | 2.3 | 5.53 | 0.085 |
| *Cissampelospareira* | 75 | 3.4 | 3.80 | 0.050 |
| *Calatropisgigantea* | 60 | 2.1 | 2.62 | 0.043 |
| *Calotropisprocera* | 50 | 2.5 | 2.10 | 0.042 |
| *Parkinsonia aculeate* | 80 | 3.5 | 3.43 | 0.042 |
| *Abutilon ramosum* | 75 | 3.4 | 3.13 | 0.041 |
| *Blepharismaderaspatensis* | 70 | 3.5 | 2.92 | 0.041 |
| *Urenalobate* | 80 | 3.5 | 2.93 | 0.036 |
| **Block-2** | | | | |
| *Cannabis sativa* | 80 | 7.4 | 9.25 | 0.115 |
| *Justicia simplex* | 85 | 7.8 | 9.30 | 0.108 |
| *Adhatodavesical* | 80 | 5.7 | 7.60 | 0.095 |
| *Vitex negudo* | 70 | 4.1 | 5.85 | 0.083 |
| *Urenalobata* | 85 | 6.0 | 7.11 | 0.083 |
| *Abutilon indicum* | 90 | 5.6 | 6.27 | 0.069 |
| *Barleriacristata* | 80 | 4.4 | 5.50 | 0.068 |
| *Zizyphusoenoplia* | 65 | 2.2 | 3.38 | 0.052 |
| *Blepherismaderaspatensis* | 70 | 2.3 | 3.35 | 0.047 |
| *Malvestrumcoromandelianum* | 90 | 3.6 | 4.05 | 0.045 |
| *Lantana camera* | 80 | 2.9 | 3.62 | 0.045 |
| *Zizyphusnummularia* | 95 | 4.0 | 4.21 | 0.044 |
| *Durentarapens* | 85 | 3.0 | 3.58 | 0.042 |
| *Zizyphusmauritiana* | 80 | 2.4 | 2.88 | 0.036 |
| *Tinosporacordifolia* | 75 | 2.0 | 2.68 | 0.035 |
| *Parkinsoniaaculeata* | 70 | 1.3 | 1.92 | 0.027 |

which generated more heterogenous environment, giving opportunity for colonization of varied species. lower values of CD indicates that in this forest dominance is shared by more than one species but these values of CD are high in accordance with low species diversity (H'), because species diversity behave inversely to the index of dominance (Odum,1971). Whittaker (1965) had observed the range of values of Cd for certain temperate vegetation from 0.19 to 0.99. Gairola *et al* (2011) reported Cd values between 0.12 and 0.25 in the Mandal Chopta forests of Garhwal Himalaya. Raturi (2012), while working indifferent temperate and subtropical forests of Rudraprayag (Garhwal Himalaya), recorded Cd values between 0.09 and 0.63. Recently, Malik and Bhatt (2015) reported Cd values ranging between0.06 and 0.37 from a protected area of Western Himalaya.

The abundance to frequency ratio indicates that among all the study sites most of the species showed regular and random distribution pattern. The pattern of distri-

**Table 5.** Species diversity (H') and concentration of dominance (Cd) of different sites

| Sites | Stratum | Species diversity (H') | Concentration of dominance (Cd) |
|---|---|---|---|
| Hillock | Tree | 0.814 | 0.835 |
| | Saplings | 0.022 | 0.068 |
| | seedlings | 0.845 | 0.042 |
| Block-1 | Tree | 0.002 | 0.010 |
| | Saplings | 0.003 | 0.018 |
| | seedlings | 0.021 | 0.027 |
| Block-2 | Tree | 0.000 | 0.003 |
| | Saplings | 0.001 | 0.007 |
| | Seedlings | 0.002 | 0.011 |

**Table 6.** Distribution pattern of Trees, Saplings and Seedlings of different study sites

| Site/Stratum | Distribution pattern (%) of total species | | |
|---|---|---|---|
| **Hillock** | **Regular** | **Random** | **contagious** |
| Tree | 50.00 | 50.00 | - |
| Saplings | 25.00 | 75.00 | - |
| Seedlings | 50.00 | 50.00 | - |
| Shrub | - | 43.75 | 56.25 |
| **Block-1** | | | |
| Tree | 56.25 | 43.75 | - |
| Saplings | 18.18 | 81.81 | - |
| Seedlings | 10.00 | 90.00 | - |
| Shrubs | 12.50 | 50.00 | 37.50 |
| **Block-2** | | | |
| Tree | 50.00 | 50.00 | - |
| Saplings | 100.00 | - | - |
| seedlings | 60.00 | 40.00 | - |
| Shrubs | 60.00 | - | 40.00 |

**Table 7.** Beta diversity values of different stratum of studied forest sites

| Sites | Stratum | Beta diversity |
|---|---|---|
| Hillock | Trees | 3.16 |
| | Saplings | 3.25 |
| | Seedlings | 2.60 |
| | Shrubs | 1.66 |
| Block-1 | Trees | 1.90 |
| | Saplings | 1.62 |
| | Seedlings | 2.16 |
| | Shrubs | 1.56 |
| Block-2 | Tree | 1.10 |
| | Saplings | 1.18 |
| | Seedlings | 1.30 |
| | shrubs | 1.56 |

bution depends both on physic-chemical properties of environment as well as on the biological peculiarities of organism themselves. According to Odum (1971) in natural conditions contagious distribution is most common, preponderance of regular as well as random distribution it reflects the magnitude of biotic interference such as grazing and looping in the forest siteContagious distribution has also been reported byvarious authors from different parts of Garhwal Himalaya (Bhat, 2012; Gairola, 2010; Malik *et al.,* 2014; Singh, 2013; Suyal, 2011) (Table-6).

Within present study site calculated β- diversity values

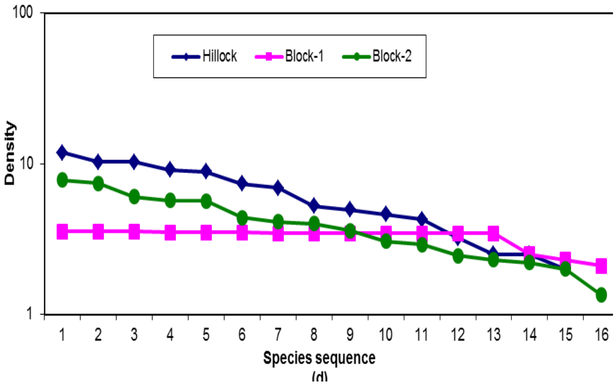


**Fig. 3.** *Comparison between D-D curves of shrubs in different study sites*

were highest in Hillock for tree, saplings, seedlings and shrubs in comparison to the Block-1 and Block-2 (Table-7). This index has often been used to indicate the variation in species composition between habitats and it is suggested that finer the division of the habitat more would be the value of beta diversity and also a disturbed community each have as much beta diversity than an undisturbed community adjacent to it (Whittaker,1975). In present study, high value of beta diversity in Hillock indicates finer division of the habitat while lower values of Block-1 and Block-2 Indicates that growth in the gradient respond in similar fashion (Adhikari *et al*., 1997)

DD curve for trees (Fig.2) seedlings and saplings at hillock showed log normal distribution, while the curve for Block-1 and Block-2 and shrubs (Fig-) of three study sites represents intermediate position between lognormal and geometric or log normal model. Log normal curve is obtained in species rich communities (Whittaker, 1965). In the present study, it was observed that 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. Destruction of established plants by disturbances creates recruitment micro sites, which allow community to be invaded by new species.

Obtained pattern of curve for Block-1 and Block-2 in this study was intermediate between log normal and geometric series. May (1971) suggested that log normal and geometric series are closely related and curve would become flatter if the disturbance acts more on the dominant species.

## Conclusion

The process of forest degradation at the study sites can also be understood from the result of this vegetation analysis, which indicates that in disturbed forest sites more space vacated by the tree stratum was taken over by the shrub and herb communities. Disturbed forest (Hillock) has open canopy and there are more chances of invasion new plant species  The present study is significant in generating useful baseline data in order to conserve and manage the native flora  of this tropical forest ecosystem in the region and elsewhere in the tropical forests in India. Information from this quantitative inventory will provide valuable documentation of forest assessment and improve our knowledge in identification of ecologically useful species. The objective of this paper were to study the community composition, species diversity, and distribution pattern in this valuable forest ecosystem. This will enable the different stakeholders to take appropriate decisions and measures in sustainable forest management

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