International Research Journal of Biological Sciences _____ ISSN 2278-3202
Vol. **7(7),** 13-26, July **(2018)** *Int. Res. J. Biological Sci.*

Phytosociological investigation, Biodiversity conservation and Life form pattern in a *Holeptelia integrifolia* community under Rajaji Tiger Reserve, Uttarakhand, India

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Available online at: www.isca.in, www.isca.me
Received 4th May 2018, revised 1st June 2018, accepted 9th June 2018

Abstract

The study assessed different composition of vegetation, pattern of plant diversity as well as biodiversity conservation in Rajaji Tiger Reserve, Haridwar-Pauri forest divison (29°15' to 30°31' N, 77°52' to 78°22' E, altitude 250–1100 m) in Shivalik Hills of outer Himalaya. The site represents the different combination of dominants and co- dominant species. In trees, most of the species showed contagious pattern of distribution but Listea chinensis, Morus alba Mallotus phillipensis, Cassia fistula showed random pattern of distribution. On the other hand maximum shrubs species showed contagious pattern but only one species showed regular pattern of distribution. In herbs most of the species showed contagious distribution while four species showed the random pattern but none of the species showed regular pattern. The Shannon diversity index for trees was 1.887 and for shrubs and herb it was 1.893 and 2.987 respectively. Plant species with higher number always show high diversity in the forest. The Simpson index for trees was 0.193 and 0.330, for shrubs and herbs it was 0.058. The Pielou eveness index was 0.68 for trees, 0.86 for shrubs and 0.88 for herbs. The species richness index (Margalef index) was 2.60 for trees, 1.21 for shrubs, and 4.82 for herbs.

Keywords: Diversity, community, herb, shrub, trees, Rajaji National Park, density, importance value index.

Introduction

Rajaji National Park has recently been notified as Rajaji Tiger Reserve which is situated in Uttarakhand. It encompasses the Shivalik range, in outer Himalayas. The tiger reserve comes under Rajaji-Corbett elephant reserve. It retain about 90% of 1000 odd elephants in Northern India[1].

The Tiger Reserve spread in area of 820.42 sq km in three districts i.e., Dehardun, Haridwar and Pauri Garhwal. The topography, altitude and climate of Rajaji Tiger Reserve vary greatly, due to which it supports a rich floristic diversity that has been used by local people for their day by day needs. A number of forest products such as food, fodder, fiber, medicine, spices etc. are obtained from Rajaji Tiger Reserve. The park is distinct for scenic beauty and rich biodiversity. It is foliated by sal forest and a number of other forest types which include the Western gangetic moist, Northern dry deciduous and Khair-Sissoo forest. The park is home of Tiger, Leopard, Himalayan Bear, Cheetal, Elephant etc.

Rajaji tiger reserve was established in 1983 as a National park to protect the viable number of Asiatic elephant but the final notification of the park was issued in 2013 because of the non settlements of the rights of the community residing inside the area, which provided a legal status to it and strengthened the various protection activities for flora and fauna in the reserve forest. The core area of the tiger reserve spread in 819.54 Km^2 but now a few portions of Kotdwar and Laldhang forest area of Lansdowne as well as the Shyampur forest range of the Haridwar have been included in the tiger reserve making it about 1075 Km^2. Recently the lansdown forest division has been included with the Rajaji tiger reserve, is now the tenth range along with the all forest range of the tiger reserve[2].

Rajaji Tiger Reserve is fourthly eighth tiger reserve in the country and second tiger reserve in terms of area in Uttarakhand state after Corbett tiger reserve. It was declared Tiger Reserve because it sustains wide range of tigers in upper Gangetic plains. The tiger reserve is an essentials part of the terai-arc landscape between Sharda and Yamuna river. This area is collectively known as Rajaji – Corbett conservation unit in Shivalik landscape which maintains the viable population of tiger[3].

Rajaji Tiger Reserve presents a rich and diverse forest ecosystem. The forest area is comprises of various association of plant community such as the *Shorea robusta –Cassia – Mallotus community, Shorea – Adina - Terminalia*-community, *Dalbergia-Mallotus-Acacia* Community as well as *Syzgium-Phoebe-Dryptes* community. Based on the Physiognomy the permanent vegetation of the tiger reserve can be classified

broadly under the Northern tropical moist deciduous forest and can be grouped into six types: i. Sal forest, ii. Mixed forest, iii. Riverine forest, iv. Scrubland, v. Grassland, vi. Sub tropical Pine forest. The three main seasons in the Rajaji National Park are winter, summer and monsoons. Winter season start from November to February when the days are pleasant (20-25^{0}C), nights are generally cold but the level of humidity is low. Temperature rises rapidly to 40-45^{0}C in the summer season (March to June) whereas the rainfall increases with the occasional thunderstorm but the level of humidity is high in the rainy season (July to October). Annual rainfall ranges from 1200-1500 mm. Soils of the tiger reserve is generally poor and infertile but accumulation of humus in soil occur only at few places. Approximately 84% area of the Tiger Reserve is forested. Among the ten ranges of the tiger reserve, four remains open (15 Nov-15 June) for tourists every years. The numbers of the tourist increases in last 5-6 years. It has been observed that ssuccessful implementation of the ecotourism policy would be useful in reducing the confliction among man and animal and it would also ensure active involvement of the residing community in conservation initiatives[4].

Rajaji tiger reserve appears to be India's one of the most successful conserved area and its development has boost up the population of Asian elephants and tiger in their natural habitat. The number of tigers in last few years has greatly increases that is why the status of tiger reserve to it is given by government of India.

Rajaji Tiger Reserve is one of the important conservation unit in Shivalik landscape, which also forms the North- Western limit of tigers but due to the anthropogenic activity and destruction by animals many species of the plants and are getting effected in the park. The foothills of the Himalayas and the shivalik are called Bhabar. The terai belt consists of dense tall grasses along with the Asiatic elephants and large number of mammalian fauna. Large number of elephant population depends on the bark of *Mallotus philllipensis, Shore robusta*. The chilla- Motichur corridor is 3 km long, 1 km wide lying across the river ganga close to the Haridwar town and the Kotwar corridor lies across the Koh river in Lansdowen forest division. The activity of the elephant near Kotwar corridor getting affected because of the construction of road along with the Koh river but grazing by local's cattle effecting the floral diversity in the area[5]. Many alien and indigenous weeds like *Lantana camara*, *Parthenium hyterophorus* dominated the vegetation in many places.

The Chilla range of the tiger reserve comprises an area of 249.00 km². in the east. It is spreading over 14, 829.8 hac. and situated between 29º 5" 26" to 30º 03" 00" N latitude and 78º, 3" 26" to 78º 23" 36" E longitude.

The Chilla-Gohri range of the Tiger reserve is facing most of the habitat lose, degradation and fragmentation due to the increase of human population. The pressure in Chilla especially the western boundary is also due to the discontinuity of the forest and worst examples of anthropogenic influences[6]. Van Gujjars, now permanently residing in the tiger reserve and raising their cattle for milk and meat feed them by grazing and lopping of the trees.

Material and methods

The present study was carried out in Chilla Range of Rajaji Tiger Reserve, Uttarakhand which comes under the Shivalik range in the foothills of Himalayas during 2015-2017 (Figure-1). The main objectives of the present study were to assess the status of the different layers of the plants by Nested quadrate sampling method. Quadrate size of 20×20 m^2 for tree species and 5×5 m^2 for shrub layer. 1×1 m^2 size of quadrate was laid down randomly to collect the information of the herbaceous species and of ground layer. The diameter at breast height (dbh) of all the estimated individuals in each quadrate was measured for all trees, shrubs and herbs.

Data analysis: The vegetation data were quantitatively analysed for frequency, density, and abundance[7]. Relative frequency, relative density, relative dominance were calculated[8]. The importance value index (IVI) at species level was calculated as the sum of relative frequency, relative density, relative dominance[9]. The following formulas were used to calculate the quantitative parameters:

$$\text{Frequency (\%)} = \frac{\text{Number of the quadrates in which the species occurred}}{\text{Total number of quadrates studied}} x100$$

$$\text{Density} = \frac{\text{Number of individuals of a species in all quadrates}}{\text{Total number of quadrates taken}}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates in which the species occurred}}$$

$$\text{Relative Frequency (RFR)} = \frac{\text{Frequency of individual species}}{\text{Frequency of all species}} x\ 100$$

$$\text{Relative Density (RD)} = \frac{\text{Density of individual species}}{\text{Density of all species}} x\ 100$$

$$\text{Relative Dominance (RDo)} = \frac{\text{Basal area of a species}}{\text{Basal area of all species}} x\ 100$$

Importance value index (IVI) = Relative Frequency + Relative density+ Relative dominance.

The ratio of abundance to frequency was used to determine the distribution pattern of species[10]. The ratio of abundance to frequency indicates regular distribution if below 0.025, random distribution between 0.025-0.05 and contagious if it is >0.05[11]. Similarity index was calculated by using the Importance value index data of trees, shrubs and herb data[12].

Shannon's diversity index: Diversity indices reflect the manner in which abundance is distributed among the different species constituting the community. Species diversity index (H') was determined separately from the Shannon-Wiever's information function[13].

$H' = -\Sigma\, pi \ln p_i$

Where, pi = ni/N, which denotes the importance probability of each species in a population; ni = importance value for species "i", N = total of importance values. Concentration of dominance (Cd), known as Simpson index[14].

$Cd = \Sigma\, p_i^{\,2}$

The evenness index was determined by[15]:

$J' = H'/\ln s$

The Richness index was determined by[16]

$R = S-1/\ln(N)$

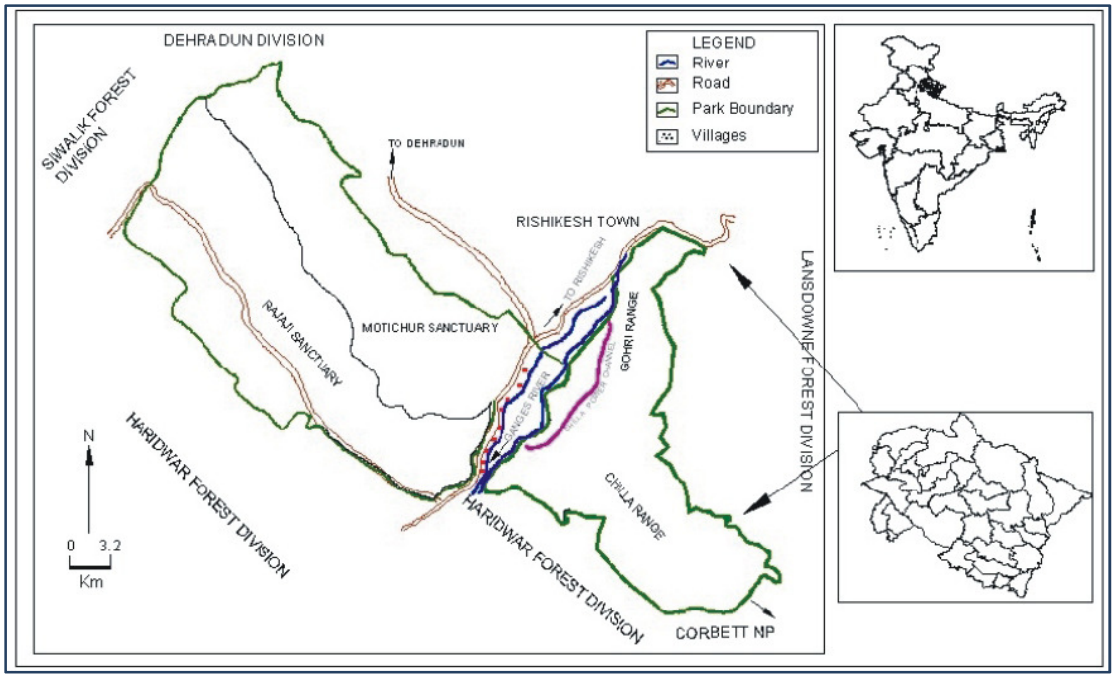

Figure-1: Map of Rajaji National park showing the Study area (Chilla range).

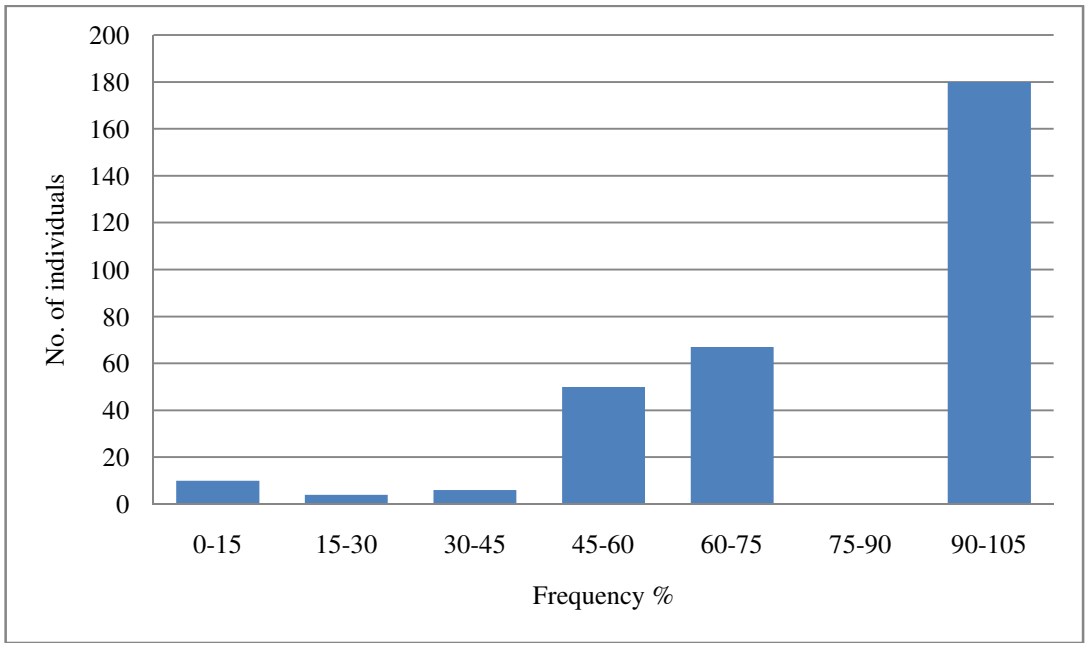

Figure-2: Frequency class distribution of tree species in the study area.

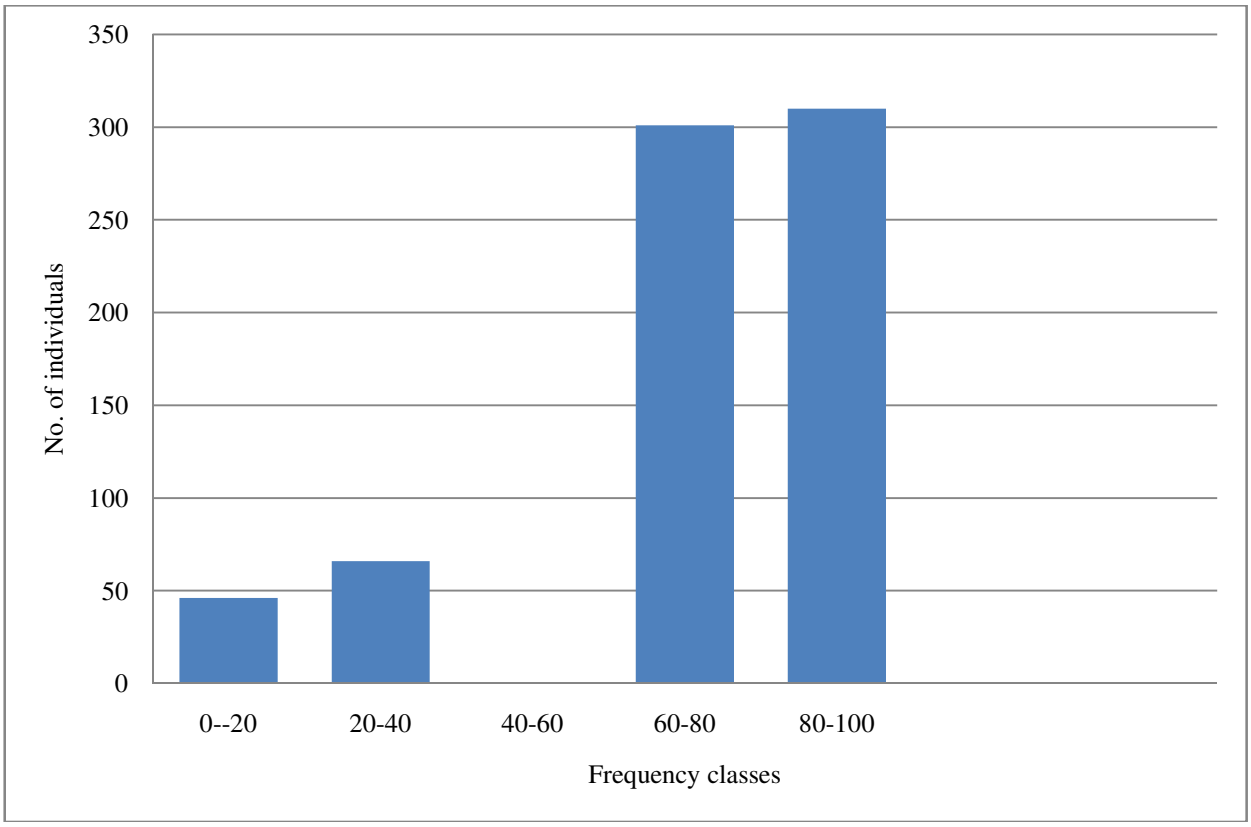

Figure-3: Frequency class distribution of shrub species in the study area.

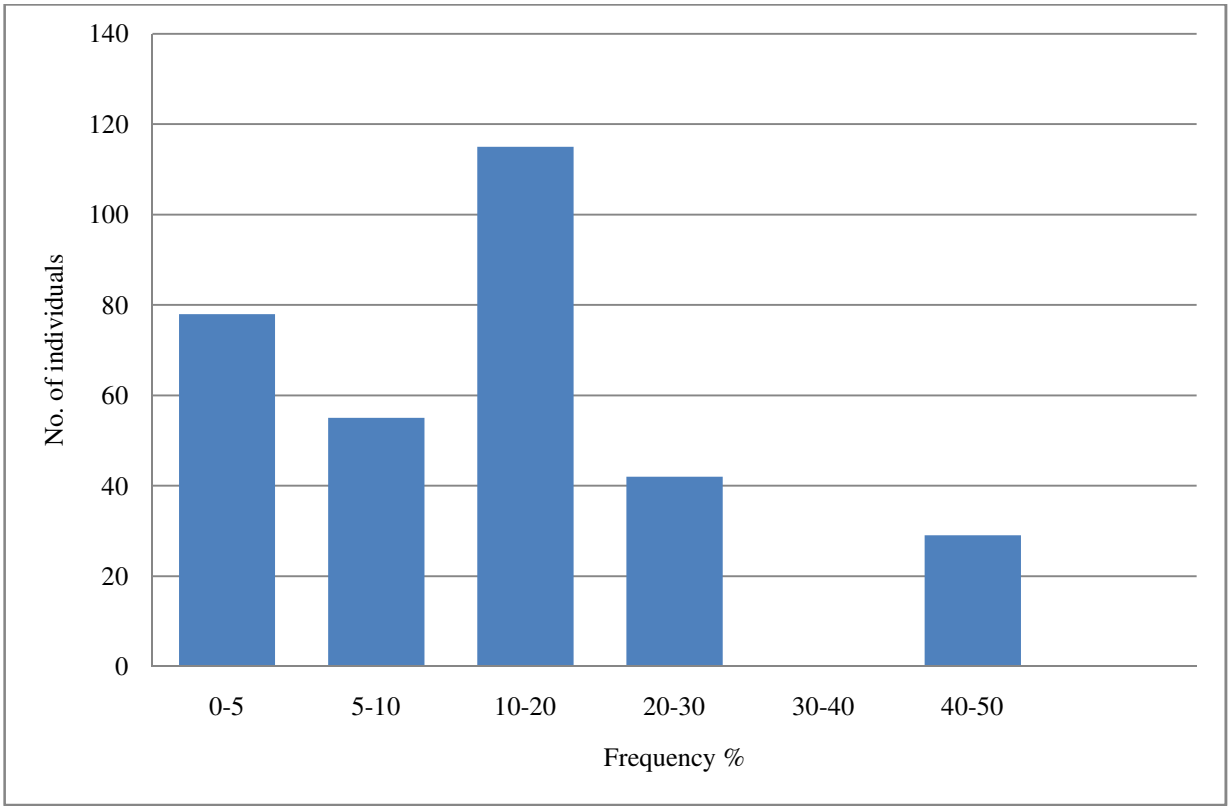

Figure-4: Frequency class distribution of herb species in the study area.

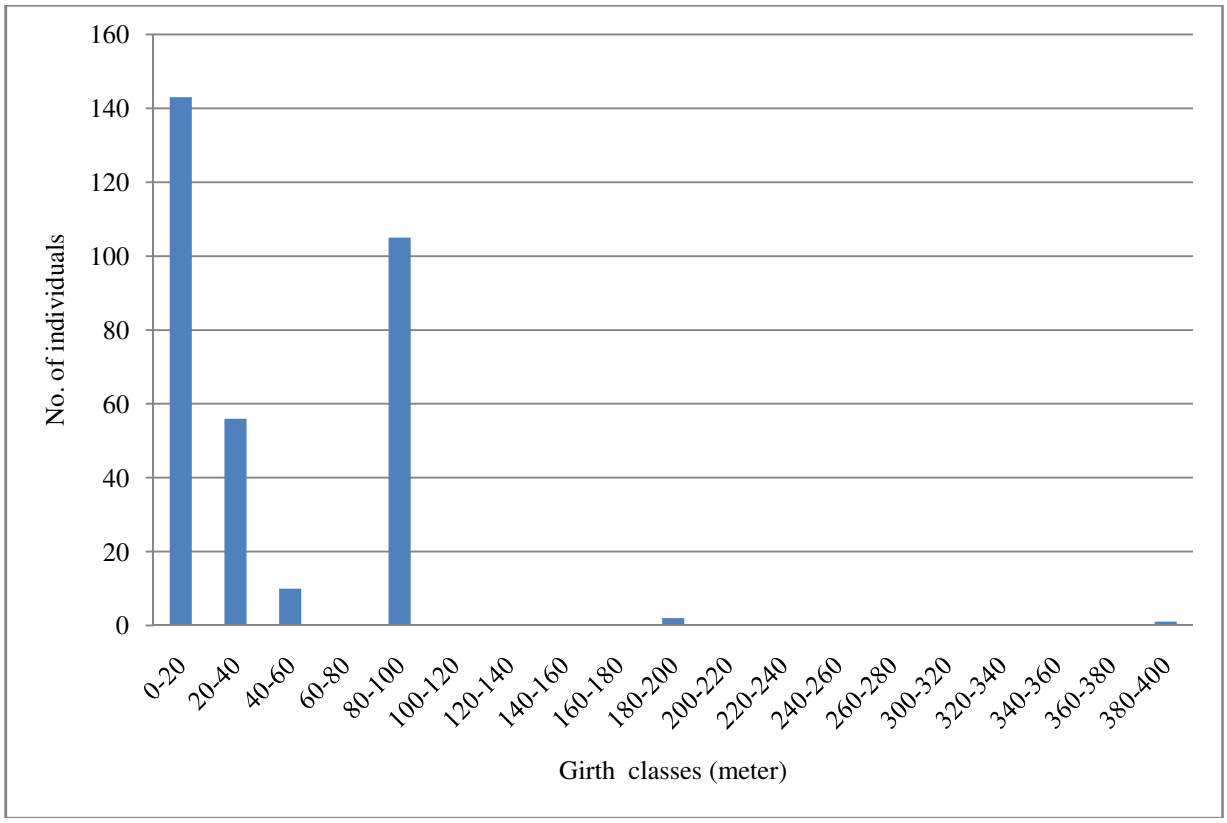

Figure-5: Girth Class distribution of trees in study area.

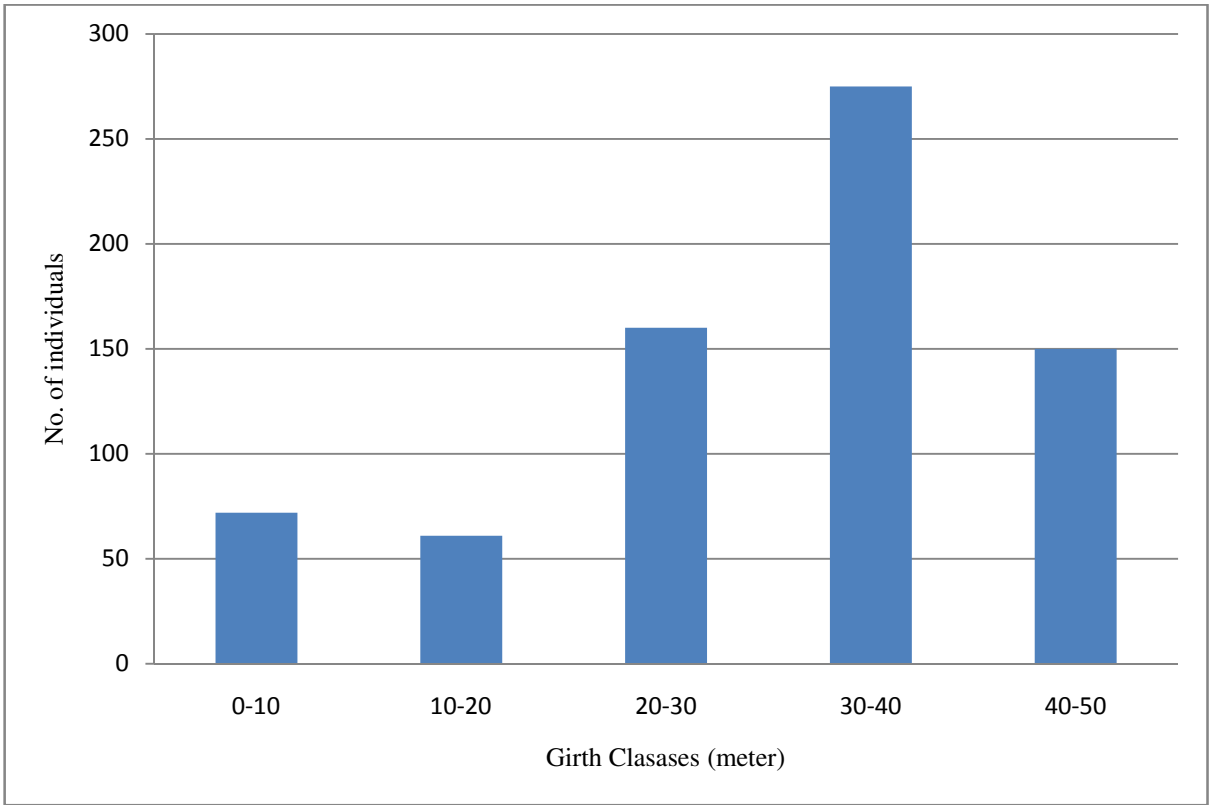

Figure-6: Girth Class distribution of shrubs in study area.

Table-1: Frequency, Density, TBC, Abundance, A/F, Relative Frequency, Relative density, Relative dominance and Importance value index of trees in the study area.

Species	Family	Density/ hectare	TBA (m^2 hac^{-1})	A /F	RF	RD	RDo	IVI
Holoptelia integrifolia	Ulmaceae	216.6665	11.74758	0.08667	16.901	32.504	67.886	117.291
Ehertia laevis	Ehretiaceae	43.75	0.16056	0.07	8.451	6.563	0.928	15.942
Alstonia Scholaris	Apocynaceae	2.08325	0.13435	0.12	1.408	0.313	0.776	2.497
Naringi crenulata	Rutaceae	139.58325	0.19542	0.09926	12.676	20.94	1.129	34.745
Cassia fistula	Fabaceae	12.5	0.3195	0.045	5.634	1.875	1.846	9.355
Mallotus phillipensis	Euphorbiaceae	62.5	0.11813	0.02975	15.493	9.376	0.683	25.552
Morus alba	Moraceae	12.5	0.0895	0.36	1.408	1.875	0.517	3.8
Cedrella toona	Meliaceae	2.08325	0.186645	0.12	1.408	0.313	1.079	2.8
Orozylum indicum	Bignoniaceae	4.1665	0.05991	0.06	2.817	0.625	0.346	3.788
Crateva religiosa	Capparidaceae	60.4166	0.12446	0.07102	9.859	9.064	0.719	19.642
Ficus palmate	Moraceae	2.0825	0.01035	0.12	1.408	0.313	0.06	1.781
Celtis australis	Cannabaceae	2	0.01432	0.12	1.408	0.3	0.083	1.791
Ficus religiosa	Moraceae	4.1665	0.08789	0.06	2.817	0.625	0.508	3.95
Adina cordifolia	Rubiaceae	2.08325	2.65381	0.12	1.408	0.313	15.336	17.057
Listea chinensis	Lauraceae	95.8325	0.17921	0.02975	15.493	14.377	1.036	30.906
Terminalia bellerica	Combretaceae	4.1665	1.22233	0.24	1.408	0.625	7.064	9.097
Total		666.57	17.304		99.99	100.	99.34	299.994

Table-2: Frequency, Density, TBC, Abundance, A/F, Relative Frequency, Relative density, Relative dominance and Importance value index of shrubs in the study area.

Species	Family	Density/ hactare	TBA (hac)	A /F	RF	RD	RDo	IVI
Murraya koenigii	Rutaceae	2300	26.313	0.1146	14.407	19.22	24.802	58.429
Lantana camara	Verbenaceae	2500	38.525	0.0625	20.339	20.891	36.313	77.543
Adhatoda vesica	Acanthaceae	2666.64	16.7465	0.08707	17.797	22.284	15.785	55.866
Helictres isora	Sterculaceae	350	0.14	0.31499	3.39	2.925	0.132	6.447
Cassia occidentalis	Fabaceae	483.332	0.70083	0.08593	7.627	4.039	0.661	12.327
Clerodendrum viscosum	Verbenaceae	22883.33	22.51363	0.11377	14.407	19.081	21.221	54.709
Calotropis procera	Apocynaceae	533.32	0.85331	0.3072	4.237	4.457	0.804	9.498
Colebrookia oppositifolia	Lemiaceae	416.6685	0.21667	0.37499	3.39	3.482	0.204	7.076
Indigofera spp	Fabaceae	433.332	0.08233	0.00353	14.407	3.621	0.78	18.808
Total		11966.62	106.09		100.00	100.00	100.00	300.00

Table-3: Frequency, Density, Abundance, A/F, Relative Frequency, Relative density, Relative dominance and Importance value index of herbs in the study area.

Species	Family	Density/m^2	A/F	RF	RD	RDo	IVI
Kallinga monochephala	Cyperaceae	56.944	1.05426	1.532	8.836	10.158	20.526
Adiantum spp	Pteridaceae	29.167	0.03429	11.488	4.526	1.264	17.278
Ageratum conyziodes	Asteraceae	40.278	0.045	15.864	6.25	13.042	35.156
Achyranthus aspera	Amaranthaceae	16.667	0.060.08	6.564	2.58,6	4.302	13.452
Cyanodon dactylon	Poaceae	12.5	0.08	4.923	1.94	0.105	6.968
Sida spinosa	Malvaceae	36.11	0.52002	3.282	5.603	5.965	14.85
Mucuna pruriens	Fabaceae	1.389	0.71994	0.547	0.216	0.037	0.8
Centella asiatica	Apiaceae	16.667	2.15983	1.094	2.586	0.333	4.013
Oxallis corniculata	Oxallidaceae	19.444	0.6295	2.19	3.017	0.031	5.238
Abutilon indicum	Malvaceae	177.778	0.14222	4.923	27.586	39.975	72.487
Cayratia trifolia	Vitaceae	16.667	0.36	1.094	2.586	0.333	4.013
Xanthium strumarium	Asteraceae	9.722	0.31497	2.188	1.509	1.028	4.725
Parthenium hysterophorus	Asteraceae	26.389	0.1368	5.47	4.095	16.361	25.926
Cissampelos prariara	Menispermaceae	22.222	0.08	6.564	3.448	1.172	11.184
Borhavia diffusa	Nyctaginaceae	4.167	2.15983	0.547	0.647	0.002	1.196
Commelina benghalensis	Commelinaceae	11.111	0.35997	2.188	1.724	0.294	4.206
Perilla frutscense	Lamiaceae	6.944	0.23998	1.641	1.078	0.184	2.903
Euphorbia hirta	Eophorbiaceae	9.722	1.2599	1.094	1.509	0.017	2.62
Pogostemon benghalensis	Lamiaceae	6.944	0.47996	1.641	1.078	0.184	2.903
Cyprus rotundus	Cyperaceae	26.389	0.16889	4.923	4.095	0.634	9.652
Evolvulus nummularius	Convolvulaceae	9.722	0.35997	1.094	1.509	0.017	2.62
Oplimensus burmanii	Poaceae	1.389	0.71994	0.547	0.216	0.028	0.791
Ichnocarpus frutescense	Apocynaceae	29.167	0.0672	8.205	4.526	3.201	15.932
Asparagus racemosus	Asparagaceae	4.167	0.23988	1.641	0.647	0.062	2.35
Cheilanthes spp	Pteridaceae	33.333	0.27	4.376	5.172	0.941	10.489
Vitis latifolia	Vitaceae	9.722	0.71994	0.547	1.509	0.017	2.073
Aerva sanguinolenta	Amaranthaceae	4.167	0.23998	1.641	0.647	0.083	2.371
Bahunia vahlii	Fabaceae	1.388	0.72	0.547	0.215	0.147	0.909
Launea procummbens	Asteraceae	4.167	0.02493	1.58	0.647	0.083	2.31
Total		644.44		99.93	100.00	100.00	299.941

Dominance diversity (d-d) curve: The dominance diversity curve is generally used to determine the grouping of the community in terms of the sharing resource and ecological niche space[17]. Organization of trees, shrubs, and herbs on the basis of importance value index and species sequence, dominance-diversity curve were drawn.

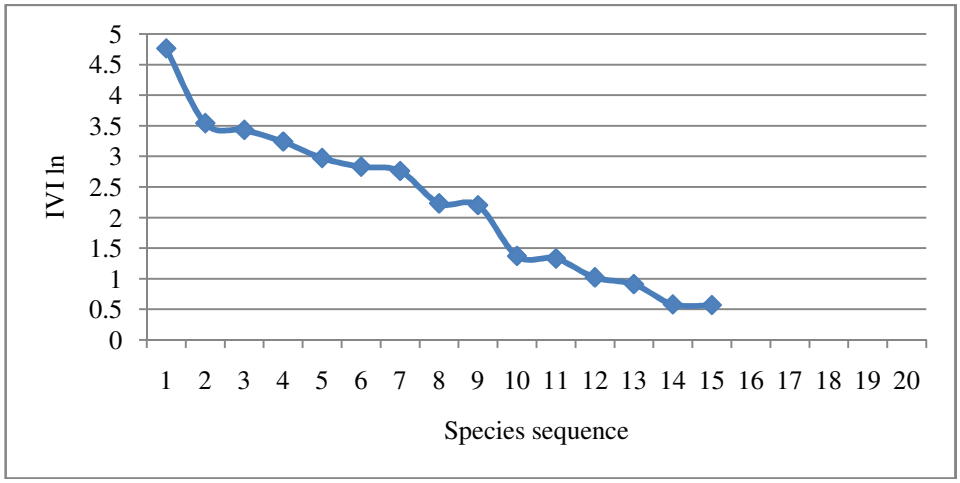

Figure-7: Dominance-diversity curve for trees.

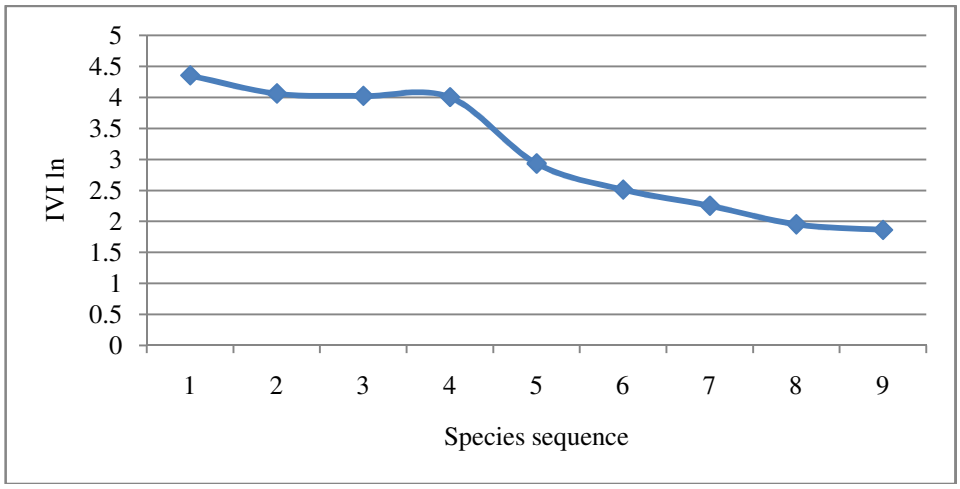

Figure-8: Dominance-diversity curve for shrubs.

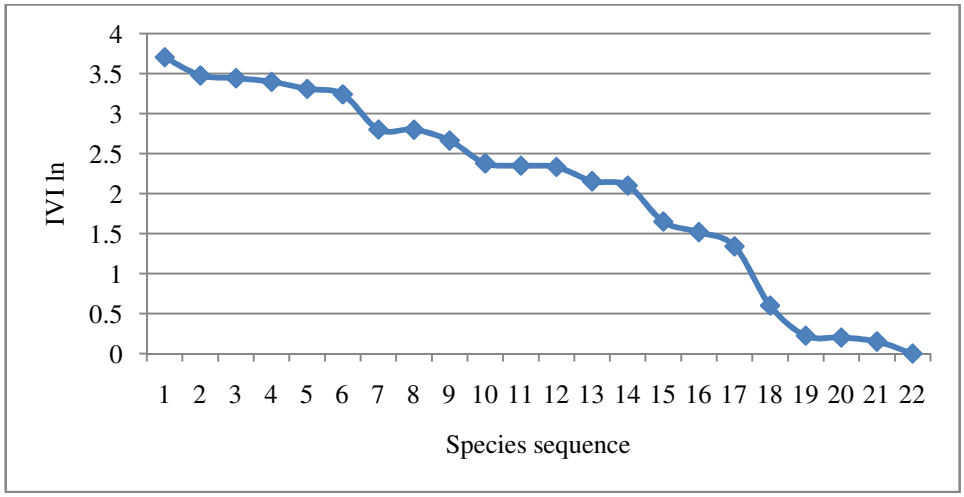

Figure-9: Dominance-diversity curve for herb.

Table-4: Characteristics of trees, Shrubs and Herb in the study area.

Parameter	Tree	Shrub	Herb
Shannon's diversity index	1.887	1.893	2.987
Simpson Index(cd)	0.193	0.330	0.058
Pielou Eveness Index	0.68	0.86	0.88
Richness index	2.60	1.21	4.82

Results and discussion

Tree species composition: A total of 16 tree species belonging to 15 genera under 14 families were recorded in the study area (Table-1). In trees, most of the species belongs to family Moraceae (3) followed by the Ulmaceae, Ehretiaceae, Apocynaceae, Rutaceae, Fabaceae, Euphorbiaceae, Bignoniaceae, Lauraceae, Rubiaceae, Cannabaceae, Capparadiaceae, Combretaceae (1 species each). The total stem density in the study area was 666.5797 individuals hac^{-1} in which highest was recorded for *Holoptelia integrifolia* (216.6665 hac^{-1}) and lowest was recorded for *Alstonia Scholaris, Cedrella toona, Ficus palmata*, *Adina cordifolia* (2.08325 hac^{-1} each). The basal area ranged from 11.74758-0.01035 m^2 hac^{-1} for different tree species in the study area (Table 1). The total basal area was 17.30493 m^2 hac^{-1} in which the highest basal area was of *Holoptelia integrifolia (*11.74758 m^2 hac^{-1}) and lowest of *ficus palmata* (0.01035 m^2 hac^{-}).

The importance value index (IVI) of trees species ranged form 1.781 - 117.291 (Table-1). *Holoptelia integrifolia* had the maxium IVI of 117.291, this states that *Holoptelia integrifolia* was the most dominated species of the study area while *Ficus palmata* and *Celtis australis* were the least dominant species in the study area.

The abundance frequency ratio (A/F) of maximum trees showing contagious distribution of the species and only four species showed the random pattern of distribution but none of the species showed regular pattern of the distribution.

Shrub species composition: Nine (9) species of shrub were recorded in the study area under *Holeptelia integrifolia* community (Table. 2). In shrub, most of the species belongs to the family Verbenaceae (2) followed by Fabaceae (2), Rutaceae, Acanthaceae, Sterculaceae, Apocynaceae, Leminacea (one species each). Stem density for shrub ranged from 350 to 22883.33 hac^{-1} . The highest stem density was 22883.33 hac^{-1} which was recorded for *Clerodendrum viscosum and* lowest was 350 hac^{-1} for *Helictres isora.* The basal area ranged from 0.14-22.51363 m^2 hac^{-1} which was again highest for *Clerodendrum viscosum (*22.51363 m^2 hac^{-1}) and lowest for *Helictres isora* (0.14 m^2 hac^{-1}).

The importance value index of shrub was highest for *Lantana camara* (77.543) indicating that it was the most dominant species of the shrub in the study area followed by *Murraya koenigii* (58.429), *Adatodha vasica* (55.866), *Clerodendrum viscosum (*54.709). The lowest IVI was recorded for *Helictres isora (*6.447) indicating that species was the least dominated in the study area.

The abundance frequency ratio (A/F) of maximum shrub showed contagious distribution of the species and only one species showed the regular pattern of distribution but none of the species showed random pattern of the distribution.

Herb species composition: A total of 29 herb species under 23 families recorded from the study site under *Holeptelia integrifolia* (Table-3). In herb most of the species belonging to the family Asteraceae (4) followed by Poaceae (2 species each), Fabaceae (2species each), Lamiaceae, Pteridaceae, Commelinaceae, Cyperaceae, Amaranthaceae, Malvaceae, Apiaceae, Oxallidaceae, Memispermaceae, Vitaceae, Nyctaginaceae, Euphorbiaceae, Convulvulaceae, Apocynaceae, Asparagaceae, (1 species each). The stem density of herbal species ranged from 1.389- 177.778 cm^2 in which highest was recorded for 177.778 for *Abutilon indicum* and lowest was for *Mucuna pruriens, Oplimensus burmanii (1.389* cm^2*).*The importance value index (IVI) ranged from 0.791-72.487 of the herb layer in the study site. Highest IVI was recorded for *Abutilon indicum (*72.487) indicating the most dominant species of herb and lowest IVI was recorded for *Oplimensus burmanii* (0.791) which was the lowest distributed species in the area.

The abundance frequency ratio (A/F) of maximum herb showed contagious distribution of the species and only 4 species showed the random pattern of distribution but none of the species showed regular pattern of the distribution.

The correlation between different vegetational parameter of trees, shrubs and herbs are given in Figure-11,12,13). The density was positively correlated with the total basal area in all the strata. In trees it was (r=0.244), shrubs (r=0.075) and herbs (r = 0.096).

Discussion: In Himalayan forest ecosystem different form of disturbance exists in which locals inhabitants remove a little portion of plant biomass in different form like lopping, grazing, scraping etc. The disturbance causes adversely effects on the forest ecosystem and retards the successional process in the area. Different types of forest ecosystem arises on different altitude due to the anthropogenic disturbances and others factors. In addition, variation in topography, rainfall, soil, rainfall and other climatic conditions are responsible for sustaining the specific types of plant community[18]. Our study also states that the different plant community like *Shorea robusta- Mallottus phillipensis, Dalbergia sisoo, Holeptelia integrifolia,* and mixed forest community in Rajaji Tigere Reserve has evolved due to the anthropogenic activity, different

temperature at different sites of the park, different soil, rainfall pattern and different climatic condition. It has been also observed in the study area that these different plant communities have different temperature, climatic, different coordinates, soil, rainfall and different environmental conditions.

In a forest ecosystem, high level of frequency revels its frequent distribution in forest ecosystem due to different climatic condition. In North West Himalaya, 100% frequency for *Callipedium parviflorum* was observed[19]. In our study, we have also recorded 100% frequency of *Holoptelia integrifolia*. In a forest ecosystem, every species play particular role and there is a specific relationship in terms of quantity between abundance as well as the rareness of species[20]. High importance value index ((IVI)) indicates that all the available resources are being are utilized by that species and left over being trapped by other competitors and associated species in the area. The high IVI of the species also states its dominance and ecological success, its better power of regeneration and ecological amplitude. In present study, the importance value index (IVI) of *Holeptelia integrefolia* was highest (117.291) for tree species in comparison to others competitors and associated species which was also similar to the result of other worker[19].

In present study, the abundance to frequency (A/F) ratio reveals that maximum species of the trees, shrubs and herb showed the contagious pattern of distribution (Table-1,2,3). The contagious pattern of species is the characteristics pattern of nature[21] and also same contagious pattern of species distribution was reported in the disturbed lands of Garhwal Himalayas[22-25] and in others area of forest ecosystem as well[26-28]. The contagious pattern of distribution of the species was due to the multitude of environmental conditions[26,29]. In our results, the observation of the *Holoptelia integrifolia* community also indicates that contagious pattern of distribution was due to the multitude of environmental factors. Only one species of the shrub had showed the regular pattern of distribution in shrub which may be occurs due to the severe competition exists between individuals. The random pattern of species occurs only in very uniform environmental conditions of the area.

The species with higher number and diversity always give higher diversity in the forest[30]. The Shannon weaver index for tree was 1.88, 1.89 for shrub and 2.89 for herb. The values of the Shannon weaver diversity was also reported from the Western part of the Himalayas in Uttarakhand by different workers whose value were (2.43-3.33)[31], (0.78-3.45)[32], (0.95-3.30)[33]. The concentration of dominance (Simpson Index) was 0.19 for trees, 0.33 for shrubs and 0.05 for herb in the study area. Similar result was reported form Western part of Himalaya in Uttarakhand which ranges from 0.06-0.1 for higher and lower altitude in tree layer and 0.08-0.09 in shrub layer for lower and mid altitude[34]. The concentration of dominance strongly affected by first three IVI values of the species[35]. In the present study the Pieloe Eveness index was 0.68 for trees, 0.86 for shrubs and 0.88 for shrubs. Similar results obtained from different study by worker in Garhwal Himalayas who reported 0.47-0.83 for trees, 0.69-0.87 for shrubs from[36]. The Pielou index was 0.73 for trees, 0.89 for shrubs and it was 0.83-0.90 for herbs from the study of moist temperate forest in Garhwal[31].

The community occurs at different environmental conditions differs in the species they contain. The Margalef index for trees was 2.60, for shrub it was 1.21 and 4.82 for herbs in *Holoptelia integrifolia* community of the present studied area. Similar results was obtained from the forest of Garhwal Himalaya by other worker whose value ranges from 2.37-4.63 for trees, 1.78-3.06 for shrub[34]. Similar results was also reported from different parts of the Uttarakhand by worker whose value ranges 2.21-7.00 for trees and 3.74-5.93 for shrubs[36], 1.36-2.17 for trees and 0.63-1.69 for shrubs[31]. The maximum species richness at high altitude of the forest may be due to high moisture, rain fall, humidity. The area with mid altitude and temperature with 10º-24º C contains 60% of the total species[37]. The high richness for herb in the tiger reserve under *Holoptelia integrifolia* community also may be due to the less grazing, and any other biotic pressure. Some area of the community is less affected by van gujjar and their cattle so maximum numbers of the herb species were recorded at there.

Perspective of forest conservation in Rajaji tiger reserve: National Park, Wildlife sanctuary, Tiger reserve can incorporate strategies in climate change adaptation in routine adaptation such as fire management by construction of fire line, wildlife management. Protected areas enable a country to protect biodiversity in a natural habitat. Different studies concluded that National park and other conservative areas are very effective in preventive habitat loss[38,39]. At the beginning of the establishment of National park and other conservative areas it was thought that local people living in tend to overuse which destroy the biological and Natural resources therefore excluded to ensure effective conservation[40-42]. Wildlife sanctuary, National park, Tiger reserve, forest are created not only for the animals and plants but with the aim of preserving the environment, cultural, social, and historic value[43]. In other words protected areas are the policy instrument that aim sustainable use of biological and natural resources within the defined geographic area. There are about 150,000 protected areas worldwide[44].

Plants sociological characters such as density, frequency, abundance were influences by anthropogenic as well as natural stress. The Chilla range of the Rajai Tiger reserve (earlier named as Rajai Nationl Park) dominated with *Shorea robusta, Dalbergia sissoo, Holoptelia integriflolia.* All of these plants have economic value. Fodder Plants like, *Ficus religiosa,F,auriculata,F. palmate, Emblica officinalis Anogeissus latifolia, Dendrocalamus strictus, Bauhinia variegata, Grewia oppositifolia, Lagerstroemia parviflora, Ficus bengalensis, Schleichera oleosa, Aegle marmelos* getting lopped by Gujjar residing in the tiger reserve. Lopping of trees in forest areas is a conventional practice and it is a significant

forest-based economic activity for the people residing in the vicinity of forest areas since it produces benefits to them from forest crops in the form of firewood and fodder[45].

Besides all the anthropogenic as well as abiotic pressure in this area the faunal as well as the floral diversity is increasing in the study area due the large forested area. The relocation programme is still going for the local villagers and Gujjars residing in the area. The relocation programme of the government also make great reinforcement for the conservation of the biodiversity in the study area. The biodiversity conservation is associated with the relocation of the residing people and has emerges an important issues in the conservation of the biodiversity[46]. Grasses slip, broadcasting seeds and other pioneer species such as *Dalbergia sissoo, Acacia catechu, Bauhinia variegata* has been planted in restoring of sand. The remains of the uprooted weed such as *Lantana camara, Cassia tora* pressed with the boulder to stop them from being blown away by wind. In this way a carbon rich substrate for seed remains in soil.The undisturbed condition created due to the relocation has made great effect on the population of elephant and tiger. The animals of the reserve area currently utilizing the entire internal corridor which passes the abandoned areas of the Gujjars and also utilizing all of the available waterholes available in the area to fulfill their routine requirements throughout the day. Floral species also increases in numbers in that area where the activity of the human is restricted. Systematic fuel wood plantation in the area where villagers/community residing or setting the forest compartments for fuel wood would be a viable strategy to ease the biotic pressure in protected areas. Thus systematic biodiversity conservation efforts would be require conserving the wildlife especially in tropical forest. Since the concept of the biodiversity is multidimensional that is why it cannot be expressed in a single scalar quantity. It can be better expressed by the information of taxonomic information of the species, geographical information, abiotic factors and life forms variation to describe the biodiversity of a forest.

Conclusion

Our study indicated that Rajaji tiger reserve has the greater diversity in terms of flora as well as fauna. The *Holptelia integrifolia* community comprises of many species of the trees, shrubs and herbs, which have ecologically significance. Though the tiger reserve was established to prevent the Asiatic elephant in 1983, but now it also inhabits large population of tigers. In some places the reserve is facing serious disturbances due to the biotic as well as abiotic pressure but it is maintaining the biodiversity and helping in many ways to conserve the floral as well as the faunal wealth due to the large area of the reserve forest. The relocation programme for the people in the tiger reserve by government also keeping the forest free from the biotic pressure. The forest has large number of floral wealth which can be used for future aspects. So many medicinal plants, aromatic plants are now safely growing in the forest. Preventing the wildlife is not only crucial for maintaining the biodiversity, but also meeting the basic need of other beings. Proper care, maintenance of the tiger reserve needed so that the wildlife can be prevented.

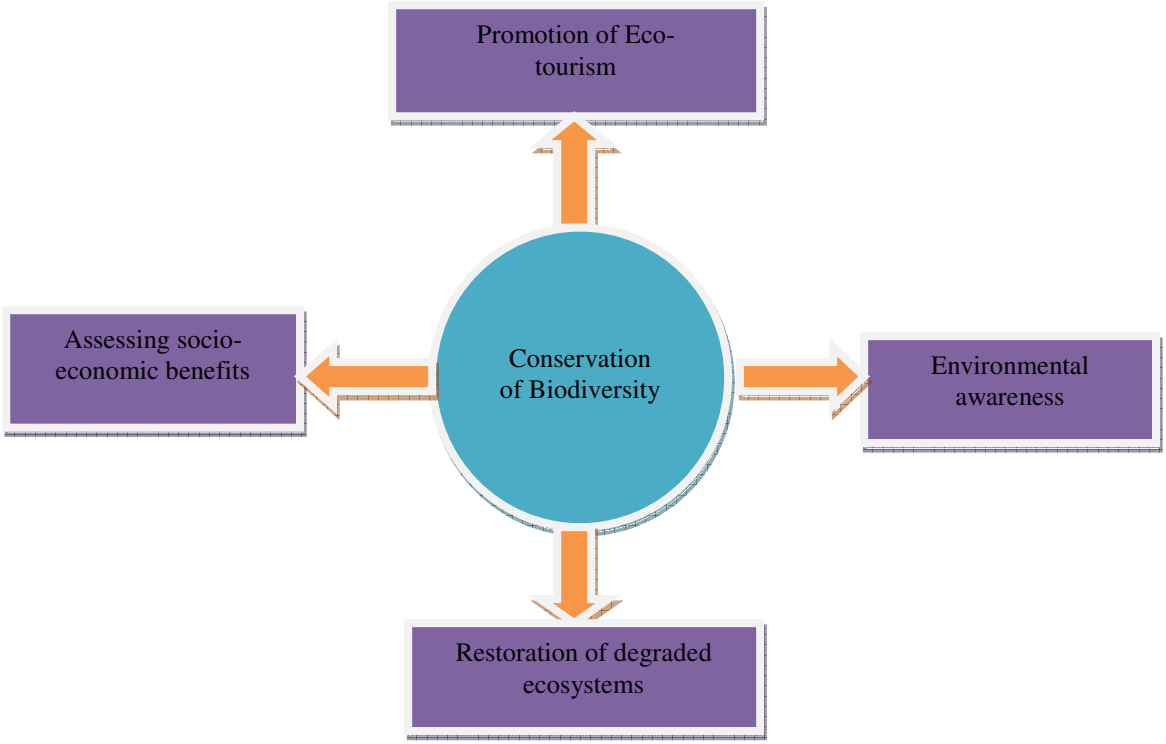

Figure-10: Benefits of biodiversity conservation in a protected area.

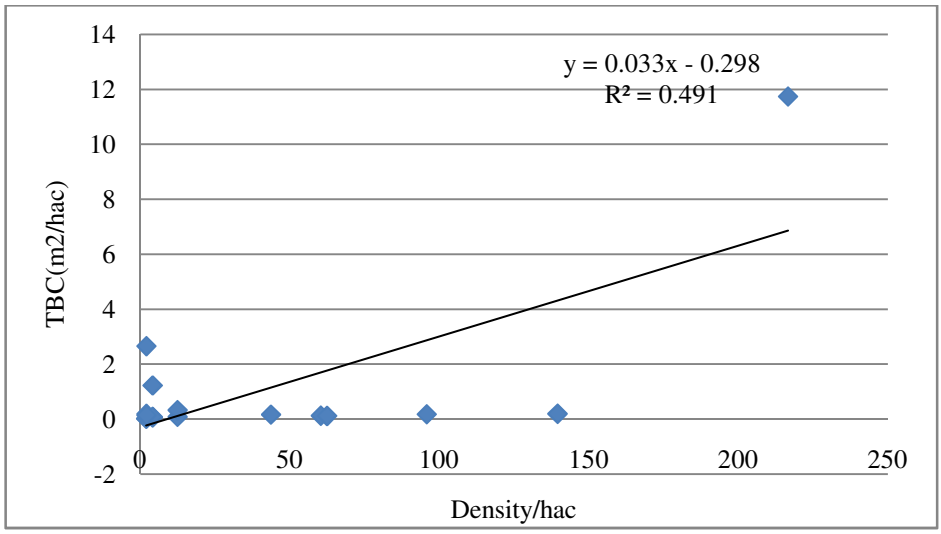

Figure-11: Correlation between density/hac and total basal area in tree layer.

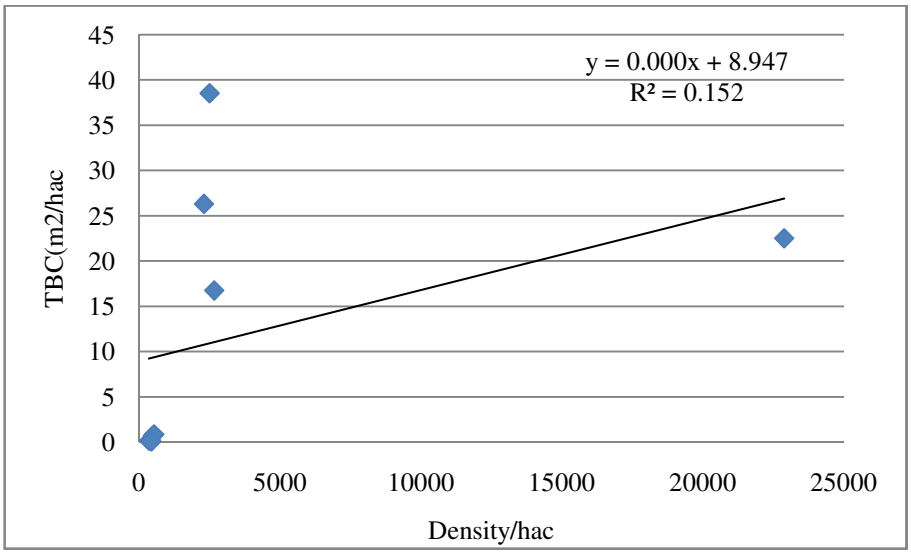

Figure-12: Correlation between density/hac and total basal area in shrub layer.

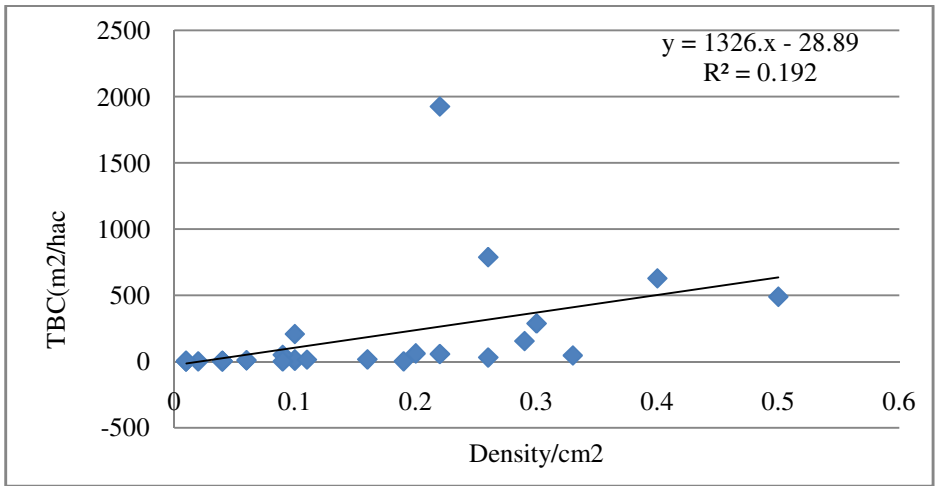

Figure-13: Correlation between density/hac and total basal area in herb layer.

Acknowledgement

The author is grateful to the Director, Forest guard of the Rajaji tiger reserve for their help during the field work.

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