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VEGETATIONAL ANALYSIS OF WOODY VEGETATION IN BURNT AND UNBURNT FOREST COMMUNITIES OF PAURI, GARHWAL HIMALAYA

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Abstract

The present work was carried out in four different forest regimes of Pauri, Garhwal and analyzed the consequence of forest fire on different attributes of the forest ecosystem. Four permanent sites were selected of which two were burned and other two were unburned. Vegetational data were collected from all the sites and analyzed i.e., Floristic composition, frequency, density, TBC, A/F and IVI etc. Different diversity indices i.e., Shannon Wiener index, Simpson's index of dominance (Cd) and Margalef species richness index etc. were also applied for the data analysis. The results revealed that burned forests were more dense and rich than unburned forests. The values of diversity indices were higher on the burned sites than unburned sites. The maximum number of species was randomly and contagiously dispersed while regular distribution is rarely observed in some species. The observed results of the study indicates that phytosociological changes in woody vegetation of forest were carried out by forest fire, anthropogenic and other biotic pressure in terms of floristic composition, frequency, density and dispersion pattern.

Key words : Dominance, floristic composition, contagiously, dispersion and biotic pressure.

Introduction

Forest fire is burning issue in all over the world. Fire affects all forms of life i.e. vegetation structure, soil behavior, animals and also microorganism. Forest play important role in human life as well as wild life and also maintain or balance the ecosystems. During the last decade, many countries have experienced extremely severe wildfire episodes. Forest fire is the principal disturbance factor in the forest community and also organizes the abiotic and biotic aspects of forest, shaping landscape diversity and manipulating flow of energy and biogeochemical cycles (Weber and Flannigan, 1997). Forest fire mainly influences the physical, chemical, mineralogical and biological properties of the soil. Severe burning and increased temperature are usually outcome of type and extent of fire (Certini, 2005). Fire plays significant role in both the creation and the destruction of forest. Prescribed burning is presently being used by various nations as a management tool to shrink the fuel burden, im-prove the forest habitat, and to repair the composition and function of ecosys-tem. Usually prescribed fires yield desirable results if applied scientifically and wild fires destroy the forest (Elliott *et al*., 2009).

Globally, it can participate in maintaining characteristic environments and human community. Although forest fire is one of chief reasons for loss of biodiversity, degradation of the environment but also plays imperative part in shaping forest and climate change. But degree of effectiveness of blaze in the landscape is largely determined by the mode of fire. Forest fire is used comprehensively to encourage restoration of vegetation for livestock in the hilly areas. Occasionally some forests depend on blazing for regeneration, others are prone to severe damage as burning can escort to the loss of native species, changes in the composition of forest, succession stages and also activate generous changes in the functions of ecosystem (Jackson and Moore, 1998).

In Indian context, man caused fire is more common than the natural fire. The unknown causes of fires need to be investigated by young pyrologists. It is proved that there were 25% accidental and 75% intentional cause of fire. After making survey of different landscape types in sub–montane and montane zone of Garhwal Himalaya, they experienced that most of forest fire were man caused

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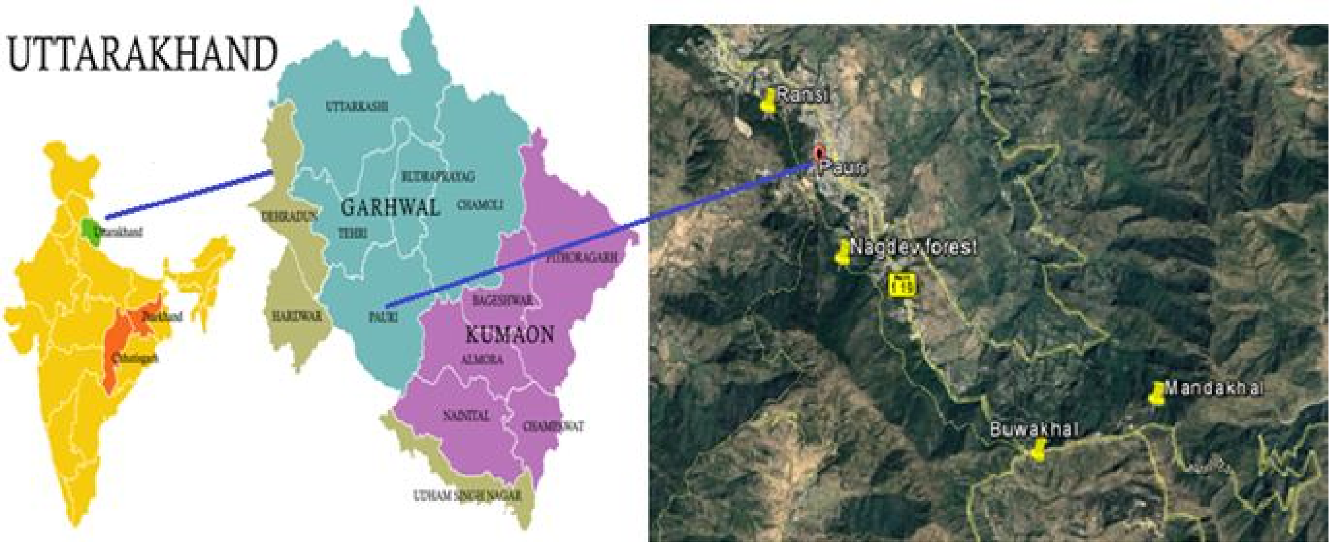


Fig. 1 : Map showing the location of study areas (Source- Google map).

or intentional fire (Tiwari *et al*., 1986). Historic perceptions indicate that expanded aridness additionally leads towards prevalent fire and forest cease to exist. These occasions intersperse slow changes to biological communities and moreover cause numerous changes in the forest community (Charles *et al*., 2012). Several factors such as forest ecosystem management, soil attributes and biodiversity are influenced by ecological function of fire (Smith and Fisher, 1997). However disorderly use of flames can be reason behind the environment degradation and unfriendly effects on the human culture. Annually fire may diminish the expansion of the grasses, forbs and bushes, which may bring about increased soil erosion and mainly ground fire annihilates the organic matter, which desirable to keep up an ideal level of humus in the soil layer (Kandya *et al*., 1998). This paper deals with the effects of fire on diverse aspects of forest vegetation.

Materials and Methods

Study area

The area preferred for the present study falls under Pauri, Garhwal Uttarakhand, India and is located at Pauri (30°09'N-30.15°N latitude and 78°78'E-78°47E longitude) covering the elevation between 1700 to 2000 m asl. The southern periphery of Pauri Garhwal district borders with Bijnor district of U.P and other three sides with Haridwar, Dehradun, Tehri, Rudraprayag, Chamoli, Almora and Nainital district. Pauri is a spectacular place bounded by intense forest cover. Natural vegetation of the vicinity includes dominance of *Quercus leucotrichophora*, *Cupressus torulosa*, *Cedrus deodara* and *Pinus roxburghii* in lower altitude to mixed conifer species at the higher altitude. Four sites encompassing an altitudinal range from 1700-2200 m asl were selected in Ransi – Nagdev and Mandakhal– Buakhal. Four plots were demarked in Pauri of which two were burnt *i.e.*, MBS and RBS (Mandakhal burnt site and Ransi burnt site) and other two were unburnt *i.e.*, BUS and NUS (Buakhal unburnt site and Nagdev unburnt site). Each site was covering the area of 1 hectare. These sites were studied starting 3 month after ground and surface burning conducted by forest officials in January 2015. There was no history of prior burning on the unburnt site although the burnt sites had experienced frequent fires episodes at 2-3 years intervals. The study area experienced temperate type of climate of very cold in winter, rainy and pleasant in summer. Temperature of the area ranged between -2ºC to 20ºC in January and 24ºC to 36ºC in June- July.

Methods

Phytosociological analysis of woody vegetation was carried out in both burnt and unburnt sites. To understand the vegetation structure and phytosociological features of plant community, 10 quadrats of 10m x 10m and 20 quadrats of 5m × 5m size sample were randomly placed on all the sites for the assessment of composition (Misra, 1968). In each quadrat, all trees (>31.5 cm cbh), saplings (10.5-31.4 cm cbh) and shrubs were individually measured. The individuals of trees with less than 10 cm CBH were recorded as seedlings. The vegetational data were quantitatively analyzed, separately for each species and for each layer, for frequency, density and abundance (Curtis and Mclntosh, 1950) and for importance value index (IVI) following (Phillips, 1959). The abundance to frequency (A/F) was used to investigate the distribution pattern of the species, ratio less than 0.025 indicates regular distribution, random distribution, if it falls between 0.025 to 0.05 and contagious distribution if the value is greater than 0.05 (Curtis and Cottam, 1956). Total basal cover (TBC) of all species was measured to reflect the area occupied by the particular species (Misra, 1968). In the present study, several indices were used and were calculated separately for each stratum (trees, saplings, seedlings and shrubs) on the basis of density. Shannon-Weiner Index is used to determine the species diversity and denoted by $\overline{H}$. It was calculated by the equation $H = \Sigma(ni/n)^{log2}(ni/n)$, where ni is the density of a species and n is the sum of total density of all species in that forest type (Shannon and Wiener, 1963). The Simpson's concentration of dominance (Simpson, 1949) was measured as $Cd = \Sigma Pi^2$, where $\Sigma Pi = \Sigma ni/n$. Equitability Index: The Shannon's equitability Index is expressed as $(EH) = \overline{H}/Hmax = \overline{H}/\ln S$. Species richness Margalef's species richness Index is calculated by $D = (S-1)/\ln N$. Where, S = number of species. N = total number of individuals (Margalef, 1958). Berger-Parker dominance index is determined by the equation $d = Nmax/N$, Where, Nmax = Number of individuals of the most abundant species, N = Total number of individuals in the site (Berger and Parker, 1970).

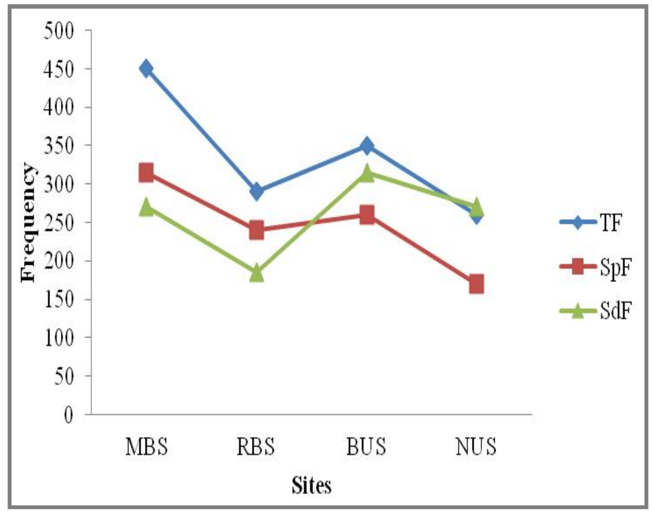
Results and Discussion

Floristic composition

On the MB site of study area 7 tree species belonging to 7 genera and 6 families were recorded and a total of 26 species belonging to 23 genera and 14 families were present in shrub layer. On RB site of study area 4 tree species belonging to 4 genera and 4 families and shrub layer consist of 13 species belonging to 11 genera and 9 families. On BU site of study area only 6 tree species belonging to 5 genera and 5 families were present and in the shrub layer 24 species belonging to 21 genera and 14 families were recorded. On NU site 3 tree species belonging to 3 genera and 3 families while 12 shrub species distributed among 11 genera and 9 families. The findings of all sites were comparable with numerous researchers (Mehta *et al*., 1997; Shafi *et al*., 2016; Joshi *et al*., 2013) in different forests of Garhwal and Kumaun Himalaya.

Vegetational analysis

The vegetational analysis conceded out in MB site revealed that *Quercus leucotrichophora* was the most dense among tree layer and exhibits absolute dominance in terms of density (390 tree/ha) and TBC (5.86 m^2/ha). Among the shrubs *Eupatorium adenophorum* was



Abbreviations: TF - tree frequency, SpF - saplings frequency and SdF – seedling frequency.

Fig. 2 : Graph showing the frequency of all studied sites.

dominant in terms of density (1000 shrub/ha) and on the basis of TBC *Himalrandria tetrasperma* exhibits maximum TBC (0.23 m^2/ha). The data revealed that *Pinus roxburghii* and *Myrica esculenta* were the competing species in the sapling layer and these two species were also competing with *Rhododendron arboreum* in the seedling layer, and among the shrubs, *Himalrandria tetrasperma*, *Rhus paruiflora* and *Desmodium multiflorum* were competing members.

Pinus roxburghii was dominated in all the formats *i.e.*, trees, sapling and seedling however shrub layer was dominated by *Eupatorium adenophorum* on RB site. *Pinus roxburghii* was leading tree species in terms of density (250 tree/ha) and TBC (6.48 m^2/ha) while the chief associates were *Rhododendron arboreum* and *Myrica esculenta*. Lower number of saplings and seedlings of *Cupressus torulosa, Myrica esculenta* and *Rhododendron arboreum* etc. were also present. *Eupatorium adenophorum* was dominant in terms of density (1580 shrub/ha) and on the basis of TBC *Pyracantha crenulata* exhibits maximum value (TBC=0.098 m^2/ha) in the lower woody strata. *Berberis asiatica, Leptodermis lanceolata* and *Rhus parviflora* etc were the contending species.

On BU site of study area tree layer was mostly occupied by *Quercus leucotrichophora* and also exposed as maximum density (350 tree/ha) and TBC (6.65 m^2/ha). The sapling and seedling layers were also dominated by *Quercus leucotrichophora* in terms of density (560 sap/ha and 640 seedl/ha) and co-dominated by *Myrica esculenta* and *Rhododendron arboreum* etc. *Eupatorium adenophorum* was dominant shrub (D =

700 shrub/ha) while *Himalrandria tetrasperma* showed maximum TBC value (0.20 m^2/ha) and the competing shrubs were *Myrsine africana*, *Berberis aristata* and *Indigofera heterantha* etc.

On NU site considering the same attributes, *Cupressus torulosa* was dominated in the tree and sapling strata with elevated density (220 tree/ha and 360 sap/ha) and TBC (8.51 m^2/ha and 1.191 m^2/ha) while in case of seedling *Myrica esculenta* showed absolute dominance in terms of density (620 seedl/ha) and TBC (0.21 m^2/ha). The co-dominants in sapling and seedling layers were *Cupressus torulosa*, *Rhododendron arboreum*, *Cedrus deodara* and *Pinus roxburghii*. *Eupatorium adenophorum* was dominant in terms of density (760 shrub/ha) and *Pyracantha crenulata*, *Berberis asiatica* and *Asparagus adscendens* were the competing species in shrub layer. However, *Pyracantha crenulata* was showed maximum TBC values (0.098 m^2/ha) as shown in tables 1, 2, 3 and 4.

On MB site total density and TBC for tree layer was ranged between 20 tree/ha to 390 tree/ha and 0.45 m^2/ha to 5.86 m^2/ha, respectively. The overall tree stratum range of density and TBC were lies between 50 tree/ha to 250 tree/ha and 2.30 m^2/ha to 6.50 m^2/ha on RB site respectively. The total density of BU site were fallen in range from 10 tree/ha to 350 tree/ha and TBC from 0.21 m^2/ha to 6.65 m^2/ha, respectively. The density of NU site ranges from 130 tree/ha to 220 tree/ha and TBC ranges between 3.35 m^2/ha to10.83 m^2/ha were observed. The values of saplings, seedlings and shrubs of all the sites were also given in tables 1, 2, 3 and 4. The vegetation has constantly been documented as most illustrious and distinctive aspects of landscape. The ranges of density of tree stratum in the Himalayan forests were recorded earlier by several researchers (Sexena, 1979; Sundarapandian and Swamy, 2000; Kumar*, et al*., 2010). However, the range of density in the present study was lower from the above findings. The reason behind the

Table 1 : Plant density, Frequency%, TBC and A/F ratio of trees, saplings and seedlings layers at MBS and BUS.

S. no.	Name of the species	Frequency (%)		Density (ind/ha)		TBC(m^2/ha)		A/F Ratio	
	Trees								
		MBS	BUS	MBS	BUS	MBS	BUS	MBS	BUS
1	***Ficus racemosa***	30		30		0.450		0.033	
2	***Lyonia ovalifolia***	70		90		1.428		0.018	
3	***Myrica esculenta***	80	**90**	150	**140**	2.185	**2.081**	0.023	**0.017**
4	***Pinus roxburghii***	80	**50**	140	**50**	2.825	**0.853**	0.022	**0.020**
5	***Pinus wallichiana***		**20**		**20**		**0.211**		**0.050**
6	***Prunus cerosoides***	20	**10**	20	**10**	0.615	**0.339**	0.050	**0.100**
7	***Quercus leucotrichophora***	100	**100**	390	**350**	5.863	**6.659**	0.039	**0.035**
8	***Rhododendron arboreum***	70	**80**	90	**120**	1.993	**3.522**	0.018	**0.019**
	Sapling								
1	***Ficus racemosa***	10		40		0.076		0.100	
2	***Lyonia ovalifolia***	30		160		0.361		0.044	
3	***Myrica esculenta***	45	**55**	260	**300**	0.706	0.616	0.032	**0.025**
4	***Pinus roxburghii***	55	**20**	280	**120**	0.633	0.289	0.023	**0.075**
5	***Pinus wallichiana***		**15**	**60**	**60**		0.102		**0.067**
6	***Prunus cerosoides***	10	**10**	60	**40**	0.130	0.074	0.150	**0.100**
7	***Quercus leucotrichophora***	80	**75**	600	**560**	1.301	1.364	0.023	**0.025**
8	***Rhododendron arboreum***	50	**45**	240	**240**	0.472	0.529	0.024	**0.030**
9	***Celtis australis***	15	**20**	60	**100**	0.068	0.050	0.067	**0.063**
10	***Pyrus pashia***	20	**20**	80	**80**	0.062	0.044	0.050	**0.050**
	Seedling								
1	***Ficus racemosa***	15		80		0.007		0.089	
2	***Lyonia ovalifolia***	25		140		0.043		0.056	
3	***Myrica esculenta***	25	**70**	200	**340**	0.032	**0.010**	0.080	**0.017**
4	***Pinus roxburghii***	55	**30**	300	**140**	0.081	**0.003**	0.025	**0.039**
5	***Pinus wallichiana***		**10**		**40**		**0.002**		**0.100**
6	***Prunus cerosoides***	5		20		0.013		0.200	
7	***Quercus leucotrichophora***	80	**90**	500	**640**	0.148	**0.161**	0.020	**0.020**
8	***Rhododendron arboreum***	40	**65**	220	**320**	0.038	**0.048**	0.034	**0.019**
9	***Celtis australis***	10	**30**	100	**120**	0.002	**0.004**	0.250	**0.033**
10	***Pyrus pashia***	15	**20**	120	**100**	0.002	**0.287**	0.133	**0.063**

Table 2 : Plant density, Frequency %, TBC and A/F ratio of trees, saplings and seedlings layers at RBS and NUS.

S. no.	Name of the species	Frequency%		Density(ind/ha)		TBC(m^2/ha)		A/F Ratio	
	Trees								
		RBS	**NUS**	**RBS**	**NUS**	**RBS**	**NUS**	**RBS**	**NUS**
1	***Cedrus deodara***		**90**		**150**		**10.835**		**0.019**
2	***Cupressus torulosa***	40	**100**	50	**220**	2.291	**8.509**	0.031	**0.022**
3	***Myrica esculenta***	80		120		4.290		0.019	
4	***Pinus roxburghii***	100		250		6.488		0.025	
5	***Rhododendron arboreum***	70	**70**	120	**130**	3.266	**3.359**	0.024	**0.027**
	Sapling								
1	***Cedrus deodara***		**30**		**180**		**0.385**		**0.050**
2	***Cupressus torulosa***	30	**60**	160	**360**	0.294	**1.191**	0.044	**0.025**
3	***Myrica esculenta***	45	**30**	280	**160**	0.858	**0.515**	0.035	**0.044**
4	***Pinus roxburghii***	90	**15**	620	**120**	1.413	**0.263**	0.019	**0.133**
5	***Pinus wallichiana***		**10**		**80**		**0.123**		**0.200**
6	***Quercus leucotrichophora***	20		120		0.335		0.075	
7	***Rhododendron arboreum***	55	**25**	320	**160**	0.823	**0.414**	0.026	**0.064**
		240	**170**	1500	**1060**	3.723	**2.890**		
	Seedling								
1	***Cedrus deodara***		**35**		**240**		**0.094**		**0.049**
2	***Cupressus torulosa***	25	**75**	140	**420**	0.058	**0.175**	0.056	**0.019**
3	***Myrica esculenta***	20	**90**	120	**620**	0.041	**0.210**	0.075	**0.019**
4	***Pinus roxburghii***	85	**15**	680	**100**	0.227	**0.031**	0.024	**0.111**
5	***Pinus wallichiana***		**10**		**60**		**0.013**		**0.150**
6	***Quercus leucotrichophora***	15		60		0.024		0.067	
7	***Rhododendron arboreum***	40	**45**	240	**260**	0.111	**0.202**	0.038	**0.032**

declining density of forest might be due to the forest age, biotic pressure and overexploitation of resources. In the present study total basal area of all the sites ranged from 13.66 m^2/ha to 22.70 m^2/ha. The values of total basal cover were more or less similar to values reported by Kusumlata and Bisht (1991), Bhat (2012), Raturi (2012), Mehta *et al*. (1997). The finding also indicate that *Pinus roxburghii* and *Eupatorium adenophorum* showed its maximum presence on all the site this may be to the incursion of fire because fire also promotes invasion of fire adopted and exotic species and these results were supported by IFFN (2002), Parveen *et al*. (2017), Kumari *et al*. (2017).

Spatial Dispersion Pattern

The spatial dispersion pattern of trees and shrub layer on MB site and RB site were regular and random. However sapling and seedling layer were mostly contagiously and randomly distributed on both the burnt sites. The tree layer of BU site and shrub layer of NU site were regularly, contagiously and randomly distributed whereas tree layer of NU site and shrub layer of BU site showed regular and random dispersion. The sapling layers of both the unburnt sites and seedling layer of NU site were mostly contagiously distributed while seedling layer of BU site was mostly regularly distributed. The variation in the distribution pattern revealed the reactions of species to disturbances *i.e.*, fire, grazing and harvesting etc. as well as to changes in the microclimatic conditions (Sagar, *et al*., 2003). The most common distribution pattern in the forest is the aggregated distribution pattern reported by several researchers in forests of Garhwal Himalaya (Kumar and Bhatt, 2006; Mehta *et al*., 1997) and random dispersion is established in homogeneous environment (Odum, 1971). The regular distribution happens where intense competition occurs among the individuals (Panchal and Pandey, 2004) and the present study revealed that forest showed extreme rivalry in the species. Rawat and Chankhok (2009) observed that dispersion pattern of tree, sapling and seedling layers were randomly scattered, even as various species of trees and saplings were regularly dispersed. Raturi (2012) examined that tree layer was randomly distributed however shrub layer was randomly and regularly scattered in the different forest types of Himalaya.

Table 3 : Plant density, Frequency %, TBC and A/F ratio of shrubs at RBS and NUS.

S. no.	Name of the species	Frequency%		Density (ind/ha)		TBC(m^2/ha)		A/F Ratio	
	Shrubs								
		RBS	NUS	RBS	NUS	RBS	NUS	RBS	NUS
1.	***Asparagus adscendens***	75	**75**	380	**360**	0.0030	**0.0037**	0.017	**0.016**
2.	***Berberis asiatica***	85	**70**	460	**400**	0.0629	**0.0507**	0.016	**0.020**
3.	***Carissa opaca***	45	**40**	240	**180**	0.0035	**0.0061**	0.030	**0.028**
4.	***Cotoneaster rotundifolius***	40		180		0.0330		0.028	
5.	***Daphne papyraceae***	50	**15**	260	**160**	0.0100	**0.0079**	0.026	**0.178**
6.	***Eupatorium adenophorum***	95	**80**	1580	**760**	0.0078	**0.0010**	0.044	**0.030**
7.	***Leptodermis lanceolata***	70	**25**	440	**200**	0.0066	**0.0072**	0.022	**0.080**
8.	***Pyracantha crenulata***	60	**80**	340	**440**	0.0980	**0.0979**	0.024	**0.017**
9.	***Rhus cotinus***	65	**50**	380	**320**	0.0206	**0.0162**	0.022	**0.032**
10.	***Rhus parviflora***	80	**35**	420	**240**	0.0067	**0.0046**	0.016	**0.049**
11.	***Rubus ellipticus***	50	**30**	320	**280**	0.0040	**0.0043**	0.032	**0.078**
12.	***Rubus niveus***	30	**60**	160	**340**	0.0099	**0.0195**	0.044	**0.024**
13.	***Viburnum mullaha***	65	**25**	340	**240**	0.0150	**0.0121**	0.020	**0.096**

Table 4 : Plant density, Frequency %, TBC and A/F ratio of shrubs at MBS and BUS.

S. no.	Name of the species	Frequency%		Density(ind/ha)		TBC(m^2/ha)		A/F Ratio	
	Shrubs								
		MBS	BUS	MBS	BUS	MBS	BUS	MBS	BUS
1	***Asparagus adscendens***	60	**60**	380	**320**	0.0040	**0.0037**	0.026	**0.022**
2	***Berberis aristata***	45	**75**	240	**400**	0.0942	**0.0984**	0.030	**0.018**
3	***Berberis asiatica***	55	**60**	300	**300**	0.1000	**0.0589**	0.025	**0.021**
4	***Campylotropis speciosa***	60		280		0.0004		0.019	
5	***Carissa opaca***	35	**60**	200	**300**	0.0213	**0.0030**	0.041	**0.021**
6	***Cotoneaster rotundifolius***	50	**50**	300	**240**	0.0687	**0.0479**	0.030	**0.024**
7	***Daphne papyraceae***	60	**65**	360	**320**	0.0122	**0.0127**	0.025	**0.019**
8	***Desmodium multiflorum***	95	**40**	520	**200**	0.0055	**0.0001**	0.014	**0.031**
9	***Eupatorium adenophorum***	95	**75**	1000	**700**	0.0048	**0.0029**	0.028	**0.031**
10	***Flemingia fruticulosa***	40		180		0.0008		0.028	
11	***Himalrandria tetrasperma***	90	**65**	780	**360**	0.2292	**0.2021**	0.024	**0.021**
12	***Hypericum ovlongifolium***	75	**40**	320	**260**	0.0005	**0.0005**	0.014	**0.041**
13	***Indigofera heterantha***	75	**70**	340	**400**	0.0017	**0.0018**	0.015	**0.020**
14	***Inula cappa***	45	**55**	220	**260**	0.0010	**0.0008**	0.027	**0.021**
15	***Leptodermis lanceolata***	85	**40**	360	**200**	0.0095	**0.0008**	0.012	**0.031**
16	***Myrsine africana***	85	**75**	560	**460**	0.0039	**0.0024**	0.019	**0.020**
17	***Pyracantha crenulata***	45	**45**	260	**260**	0.1291	**0.0764**	0.032	**0.032**
18	***Reinwartia indica***	55	**65**	260	**320**	0.0002	**0.0007**	0.021	**0.019**
19	***Rhus parviflora***	80	**50**	360	**240**	0.0071	**0.0031**	0.014	**0.024**
20	***Rhynchosia rothii***	70	**45**	320	**240**	0.0005	**0.0001**	0.016	**0.030**
21	***Rosa brunonii***	40	**30**	200	**140**	0.0027	**0.0009**	0.031	**0.039**
22	***Rubus ellipticus***	60	**50**	380	**300**	0.0061	**0.0030**	0.026	**0.030**
23	***Rubus niveus***	40	**40**	260	**180**	0.0121	**0.0097**	0.041	**0.028**
24	***Rubus paniculatus***	35	**30**	220	**140**	0.0067	**0.0040**	0.045	**0.039**
25	***Urena lobata***	75		400		0.0236		0.018	
26	***Vibernum mullaha***	50	**45**	260	**280**	0.0160	**0.0152**	0.026	**0.035**
27	***Zanthoxylum americanum***		**40**		**180**		**0.0428**		**0.028**

Table 5 : Diversity (H), Margalef species richness (D), Equitability, Concentration of Dominance (CD) and Berger Parker Dominance (d) calculated for all the sites.

Compo-nents	Diversity indices	MBS	RBS	BUS	NUS
Trees	Shannon $\overline{H}$	1.602	1.245	1.326	1.073
	Equitability	0.823	0.898	0.740	0.976
	CD	0.256	0.409	0.335	0.351
	Margalef	1.330	0.752	1.181	0.511
	Berger-Parker	0.429	0.463	0.507	0.440
Sapling	Shannon $\overline{H}$	1.878	1.449	1.747	1.680
	Equitability	0.855	0.900	0.840	0.938
	CD	0.191	0.269	0.221	0.208
	Margalef	1.782	0.9265	1.621	1.259
	Berger-Parker	0.337	0.413	0.373	0.340
Seedling	Shannon $\overline{H}$	1.949	1.266	1.652	1.562
	Equitability	0.887	0.787	0.849	0.872
	CD	0.170	0.896008	0.307	0.242
	Margalef	1.806	0.969	1.351	1.125
	Berger-Parker	0.30	0.548	0.377	0.365
Shrubs	Shannon $\overline{H}$	3.155	2.339	3.108	2.387
	Equitability	0.968	0.912	0.978	0.961
	CD	0.048	0.128	0.048	0.102
	Margalef	4.073	2.136	3.926	2.084
	Berger-Parker	0.108	0.287	0.100	0.194

Diversity Indices (Shannon-Wiener diversity index-$\overline{H}$ and Margalef's species richness index-D)

Across all the sites (MBS, RBS, BUS and NUS) the value of Shannon-Wiener diversity index ($\overline{H}$) (1.602, 1.245, 1.326 and 1.073) and Margalef's species richness index (D) of trees layers (1.330, 0.752, 1.181 and 0.511) were recorded. The diversity indices for sapling, seedling and shrub layer were higher on the MBS and BUS while lower on the RBS and NUS. The value of $\overline{H}$ and D for tree, sapling, seeding and shrubs stratum were maximum on MB site *i.e.* 1.60 and 1.33, 1.87 and 1.78, 1.94 and 1.80, 3.15 and 4.07, respectively, as shown in table 5. The values of and D for tree stratum were lower while ranges of shrub layer in the present study were comparable to ranges reported by Singh *et al*. (2010) in the forest of Garhwal Himalaya. These values were also more or less equivalent to the values recorded by Uniyal *et al*. (2010), Kunwar and Sharma (2004). The decreasing species diversity and richness in trees stratum may be due to inauspicious climatic conditions and unwanted disturbances. Species diversity was superior in the burned sites than the unburned sites and our results were similar to the findings of the Sanghoon *et al.* (1997), Mehta *et al.* (1997).

Equitability, Concentration of Dominance (CD) and Berger Parker Dominance (d)

The value of equitability, concentration of dominance (CD) and Berger Parker dominance (d) for tree, sapling, seedling and shrubs were shown in table 5. The values of Berger-Parker index and equitability for trees and shrubs stratum were slightly higher than the values reported by the Pala *et al.* (2016), Mishra *et al.* (2004). The values of concentration of dominance were generally comparable to the values reported by several researchers

Table 6 : Correlation between different studied parameters.

Correlations

	Taxa	Ind	D	S	H	Ev	M	E	BP
Taxa	1								
Individuals	**.964****	1							
Dominance	**-.874****	**-.825****	1						
Simpson	**.874****	**.825****	**-1.000****	1					
Shannon	**.970****	**.931****	**-.962****	**.962****	1				
Evenness	.340	.390	-.369	.369	.353	1			
Margalef	**.994****	**.935****	**-.895****	**.895****	**.977****	.289	1		
Equitability	.491	**.527***	**-.585***	**.585***	**.539***	**.957****	.455	1	
Berger-Parker	**-.889****	**-.842****	**.972****	**-.972****	**-.951****	**-.534***	-.897**	**-.713****	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Abbreviations: Ind- Individuals, D- Dominance, S- Simpson, H-Shannon, Ev- Evenness, M- Margalef, E- Equitability and BP- Berger-Parker.

(Devlal and Sharma, 2008; Risser and Rice, 1971; Singh and Singh, 1986). The poorer range of CD in the temperate forests might be because of lower rate of enhancement and diversification of population (Simpson, 1949) and adverse conditions in the atmosphere (Conell and Oris, 1964). Concentration of dominance and Species diversity are mostly inversely interrelated (Mehta *et al*., 1997).

Carl-Pearson Correlation Coefficient

The two-tailed Carl-Pearson correlation coefficient was calculated between different studied parameters as shown in table 6. The value of Simpson is significantly and positively correlated with taxa and individuals and negatively correlated with dominance. Shannon is significantly and positively correlated with taxa, individuals, Simpson and Margalef except dominance. Equitability is significantly and positively correlated with individuals, Simpson, Shannon and evenness whereas this value is negatively correlated with dominance. Berger-Parker is negatively correlated with almost all the parameters with the exception of dominance.

Conclusion

Although, forest fire is a prime reason behind the degradation of forest ecosystem but controlled way of burning may overcome this serious issue. The present finding indicates that fire affects almost all the attributes of forest and burned forest were more dense and rich than unburned forest. The maximum number of species was randomly and contagiously dispersed while regular distribution is also observed in some species. The values of diversity indices were elevated on the burned sites than unburned sites. The present study also revealed that, though fire enhances thickness of the forest yet it also promotes introduction of fire adopted (*Pinus roxburghii*) and invasive species (*Eupatorium adenophorum*) in the forest. Therefore, this paper represents the relationship of fire between human need and forest ecosystem.

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