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Effect of forest fire on floristic composition, structure, dominance and species richness in subtropical pine forest of Ponda watershed, Rajouri, J&K

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Abstract

Forest fires have profound impacts on physical environment including land cover, land use, forest ecosystem and biodiversity. In the present study the effect of fires on floristic composition, structure, dominance and species richness in subtropical pine forest of Ponda watershed, Rajouri, J&K, lying at an altitude range of 800 m to 1000 m above mean sea level, was assessed. The forests in the study area were divided into two strata *i.e.*, burnt and un-burnt forest. Random sampling was carried out by laying out forty sample plots in all, with twenty sample plots in each strata covering burnt and unburnt forest sites of the study area. The plot dimensions of 20m x 20m were used for studying trees and 5m x 5m for shrubs (laid within the plots for trees). The density, basal area and IVI along with diversity and concentration of dominance of trees and shrubs in both forest sites were studied. Similarity index was also calculated for burnt and unburnt forest of the study area. The results show that the total density and total basal area of trees and shrubs was highest in un-burnt forest sites with density values of 468.75 and 5284 individuals/ha and 85.33 m^2/ha and 25.42 m^2/ha, respectively. The results on the basis of the comparison of IVI values of all species in both forest stands also reveal that the respective dominant tree and shrub species were *Pinus roxburghii* and *Carissa opaca.* The calculated values of Shannon-Wiener, Margalef and Menhinick indices *i.e.* 1.93, 2.53 and 0.82 for trees and 1.80, 2.08 and 0.44 for shrubs, respectively, reveal that the species richness and diversity was high for unburnt forest stand whereas, Simpson's index value of tree (0.48) and shrub (0.75) show that an concentration of dominance was highest in burnt forest stands. The calculated value of Sorenson's and Jaccard's index of similarity for trees (0.60 and 0.43) was maximum as compare to shrubs (0.47 and 0.31) which shows that forest fire have profound effect on shrub than trees.

Keywords: *density, dominance, diversity, forest fire, shrubs, trees*

Introduction

Fire has been closely associated with mankind from the beginning of civilization. The influence of human caused fires, doubtlessly date back to the arrival of first human in the subcontinent. The menace has been aggravated with rising human and cattle population and the consequent increase in demand for forest products by individuals and communities (Bahuguna and Upadhyay, 2002). Forest fires have been taking place historically, shaping landscape structure, pattern and ultimately the species composition of ecosystems. Forest fires are considered vital natural processes that initiate natural vegetation succession. As a natural process it also serves an important function in maintaining the health of certain ecosystems (Saklani, 2008). The ecological role of fire is to influence several factors such as plant community development, soil nutrient availability and biological diversity (Kumar *et al*., 2012; Saklani, 2008). However uncontrolled and misuse of fire can cause tremendous adverse impacts on the environment and the human society. Ground fire destroys the organic matter, which is needed to maintain an optimum level of humus in the soil. Annual fires may decrease the growth of the grasses, herbs and shrubs, which may result in increased soil erosion (Kandya *et al*., 1998). Frequent occurrence of fire is one of the reasons for the degradation of forests in India. Around 90 percent of the forest fires in India are anthropogenic in nature (Jaiswal *et al*., 2002). In Jammu region of Jammu and Kashmir forest fires are prevalent in hot and dry summer months mostly in sub-tropical chir pine forests, when fuel in the form of dry branches, needles, grasses and scrub on the forest floor become highly flammable. Study conducted by Forest Survey of India revealed that 46 percent of area of Jammu and Kashmir is subjected to repeated fires and the major

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loss are suffered by chir pine forests (Sharma *et al.*, 2009). The subtropical pine forests of district Rajouri are also prone to forest fires as they are under the influence of varying levels of anthropogenic disturbances. The frequent deliberately ignited fires in the study area are one of the main manmade forces that influence the plant communities and have many implications for biological diversity and responsible for overall degradation of the area. Thus it becomes mandatory to study the quantitative and qualitative parameters related to woody vegetation and impact of fire on them.

Material and Methods

The study area i.e. Ponda watershed lies in Rajouri Forest Range of district Rajouri, Jammu and Kashmir (Fig.1).

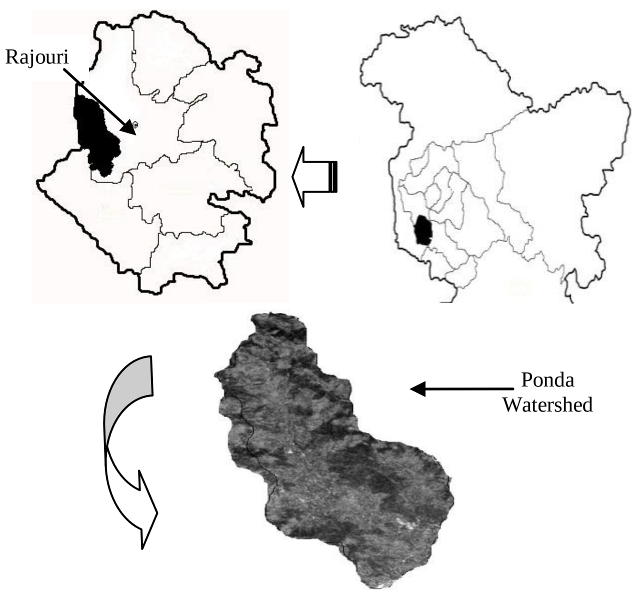

Fig.1 Location map of Ponda watershed

The area of interest is located between 33^0 50' to 33^0 30' N latitude and 74^0 to 74^0 10'E longitudes within altitude range of 800m to 1000m above mean sea level. It is located in foot hills of Pir Panjal Range. Physiographically most of the area is mountainous and rugged consisting of low lying undulating hills and valleys having steep slopes facing east and west. The Climate of study area is sub-tropical and somewhat cooler than rest of the areas. The average annual rainfall is 1150 mm. The winter is cool with average temperature of around 7^0 C and in summers the average temperature is around 37^0C.To layout the sample plots in the study area, the topo-maps of the area were divided into 1 cm x 1 cm grids and were numbered. The selection and location of the sample plots in the study area was identified using random table. These plots were located on the ground with possible precision using GPS. Phytosociological analysis was carried out using 20m x 20 m and 5 x 5m size sample plots for trees and shrubs in study area. In each sample plot, plants having cbh (1.37 m from the ground) ≥ 30 cm were treated as trees and for which information was collected. The data collected regarding vegetation from the sample plots was analyzed for abundance, density and frequency according to the formulae given by Curtis and McIntosh (1950). The basal area was calculated by using following formula.

$$\textbf{Basal area} = \frac{(cbh)^2}{4\pi}$$

In calculating the importance value index (IVI), which determines vegetation status and importance of component species with in a stratum stand, the percentage value of relative frequency, relative density, and relative dominance obtained were summed. Species diversity was computed following Shannon-Weaver (1949) and Simpson (1949). Species richness was calculated using Menhinick's Index (1964) and Margalef's Index (1968) whereas index of similarity between different forest sites was calculated following Sorenson (1948) and Jaccard (1912).

Results and Discussion

Structure and Composition

The burnt and unburnt sites of the study area are dominated by *Pinus roxburghii*. In burnt sites of the study area, only 7 tree and 5 shrub species belonging to 13 genera and 11 families (Fig.2) were observed, whereas, in the unburnt forest sites a total of 16 species of trees and 16 species of shrubs belonging to 25 genera and 30 families were found(Fig. 2). The tree density recorded during the study varied within burnt and unburnt forest sites which were 301.25 and 468.75 individuals/ha, respectively. The low tree density in burnt forest can be attributed to less regeneration and survival of saplings (Kumar and Thakur, 2008; Joshi *et al.*, 2013).

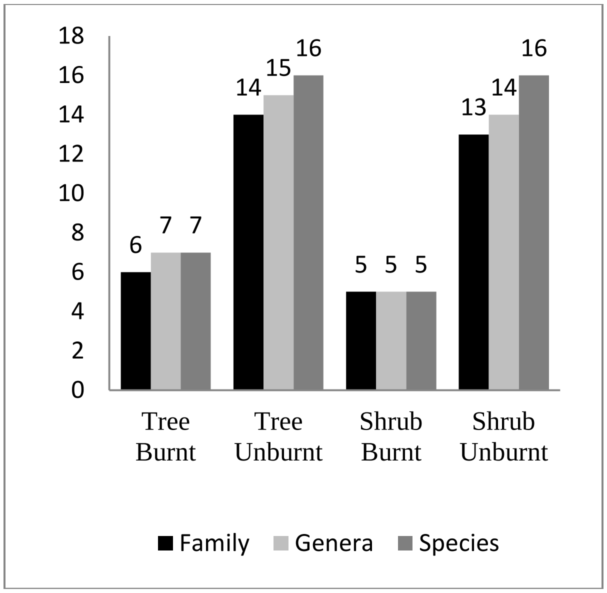

Fig.2 Floristic composition of woody vegetation in study area

The tree density recorded during the study varied within burnt and unburnt forest sites which were 301.25 and 468.75 individuals/ha, respectively. The low tree density in burnt forest can be attributed to less regeneration and survival of saplings (Kumar and Thakur, 2008; Joshi *et al.*, 2013). The phyto-sociological analysis carried out in the study area also revealed that *Pinus roxburghii* is the most dense tree species in both sites with tree density of 200 individuals/ha in burnt forest site and 222.5 individuals/ha in unburnt forest site, followed by *Mallotus philippensis* having density of 56.25 individuals/ha in burnt site and 42.50 individuals/ha in unburnt site (Table 1). The total tree density reported in the present study falls within the range values of 160-910 individual/ha also reported earlier for different fire effected subtropical pine forests of central Himalaya with *Pinus roxburghii* as the dominant tree species (Gupta *et al.*, 2009; Joshi and Tewari, 2011; Joshi *et.al.*, 2013).The total basal area of the tree species in burnt site was found to be 86.80 m^2 ha,$^{-1}$ whereas, in un-burnt forest it was 85.33 m^2 ha^{-1} with highest basal area of 76.33 m^2 ha^{-1} and 69.70 m^2 ha^{-1} for *Pinus roxburghii* in burnt and unburnt forest sites, respectively (Table 2). The lower basal area of pine in the unburnt forest sites as compared to burnt forest sites can be attributed to presence of young trees of the species in the unburnt sites. Similar results have been reported by Sangye (2005) while studying the impact of fire frequency on the regeneration of *Pinus roxburghii* in Eastern Bhutan. Among the shrubs, the total density was observed as 2192 individual/ha in burnt forest site and 5284 in unburnt forest site. *Carissa opaca* was the most dominant species in term of density with 1896 individuals per hectare for burnt sites and 2760 individual per hectare for unburnt forest sites (Table 3). The total basal area for shrubs was found to be 12.21 m^2 ha^{-1} in burnt forest sites, whereas, the values obtained for unburnt forest sites were 25.42 m^2 ha^{-1} with highest basal area of 10.15 m^2 ha^{-1} and 16 m^2 ha^{-1} for *Carissa opaca* in both burnt and unburnt sites, respectively (Table 4).

Table 1. Density (ind/ha) of Trees in Burnt (BF) and Unburnt forest (UF) site of study area

Name of the species	BF	UF	Name of the species	BF	UF
Butea monosperma (Lam.) Taub.	-	2.5	*Mallotus philippensis* (Lam.) Muell.Arg.	56.25	42.5
Cassia fistula Linn.	8.75	30	*Olea ferruginea* Royle	-	27.5
Callistemon lanceolatus (Sm.)	-	3.75	*Phoenx acaulis* Rosb.ex Buch.Ham.	-	27.5
Phyllanthus emblica Linn.	3.15	10	*Pinus roxburghii* Sarg	200	222.5
Ficus palmata Forssk.	-	30	*Pyrus pashia* Buch. Ham.ex.D.Don	17.5	33.75
Ficus racemosa Linn.	-	7.5	*Syzygium cumini* (L.) Skeels	6.25	3.75
Grewia optiva Drumm.exBurret.	8.75	3.75	*Woodfordia fruticosa* (L.) Kurz	-	12.5
Lannea coromandelica (Houtt.) Merr.	-	2.5	*Bauhinia variegata* Linn.	-	8.75
Total				**301.25**	**468.7**

Table 2. Basal area (m^2 ha^{-1}) of Trees in burnt (BF) and unburnt forest (UF) site of study area

Name of the species	BF	UF	Name of the species	BF	UF
Butea monosperma (Lam.) Taub	-	0.176	*Mallotus philippensis* (Lam.) Muell.Arg.	8.60	7.279
Cassia fistula Linn.	0.11	1.882	*Olea ferruginea* Royle	-	2.617
Callistemon lanceolatus (Sm.)	-	0.080	*Phoenx acaulis* Rosb.ex Buch.Ham.	-	0.875
Phyllanthus emblica Linn.	0.18	0.343	*Pinus roxburghii* Sarg	76.33	69.70
Ficus palmata Forssk.	-	0.225	*Pyrus pashia* Buch. Ham.ex.D.Don	0.87	1.045
Ficus racemosa Linn.	-	0.267	*Syzygium cumini* (L.) Skeels	0.12	0.047
Grewia optiva Drumm.exBurret.	0.75	0.181	*Woodfordia fruticosa* (L.) Kurz	-	0.216
Lannea coromandelica (Houtt.) Merr.	-	0.068	*Bauhinia variegata* Linn.	-	0.322
Total				**86.80**	**85.33**

Table 3. Density (ind/ha) of shrubs in Burnt (BF) and Unburnt (UF) forest site of study area

Name of the species	BF	UF	Name of the species	BF	UF
Justicia adhatoda Linn.	-	456	*Punica granatum* Linn.	44	44
Berberis lycium Royle.	88	484	*Rubus ellipticus* Smith.	-	56
Carissa opaca Stapf.	1896	2760	*Zanthoxylum armatum* DC.	-	32
Flacourtia indica (Burm. f.)Merr.	124	184	*Dodonaea viscosa* Jacq.	-	64
Gymnosporia royleana Wall. Ex M.A.Lawson.	-	336	*Prinsepia utilis* Royle	-	56
Ziziphus oxyphylla Edgew	-	68	*Randia tetrasperma* (Wall. ex Roxb.) Benth. & Hook.f. ex Brandis	-	20
Ipomoea carnea Jacq.		352	*Debregeasia salicifolia* (D.Don) Rendle	-	116
Nerium indicum Mill.	-	112	*Ziziphus nummularia* (Burm. f.) Wight & Arn.	40	144
Total				**2192**	**5284**

Table 4. Basal area ($m^2 ha^{-1}$) of shrubs in Burnt (BF) and Unburnt forest (UF) site of study area

Name of the species	BF	UF	Name of the species	BF	UF
Justicia adhatoda L.	-	1.053	*Punica granatum* L.	0.229	0.230
Berberis lycium Royle.	0.652	0.854	*Rubus ellipticus* Smith.	-	0.598
Carissa opaca Stapf.	10.15	16.00	*Zanthoxylum armatum* DC.	-	0.287
Flacourtia indica (Burm. f.)Merr.	0.930	0.835	*Dodonaea viscosa* Jacq.	-	0.247
Gymnosporia royleana Wall. Ex M.A.Lawson.	-	1.169	*Prinsepia utilis* Royle	-	0.404
Ziziphus oxyphylla Edgew	-	0.557	*Randia tetrasperma* (Wall. ex Roxb.) Benth. & Hook.f. ex Brandis	-	0.122
Ipomoea carnea Jacq.	-	1.203	*Debregeasia salicifolia* (D.Don) Rendle	-	0.590
Nerium indicum Mill.		0.507	*Ziziphus nummularia* (Burm. f.) Wight & Arn.	0.249	0.750
Total				**12.21**	**25.42**

However, in burnt sites the least basal area of 0.22 m^2/ha was calculated for *Punica granatum* and in unburnt site, *Randia tetrasperma* recorded the lowest basal area of 0.12 m^2 ha^{-1}. Importance value index (IVI) of tree species varied between 196.9 to 5.67 for burnt forest site and 150.67 to 1.97 for unburnt forest site with maximum IVI was calculated for *Pinus roxburghii* in both sites (Joshi *et.al.*, 2013).Whereas, *Pyrus pashia* and *Callistemon lanceolatus* were found to be the tree species having least IVI i.e., 5.67 and 1.97 in burnt and unburnt forest sites, respectively (Fig.3).The results pertaining to IVI among the shrubs revealed that *Carissa opaca* recorded the highest IVI in both burnt (224.46) and unburnt sites (140.46). The shrub species such as *Ziziphus nummularia* and *Randia tetrasperma* showed a lowest IVI of 10.31 and 1.62 in both burnt and unburnt sites, respectively (Fig. 4).

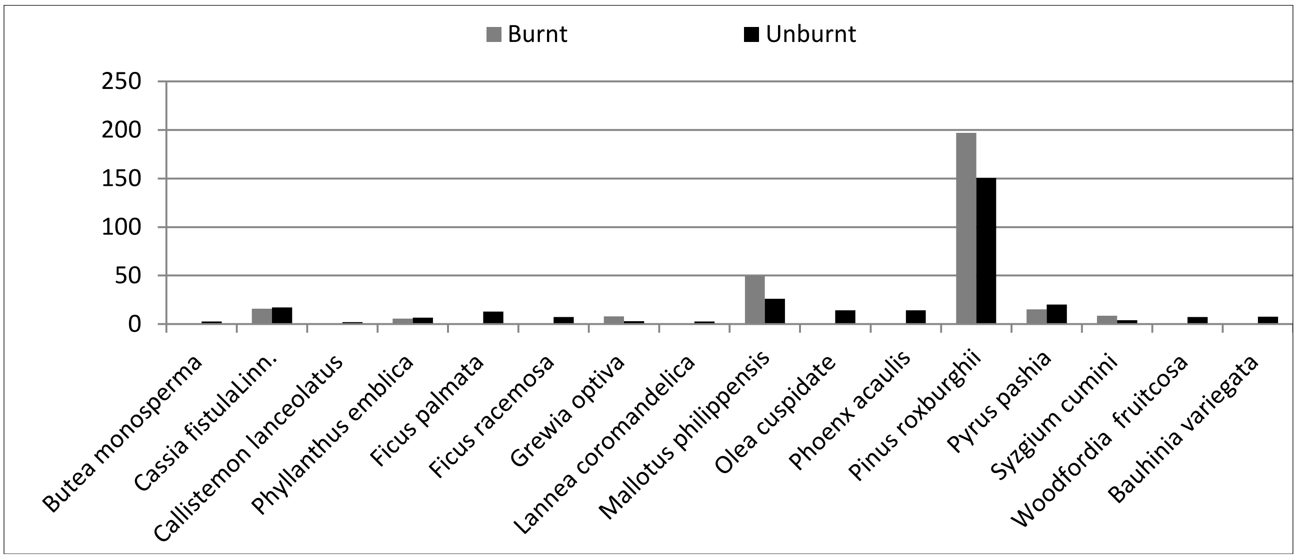

Fig. 3 Comparative IVI of trees in Burnt and Unburnt forest sites

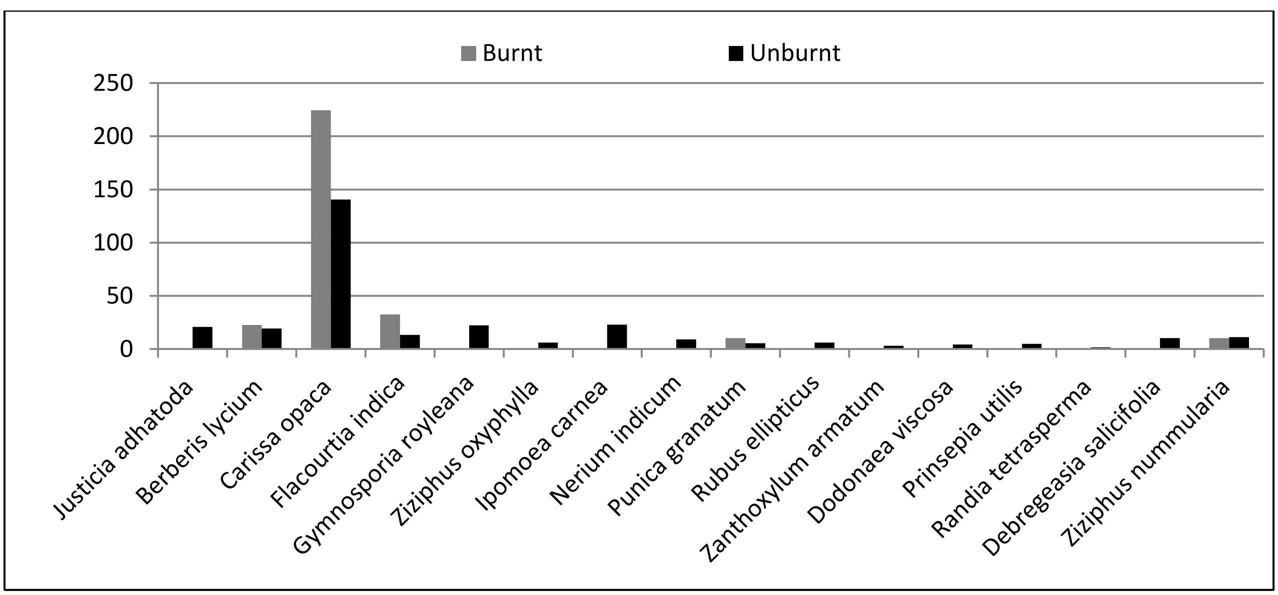

Fig. 4 Comparative IVI of shrubs in Burnt and Unburnt forest sites

Dominance and diversity analysis

The Shannon-Wiener's index values of diversity (H) obtained for trees in unburnt burnt forest sites were 1.93 and 1.09. The species richness was calculated with the help of Margalef's and Menhinick's indices and their values obtained for trees were 1.09 and 0.45 in the burnt forest site(Fig. 5). The value of Shannon index of diversity for shrubs was highest *i.e.*, 1.80 in unburnt forest site followed by 0.56 at burnt forest site. The Margalef's and Menhinick's indices values for species richness in burnt and unburnt forest sites were 0.63 and 0.44, respectively (Fig. 6).

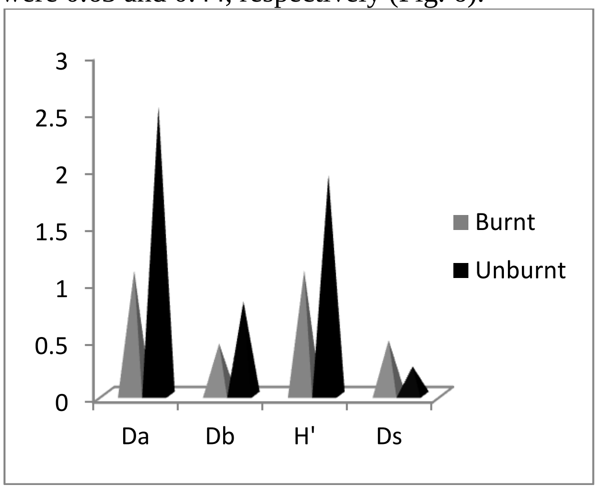

Fig. 5 Diversity and dominance of trees in Burnt and Unburnt forest sites

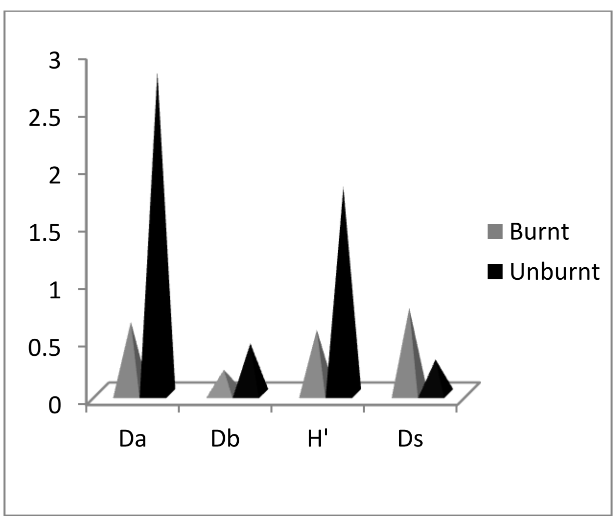

Fig. 6 Diversity and Dominance of shrub in Burnt and Unburnt forest site

The Simpson'index of dominance (Ds) is generally inversely related to species diversity and species richness and the same trend was observed in our study where it was high at sites where density of single dominant species was more as compared to others associated species. The same observations were also reported by Kumar and Thakur (2008).

Similarity between burnt and unburnt sites

In the present study similarity of tree and shrub species between burnt and un-burnt forest sites was estimated by using Sorenson and Jaccard similarity indices. High similarity in trees species was observed between burnt and un-burnt forest with Sorenson's similarity index value of 0.60 and Jaccard similarity index value of 0.43. In shrubs, Sorenson's similarity index value of 0.47 and Jaccard similarity index value of 0.31 was found (Table 5). Kumar and Thakur (2008), in their study also obtained Sorenson's similarity index value ranging between 0.50 to 1 in four fire affected sites and one controlled site of chir pine forest of Solan Forest Division (H.P). Saklani (1997) also reported high degree of similarity between un-burnt and burnt stands of Mankhet Forest Range, Garhwal which was 90 percent. Thus, result indicated that fire cause no pronounced effect on trees (Saklani, 1997). The low value of similarity index for shrubs in comparison to trees may be due to forest fire and other biotic interferences.

Table 5. Similarity between burnt (BF) and Unburnt (UF) forest sites

Sorensen Similarity Index (S)			Jaccard Similarity Index (J)		
Life form	Forest type	UF	Life form	Forest type	UF
Tree	BF	0.60	Tree	BF	0.43
Shrub		0.47	Shrub		0.31

Fire has been observed as the main cause of disturbance in chir pine forests of Ponda watershed resulting in low number of woody species in these forests of the area. The species such as *Pinus roxburghii*, *Carissa opaca etc.* present in both burnt and un-burnt forest sites is possibly due to their resistance to fire. These findings are also in agreement to the results of a study carried out by Semwal and Mehta (1996) concerning forest fire ecology of chir pine forests of Garhwal Himalaya.

Moreover the forests are put to fire by the local resident mainly *Gujjar* and *Bakarwal* during summer when temperature is at peak and before start of monsoon in order to increases the production of grasses for grazing their cattle during off season and for clearing the area from bushes to increase agriculture area. As the chir pine is rich in resin they easily get damaged by fire. Kumar and Ram (2005); Sharma *et al*. (2008) were of the similar opinion while studying anthropogenic disturbances and plant biodiversity in forests of Uttaranchal, Central Himalaya and Birhun watershed in district Udhampur respectively. Impacts of the forest fires have also been reported by Pant *et al*. (1996) in the forest ecosystem of Western Ghats and Central Himalayas.

Conclusion

It has been reported that fires can change plant communities by reducing dominance of some plants while enhancing the abundance of others. However, in this study there was no concerted monitoring trend of woody plant species loss. Although total basal area of tress between burnt and unburnt site were almost same. However the total density of burnt forest site was low as compared to unburnt site. Thus, repeated fires may have reduced densities of fire intolerant plants and failed to do so for fire tolerant species. There is no remarkable change in the total basal area of tree in both forest sites, however low basal area of shrubs was observed in burnt forest sites. It has also been concluded that concentration of dominance was high in burnt forest site, where density of single dominant species is highest as compared to others associated species. On the contrary lowest concentrations of dominance was observed in unburnt forest site where high species richness and diversity was observed.

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