EFFECT OF FOREST FIRE ON TREES, SHRUBS AND REGENERATION BEHAVIOR IN CHIR PINE FOREST IN NORTHERN ASPECTS UNDER SOLAN FOREST DIVISION, HIMACHAL PRADESH

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Abstract: Effect of forest fire on woody vegetation and regeneration behavior was studied in Chir pine forest situated between 1150-1800 m in Solan Forest Division in Himachal Pradesh, India. Four fire affected Sites and one control Site were surveyed for floristic composition, density, basal area, IVI, A/F, Shannon-Weaver index, Simpson's Index of dominance (Cd), Species richness (d), Sorenson index (S) and natural regeneration potential of tree and shrubs. A total of 3 tree species and 10 shrub species were recorded on the five experimental sites. Fire resistant species were observed more in selected Chir pine forests. There was not observed any consistent trend for density, basal area, IVI, $\overline{H}$. Sorenson's index of similarity between fire affected and control sites for trees. Density and basal area in fire affected sites were lesser than control sites for shrubs. Contagious pattern of distribution for trees and shrubs was common. Seedlings density of trees and shrubs was higher on occasional fire affected sites than control sites. Density of saplings of trees was higher in control sites than fire affected sites.

INTRODUCTION

The Himalayan forest vegetation ranges from tropical dry deciduous forests in the foothills to alpine meadows above timberline. Vegetation is the outcome of the habitat, environmental condition and existing biotic influences. Fire is considered to be one of the main causes of disturbance in Chir pine forests. Himachal Pradesh forms a part of North-Western Himalayas and lies between the East longitude 75°47' 55" to 79° 04' 22" and North latitude 30° 12' 40" to 33° 12' 40". The disturbance has become a requirement for vigorous ecosystem functioning (Haper, 1977) and should be considered a normal part of an ecosystem's physical environment. Fire plays a typical role in maintaining the different plants requirement of woodlands and close forests. The findings will help environmentalists and ecologists to work in other localities of the same area. Therefore the present study was undertaken to investigate the effect of forest fire on plant population.

MATERIALS AND METHODS

The study was carried out in the Department of Tree Improvement and Genetic Resources, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during 2002. The details about the experiment sites are given in Table -1.

Field survey was conducted for the selection of fire affected Sites as well as control Site in Northern aspects in the Chir pine forests (PB 1or 2) in the zone of its occurrence (1150 -1800 m) at 5 locations in Solan Forest Division. Studies were conducted in 4 fire affected Sites along with 1 control Site in Northern aspects in Chir pine forests. Relevant characteristics of the selected Sites were recorded prior to the initiation of study. Studies were conducted by grid pattern method. Vegetation data were collected using 10 randomly distributed quadrates of 10 x 10m for trees, 20 quadrates of 5 x 5m for shrubs, seedlings and saplings as given by Mishra (1968) so as to cover 0.1 ha area under observations. Floristic composition were recorded by listing of all plant species i.e. trees and shrubs in all Sites (Table - 2). The data on vegetation was quantitatively analyzed for density, frequency and abundance (Curtis and McIntosh,1950). The tree basal area was also determined as:

$$\text{Basal area} = \pi r^2$$

$$C = 2\pi r, \quad r = C/2\pi$$

Where,

C = Circumference at breast height

r = Radius

Phytosociological studies were carried out in accordance with standard methods as described by Misra (1968). The IVI which is an integrated measure of the relative frequency, relative density and

Table-1: Details of survey areas of Solan Forest Division

Name	Oachghat (Site 1)	Jabli (Site 2)	Shilli (Site 3)	Vaknaghat (Site 4)	Nigali Site 5 (Control)
District	Solan	Solan	Solan	Solan	Solan
Range	Oachghat	Parwanoo	Solan Wildlife Sanctuary	Kandaghat	Dharmpur
Division	Solan	Solan	Solan	Solan	Solan
Altitude	1200-1300 m	1150-1200m	1420-1460m	1600-1800m	1540-1620m
Aspect	Northern	Northern	Northern	Northern	Northern
Latitude	31°52′ N	31°19′ N	31°53′ N	31°55′ N	31°12′ N
Longitude	77°09′ E	77°12′ E	77°17′ E	77°15′ E	77°16′ E
Geomorphology					
Slope	Moderate	Moderate	Moderate	Moderate	Moderate
Rock type	Ferromagnesian, carbonaceous shales and dolomitic limestones	Ferromagnesian, carbonaceous shales and dolomitic limestones	Ferromagnesian, carbonaceous shales and dolomitic limestones	Ferromagnesian, carbonaceous shales and dolomitic limestones	Ferromagnesian, carbonaceous shales and dolomitic limestones
Erosion	Moderate	Moderate	Moderate	Moderate	Moderate
Soil structure	Sub angular to blocky	Sub angular to blocky	Sub angular to blocky	Sub angular to blocky	Granular
Fire History					
(a) Causes	Unextinguished bidis, cigarette butts, matchsticks etc. by graziers, travelers, even forest labourers, residues of torchwoodor by road side charcoal panniers	Unextinguished bidis, cigarette butts, match- sticks etc. by graziers, travelers, even forest labourers, residues of torchwoodor by road side charcoal panniers	Unextinguished bidis, cigarette butts, matchsticks etc. by graziers, travelers, even forest labourers, residues of torchwoodor by road side charcoal panniers	Unextinguished bidis, cigarette butts, matchsticks etc. by graziers, travelers, even forest labourers, residues of torchwoodor by road side charcoal panniers	Unextinguished bidis, cigarette butts, matchsticks etc. by graziers, travelers, even forest labourers, residues of torchwoodor by road side charcoal panniers
(b) Interval	There was fire in 1992,1993, 1994, 1997, 1999, 2000 and 2001	There was fire in 1990,1991,1992, 1993,1994, 1997, 1998, 1999 and 2001.	There was fire in 1994, 1998 and 2001.	Twenty year back (1982) there was fire.	There was fire in 1990, 1996, 1998 and 2001.

Table-2: Floristic composition of Chir pine Forest along its range of distribution (control and fire affected sites) in Northern aspects under Solan Forest Divisions in Himachal Pradesh

	Species	Oachghat (Site 1)	Jabli (Site 2)	Shilli (Site 3)	Vaknaghat (Site 4)	Nigali Site 5 (Control)
1.	*Berberis lycium* Royle			+	+	+
2.	*Buddleja asiatica* Lour.	+	+	+	+	
3.	*Carissa carandas* L.		+	+		+
4.	*Hypericum montanum*					+
5.	*Indigofera pulchella* Roxb.	+				
6.	*Myrsine africana* L.	+	+	+	+	+
7.	*Phoenix humilis* Rayle ex Bacc.		+			
8.	*Pinus roxburghii* Sarg.	+	+	+	+	+
9.	*Pyrus pashia* Buch.-Ham. ex D.Don			+	+	
10.	*Quercus leucotrichophora* A. Camus	+		+		+
11.	*Rosa moschata* Herrm.					+
12.	*Rubus ellipticus* Smith	+		+	+	
13.	*Woodfordia floribunda* (L.) Kurz				+	

relative basal area, was calculated from the basic data for each species of trees and shrubs (Phillips, 1959). Spatial distribution of a species in a community was obtained on the basis of abundance frequency ratio (A/F) (Curtis and Cottom, 1956).

A/F ratio was used to interpret the distribution pattern of species. This ratio indicates regular distribution if it is (< 0.025), random (0.025 to 0.050) and Contagious (>0.050).

Number of a species or any other higher ranks of taxonomic organization in a Site are termed as α–Diversity (Whittakar, 1972). Simpson's Index of Dominance (Cd) was calculated as described by Simpson (1949) as:

$$Cd = \sum(ni/N)^2$$

Where,

ni = Importance value for each species (number of species)

N = Total of importance values

The species diversity was calculated using Shannon-Wiener index, (Shannon and Weaver, 1963) as follows:

$$\bar{H} = .\sum Pi \ln Pi$$

Where,

$\bar{H}$ = Mmeasure of diversity

Pi = Proportion of i^{th} species

ln Pi = Natural log of the proportion of each species.

Species richness (d) was calculating using Margalef's and Menhinick's Index (Margalef, 1951)

$$d = \frac{S-1}{\ln \mu}$$

Where,

μ = Total number of individuals

S = Total number of species present in the plot

The rate of change of species composition across communities in a landscape is called ß – Diversity (Magurran, 1988, Negi and Gadgil, 2002.) was calculated for mutual comparison of different Sites using the formula given by Sorenson (1948) :

$$S = \frac{2C}{A+B}$$

Where,

A = No. of species in community A
B = No. species in community B
C = No. of species common to both of the communities

Studies were conducted to examine the effect of forest fire on natural regeneration of trees and shrubs in control and fire affected Sites. Natural regeneration potential was observed randomly in 20 quadrats of 5m x 5m for seedling and saplings for trees and seedlings of shrubs in all Sites as:

- Number of saplings/25 m^2 for trees
- Number of seedlings/25 m^2 for trees and shrubs

RESULT AND DISCUSSION

The detailed characteristics of different forest Sites of Chir pine forest in Solan Forest Division are mentioned in Table-1. Total 3 tree species and 10 shrub species were recorded on the five experimental Sites (Table -2). Maximum number of species was 8 at Site 13 and minimum (5) at Site 12. The difference in number of tree species on different forest Sites could be due to the degree of biotic disturbance and topographic factor. The low number of woody species in Chir pine forest could be due to repeated forest fire in this region. The species which were present in both fire affected and control areas, were fire resistant species. Fire tender species were also present in control area. These result are more or less similar to Semwal and Mehta (1996) and Anita (2001).

Total density/100 m^2 varied from 6.10 at Site 5 (control) to 10.70 at Site 3 and total basal area (cm^2/100 m^2) vary from 4.60 at Site 2 to 10.90 at Site 3 for trees (Table-3). There was not consistent trend between fire affected Sites and control Site for density and basal area. It may be due to difference in age of stands. Moreover, Chir pine is fire resistant species it is evident from fire scars present unto 1.5 – 2 m height in the stems in fire affected Sites. Identical observations were also reported by Rodgers *et al.* (1986).

Table-3: Total Density /100 m^2 and Total Basal Area (cm^2/100 m^2) of trees for selected sites

Sr. No.	Sites	Density	Basal Area
1	Site 1	8.20	10.30
2	Site 2	7.40	4.60
3	Site 3	10.70	10.90
4	Site 4	9.70	9.20
5	Site 5 (Control)	6.10	5.60

Total density /100m^2 of shrubs was maximum (20.30) at Site 5 (control) and minimum (3.20) at Site 2 (Table-4). Basal area (cm^2/25 m^2) of shrubs was recorded highest (81.261) at Site 5 (control) and lowest (9.191) at Site 1 (Table-4). This may be due to less degradation of control Site as compared to fire affected Sites. These observation are in accordance with the studies of Schwartz and Heim (1996).

Table-4: Total density /25 m^2 and Total Basal Area (cm^2/25 m^2) of Shrubs for selected sites

Sr. No.	Sites	Density	Basal Area
1	Site 1	3.85	9.191
2	Site 2	3.20	26.100
3	Site 3	4.70	15.587
4	Site 4	5.40	12.743
5	Site 5 (Control)	20.30	81.261

Pinus roxbughii was dominant tree species of Chir pine forests showed maximum IVI in all the selected Sites (Tables-5 to 9). Associated tree species were *Quercus leucotricophora* at Sites 1, 3 and 5, and *Pyrus pashia* at Site 4. Anita (2001) also reported that *Quercus leucotricophora* and *Pyrus pashia* were associated species in fire affected areas in Chir pine forests.

On the basis of IVI, perusal of data (Tables-5 to 9) for shrubs revealed that dominant species were *Rubus ellipticus* (117.202) at Site 1, *Carissa carandas* (152.671) at site 2. *Carissa carandas* (112.047) at Site 3, *Myrsine africana* (159.846) at Site 4 and *Myrsine africana* (173.409) at Site 5 (control). The results are also in accordance with Anita (2001).

Table-5: Phytosociological Attributes of Trees and Shrubs at Site 1 (Oachghat)

Species	IVI	A/F	Cd	$\bar{H}$
Trees				
Quercus leucotrichophora	41.774	0.167	0.019	0.275
Pinus roxburghii	258.226	0.067	0.741	0.129
Total			0.760	0.404
Shrubs				
Buddleja asiatica	21.905	0.089	0.005	0.191
Indigofera pulchella	62.337	0.089	0.043	0.326
Myrsine africana	98.557	1.650	0.108	0.366
Rubus ellipticus	117.202	0.059	0.153	0.367
Total			0.309	1.250

Table-6: Phytosociological Attributes of Trees and Shrubs at Site 2 (Jabli)

Species	IVI	A/F	Cd	$\bar{H}$
Trees				
Pinus roxburghii	300.000	0.074	1.000	0.000
Total			1.000	0.000
Shrubs				
Buddleja asiatica	72.937	0.012	0.059	0.344
Carissa carandas	152.671	0.026	0.259	0.344
Myrsine africana	18.967	0.400	0.004	0.175
Phoenix humilis	55.424	0.100	0.034	0.312
Total		0.537	0.356	1.175

The distribution of different tree species was mainly Contagiousat all the Sites. *Pinus roxburghii* showed random distribution at Site 5 only (Tables - 5 to 9). Odum (1971) also stated that Contagious distribution is common in natural condition. This is in conformity with the observations of Tiwari and Singh (1985).

Table-7: Phytosociological Attributes of Trees and Shrubs at Site 3 (Shilli).

Species	IVI	A/F	Cd	$\bar{H}$
Trees				
Quercus leucotrichophora	22.338	0.175	0.006	0.193
Pinus roxburghii	268.981	0.099	0.804	0.098
Pyrus pashia	8.682	0.100	0.001	0.103
Total			0.810	0.394
Shrubs				
Berberis lyceum	38.005	0.037	0.016	0.262
Buddleja asiatica	25.426	0.064	0.007	0.209
Carissa carandas	112.047	0.156	0.139	0.368
Myrsine africana	93.223	0.076	0.097	0.363
Rubus ellipticus	31.299	0.138	0.011	0.236
Total			0.270	1.438

Table-8: Phytosociological Attributes of Trees and Shrubs at Site 4 (Vaknaghat)

Species	IVI	A/F	Cd	$\bar{H}$
Trees				
Pinus roxburghii	289.854	0.096	0.934	0.033
Pyrus pashia	10.146	0.100	0.001	0.115
Total			0.935	0.148
Shrubs				
Berberis lyceum	94.041	0.027	0.098	0.364
Buddleja asiatica	21.107	0.100	0.005	0.187
Myrsine africana	159.846	0.120	0.284	0.335
Rubus ellipticus	16.496	0.133	0.003	0.159
Woodfordia floribunda	8.510	0.800	0.001	0.101
Total			0.391	1.146

Shrub population showed mainly Contagious population distribution pattern in all the Sites. Regular distribution was observed for *Buddleja asiatica* at Site 2. While random distribution was observed for *Carissa carandas* at Site 2, *Berberis lycium* at Sites 3 and 4 (Tables - 5 to 9).

Simpson's index (Cd) was maximum (1.000) at Site 2 followed by 0.935 at Site 4, 0.810 at Site 3, 0.760 at Site 1 and 0.551 at Site 5 (control) for trees.

Simpson's index of dominance for shrubs was maximum (0.407) at control Site 5 followed by 0.391 at Site 4, 0.356 at Site 2, 0.309 at Site 1 and 0.270 at Site 3 (Tables - 5 to 9).

Table-9: Phytosociological attributes of trees and shrubs at control site 5 (Nigali)

Species	IVI	A/F	Cd	$\bar{H}$
Trees				
Quercus leucotrichophora	101.980	0.055	0.116	0.367
Pinus roxburghii	198.020	0.034	0.436	0.274
Total			0.552	0.641
Shrubs				
Berberis lycium	73.954	0.073	0.061	0.345
Carissa carandas	9.201	0.450	0.001	0.107
Hypericum montanum	27.949	0.800	0.009	0.221
Myrsine africana	173.409	0.160	0.334	0.317
Rosa moschata	15.487	0.125	0.003	0.153
Total			0.408	1.143

The Shannon index $\bar{H}$ of diversity for trees was maximum (0.641) at Site 5 (control) and nil diversity was observed in Site 2. Shannon index (H) of diversity for shrubs was maximum (1.438) at Site 3 followed by 1.250 at Site 1, 1.174 at Site 2, 1.146 at Site 4 and 1.143 at Site 5 (Tables - 5 to 9). Present investigation reveals that concentration of dominance (Cd) is generally inversely related to species diversity and species richness. It is maximum at Sites, where density of a single dominant species is highest as compared to other associated species . On the contrary lowest (Cd) concentration of dominance occur due to high species richness and species diversity.

The highest value of species richness index for trees was 0.428 at Site 3 and was zero at Site 2 (Table -10). The species richness index was maximum (0.880) at Site 3 and minimum value was 0.666 at control Site 5 for shrubs (Table-10).

The value for Sorenson's index (S) for trees was recorded maximum as a unity between Sites 1 and 5 and minimum value was 0.500 between Sites 2 and 3, Sites 1 and 4, Sites 4 and 5 (Table -11). This may be due to presence of Chir pine (*Pinus* roxburghii) in every Sites and less number of associated tree species in the selected Sites. Saklani (1997) also reported that degree of similarity was 0.92 between unburned and burned stands. The results indicated that fire caused no pronounced impact on trees.

Sorenson's index of similarity (S) for shrubs was recorded maximum (0.667) between Sites 2 and 3 and minimum (0.222) between Sites 1 and 5 (Table-12). The lower value of beta-diversity may be the reflection of difference in altitude, aspects, forest fires and long term biotic interferences.

Table-10: Species Richness (d) for trees and shrubs for selected sites

Sr. No.	Sites	Trees(d)	Shrubs(d)
1	Site 1	0.227	0.691
2	Site 2	0.000	0.721
3	Site 3	0.428	0.880
4	Site 4	0.219	0.854
5	Site 5 (Control)	0.243	0.666

Table-11: Sorenson's Index of similarity (S) for trees

Site	Site 2	Site 3	Site 4	5 Sites (control)
Site 1	0.667	0.800	0.500	1.000
Site 2		0.500	0.667	0.667
Site 3			0.800	0.800
Site 4				0.500

Table-12: Sorenson's Index of similarity(S) for shrubs

Site	Site 2	Site 3	Site 4	5 Sites (control)
Site 1	0.500	0.444	0.667	0.222
Site 2		0.667	0.444	0.444
Site 3			0.600	0.600
Site 4				0.400

NATURAL REGENERATION

Regeneration potential of woody species (Table-13) as seedlings and saplings of tree species and seedlings of shrubs were recorded in all the Sites. Total density of seedlings of trees /25 m^2 was highest (4.00) at Site 3 followed by 0.80 at Site 4, 0.55 at Site 5 (control). Highest value of total density

Table -13: Regeneration potential of woody species (total no. of seedlings/25 m^2) in selected sites at Solan Forest Division

Species	Site 1	Site 2	Site 3	Site 4	Site 5 (Control)
Trees					
Flacourtia indica	- -	0.05 (0.80)	- -	- -	- -
Mallotus phillippinensis		-			-
		(0.25)	-	-	(0.25)
Myrica esculenta	-	-	-	-	-(0.15)
Pinus roxburghii	0.50 (0.20)	14.10 (0.25)	4.00 -	0.80 (0.35)	0.55 (3.00)
Prunus padus	0.05 -	- -	- -	- -	- -
Pyrus pashia	0.10 -	- -	- (0.40)	- (0.35)	- (0.25)
Quercus leucotrichophora	0.65 -	- -	- (0.70)	- -	- (1.25)
Toona ciliata	-	-	-	-	-
					(0.55)
Total	1.30 (0.20)	14.15 (1.30)	4.00 (1.10)	0.80 (0.70)	0.55 (5.45)
Shrubs					
Berberis lyceim	0.10	-	-	0.60	0.10
Buddleja asiatica	0.75	0.05	0.40	0.30	-
Carissa carandas	-	0.20	0.15	-	0.15
Gerardiana heterophylla	-	-	0.50	-	-
Hypericum montanum	-	-	-	-	0.15
Indigofera pulchella	0.20	-	-	-	-
Lantana camara	-	-	-	-	-
Murraya koenigii	-	1.45	-	-	-
Myrsine Africana	-	-	3.80	1.25	0.15
Rosa moschata	-	-	-	-	0.45
Rubus ellipticus	1.25		0.35	0.50	0.50
Solanum khasianum	-	-	-	-	-
Woodfordia floribunda	-	-	-	0.20	-
Zanthoxylum alatum	-	-	-	-	-
Total	2.30	1.70	5.20	2.85	1.50

The value written in parenthesis () are saplings of trees

of saplings/25 m^2 of trees was observed highest (5.45) at control Site 5, followed by 1.65 at Site 2, 1.10 at Site 3, 0.70 at Site 4 and 0.20 at Site 1. These results are in accordance with the studies made by Lust (1998).

Total density of seedlings of shrubs/25 m^2 (Table -13) was maximum (5.20) at Site 3 and minimum (1.45) at Site 5 (control). Natural regeneration potential for shrubs was recorded more in fire affected Sites as compared to control Sites. The maximum numbers of species germinates or emerge from perennating organs, or vegetatively or there may be less competition due to open canopy. Shrubs are generally believed to increase prolifically after fire due to the fact that heat may stimulate the seed germination of some of the shrub species which may result in an increase in population density. Similar observations were made by Rodgers *et al.* (1986). Joshi (1990) observed higher values of seedlings density on burned stand as compared to the unburned stand. Occasional fires provide suitable conditions for regeneration and growth of seedlings of woody species in Chir pine forest.

CONCLUSION

Fire resistant species were observed more in selected Chir pine forest. There was not observed any consistent trend for density and basal area between fire affected and control Sites for trees. Density and basal area in fire affected Sites were lesser than control Sites for shrubs. Contagious pattern of distribution for trees and shrubs was common. A consistent pattern for trees and shrubs for IVI, $\overline{H}$ evenness index, Sorenson's index of similarity was not observed between fire affected Sites and control Sites. Density of seedlings of trees and shrubs were more on occasional fire affected Sites than control Sites. Density of saplings was more in control Sites than fire affected Sites.

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