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Pre and Post-Fire Vegetational Study in a Chir-Pine Forest of Garhwal Himalaya

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ABSTRACT

Effect of forest fire on the vegetational diversity of Chir-pine forest is being studied in the Khirsu region of Pauri Garhwal District, Uttarakhand. Study was done with the help of random quadrat sampling method in the pre and post-fire seasons. Site was surveyed for the analysis of density, basal area, IVI, A/F, Shannon-Weiner Diversity Index ($\bar{H}$), Simpson's Index of Dominance (SDI) and Species richness (d). The study revealed that there is high vegetational diversity after fire. Grasses showed more diversity and productivity which are the most important source of fodder for natives. Moderate intensity forest fires are useful in such forest ecosystem for maintaining heterogeneity luxuriant growth of herbs and shrubs.

Keywords Fire, Chir-pine, Garhwal Himalaya, Diversity, Vegetation.

INTRODUCTION

Indian Himalayan region is one of the mega centres of biodiversity in the world. The Himalayan vegetation ranges from tropical dry deciduous forest in the foot hills to alpine meadows above the timberline (Champion and Seth 1968). The vegetation pattern in the region follow the usual latitudinal zonations i.e., tropical, sub-tropical, temperate and alpine. Forests of the Garhwal Himalayan Region are mainly dominated by Oak and Chir-pine species. In Garhwal Himalaya, forests situated between 300 to 2000 m are dominated by Chir-pine and can be considered as fire prone.

Fire is a natural phenomenon which is the main cause of disturbance in these forest ecosystems. Fire on the one hand helps in simplifying the forest complexity, on the other leads to the enormous growth of vegetation, as post-fire conditions are suitable for the luxuriant growth of ground diversity of grasses, herbs, shrubs, sedges and legumes. Fire greatly influences spatial and temporal patterns of biodiversity, impacting plant and wildlife community, composition and species abundance (Pickett and White 1985, Sugihara *et al.* 2006). Also the thin canopy of Chir-pine forests is suitable for the maximum ground diversity. The herbaceous vegetation increase after fire events because of general reduction in tree cover that brings more insolations to the soil favoring the growth of understory or herbaceous cover (Moretti *et al.* 2002, Sheuyange *et al.* 2005, Keith *et al.* 2010). Fire also plays a significant role in regulating ecosystem productivity and diversity by promoting mineralization of nutrients stored in organic matter and allowing the invasion of rapid growing early successional species (Bhandari *et al.* 2012, Busse *et al*. 1996, DeBano *et al*. 1998, Boerner *et al.* 2009).

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Post-fire successional process also contributes to the gamma diversity of the region as each seral stage has its own specific plant and animal species composition (Tavsanoglu 2008, Kaynas 2017).

One of the important parameter i.e., species diversity, describes ecosystem and its functioning (Scherer-Lorenzen *et al.* 2005) and analysis of this parameter provide an insight of many communities. Therefore, the present study aims to assess the pre-fire ground diversity and the post-fire vegetational diversity in the Chir-pine forest ecosystem.

MATERIALS AND METHODS

The study was conducted in the Chir-pine forest area of the Khirsu division of Pauri Garhwal District. The forest area is dominated with Chir-pine trees and is the most fire prone area of the region. The study sites was located at 29°45´ to 30°15´ latitude to78° 24´ to 79°23´ E longitude. Average temperature of the area is 25°C and annual rainfall 215 cm.

The study was carried out in the pre-fire season during March-April followed by post-fire sampling in the year 2019. Repeated field surveys were carried out in order to select the sites. A total of 30 quadrats (1*1m) were laid down in the forest to study the ground vegetation. Study of pre-fire vegetation is done with the help of 15 quadrats and also post-fire vegetational study is completed with the help of 15 quadrats. Data were quantitatively analyzed for abundance, density, frequency (Curtis and McIntosh 1950). IVI is calculated following Phillips (1969).

A/F ratio was calculated to interpret the distribution pattern of the species. If the value is < 0.025 it depicts regular distribution, if the value comes between 0.025–0.050, it indicates random distribution and the value > 0.050 shows contiguous distribution of species (Curtis and Cottam 1956).

Simpson's Diversity of Index (SDI) is calculated with the help of formula described by Simpson in 1949: $SDI = \sum(ni/N)^2$.

Where, ni = Number of species ; N= Total number of individuals of all the species.

Shannon-Weiner diversity is calculated (Shannon and Weaver 1963) as : $H = \sum Pi \ln Pi$.

Where, $\bar{H}$ = Measure of diversity ; Pi= Proportion of ith species ; ln Pi = Natural log of the proportion of each species.

Species richness (d) is calculated by using Margalef's and Menhinick's Index (Margalef 1951) as $d = S-1/\ln\mu$.

Where, μ= Total number of individuals ; S= Total number of species present.

RESULTS AND DISCUSSION

Studies of pre-fire season reported the presence of 33 species from 16 families and post-fire season studies shows the presence of 42 species belong to 18 families.

In the pre-fire season, maximum IVI value is shown by *Cymbopogon martini* (28.06), member of the family Poaceae and minimum by the *Galinsogaquadriradiata* (1.77) of the family Asteraceae. The highest A/F ratio is shown by the grass species *Themeda anathera* (7.20) and *Cissampelos pariera* (0.08) species of Menispermaceae family showed lowest A/F ratio (Table 1). Shannon -Weiner diversity index of pre-fire season is calculated as 2.7467 ; Simpson's Diversity Index as 0.041 and Margalef's Specis Richness Index as 4.9324.

The post-fire season studies have shown the maximum IVI by the species *Rubus ellipticus* of the family Rosaceae with the value of 32.45 and minimum by the species *Artemisia japonica* of the family Asteraceae which is 1.45. The maximum A/F ratio is shown by the species *Arthraxon prionodes* belongs to the family Poaceae which is 3.29 and minimum by the species *Cissampelos pareira* belongs to the family Menispermaceae which is 0.07 (Table 2). Shannon-Weiner Diversity Index is calculated as 3.1832 ; Simpson's Diversity Index value as 0.9477 ; Margalef's Species Richness Index value as 6.2423 (Table 3).

In the Himalayan forest ecosystems, disturbances

Table 1. IVI, A/F and distribution pattern of the species in the pre-fire season.

Sl. No.	Species	Family	IVI	A/F	Dist.
1	*Micromeria biflora* (Buch.-Ham. Ex D. Don)	Lamiaceae	19.7	0.31	C
2	*Geranium rotudifolium* L.	Geraniaceae	12.3	0.11	C
3	*Galium apairne* L.	Rubiaceae	7.19	0.30	C
4	*Cynodon dactylon* L.	Poaceae	4.2	2.85	C
5	*Anisomeles indica* L.	Lamiaceae	6.2	0.30	C
6	*Desmodium* spp.	Fabaceae	6.69	0.49	C
7	*Oxalis corniculata* L.	Oxalidaceae	14.27	0.10	C
8	*Sarcococca saligna* (D. Don)	Buxaceae	2.94	0.75	C
9	*Cissampelos pareira* L.	Menispermaceae	18	0.08	C
10	*Anaphalis adnata* Wallich ex DC	Asteraceae	1.53	0.15	C
11	*Asparagus* spp.	Asparagaceae	4.38	0.30	C
12	*Eupatorium adenophorum* Sprengel	Asteraceae	22.89	0.75	C
13	*Rubus ellipticus*	Rosaceae	2.87	0.15	C
14	*Arundodonax* L.	Poaceae	1.81	0.45	C
15	*Gnaphalium luteo-album* L.	Asteraceae	6.19	0.08	C
16	*Rubias* pp.	Rubiaceae	4.27	0.75	C
17	*Arundinellaraddi*	Poaceae	2.93	1.65	C
18	*Viola biflora* L.	Violaceae	4.05	0.38	C
19	*Themeda anathera* (Nees ex Steudel)	Poaceae	8.5	7.20	C
20	*Artemisia japonica* Thunb.	Asteraceae	1.56	0.15	C
21	*Launea procumbens* (Roxb.)	Asteraceae	6.23	0.45	C
22	*Blepharis edulis*	Acanthaceae	22.62	0.12	C
23	*Adiantum pedatum*	Pteridaceae	10.48	1.20	C
24	*Lathyrus* spp.	Fabacea	5.31	0.41	C
25	*Plectranthus mollis* (Aiton) Sprengel, Syst. Veg.	Lamiaceae	7.65	0.53	C
26	*Reinwardtia indica Dumortier*	Linaceae	7.74	0.30	C
27	*Chrysopogon gryllus* L.	Poaceae	3.81	0.34	C
28	*Galinsoga quadriradiata*	Asteraceae	1.77	0.15	C
29	*Poa annua* L.	Poaceae	4.29	0.45	C
30	*Euphorbia hirta* L.	Euphorbiaceae	2.11	0.45	C
31	*Apluda mutica* L.	Poaceae	24.24	0.47	C
32	*Cymbopogon martini* (Roxb.) W.	Poaceae	28.06	0.71	C
33	*Aleuriopteris argentea*	Pteridaceae	22.32	0.09	C

are prominent and exist widely. Fire is a major agent of disturbance and the Chir-pine forest ecosystems of Himalayan region are most fire prone ecosystems. Generally, wildfires occur during dry period under the influence of strong winds (Heinselman 1971, 1973). Fires vary widely in their extent, intensity and duration (Rotenberry *et al.* 1995). The biodiversity of an area is widely influenced by disturbing factors and fire in the Chir-pine forest ecosystem is the most positive type of disturbance ever witnessed in relation to ground diversity as it provides suitable habitat for number of species and also encourage the growth of fire-resistant and enduring species. Heinselman (1971), Loucks (1970) also studied and concluded that richness of plant species and structural complexity of communities are frequently increased by fire. Low intensity fires with moderate severity are considered as an important factor in maintaining the heterogeneity of such ecosystems. Fire severity and stand characteristics are important determinants of post-fire response (Whittaker 1960, Gimingham 1972).

Chir-pine forest ecosystems are often blamed at social and scientific platforms for being fire prone due to xeric elements and less productive but nonetheless there are many other positive outcomes resulted post-fire like innumerous growth of ground diversity which

Table 2. IVI, A/F and distribution pattern of the species in the post-fire season.

Sl. No.	Species	Family	IVI	A/F	Dist
1	*Cyanodon dactylon* L.	Poaceae	9.57	2.03	C
2	*Anaphalis adnata* Wallich ex DC	Asteraceae	4.57	0.23	C
3	*Arundinella raddi*	Poaceae	10.8	0.25	C
4	*Micromeria biflora* (Buch.-Ham. Ex D. Don)	Lamiaceae	21.16	0.20	C
5	*Thalictrum foliolosum*	Ranunculaceae	10.39	0.22	C
6	*Viola biflora* L.	Violaceae	7.06	0.17	C
7	*Rubus ellipticus*	Rosaceae	32.45	0.07	C
8	*Oxalis corniculata* L.	Oxalidaceae	17.98	0.11	C
9	*Anisomelis indica* L.	Lamiaceae	3.55	0.30	C
10	*Desmodium* spp.	Fabaceae	6.59	0.49	C
11	*Sarcocoa saligna* (D. Don)	Buxaceae	2.25	0.30	C
12	*Anaphalis adnata* Wallich ex DC	Asteraceae	2.98	0.75	C
13	*Cissampelos pareira* L.	Menispermaceae	6.27	0.06	C
14	*Geranium nepalense*	Geraniaceae	8.56	0.13	C
15	*Cassia mimosoides*	Fabaceae	1.56	0.47	C
16	*Gnaphalium luteo-album* L.	Asteraceae	8	0.07	C
17	*Eupatorium rotundifolium*	Asteraceae	13.94	0.75	C
18	*Conyzabonariensis* L.	Asteraceae	7.59	4.42	C
19	*Rubia* spp.	Rubiaceae	1.79	0.75	C
20	*Themeda anathera* (Nees ex Steudel)	Poaceae	8.12	7.20	C
21	*Artemisia japonica*	Asteraceae	1.45	0.15	C
22	*Launea procumbens* (Roxb.)	Asteraceae	4.95	0.45	C
23	*Blepharis maderaspatensis* (L.)	Acanthaceae	3.99	0.12	C
24	*Aleuritopteri sargentea*	Pteridaceae	19.86	0.10	C
25	*Adiantum* spp.	Pteridaceae	2.09	1.19	C
26	*Lathyrus* spp.	Fabaceae	3.96	0.41	C
27	*Plectranthusmollis* (Aiton) Sprengel	Lamiaceae	4.74	0.53	C
28	*Reinwardtia indica*	Linaceae	7.03	0.30	C
29	*Chrysopogon aciculatus* (Retz.)	Poaceae	3.17	0.33	C
30	*Poaannua*	Poaceae	3.69	0.45	C
31	*Galinsoga parviflora* Cav.	Asteraceae	2.43	0.15	C
32	*Ageratum conyzoides*	Asteraceea	3.69	1.79	C
33	*Gallium apairne* L.	Asteraceae	3.21	0.26	C
34	*Euphorbia hirta* L.	Euphorbiaceae	5.89	0.19	C
35	*Heteropogon contortus* L.	Poaceae	2.58	0.19	C
36	Pine seedling	Pinaceae	4.63	0.15	C
37	*Apluda mutica* L.	Poaceae	9.14	0.75	C
38	*Wulfenia* spp.	Plantanginaceae	1.99	0.29	C
39	*Arthraxon prionodes*	Poaceae	4.31	3.29	C
40	*Indigofera* spp.	Fabaceae	2.19	0.08	C
41	*Flemingiap rocumbens* (Roxb.)	Fabaceae	7.76	0.45	C
42	*Cymbopogon martini* (Roxb.)	Poaceae	12.15	0.82	C

null and void the discussion of its blame. Ecosystems may be fire adapted and it's our failure that we did not understand which is resulting into mismanagement of many natural resources (Odum 1969). Forests adapted to frequent low-intensity fires, result in increase of stand density and fuel loading if such ecosystems face fire suppression along with heavy grazing (Harrington and Sackett 1990, Covington and Moore 1944a, b, Sackett *et al.* 1994, 1996, Arno *et al.* 1995, Minnich *et al.* 1995, Touchan *et al.* 1995). Consequently, outbreak of fires in such forests after long span made their intensity more intense, larger and more likely results in stand replacement (Harrington and Sackett 1990, Swetnam 1990, Covington and Moore 1944a, Sackett *et al.* 1994). Such high intensity fires has more prominent and dramatic effects which may

Table 3. Diversity indices of species of pre and post-fire season. Where, H̄ = Shannon-Weiner Diversity Index, SDI = Simpson's Diversity Index, d = Margalef's Species Richness Index.

Season	H̄	SDI	d
Pre-fire (March-April)	2.7467	0.0959 (1-0.0959)=0.041	4.9324
Post-fire (August-September)	3.1832	0.0523 1-0.0523=0.9477	6.2423

even burn crown cover of trees and badly destroy ground vegetation also.

and Margalef's Species Richness Index clearly demarcated high values in the post-fire season's study which shows how low intensity forest fires boosts the growth of ground vegetation by providing suitable growth conditions. In the post-fire season studies, *Rubus ellipticus* has high IVI value, which is a fire tolerant species. The members of Poaceae family show contiguous distribution, which contribute as an important source of fodder species.

Post-fire conditions resulted from moderate intensity forest fires are suitable for number of communities and nature finds a way to balance itself in such conditions. Such forest ecosystems are more productive in post-fire season following the rainy season.

Studies immediately before and after fire in the forest ecosystems especially in the Chir- pine forest ecosystems are few. Lyon *et al*. (1978) also mentioned that there is a need for information on short-responses or results post fire. Therefore, this study is conducted which concluded that post-fire season shows more luxuriant growth of ground diversity which includes different species of herbs, shrubs, sedges, legumes and pteridophytes. Also, the post-fire studies showed that there was rich growth of grasses in the study area which serve as a source of fodder for the natives of adjacent villages. These seasonal forest fires are also helpful in the growth of fire-resistant species. Low and moderate intensity ground fires in such forest ecosystems are beneficial for the number of species as post-fire conditions offer suitable habitat environment for many. Study also concluded that little disturbances are important in such kind of ecosystems as they are helpful in maintaining the heterogeneity of the environment. Caswell (1976), Huston (1979) also noted that disturbance open opportunities for establishment of additional species and increases the growth rate of others. Therefore, it is imperative to carry out such studies in such fire prone forest ecosystems which are only the topic of blame in discussions at scientific platform but are far more productive and important in ground reality.

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