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Impact of Controlled Burning on Herbs in High Altitude Zone of Chirpine Forests in Solan and Nahan Circles, Himachal Pradesh

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Abstract

People are dependent on chirpine forests for direct and indirect benefits. The forest fire is very common phenomenon in chirpine forests. The severe forest fire cause financial as well as ecological losses in the chirpine landscape. Forest fires change composition of species and also the diversity of herbs. Controlled burning is practiced in winter to reduce the incidence of forest fire. The present investigation was carried out in higher altitude zone of chirpine forests in Nahan and Solan Circles of Himachal Pradesh Forest Department to evaluate the effect of controlled burning on the diversity of the herbs by selecting one site each in three forest divisions (Solan, Rajgarh and Nahan Forest Divisions). Controlled burning in winter was carried out in 1.5 ha (B_1) during 2017 and 0.50 Ha areas was kept as control (C) in all three sites. The observation for phytosociological data was taken during October to December, 2017. The number of species varied from 21 to 24 in control sites and 23 to 30 in burnt sites. The density for herbs was higher in burnt sites compared to control sites. The diversity index (H) was maximum (3.30) at Bagpashog (B_1) and minimum (2.63) at Lwasachowki (C). The richness index (R) was highest (4.30) for Bagpashog (B_1) and lowest (3.22) for Mangotimor (C). The evenness index (E) was highest (0.974) at Mangotimor (B_1) and lowest was 0.863 at Lwasachowki (C).

Keywords: Controlled burning, herbs, diversity and chirpine forests

1. Introduction

The Himalayan region is known for its unique and diverse flora and fauna. The biodiversity of the region is utilised by people for various uses like fodder, fuel wood, medicine and timber. Forest fire is very common problem in various forests in world and are the main cause of changes in population of plants and animals. It even affects the biodiversity and environment. Forest fires are important component of disturbance regime of various forests of the world and altering composition and structures of vegetation types (Elliot et al., 1999; Barden and Woods, 1976; Harmon, 1982; Buckner, 1989; Van Lear and Waldrop, 1989; De Vivo, 1991; Van Lear, 1991).

The sub-tropical pine forest occupy 18,102 km^2 area, which constitute 2.36 % of the total forest area of the country (FSI, 2019). The sub-tropical pine forest are found in Jammu & Kashmir, Himachal Pradesh, Haryana, Punjab, Uttrakhand, Assam, Manipur, Mizoram, Meghalya, Nagaland and Arunachal Pradesh (FSI, 2011)

Himalayas are home to pines with history of forest fires as old as the

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forests themselves. The health of the forests is the indicator of ecological condition present in any site. The repeated forest fires of different intensity are the main cause of habitat's modification of flora and fauna in any landscape. Chirpine forests are prone to forest fire every year and forest fire is one of important cause which does incalculable harm to chirpine forests. The main cause of damage to forest after deforestation is forest fire. The occurrence of forest fires destroy or degrade forest and even finish the hard work of forest managers of generation. The cause of forest fire can be divided into three classes i.e. natural, people's carelessness and due to deliberate and intentional action. Fire has been used as a silviculture treatment in various landscapes to restore productivity and diversity (Swift et al., 1993 and Elliott et al., 1999). Forest fire affects the diversity of herbaceous flora. The physical environment has been modified for our benefit by human being since long time and fire is one tool used for gaining the benefits (Schmerbeck and Fiener, 2015, Pyne, 1995).

Controlled burning is a tool in management of chirpine forest to reduce incidence of forest fire. The burning treatments are used throughout the world to reduce the fuel load (Cronan, et al., 2015, Schwilk et al., 2009 and Stephens et al., 2012) to mitigate the uncontrolled fire. Various workers have conducted study on impact of burning in various landscapes of world (Alcaniz et al., 2018; Borja et al., 2016; Butnor et al., 2020; Catherine and Andersen, 2006; Eales et al., 2016; Elliot et al., 1999; Fernandes and Botelho, 2003; Hood et al., 2020; Huisinga et al., 2005; Magallanes, et al., 2020; Rawat, 1949 and Zhan et al., 2020). Forest fires generally occur in summers in these forests but sometime it is reported in other seasons also. The controlled burning is practiced in winter in chirpine forests in Western Himalaya. The lower cost and easiness may be the main reasons to use the controlled burning in winter to reduce the damage caused by forest fire of high intensity to environment in summer in chirpine forests.

The database on controlled burning and its impact on the diversity of herbs and natural regeneration of woody species in Chirpine forest is not sufficient in India. There is a need for understanding the impact of controlled burning on herbaceous vegetation in Chirpine forest, hence, the present investigation was carried out to study the effect of controlled burning on herbaceous diversity including regeneration of trees and shrubs.

2. Materials and Methods

2.1. Study area

The investigation was carried out at altitude zone (>1200 m amsl) of chirpine forests in three forest divisions of Nahan and Solan Forest Circles of Himachal Pradesh, India. One site each in three forest divisions was selected i.e. Mangotimor in Solan Forest Division, Bagpashog in Rajgarh Forest Division, Lawasachowki in Nahan Forest Division. The details of study sites is given in Table 1.

Table 1: The geo-coordinates and other details of study sites

Sl. No.	Name of the site	Name of beat	Name of Forest Range	Geo coordinate			Elevation (m)
				Latitude (N)	Longitude (E)	Aspect	
1.	Mangotimor	Sanawar	Parwanoo	30˚53' 49.3''	077˚00' 06.5''	SE	1550
2.	Bagpashog	Panwa	Sarahan	30˚45' 41.5''	077˚09' 52.6''	NW	1522m
3.	Lawasa Chowki	Saroga	Jamta	30˚40' 32.8''	077˚11' 45.7''	SW	1344

The study area of 2 ha in each site was selected. Controlled burning was carried out once (B_1) in 1.5 ha during winter in 2017 with 0.50 ha areas kept as control (C) in all three sites. The geographic details of study sites are given in Table 1. Maximum temperature (°C) ranged from 16.4 to 30.50 and the minimum temperature (°C) ranged from 3.1 to 20.4. Average humidity (%) varied from 45 to 82 and total rainfall (mm) ranged from 7.6 to 233.8 (Source Meteorological Center, Department of Environment Science, Dr. YSP, UHF, Nauni, the meteorological data has been taken for January, 2017 to September, 2017). These study sites fall in upper or Himalaya, Chirpine forest (9/C1b) forest type (FSI, 2011).

2.2. Field sampling and data collection

Sampling for phytosociological observations was carried out after rainy season in 2017 by laying 40 quadrates of 1×1 m^2 in each treatments i.e. C and B_1. Natural regenerations of trees and shrubs have also been included in phytosociological analysis with herbs.

2.3. Data analysis

Density, frequency and abundance was calculated by Curtis and McIntosh (1950). Importance value index (IVI) was estimated by addition of relative values of density, frequency and basal area. The distribution pattern was estimated by calculating the abundance to frequency ratio (A/F) for different species. The ratio indicates contiguous (>0.050), random (0.025 to 0.050) and regular (<0.025) distribution (Curtis and Cottam, 1956).

The plant diversity was calculated by using Shannon- Wiener diversity index (H) (Shannon-Wiener, 1963).

$$H = \sum_{i=1}^{S} (ni/N) \ln(ni/N)$$

Concentration of dominance (Cd) was calculated by Simpson's index (Simpson, 1949).

$$Cd = \sum_{i=1}^{S} (ni/N)^2$$

Where ni= importance value of species i and N= total importance value of all the species in both the indices.

Richness Index (R) was measured by using following formula (Margalef, 1958).

R=S-1/ln N

Evenness index (E) was estimated as per following formula (Hill, 1973)

E=H/ln S

Where S= total number of species, N= total number of individuals of all the species, H= Index of diversity.

3. Results and Discussion

Total 41 species belonging to 41 genera and 26 families were observed in all three sites. The number of species was 32 and 41 in control (C) and burnt (B_1), respectively. Total number of species varied from 21 at Lwasachowki and Mangotimor to 24 at Bagpashog in control (C) whereas burnt site (B_1) it varied from 23 at Lwasachowki to 30 at Bagpashog.

3.1. Site-mangotimor

At Control (C) area, total 21 species of herbs were recorded at Mangotimor (Table 2). *Carex meiogyna* showed highest value for density/m^2 (3.00) at C followed by *Heteropogon contortus* (2.53)*, Chrysopogon montanus* (2.28), *Adiantum lunulatum* (1.05), and lowest value (0.08) was observed for *Pyrus pashia* seedlings (Table 2). Maximum frequency % was observed for *Chrysopogon montanus* (40.00) and *Heteropogon contortus* (40.00) followed by *Carex meiogyna* (37.*50*), *Adiantum lunulatum* (17.50), *Fragaria vesca* (12.50)*, Oxalis corniculata* (12.50) and minimum value (5.00) was observed for seedlings

Table 2: Density/m^2 of control and burnt area in selected study sites in chirpine forests

Sl. No.	Name of species	Mangotimor		Bagpashog		Lwasachowki	
		C	B_1	C	B_1	C	B_1
1.	*Adiantum lunulatum Burm.* f.	1.05	1.45	0.50	0.63	0.50	0.63
2.	*Ageratum conyzoides* (L.) L.		3.10			0.50	0.63
3.	*Ajuga integrifolia* Buch.-Ham			0.50	0.63		
4.	*Anaphalis triplinervis* C. B. Clarke	0.25	0.30	0.30	0.75	0.30	0.75
5.	*Artemisia vulgaris* Linn			0.25	0.33		
6.	*Berberis lycium* Royle**		0.33	0.28	0.75		
7.	*Carex meiogyna* Nees	3.00	2.15				
8.	*Carissa carandas* L.**	0.15	0.40			0.30	0.33
9.	*Cheilanthes farinosa* (Forssk.) Kaulf.	0.18	0.85	0.28	0.40	0.35	0.75
10.	*Chrysopogon montanus* Trin.	2.28	2.53	2.30	3.40	1.88	3.40
11.	*Cirsium wallichii* DC.	0.30	0.70	0.25	0.60	0.25	0.60
12.	*Cissampelos pareira* L.	0.20	0.60	0.23	0.30	0.25	0.40
13.	*Dicliptera bupleuroides* Nees	0.23	0.65	0.30	0.53	0.55	0.53
14.	*Ficus palmata* Forssk.*				0.40		0.38
15.	*Flacourtia indica* (Burnm.f.) Merr.*						0.40
16.	*Fragaria vesca* L.	0.25	0.70	0.40	0.48	0.30	0.40
17.	*Galium aparine* Linn.		0.90		0.55		
18.	*Geranium wallichianum* D. Don ex Sweet.		0.30	0.18	0.40	0.08	0.55
19.	*Heteropogon contortus* (L.) P. Beau. ex Roem. & Schult.	2.53	2.13	2.13	3.30	1.50	3.30
20.	*Hydrocotyle asiatica* L.	0.20	0.68				
21.	*Lantana camara* L.**		2.25				
22.	*Leucas lanata* Benth.		0.33	0.30	0.85	0.63	0.85
23.	*Mallotus philippensis* (Lam.) Mull. Arg.*					0.18	0.38
24.	*Murraya koenigii* (L.) Spreng.**					0.40	0.85
25.	*Myrica esculenta* Buch.-Ham.ex. D. Don*				0.35		
26.	*Myrsine africana* L.**			0.30	0.55	0.30	0.43

Table 2: Continue...

Sl. No.	Name of species	Mangotimor		Bagpashog		Lwasachowki	
		C	B_1	C	B_1	C	B_1
27.	*Oxalis corniculata* L.	0.38	0.48	0.30	0.38	0.50	0.60
28.	*Parthenium hysterophorus* L.	0.13	0.30				
29.	*Pinus roxburghii* Sarg.*	0.10	0.28	0.15	0.40	0.23	0.33
30.	*Prinsepia utilis* Royle**				0.60		
31.	*Pteris cretica* L.				0.85		
32.	*Pyrus pashia* Buch.-Ham.ex D. Don*	0.08	0.25	0.18	0.40		
33.	*Rubia cordifolia* L.			0.18	0.60		
34.	*Rubus ellipticus Sm.*	0.25		0.30	0.38	0.15	0.35
35.	*Sapium insigne* (Royle) Trimen*		0.13				
36.	*Solanum nigrum* L.	0.23		0.30	0.85		
37.	*Sonchus asper* (L.) Hill			0.30	0.43	0.30	0.25
38.	*Thalictrum foliolosum* DC.	0.25	0.45				
39.	*Thymus linearis* Benth.				0.60		
40.	*Viola serpens* Wall. ex Ging.	0.30	0.53	0.28	0.35	0.48	0.55
41.	*Zanthoxylum armatum* DC.**	0.13		0.25	0.25		
Total		12.43	22.73	10.70	21.25	9.90	17.60

*: Natural regeneration of trees; **: natural regeneration of shrubs

of *Pinus roxburghii* and *Pyrus pashia* as well as *Parthenium hysterophorus* (Table 3). Maximum abundance was observed for *Carex meiogyna* (8.00) followed by *Heteropogon contortus* (6.31), *Adiantum lunulatum* (6.00), *Chrysopogon montanus* (5.69), and minimum value (1.50) was observed for *Pyrus pashia* (Table 4). *Carex meiogyna* (38.26) was dominant species on the basis of IVI at C followed by *Heteropogon contortus* (35.42), *Chrysopogon montanus* (33.73), *Adiantum*

Table 3: Frequency (%) of control and burnt area in selected study sites in chirpine forests

Sl. No.	Name of species	Mangotimor		Bagpashog		Lwasachowki	
		C	B_1	C	B_1	C	B_1
1.	*Adiantum lunulatum Burm.* f.	17.50	22.50	10.00	22.50	10.00	22.50
2.	*Ageratum conyzoides* (L.) L.		25.00			10.00	15.00
3.	*Ajuga integrifolia* Buch.-Ham			10.00	15.00		
4.	*Anaphalis triplinervis* C. B. Clarke	7.50	7.50	5.00	15.00	5.00	15.00
5.	*Artemisia vulgaris* Linn			5.00	7.50		
6.	*Berberis lycium* Royle**		7.50	7.50	20.00		
7.	*Carex meiogyna* Nees	37.50	20.00				
8.	*Carissa carandas* L.**	7.50	10.00			5.00	7.50
9.	*Cheilanthes farinosa* (Forssk.) Kaulf.	10.00	15.00	10.00	10.00	7.50	20.00
10.	*Chrysopogon montanus* Trin.	40.00	40.00	30.00	47.50	37.50	47.50
11.	*Cirsium wallichii* DC.	7.50	12.50	5.00	15.00	5.00	15.00
12.	*Cissampelos pareira* L.	7.50	12.50	5.00	15.00	5.00	10.00
13.	*Dicliptera bupleuroides* Nees	10.00	12.50	5.00	12.50	7.50	12.50
14.	*Ficus palmata* Forssk.*				10.00		12.50
15.	*Flacourtia indica* (Burnm.f.) Merr.*						10.00
16.	*Fragaria vesca* L.	12.50	12.50	7.50	12.50	5.00	10.00

Table 3: Continue...

Sl. No.	Name of species	Mangotimor		Bagpashog		Lwasachowki	
		C	B_1	C	B_1	C	B_1
17.	*Galium aparine* Linn.		15.00		10.00		
18.	*Geranium wallichianum* D. Don ex Sweet.		15.00	5.00	10.00	2.50	10.00
19.	*Heteropogon contortus* (L.) P. Beau. ex Roem. & Schult.	40.00	40.00	25.00	45.00	385.00	45.00
20.	*Hydrocotyle asiatica* L.	7.50	20.00				
21.	*Lantana camara* L.**		22.50				
22.	*Leucas lanata* Benth.		15.00	5.00	15.00	7.50	15.00
23.	*Mallotus philippensis* (Lam.) Mull. Arg.*					5.00	10.00
24.	*Murraya koenigii* (L.) Spreng.**					5.00	17.50
25.	*Myrica esculenta* Buch.-Ham.ex. D. Don*				10.00		
26.	*Myrsine africana* L.**			7.50	10.00	7.50	12.50
27.	*Oxalis corniculata* L.	12.50	17.50	7.50	10.00	7.50	12.50
28.	*Parthenium hysterophorus* L.	5.00	10.00				
29.	*Pinus roxburghii* Sarg.*	5.00	7.50	5.00	12.50	7.50	10.00
30.	*Prinsepia utilis* Royle**				15.00		
31.	*Pteris cretica* L.				17.50		
32.	*Pyrus pashia* Buch.-Ham.ex D. Don*	5.00	7.50	7.50	12.50		
33.	*Rubia cordifolia* L.			5.00	15.00		
34.	*Rubus ellipticus Sm.*	7.50		5.00	10.00	5.00	10.00
35.	*Sapium insigne* (Royle) Trimen*		7.50				
36.	*Solanum nigrum* L.	10.00		7.50	17.50		
37.	*Sonchus asper* (L.) Hill			7.50	12.50	7.50	7.50
38.	*Thalictrum foliolosum* DC.	7.50	12.50				
39.	*Thymus linearis* Benth.				12.50		
40.	*Viola serpens* Wall. ex Ging.	10.00	15.00	10.00	10.00	7.50	12.50
41.	*Zanthoxylum armatum* DC.**	5.00		5.00	7.50		

*: Natural regeneration of trees; **: natural regeneration of shrubs

lunulatum (20.71) and least dominant was *Pinus roxburghii* (5.10) (Table 5).

Whereas, at burnt (B_1) area, total 25 species of herbs were recorded at Mangotimor (Table 2). *Ageratum conyzoides* showed highest value for density/m^2 (3.10) followed by *Chrysopogon montanus* (2.53), *Lantana camara* seedlings (2.25), *Heteropogon contortus* (2.13), and lowest value (0.13) was observed for *Sapium insigne* (Table 2). Maximum frequency % was observed for *Chrysopogon montanus* (40.00) and *Heteropogon contortus* (40.00) followed by *Ageratum lunulatum* (25.00), *Adiantum lunulatum* (22.50), *Lantana camara* seedlings (22.50), *Carex meiogyna* (20.00), *Hydrocotyl asiatica* (20.00) and minimum value (7.50) was observed for *Pinus roxburghii, Pyrus pashia* and *Sapium insigne* (Table-3). Maximum abundance was observed for *Ageratum conyzoides* (12.40) followed by by *Carex meiogyna* (10.75), *Lantana camara* seedlings (10.00), *Adiantum lunulatum* (6.44) and minimum value (1.67) was observed for *Sapium insigne* (Table 4). *Ageratum conyzoides* (25.42) was dominant species on the basis of IVI at B_1 followed *Chrysopogon montanus* (21.50), *Lantana camara* seedlings (20.85), *Heteropogon contortus* (19.51) and least dominant was *Sapium insigne* (6.14) (Table 5).

3.2. Site-bagpashog

Total 24 species of herbs were recorded at Bagpashog at control (C) area (Table 2). *Chrysopogon montanus* showed highest value for density/m^2 (2.30) followed by *Heteropogon contortus* (2.13), *Adiantum lunulatum* (0.50), *Ajuga bracteosa* (0.50) and lowest value (0.15) was observed for seedlings of *Pinus roxburghii* (Table 2). Maximum frequency % was observed for followed by *Chrysopogon montanus* (30.00), *Heteropogon contortus* (25.00), *Adiantum lunulatum* (10.00), *Ajuga bracteosa* (10.00), *Viola serpens* (10.00), *Berberis lycium* seedlings (7.50), *Fragaria vesca* (7.50), *Myrsine*

africana seedlings (7.50), *Oxalis corniculata* (7.50), *Pyrus pashia* seedlings (7.50), *Solanum nigrum* (7.50), *Sonchus asper* (7.50) and minimum value (5.00) was observed for *Anaphalis triplinervis, Artemisia vulgaris, Cirsium wallichii, Cissampelos pareira, Dicliptera bupleuroides, Geranium wallichianum*, *Leucas lanata, Pinus roxburghii* seedlings, *Rubia cordifilia, Rubus ellipticus* seedlings and *Zanthoxylum armatum* seedlings (Table 3). Maximum abundance was observed for *Chrysopogon montanus* (38.51) followed by *Heteropogon contortus* (34.86), *Ajuga bracteosa* (19.93), *Adiantum lunulatum* (15.18) and minimum value (6.61) was observed for *Pinus roxburghii* seedlings (Table 4). *Chrysopogon montanus* (38.51) was dominant species on the basis of IVI at C followed by *Heteropogon contortus* (24.86), *Ajuga bracteosa* (19.93), *Adiantum lunulatum* (15.18) and least dominant was *Pinus roxburghii* seedlings (6.06) (Table 5).

Whereas at burnt (B_1) area, total 30 species of herbs were recorded at Bagpashog (Table 2). *Chrysopogon montanus*

Table 4: Abundance/m^2 of control and burnt area in selected study sites in chirpine forests

Sl. No.	Name of species	Mangotimor		Bagpashog		Lwasachowki	
		C	B_1	C	B_1	C	B_1
1.	*Adiantum lunulatum Burm.* f.	6.00	6.44	5.00	2.78	5.00	2.78
2.	*Ageratum conyzoides* (L.) L.		12.40			5.00	4.17
3.	*Ajuga integrifolia* Buch.-Ham			5.00	4.17		
4.	*Anaphalis triplinervis* C. B. Clarke	3.33	4.00	6.00	5.00	6.00	5.00
5.	*Artemisia vulgaris* Linn			5.00	4.33		
6.	*Berberis lycium* Royle**		4.33	3.67	3.75		
7.	*Carex meiogyna* Nees	8.00	10.75				
8.	*Carissa carandas* L.**	2.00	4.00			6.00	4.33
9.	*Cheilanthes farinosa* (Forssk.) Kaulf.	1.75	5.67	2.75	4.00	4.67	3.75
10.	*Chrysopogon montanus* Trin.	5.69	6.31	7.67	7.16	5.00	7.16
11.	*Cirsium wallichii* DC.	4.00	5.60	5.00	4.00	5.00	4.00
12.	*Cissampelos pareira* L.	2.67	4.80	4.50	2.00	5.00	4.00
13.	*Dicliptera bupleuroides* Nees	2.25	5.20	6.00	4.20	7.33	4.20
14.	*Ficus palmata* Forssk.*				4.00		3.00
15.	*Flacourtia indica* (Burnm.f.) Merr.*						4.00
16.	*Fragaria vesca* L.	2.00	5.60	5.33	3.80	6.00	4.00
17.	*Galium aparine* Linn.		6.00		5.50		0.00
18.	*Geranium wallichianum* D. Don ex Sweet.		2.00	3.50	4.00	3.00	5.50
19.	*Heteropogon contortus* (L.) P. Beau. ex Roem. & Schult.	6.31	5.31	8.50	7.33	0.39	7.33
20.	*Hydrocotyle asiatica* L.	2.67	3.38				
21.	*Lantana camara* L.**		10.00				
22.	*Leucas lanata* Benth.		2.17	6.00	5.67	8.33	5.67
23.	*Mallotus philippensis* (Lam.) Mull. Arg.*					3.50	3.75
24.	*Murraya koenigii* (L.) Spreng.**					8.00	4.86
25.	*Myrica esculenta* Buch.-Ham.ex. D. Don*				3.50		
26.	*Myrsine africana* L.**			4.00	5.50	4.00	3.40
27.	*Oxalis corniculata* L.	3.00	2.71	4.00	3.75	6.67	4.80
28.	*Parthenium hysterophorus* L.	2.50	3.00				
29.	*Pinus roxburghii* Sarg.*	2.00	3.67	3.00	3.20	3.00	3.25
30.	*Prinsepia utilis* Royle**				4.00		
31.	*Pteris cretica* L.				4.86		

Table 4: Continue...

Sl. No.	Name of species	Mangotimor		Bagpashog		Lwasachowki	
		C	B_1	C	B_1	C	B_1
32.	*Pyrus pashia* Buch.-Ham.ex D. Don*	1.50	3.33	2.33	3.20		
33.	*Rubia cordifolia* L.			3.50	4.00		
34.	*Rubus ellipticus Sm.*	3.33		6.00	3.75	3.00	3.50
35.	*Sapium insigne* (Royle) Trimen*		1.67				
36.	*Solanum nigrum* L.	2.25		4.00	4.86		
37.	*Sonchus asper* (L.) Hill			4.00	3.40	4.00	3.33
38.	*Thalictrum foliolosum* DC.	3.33	3.60				
39.	*Thymus linearis* Benth.				4.80		
40.	*Viola serpens* Wall. ex Ging.	3.00	3.50	2.75	3.50	6.33	4.40
41.	*Zanthoxylum armatum* DC.**	2.50		5.00	3.33		

*: Natural regeneration of trees; **: natural regeneration of shrubs

Table 5: Importance Value Index (IVI) of control and burnt area in selected study sites in chirpine forests

S l . No.	Name of species	Mangotimor		Bagpashog		Lwasachowki	
		C	B_1	C	B_1	C	B_1
1.	*Adiantum lunulatum Burm.* f.	20.71	15.66	15.18	11.20	12.69	13.89
2.	*Ageratum conyzoides* (L.) L.		25.42			17.64	13.88
3.	*Ajuga integrifolia* Buch.-Ham			19.93	11.23		
4.	*Anaphalis triplinervis* C. B. Clarke	15.58	6.91	7.48	10.17	6.24	12.55
5.	*Artemisia vulgaris* Linn			7.54	7.48		
6.	*Berberis lycium* Royle**		8.09	8.51	9.19		
7.	*Carex meiogyna* Nees	38.26	14.68				
8.	*Carissa carandas* L.**	11.13	6.42			6.80	9.24
9.	*Cheilanthes farinosa* (Forssk.) Kaulf.	7.95	8.72	12.85	6.03	7.25	11.38
10.	*Chrysopogon montanus* Trin.	33.73	21.50	38.51	26.84	31.39	33.01
11.	*Cirsium wallichii* DC.	10.77	10.64	11.71	7.24	10.64	8.96
12.	*Cissampelos pareira* L.	11.60	9.47	13.90	6.73	13.16	7.46
13.	*Dicliptera bupleuroides* Nees	15.26	7.19	11.49	9.21	9.23	11.38
14.	*Ficus palmata* Forssk.*				5.18		9.73
15.	*Flacourtia indica* (Burnm.f.) Merr.*						6.41
16.	*Fragaria vesca* L.	9.47	8.21	11.57	6.49	10.43	10.75
17.	*Galium aparine* Linn.		16.18		12.39		
18.	*Geranium wallichianum* D. Don ex Sweet.		10.20	8.23	8.70	7.57	15.30
19.	*Heteropogon contortus* (L.) P. Beau. ex Roem. & Schult.	35.42	19.51	34.86	27.23	90.10	33.48
20.	*Hydrocotyle asiatica* L.	10.88	13.51				
21.	*Lantana camara* L.**		20.85				
22.	*Leucas lanata* Benth.		10.73	7.62	8.56	10.14	10.56
23.	*Mallotus philippensis* (Lam.) Mull. Arg.*					6.99	11.07
24.	*Murraya koenigii* (L.) Spreng.**					7.41	15.62
25.	*Myrica esculenta* Buch.-Ham.ex. D. Don*				4.98		

Table 5: Continue...

Sl. No.	Name of species	Mangotimor		Bagpashog		Lwasachowki	
		C	B_1	C	B_1	C	B_1
26.	*Myrsine africana* L.**			8.86	12.39	6.86	12.05
27.	*Oxalis corniculata* L.	14.00	10.17	9.09	8.95	9.11	11.01
28.	*Parthenium hysterophorus* L.	7.17	10.57				
29.	*Pinus roxburghii* Sarg.*	5.10	8.03	6.61	8.93	10.85	12.11
30.	*Prinsepia utilis* Royle**				7.24		
31.	*Pteris cretica* L.				12.65		
32.	*Pyrus pashia* Buch.-Ham.ex D. Don*	6.77	8.12	7.69	7.79		
33.	*Rubia cordifolia* L.			8.23	7.24		
34.	*Rubus ellipticus Sm.*	7.23		7.62	8.95	5.29	10.25
35.	*Sapium insigne* (Royle) Trimen*		6.14				
36.	*Solanum nigrum* L.	12.72		8.86	12.65		
37.	*Sonchus asper* (L.) Hill			9.09	9.74	6.86	9.21
38.	*Thalictrum foliolosum* DC.	7.63	8.81				
39.	*Thymus linearis* Benth.				8.91		
40.	*Viola serpens* Wall. ex Ging.	8.55	14.27	12.85	8.28	13.37	10.72
41.	*Zanthoxylum armatum* DC.**	10.08		11.71	7.44		

*: Natural regeneration of trees; **: natural regeneration of shrubs

showed highest value for density/m^2 (3.40) followed by *Heteropogon contortus* (2.30), *Leucas lanata* (0.85), *Pteris cretica* (0.85), *Solanum nigrum* (0.85), *Anaphalis triplinervis* (0.75), *Berberis lycium* seedlings (0.750 and lowest value (0.25) was observed for *Zanthoxylum armatum* seedlings (Table-2). Maximum frequency % was observed for followed by *Chrysopogon montanus* (47.50), *Heteropogon contortus* (45.00), *Adiantum lunulatum* (22.50), *Berberis lycium* seedlings (20.00) and minimum value (7.50) was observed for *Artemisia vulgaris,* and *Zanthoxylum armatum* seedlings (Table 3). Maximum abundance was observed for *Heteropogon contortus* (7.33) followed by *Chrysopogon montanus* (7.16), *Leucas lanata* (5.67), *Myrsine africana* seedlings (5.50) and minimum value (2.00) was observed for *Cissampelos pareira* (Table 4). *Heteropogon contortus* (27.23) was dominant species on the basis of IVI at B_1 followed by *Chrysopogon montanus* (26.84), *Pteris cretica* (12.65), *Myrsine africana* seedlings (12.39) and least dominant was *Myrica esculenta* seedlings (4.98) (Table 5).

3.3. Site-Lwasachowki

Total 21 species of herbs were recorded at Lwasachowki at control (C) area (Table 2). *Chrysopogon montanus* (1.88) showed highest value for density/m^2 at C followed by *Heteropogon contortus* (1.50), *Leucas lanata* (0.63), *Dicliptera bupleuroides* (0.55) and least dominant (0.08) was recorded for *Geranium wallichianum* (Table 2). Maximum frequency % was observed (385.00) for *Heteropogon contortus* followed by *Chrysopogon montanus* (37.50), *Adiantum lunulatum* (10.00), *Ageratum conyzoides* (10.00), *Cheilanthes farinosa* (7.50), *Dicliptera bupleuroides* (7.50), *Leucas lanata* (7.50), *Myrsine africana* seedlings (7.50), *Oxalis corniculata* (7.50), *Pinus roxburghii* seedlings (7.50), *Sonchus asper* (7.50), *Viola serpens* (7.50) and minimum value (2.50) was observed for *Geranium wallichianum* (Table 3). Maximum abundance was observed for *Leucas lanata* (8.33) followed by *Murraya koenigii* seedlings (8.00), *Dicliptera bupleuroides* (7.33), *Oxalis corniculata* (6.67) and minimum value (0.39) was observed for *Heteropogon contortus* (Table 4). *Heteropogon contortus* (90.10) was dominant species on the basis of IVI at C followed by *Chrysopogon montanus* (31.39), *Ageratum conyzoides* (17.64), *Viola serpens* (13.37) and least dominant (5.29) was recorded for *Rubus ellipticus* seedlings (Table 5).

Whereas total 23 species of herbs were recorded at Lwasachowki at burnt (B_1) area (Table 2). *Chrysopogon montanus* (3.40) showed highest value for density/m^2 followed by *Heteropogon contortus* (3.30), *Leucas lanata* (0.85), *Murraya koenigii* seedlings (0.85), *Cheilanthes farinosa* (0.75) and least dominant (0.25) was recorded for *Sonchus asper* (Table 2). Maximum frequency % was observed (47.50) for *Chrysopogon montanus* followed by *Heteropogon contortus* (45.00), *Adiantum lunulatum* (22.50), *Cheilanthes farinosa* (20.00) and minimum value (7.50) was observed for *Carrisa carandas* seedlings and *Sonchus asper* (Table 3). Maximum abundance was observed for *Heteropogon contortus* (7.33) followed by *Chrysopogon montanus* (7.16), *Geranium wallichianum* (5.50), *Anaphalis triplinervis* (5.00) and minimum value (2.78) were observed for *Adiantum lunulatum* (Table 4). *Heteropogon contortus* (33.48) at B_1 was dominant species on

the basis of IVI followed by *Chrysopogon montanus* (33.01), *Murraya koenigii* seedlings (15.62), *Geranium wallichianum* (15.30) and least dominant (6.41) was recorded for *Flacourtia indica* (Table 5).

3.4. Distribution pattern

The abundance to frequency ratio (A/F) for herbs was > 0.05 in C as well as B_1 in all the three sites which indicate that the distribution pattern of all the species was contiguous.

3.5. Concentration of dominance (Cd)

The value of concentration of dominance (Cd) was highest (0.12) at Lwasachowki (C) followed by 0.07 at Mangotimor (C) and lowest (0.04) at Bagpashog (B_1) (Table 6).

3.6. Diversity index (H)

The maximum value of diversity index (H) was 3.30 at Bagpashog (B_1) followed by 3.13 at Mangotimor (B_1) and minimum was 2.63 at Lwasachowki (C) (Table 6).

3.7. Species richness index (R)

The richness index (R) was highest (4.30) at Bagpashog (B_1) followed by 3.80 at Bagpashog (C) and lowest was 3.22 at Mangotimor (C) (Table 6).

3.8. Evenness index (E)

The value of eveness index (E) was maximum (0.974) at Mangotimor (B_1) followed by 0.971 at Bagpashog (B_1) and minimum (0.863) at Lwasachowki (C) (Table 6).

The total density was higher in burnt sites compared to control. The general pattern of plant distribution is contiguous in nature and has been observed by many workers (Kershaw, 1973: Singh and Yadava, 1974 and Kunhikannan et al., 1998) which means plants are adapted in chir pine forests due to frequent occurrence of forest fire. The greater value of concentration of dominance in control site (C) indicate homogenous nature of the community and vice versa (Kohli et al., 2004 and Verma, 2014). The diversity was higher in B_1 as compared to C and various research workers (Elliot et al., 1999; Royo et al., 2010 and Agra et al., 2018) have reported the variation in diversity of ground flora due to treatments of burning.

Table 6: Concentration of dominance (Cd), diversity index (H), richness index (R) and evenness index (E) of control and burnt area in selected study sites in chirpine forests

Sl. No.	Name of site	Concentration of dominance (Cd)		Diversity index (H)		Richness index (R)		Evenness index (E)	
		C	B_1	C	B_1	C	B_1	C	B_1
1.	Mangotimor	0.07	0.05	2.86	3.13	3.22	3.52	0.940	0.974
2.	Bagpashog	0.06	0.04	3.03	3.30	3.80	4.30	0.953	0.971
3.	Lwasachowki	0.12	0.05	2.63	3.04	3.34	3.36	0.863	0.968

4. Conclusion

The density and diversity of herbs including regeneration of trees and shrubs were higher in burnt sites as compared to control. There is a need of conducting research to study long term impact of controlled burning on vegetation in chirpine forests.

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