Effect of Prescribed Fire on Some Driving & Abiotic Variables of Protected and Grazing Sites at Pauri, Garhwal Himalaya

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Abstract: This study deals with the effect of prescribed fire on some driving and abiotic variables of protected and grazing sites at Pauri. Ransi-Nagdev areas were selected for the present investigation in which two were burned (protected and grazed) and the other two sites were unburned (protected and grazed). In this study data for rainfall, atmospheric temperature and relative humidity were considered as driving variables, whereas abiotic state variables are being represented by soil reaction, soil physical and chemical properties. Maximum rainfall (229.0 mm) was recorded in August 2006 and minimum (18.0mm) in December 2006 and January 2007. The mean maximum temperature ranged between 7.2 (January 2007) and 22.5 °C (June 2006). The relative humidity at 0800 hrs was maximum (82.0%) in September, 2006 and minimum (46.5%)in November, 2007, however, at 1630 hrs. it was maximum (78.5%) in September, 2006 and minimum (39.5%) in November, 2006. Across the sites, the mean soil temperature was highest on MBG(burned grazed) and lowest in MUP(unburned protected) during the year. The soil moisture percentage was higher during rainy season in MBP(burned protected) (27.50) and lower values were recorded during summer season in MBP (17.0). Total nitrogen was maximum (188.50 gm^{-2})) during summer season on MBG and minimum (133.15 gm^{-2})) in rainy season on MUG(unburned grazed). The maximum value of exchangeable phosphorus(151.15 kg ha^{-})) in rainy season on MBP and Minimum (41.50 kg ha^{-})) during winter season on MUP. Exchangeable potassium was maximum (268.50 kg ha^{-})) in winter on MUG and minimum (135.0 kg ha^{-})) during summer on MUG.

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Key Words: Garhwal Himalaya, driving and abiotic variables, grazed and protected sites, prescribed fire.

1. Introduction

This study deals with the effect of prescribed fire on driving and abiotic state variables of protected and grazing sites at Pauri. The effect of fire on the nutrients of an ecosystem depend on the nutrients of an ecosystem depend on the type and frequency of fire, the fuel load, time and season of burn, nature of plant tissue burnt, topography, successional status of the community and post fire climatic and biotic conditions acting thereupon (Semwal & Mehta 1996, Wright 1974). Tiwari et al., (1985-86, 1989) studied the physico-chemical properties of soil under different forests and grazinglands of Garhwal Himalaya in relation to fire. Semwal (1990), Mehta(1990) and Bhandari (1995) have analyzed the effects of fire on different physical and chemical properties of soils on montane and submontane forest and grazinglands of Pauri and Srinagar (Garhwal) Himalaya. Paliwal and Sundaravalli (2002) studied the effect of fire on the nutrient dynamics of a grazing land in the semi-arid region of Madurai.

In the present study efforts have been made to explain the effects of wild fire on soils of grazingland in terms of colour, texture, water holding capacity, pH, organic carbon, phosphorous, potassium and total nitrogen from different depths.

2. Material and Methods

Geographically, the Garhwal Himalaya is situated between 29°26'-31°28' N Lat. and 77°49'-80°6' E Long. Having an area of 30,000 squre km. the river Tons separates Garhwal from Himachal Pradesh in the west and the district boundaries of Nainital, Almora and Pithoragarh from the Kumaun in the East. Starting from the foothills of Shivaliks in the South, the region extends upto eternal snows forming the Indo-Tibetan border in the North. Politically, the region incorporates the six hill districts of Uttarakhand viz., Pauri, Tehri, Dehradun, Chamoli, Rudraprayag and Uttarkashi.

The sites selected for the present study are located at 30°9' N Lat., and 78°46' E Long., covering an elevation between 1800 and 2,000 msl., on the flank in which Pauri city is located. The grazingland vegetation occurs in patches on the slopes of the flank constituting the ridges and saddles at different elevation. Of the four sites characterized by ridges and saddles were selected in Ransi-Nagdev area, two were burned (the burned protected and burned grazed sites) and the other two were unburned (unburned protected and unburned grazed sites). The burning was done by forest officials under the prescribed Fire Programme in 2006.

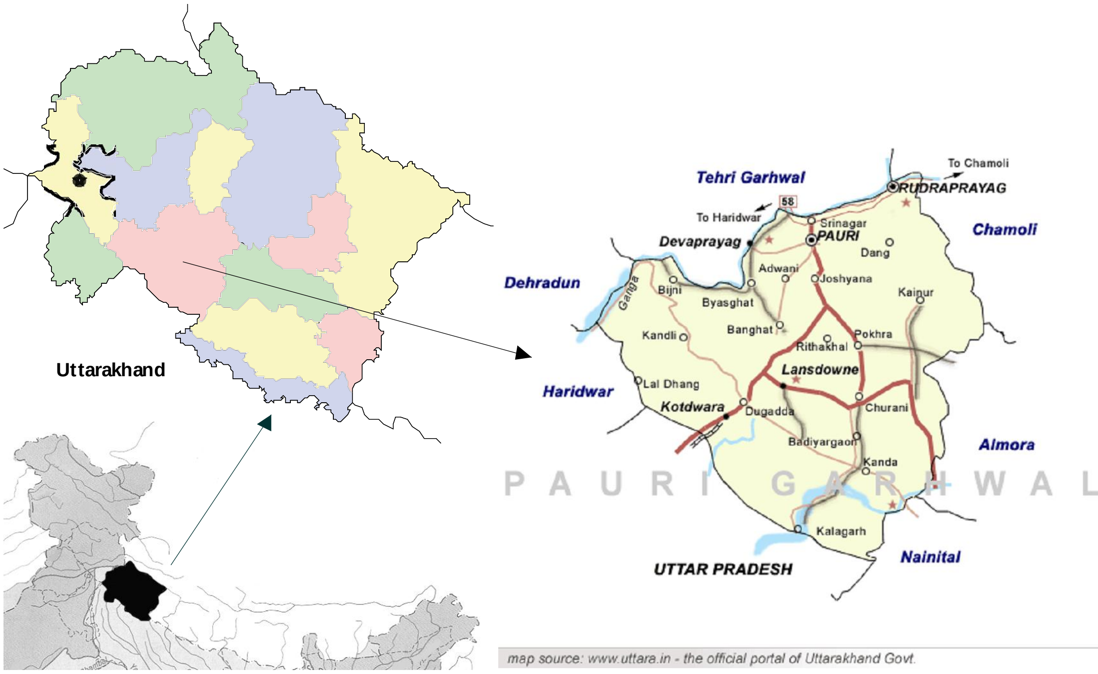

Figure 1.1 Location map of study area

There are two categories of microclimatic factors viz., driving variables and abiotic state variables, which affect mostly the ecology of any region. Data for rainfall, atmospheric temperature and relative humidity were taken from Pauri Garhwal during the study period following Smith (1977) and Tiwari and Gupta (1982). Soil temperature at 15cm. depth was observed on each sampling date for each site. Composite soil sample were taken and analyzed for water holding capacity, pH, organic carbon, exchangeable phosphorus, exchangeable potassium and total nitrogen. The soil colour was directly read off from Munsell's soil colour chart. Texture was assessed following Misra (1968). WHC of the soil was determined following the methods discussed by Misra (1968).

Soil pH was determined by Misra (1968). Organic carbon in soil samples was determined as per the methods described by Piper (1944). The exchangeable phosphorus and exchangeable Potassium were determined following Jackson (1962 and 1967), respectively. Total nitrogen was determined by colorimetric technique (Jackson, 1962).

3. Results

Driving variables: It is apparent that maximum rainfall at Pauri (229.0 mm) was registered in August, 2006 and minimum (18.0 mm) in December, 2006 and January, 2007 with total of 957.3 mm. the mean maximum temperature ranged between 72 (January, 2007) and 22.5 c (June, 1995) Table,(1.1), (Fig 1.2). The relative humidity at 0800 hr. was 82.0% in September, 2006 and 39.5% in November, 2006.

The pluviothermic diagram (Fig, 1.3) show seven wet (May-September, 2006 and February-March, 2007) and five dry months (October-December and April-May, 2007). The dry period can be divided into cool dry months (October-February) with light winter showers and snow fall and warm dry months (March-June) with occasional rain and light thunder storms.

Abiotic State Variables: Abiotic state variables include soil reaction (soil pH), soil physical and chemical characteristics.

Soil Physical Characteristics: Across the grazing lands studied, the mean soil temperature was highest on MBG followed by MBP, MUG and MUP (Table 1.2).

The soil colour ranged from dark brown (HUE 7.5 YR 3/2) to grayish brown (HUE 10 YR 5/2) in all the study sites (table 1.3). Soil moisture showed great variability in burned and unburned sites. Table 1.4 indicates that higher percentage of moisture in soil was observed during rainy season and lower value was recorded during summer on all the sites, except MBG where it was observed in winter season.

The soil moisture (%) were higher during rainy season amounting to 27.50 (MBP) followed by 27.0 (MBG), 21.50 (MUP) and 17.75 % (MUG). The minimum value were recorded 17.0 (MBP), 12.25 (MBG), 17.50 (MUP) and 11.50% (MUG). Water holding capacity was maximum on MBP (78.50%) followed by MUP (77.50%), MBG (72.40%) and MUG (69.50 %) during summer and minimum on MUG (30.50%) followed by MBG (36.0%), MBP (38.50%) and MUP (40.50%) during rainy season (Table 1.4). Soil texture has great influence over soil moisture, temperature and water holding capacity. On all the sites the soil was sand predominating (table 1.5).

Soil reaction: It is evidenced from table 1.6 that maximum pH value was recorded in the burned sites. It varied between 6.10-6.50 (MBP), 6.0-6.40 (MBG), 6.0-6.35 (MUP) and 5.75-6.25 (MUG).

Soil chemical characteristics: The organic carbon varied between 2.15 (rainy) and 2.70% (summer) on MBP, 2.25 (rainy and winter) and 2.50% (summer) on MBP, 2.25 (rainy and winter) and 2.50% (summer) on MBG, 2.12 (rainy) and 2.47% (summer) on MUP and 2.0 rainy and 2.25% (summer) on MUG site (Table 1.6).

Total nitrogen varied between 150.50 (rainy) and 159.10 gm^{-2} (winter) on MBP, 165.40 (rainy) and 188.50 gm^{-2} (summer) on MBG, 135.50 (rainy) and 152.0 gm^{-2} (winter) on MUP and 133.15 (rainy) and 172.50 gm^{-2} (summer) on MUG.

The minimum and maximum values of exchangeable phosphorus were 70.50 and 151.15 (MBP), 64.0 and 101.50 (MBG), 41.50 and 82.0 (MUP) and 88.50 and 105 kg ha^{-} (MUG). In general the amount of phosphorus was more on burned sites (table 1.6). The maximum value of exchangeable Potassium were recorded in winter season for all the sites, and minimum were in summer season on all the sites except MUP where its minimal was observed in rainy season. It is evident from Table 1.6, that the minimum and maximum contents of Potassium were 117.0 and 223.0, 147.35 and 190.0, 139.50 and 251.50, 135.0 and 268.50 kg ha^{-}, respectively, on MBP, MBG, MUP and MUG sites.

4. Discussion

Fires bring marked changes in physical, chemical and biological characters of soil. The degree of change depends upon the type, intensity and duration of fire and topographic features. In this study there was no marked difference in the soil colour and soil moisture burned and unburned sites respectively.

It is evident from (Table 1.4), that there was no significant difference in the water holding capacity of soils between burned and unburned and between grazed and protected sites. Identical results were also reported by Blaisdell (1953). Nevertheless, in this study, water holding capacity of soil was highest on MBP followed by MUP, MBG and MUG sites. The soil of all the sites was acidic (Table 1.6). Generally, the burned soils were higher in pH than those of unburned ones, although there was no significant difference between burned and unburned and between grazed and protected sites. Nevertheless, the pH of soil was higher on MBP followed by MBG, MUP and MUG sites, also reported the same finding by Semwal (1990) and Naidu and Srivasuki (1994). The increase in pH of the, burned soils might be partially due to destruction of some organic acids in the soils and partially due to release of some bases.

These results are in agreement with the views of Misra et.al., (1968), Saxena and Singh (1980), Banerjee and Chand (1981) and Naidu and Srivasuki (1994). Singh and Ramakrishnan (1982) have also reported the acidic nature of soils under different forest stands. The organic matter and nutrients are of basic importance in the study of soils as they are responsible for the various physical and chemical properties of soil and ultimately influence the vegetation. Severe burns such as those caused by wild fire can results in nearly complete destruction of organic matter and change the physico-chemical and biological properties of soil (Neal et.al., 1985). A glance over table 1.6 indicates that the organic carbon (%) was higher on burned sites than on unburned sites. Increase in the organic carbon in soil after burn in submontane Garhwal Himalayan grassland was also reported by Agarwal (1985).

Ramakrishnan and Tokey (1981) also reported higher on burned sites than on unburned sites. On the grazed sites, soil nitrogen was higher than on the protected sites. Higher soil nitrogen on the grazed sites, might be due to the availability of the decomposing dung (Mac Diarmid and Witkin 1972).

Exchangeable soil phosphorus (gm $^{-2}$) was highest on MBP followed by MUG, MBG and MUP. Ramakrishnan and Tokey (1981) also reported slight increase in exchangeable phosphorus under slash and burn. Potassium content was higher on unburned sites as compared to burned sites. Though, this was no significant change in the availability of potassium in present study. Numerous studies in different ecosystems have documented increases in exchangeable Potassium in post fire soil (Ahlgren and Ahlgren, 1977 and Ramakrishnan and Tokey 1981). Studies on chaparral soil have also reported range initial increases in Potassium following fire (Christension 1977).

In the present investigation, it was observed that there was no significant difference in abiotic state variables between burned and unburned grazed and protected sites, might be due to old burned stands (the burned protected and burned grazed sites experienced the wild or prescribed fire 9-10 years before), and if seems to be that the effects of fire on soils are decreasing.

Table 1.1 Climatic data of Pauri from May, 2006 to May, 2007

Month	Mean Atmospheric temperature (°C)		Relative humidity (%)		Total rainfall (mm)
	Minimum	Maximum	At 0800 hrs	At 1630 hrs	
May, 2006	21.5	30.5	61.0	57.5	105.5
June	22.5	33.3	59.5	54.3	74.0
July	22.2	32.5	81.3	74.5	215.5
August	20.5	31.4	79.5	74.0	229.0
September	15.7	30.5	82.0	78.5	82.0
October	15.3	23.5	62.5	54.0	30.5
November	10.5	22.6	46.5	39.5	-
December	7.5	16.5	54.5	49.5	18.0
January, 2007	7.2	15.5	50.0	49.8	18.0
February	9.5	19.5	45.5	45.3	66.5
March	12.5	21.4	54.5	47.0	64.8
April	17.5	23.7	49.5	38.5	28.5
May	21.0	30.0	61.5	57.0	25.0

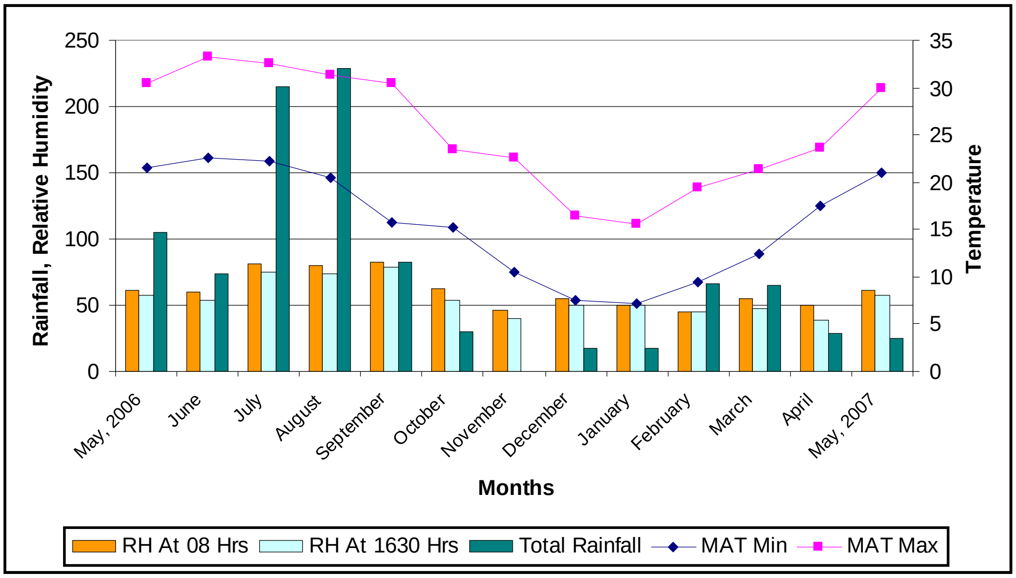

Figure 1.2 Rainfall, relative humidity and temperature during the year at Pauri District
RH- Relative humidity, MAT- mean atmospheric temperature

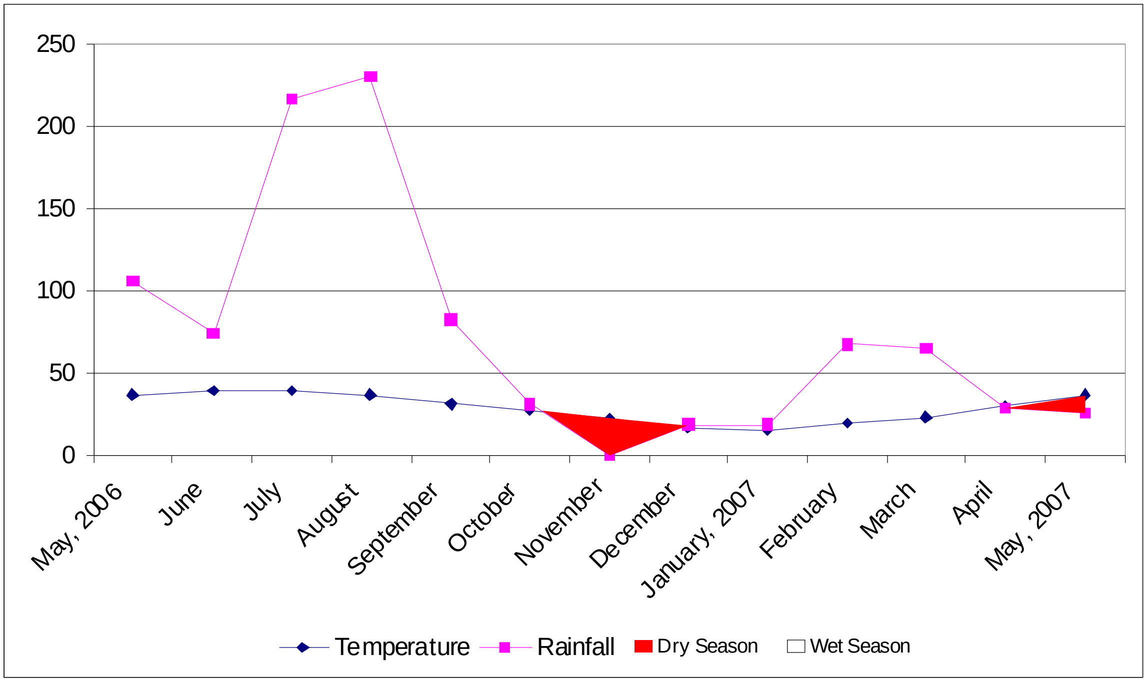

Figure 1.3 Pluviothermic diagram of temperature and rainfall, during the year at Pauri District

Table 1.2 Seasonal variations in soil temperature (°C) on different sites

Season	Sites			
	MBP	MBG	MUP	MUG
Rainy	12.50±1.75	14.0±1.0	11.25±1.30	12.25±1.75
Winter	10.50±1.50	13.10±1.10	10.50±1.0	11.0±1.50
Summer	14.75±1.25	15.50±2.0	14.10±1.50	14.50±2.0

Table 1.3 soil colour (general), at different depths of montane grazinglands

Land Scape Type	Depth	Colour (Hue/value/chroma)
Montane grazinglands	0-10 cm	Dark brown 7.5 YR 3/2
	10-20 cm	Grayish brown 10 YR 5/2
	20-30 cm	Brown 7.5 YR 4/4

Table 1.4 Seasonal variation in soil moisture (%) and water holding capacity (%) on different sites.

Season	Sites			
	MBP	MBG	MUP	MUG
Soil moisture (%)				
Rainy	27.50±4.50	27.0±5.0	21.50±4.0	17.75±4.25
Winter	15.25±5.50	9.50±4.5	18.25±3.50	13.25±2.0
Summer	13.0±3.50	12.25±3.75	17.50±3.75	11.50±3.50
Water holding capacity (%)				
Rainy	38.50±1.65	36.0±2.50	40.50±1.50	30.5±3.0
Winter	52.0±1.50	46.50±3.50	42.0±2.0	47.0±3.50
Summer	78.50±3.50	72.40±4.0	77.50±4.50	69.50±5.50

Table 1.5 Percentage of different soil separates in soil on study sites.

Site	Soil separate (%)		
	Sand	Silt	Clay
MBP	39	28	33
MBG	42	20	38
MUP	37	30	33
MUG	43	29	28

Table 1.6 Chemical characteristics of the soils on different sites in different season.

Components	Sites			
	MBP	MBG	MUP	MUG
pH				
Rainy	6.50±0.15	6.40±0.10	6.25±0.15	6.10±0.20
Winter	6.25±0.05	6.00±0.10	6.35±0.35	6.25±0.15
Summer	6.10±0.10	6.25±0.20	6.00±0.15	5.75±0.10
Organic carbon (%)				
Rainy	2.15±0.75	2.25±0.50	2.12±0.35	2.0±0.35
Winter	2.30±0.15	2.25±0.45	2.29±0.40	2.15±0.15
Summer	2.70±0.50	2.50±0.35	2.47±0.35	2.25±0.40
Total Nitrogen (gm^{-2})				
Rainy	150.50±25.50	165.40±32.0	135.50±25.0	133.15±25.0
Winter	159.10±35.0	167.0±2.50	152.0±27.0	154.50±35.0
Summer	157.0-±0.50	188.50±30.0	146.50±25.0	172.50±30.50
Exchangeable Phosphorus (kg ha^{-})				
Rainy	151.15±39.0	101.50±27.0	82.0±19.0	89.50±17.50
Winter	67.30±25.50	81.50±19.50	41.50±15.50	88.50±20.0
Summer	70.50±23.0	64.0±16.50	60.50±14.0	105.0±25.0
Exchangeable Potassium (kg ha^{-})				
Rainy	191.50±30.50	163.0±35.0	139.50±37.0	182.0±35.0
Winter	223.0±35.80	190.0±30.50	251.50±35.50	268.50±41.0
Summer	117.0±20.0	147.35±30.50	205.0±40.0	135.0±25.0

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