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RESEARCH PAPER

Short-term effect of prescribed fire on Pine and Oak dominated forest ecosystems of Pauri Garhwal, India

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ABSTRACT

An experimental prescribed burning treatment was conducted to analyze the effects on woody vegetation of four forests at Pauri Garhwal. The experiment was designed to compare two burnt (Mandakhal and Adwani forest) and two unburnt (Dandapani and Nagdev forest) of 1 hectare for various attributes of community structure. The density values for different strata were trees (610-1100 trees/ha), saplings (920-2260 sap/ha), seedlings (1900-2440 seedl/ha) and shrubs (5320-10240 shrubs/ha). Distribution pattern was contiguous among *Pinus roxburghii* dominated forest and random distribution was prevalent among *Quercus leucotrichophora* forests. Shannon-Wiener diversity index (H′) was highest for shrubs (3.15) while as Cd was maximum (0.42) for tree strata. The Margalef Index (MI) range from 0.86 to 4.05 and Menhinick's index (MEI) ranges from 0.48 to 1.41.

KEYWORDS: Forest ecosystem, fire, prescribed burn, community structure, woody vegetation
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Introduction

Forest fires are a significant concern in Indian forests especially in chir pine dominated and associated ones. The fire has played an imperative part in framing the distribution and arrangement of biomes worldwide (Keeley *et al.* 2011). Fire is an attribute that incredibly impacts the community and structure of forests (Bond et al. 2005; Lafon *et al.* 2005); acts as a natural thinning agent by decreasing litter build up (Cram *et al.* 2017). The correlation among fire and Pine ecosystem in the vegetation of Central Himalaya is one of the most distinguished examples of ecosystem dependency on disturbance mostly in Oak ecosystems. Uttrakhand is experiencing a transformation from Oak broad-leaved forests into evergreen Chir forests. Fire encouraged fire-tolerant tree species and discouraged fire-sensitive species as reported by (Ivanauskas *et al.* 2003). Currently, fires are suppressed in many forests owing to the effect of a shift of species composition, especially the current failure of Oaks (*Quercus* spp.) regeneration (Brose *et al.* 2013). While on the other hand, Pine is fire adaptive as well as it has become so much tolerant to fire that its regenerates quickly after fire. Literature review suggests that open canopy forests are more inclined to fire than closed forests as the floor in open forests is drier than closed forests due to a greater extent of sunlight infiltration (Stolle *et al.* 2003). Competition and natural disturbance have conventionally been described acting in antagonism to one another with regard to their effects on species coexistence (Platt and Cornnell, 2003). The unrestrained fires have increased worldwide negative impacts and problems thereafter. Uttarakhand has witnessed one of the worst forest fires in the recent times and the majority of fire incidents are reported from the pine forests (Sati and Juyal, 2016). Spatial and temporal deviation in severity within a fire can enclose long-term impacts on the structure and species composition of post-fire communities and the potential for future disturbances (Ryan, 2002). Vegetation and fire are interrelated so that a change in any of two variables can affect the other (Ruiliang *et al.* 2007). This intricacy is driven by heterogeneity in vegetation and fuel, topography, and local weather for individual fires and by variability in the timing, impacts and extents of multiple fires (Collins and Stephens, 2010). A forest fire is influenced by climatic conditions and is bolstered by aggregation of flammable fuel on the forest floor (Sharma and Rikhari, 1997). A potential impediment to evade huge range smash up is to employ prescribed fire. The relationship flanked by fire severity and plant community response is relevant not only in wildfire settings but also for assessing management performances as in prescribed burning (Miller and Urban, 2000). The literature alludes to the impact of fire exists to some extent, however, the fire is still growing in size and frequency of a number of recent incidents across the Uttrakhand is greater than ever. Thus, fire is one of the critical ecological plights in this region and the objectives of this paper undertaken are to amalgamate the quantitative impacts of a prescribed fire on aboveground woody vegetation on burnt protected sites and on control site as the unburnt protected site.

Materials and Methods

Study area

Uttrakhand Himalaya, a part of Indian Himalaya Region (IHR) is tranquil of two divisions called Garhwal and Kumaon Himalaya. The study was assessed out in the natural forest of Pauri district of Garhwal Himalaya. Four plots of 1 ha. were demarked in Pauri of which two were burnt and other two were unburnt viz., a) Mandakhal burnt site (MBS) b) Adwani burnt site (ABS) c) Dandapani unburnt site (DUS) and d) Nagdev unburnt site (NUS). MBS and DUS were chir dominated while as ABS and NUS were oak dominated. The study sites are shown in Fig. 1 and characteristic features are summarized in Table 1. The study was carried prior to 4 months after prescribed treatment applied by forest officials. Four permanent plots of each 1 ha were marked in different forests. The area enjoys sub-tropical to a temperate climate with cool winter and pleasant summer. Temperature ranges from -2^{0}C in January and 24-36^{0}C in July.

Methods

Data Collection

Prescribed fire treatment was carried out around winter season and commented upon the distance of 3km and emphasizes on allowing and preventing fire was maintained by branches of *Myrica esculenta*. The unburnt sites to remain free from the fire were protected from invading nearby fires. The phytosociological analysis was carried out in each of the (burnt and unburnt) sites. Data was collected by consigned 10 quadrats (sized 10×10 m) in the stratified random manner in each site for trees. Within each tree quadrat, 2 quadrats of size 5×5 m were nested for saplings, seedlings and shrubs (Misra, 1968). The circumference was measured to distinguish between the mature tree (>31.5 cm cbh), saplings (C=10.5-31.4 cm) and seedling (C < 10.5 cm).

Data analysis

The vegetational data were quantitatively analysed for frequency, density and abundance (Curtis and McIntosh, 1950). The abundance to frequency (A/F) was used to interpret the distribution pattern of the species, a ratio less than 0.025 indicates regular distribution, random distribution if it falls between 0.025-0.05, and contiguous distribution if the value is greater than 0.05 (Curtis and Cottom, 1956). Total basal cover (TBC) of all species was calculated to reflect the area occupied by the particular species. In the present study, several indices were used and were calculated separately for each stratum (tree, sapling, seedling and shrub).

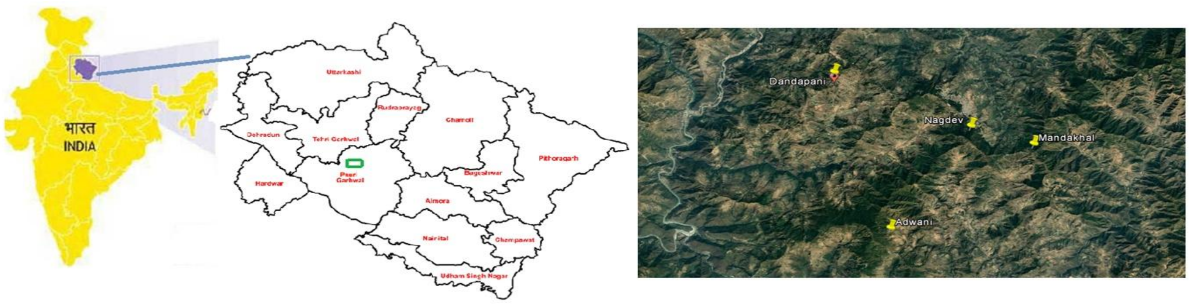

Figure 1. Map showing study sites.

Table 1. General characteristics of study sites.

Study Sites	Elevation (m asl)	Coordination	Common tree species
MBS	1720-1875	30° 7'18.81"N & 78°49'36.18"E	*Pinus roxburghii, Myrica esculenta*
ABS	1895-1985	30° 4'22.59"N & 78°43'0.18"E	*Quercus leucotrichophora, Myrica esculenta, Rhododendron arboreum*
DUS	1700-1800	30°10'7.71"N & 78°41'27.99"E	*Pinus roxburghii, Cupressus torulosa,*
NUS	1914-2100	30° 7'59.52"N & 78°46'42.24"E	*Quercus leucotrichophora, Myrica esculenta*

The diversity was determined using the Shannon Wiener information index (Shannon and Wiener, 1963),

$$H' = \sum_{i=1}^{s} (ni/n) \log_2 (ni/n),$$

where ni is the density of a species and n is the sum of the total density of all species in that forest type.

The Simpson's concentration of dominance (Simpson, 1949), was measured as

$$Cd = \sum Pi^2,$$

where ∑Pi= ∑ni/n and Simpson's diversity index (Simpson, 1949) was calculated as D=1-Cd, where D is Simpson's diversity and Cd is Simpson's concentration of dominance. Species richness was calculated following (Margalef, 1958),

$$MI = S-1 / \ln (N),$$

where S = total number of species, N =total number of individuals and Menhinick's index (1964),

$$MEI = S/\sqrt{N},$$

where, S= Number of species and N= number of individuals in the sample. The most abundant species numerical importance index was calculated by Berger-Parker (1970)

Dominance Index, d= d=Nmax/N,

where, Nmax= number of individuals of the most abundant species, N= total number of individuals in the site. The degree of relative dominance of species was calculated by equitability of evenness by Pileous (1966),

$$(Ep) = H'/\log S,$$

where, H'= Shannon index, S = number of species.

Statistical analysis
The Carl Pearson correlation coefficient was calculated to identify the relationship of different phytosociology parameters between four sites.

Results

Floristic composition
Although it is prevalent that canopy is open in Pine dominated forest ecosystem yet covered canopy is common in Oak dominated ecosystem. The studied forests MBS and DUS are dominated by coniferous evergreen open canopy Pine dominated forests and ABS and NUS are dominated by broadleaved evergreen forests. A total of 5 tree species belonging to 5 genera and 5 families and a total of 25 species of shrubs belonging to 23 genera and 15 families were present on MBS. On ABS 6 trees species were identified belonging to 6 genera and 6 families and consists a total of 26 shrubs belonging to 23 genera and 14 families. On DUS 5 tree species belonging to 5 genera and 4 families and a total of 23 shrubs belonging to 20 genera and 13 families were estimated. On NUS a total of 7 tree species belonging to 5 genera and 5 families and a total of 22 shrubs belonging to 21 genera and 14 families were recorded. Among both burnt sites and unburnt sites 5-7 tree and sapling species, 5-6 seedling species and 22-26 shrub species were estimated. Species richness of trees and shrubs reported in the present study are more or less to comparable to the result reported (14 trees and 17 shrubs) from Western Himalaya India (Dar and Sundarapandian, 2016) and also comparable with the richness reported (3-7 trees) from temperate forests (Baduni and Sharma, 1997).

Vegetational analysis
The four investigated forest strands showed differences in different attributes like frequency, density and TBC. The vegetational analysis conceded out in MBS bear out the dominance of *Pinus roxburghii* in all tree, sapling and seedling layer with an absolute density of (350 trees/ha) and TBC (10.82 m^2/ha) among tree layer. The associated species were *Myrica esculenta* (110 trees/ha) and *Quercus leucotrichophora* (90 trees/ha) with the least density showed by *Lyonia ovalifolia* (40 trees/ha) with TBC (0.18 m^2/ha) and *Dabregeasia salicifolia* (20 trees/ha) with TBC (0.31 m^2/ha). The lesser number of saplings and seedling were found of *Myrica esculenta* and *Engelhardia spicata* (80 Sps./ha). Among the shrub layer *Eupatorium adenophorum* (980 shrubs/ha) was the most dominant followed *Berberis asiatica* (800 shrubs/ha) and TBC was also higher of the *Berberis asiatica* (0.29 m^2/ha).

While the vegetational analysis carried out on ABS showed the primacy of *Quercus leucotrichophora* in all the three strata bearing density of (490 trees/ha) in tree strata amid TBC (6.01 m^2/ha). The allied species were *Pinus roxburghii* (210 trees/ha), *Myrica esculenta* (190 trees/ha) and *Rhododendron arboretum* (130 trees/ha), with less density in all three layers exhibited by *Ficus racemosa* (50 trees/ha) and *Prunus cerosoides* (30 trees/ha). Amongst the shrub layer *Eupatorium adenophorum* (1000 shrubs/ha) was dominant amongst the shrub layer on this site also, although TBC (0.29 m^2/ha) was maximum in case of *Himalrandria tetrasperma*.

The same attributes like frequency, density and TBC were also carried on unburnt sites and it was depicted on DUS *Pinus roxburghii* showed maximum dominance in all three strata bearing density (430 trees/ha) and TBC (21.07 m^2/ha) in tree strata. The co-associated species were *Cupressus torulosa* (100 trees/ha) and *Myrica esculenta* (90 trees/ha) while *Cupressus torulosa* shows the minimum density in seedling layer (120 seedl/ha). *Cedrus deodara* and *Quercus serrata* were found with the equivalent density (40 trees/ha). Besides the tree strata, *Himalrandria tetrasperma* was prevalent among shrub layer with density (780 shrubs/ha) and TBC (0.33 m^2/ha).

Whereas on NUS unburnt site depicted domination of *Quercus leucotrichophora* in all layers with an elevated density (450 trees/ha) and TBC (10.28 m^2/ha) in particular tree layer. The co-dominant species were *Rhododendron arboreum* (190 trees/ha) and *Myrica esculenta* (180 trees/ha) with TBC (4.26 m^2/ha) and (281 m^2/ha), respectively. *Prunus cerosoides* showed the minimum density in both tree layer (40 trees/ha) and sapling layer (80 sap/ha). In seedling layer, *Pinus wallichiana* exhibited minimum density (180 seedl/ha). *Eupatorium adenophorum* was the dominant shrub with an absolute density of (780 shrubs/ha). On the basis of TBC, *Himalrandria tetrasperma* showed the maximum value (0.18 m^2/ha). The chief associates were *Myrsine africana* and *Desmodium multiflorum*.

The above-discussed parameters are illustrated species-wise in Table (2-5). The two burnt forests studied MBS and ABS discussed earlier showed the dominance of *Pinus roxburghii* and *Quercus leucotrichophora*. MBS density in case of trees ranges from 20 trees/ha to 350 trees/ha and on ABS ranged between 30 trees/ha to 490 trees/ha. In ideal conditions, the associated species cannot-out compete Pine due to its broad ecological amplitude and specialised niche in subtropical zone (Ahmad *et al.* 2010). A noteworthy fact about ABS was that *Quercus leucotrichophora* in all the three layers was following the dominance of *Pinus roxburghii*. The effect of fire was quite evident as forest fire is endorsing towards chir-pine dominance in oak-dominated forests. This ever-increasing phenomenon has become common and oak forests are being invaded by pine (Saxena and Singh, 1984). Two unburnt forests studies DUS and NUS also shows the dominance of *Pinus roxburghii* and *Quercus leucotrichophora* but does not show any definite trend as a co-dominant species trend as in burnt forests. In case of DUS the tree density ranges from 40-430 trees/ha and on NUS ranged between 30-450 trees/ha. The co associates dominants include *Cupressus torulosa*, *Myrica esculenta*, *Rhododendron arboreum* and *Quercus esculenta* instead of *Pinus roxburghii*. The ranges of the density of tree stratum recorded earlier from Western Himalaya via researchers 430 to 1300 Ind/ha (Saxena and Singh, 1982), 707 to 963 Ind/ha (Bharali *et al.* 2011), 652 to 1028 m^2/ha (Kumar *et al.* 2009). Conversely in the present investigation ranges for density was comparatively low and may be because of declining rate of forests and discontinuous revival and restoration of existing species. But our density was comparable to the results (370 plants/ha) from temperate forests of Garhwal Himalaya (Kumar *et al.* 2010). The present study shows the comprehensible distinction that an unburnt plot does not promote the growth of *Pinus roxburghii* and TBC was higher at the unburnt site because of the reason fire does not affect the growth of species at this particular site. The values of TBC consolidated in the present study were more or less comparable to the results reported by (Kusumlata and Bisht, 1991., Malik and Bhatt, 2016) from the Western Himalaya.

Distribution Pattern

Contiguous distributions were common in chir pine forests. On MBS tree layer was contiguous (60%) and equally random and regular (20%). In addition, to the tree layer, sapling and seedling showed the maximum Contiguous distribution and random distribution. Sapling layer shows contagious (83%) and random (20%) and seedling layer shows contiguous (83.3%) and random (16.6%) distributions. Shrub layer also showed the prevalence of contiguous (68%), random (28%) and regular (4%). On DUS the tree and sapling layer were contiguously (80%) and randomly (20%) distributed. Seedling was also contagiously (60%) and uniformly randomly as well as regularly (20%) distributed. In case of shrubs contiguous (69.4%) and random (30.4%) distribution were common. In conversely random distribution was maximum among oak-dominated forests. Random distribution (66.6%) was dominant on ABS among tree layer followed by equivalently contiguous and regular (16.6%). Sapling and seedlings were randomly (66.6%, 57.14%) and contiguously distributed (33.3%, 42.8) alike shrubs were also randomly distributed (65.3%) followed by regular distribution (34.6%) on ABS. On NUS all the three distribution ratios were equal among tree layer (33.3%). While as sapling, seedling and shrubs showed random and contiguous distribution. Sapling showed random (57.1%) and contiguous (42.8%) and seedling showed evenly both random and contiguous distribution (50%). Shrubs showed the prominent random distribution

Table 2. Phytosociological attributes of Burnt sites (MBS and ABS) (Frequency%, Plant density, TBC and A/F ratio).

Species	MBS				ABS			
Trees	F (%)	D (trees/ha)	TBC (m^2/ha)	A/F	F (%)	D (trees/ha)	TBC (m^2/ha)	A/F
Dabregeasia salicifolia	10	20	0.32	0.2				
Ficus racemosa	20	40	0.19	0.1	30	50	0.58	0.056
Lyonia ovalifolia	40	110	0.55	0.069				
Myrica esculenta	100	350	10.82	0.035	80	190	2.56	0.030
Pinus roxburghii	70	90	1.79	0.018	110	210	2.92	0.017
Prunus cerosoides					20	30	0.41	0.075
Quercus leucotrichophora					100	490	6.02	0.049
Rhododendron arboreum					70	130	2.02	0.027
Total	**240**	**610**	**13.67**		**410**	**1100**	**14.51**	
Saplings (sap/ha)								
Celtis australis	15	100	0.12	0.111				
Ficus racemosa					10	140	0.27	0.35
Lyonia ovalifolia	10	120	0.18	0.3				
Myrica esculenta	15	80	0.14	0.089	40	380	1.03	0.059
Pinus roxburghii	45	480	0.51	0.059	65	500	1.10	0.030
Prunus cerosoides					10	80	0.18	0.2
Quercus leucotrichophora	15	140	0.26	0.156	85	780	1.72	0.027
Rhododendron arboreum					55	380	0.72	0.031
Total	**100**	**920**	**1.22**		**265**	**2260**	**5.01**	
Seedlings (seedl/ha)								
Celtis australis	15	140	0.001	0.156				
Engelhardia spicata	10	80	0.002	0.2				
Ficus racemosa	15	180	0.001	0.2	15	120	0.01	0.133
Myrica esculenta	25	280	0.001	0.112	35	380	0.06	0.078
Pinus roxburghii	75	980	0.02	0.044	55	580	0.11	0.048
Prunus cerosoides					10	60	0.02	0.150
Quercus leucotrichophora	30	240	0.0003	0.067	80	720	0.117	0.028
Rhododendron arboreum					45	380	0.04	0.047
Total	**170**	**1900**	**0.027**		**240**	**2240**	**0.351**	

(90.9%) and contiguous distribution (9%). Our results showed a shift in distribution pattern as evident from the results reported by (Sagar *et al.* 2003; Sapkota *et al.* 2009). Mostly contiguous distribution was reported from Western Himalaya (Kumar and Bhatt, 2006; Gairola *et al.* 2011a; Singh *et al.* 2016; Dar and Sundarapandian, 2016). The dispersion pattern clumped to random in our study supporting partisan the hypothesis is that existence of a random pattern is usually a result of the change from an initially clumped pattern caused by self-thinning or some other disturbance (Rozas and Fernandez, 2000). All the indices are represented in Table 6.

Shannon-Wiener Diversity Index (H′), Concentration of Dominance (Cd) and Simpson Diversity Index (D)

The H′ is the most commonly used diversity index in case of ecology. It varied among four sites MBS, ABS, DUS and NUS along four strata's trees (1.17 to 1.47), saplings (1.35 to 1.73), seedlings (1.43 to 1.66) and shrubs (2.92-3.15). The H′ was high for shrubs on all the sites and maximum value corresponds on ABS (3.15) and is somehow equivalent with the findings of diversity index (3.42) for shrubs by (Pala *et al.* 2016) but Cd value was minimum on ABS (0.05) among all sites followed by sapling on NUS (1.73), while as Cd was maximum for tree strata (0.42) on DUS. Present results revealed that Cd generally shows the reverse trend to diversity. H′ and Cd were inversely related to each other in the study area, which is, in general, the case in established forests (Zobel *et al.* 1976). The H′ values were comparable to the results reported viz. 1.79-3.17 (Khumbongmayun *et al.* 2004), 0.70-3.08 (Uniyal *et al.* 2010) and 0.78 to 3.45 (Raturi, 2012). Cd values were comparable to the results reported by (Tiwari and Singh, 1985) ranging from (0.11 to 0.93). The diversity index value of H′ (2.10 to 3.14) and Cd (0.13 to 0.32) reported by Sharma *et al.* 2009, from temperate forests of Uttarakhand is more or less comparable to the present study. The protected environment of the present sites showed the elevated diversity index of different stratum (Kumari *et al.* 2017). Simpson's diversity index ranged across all the sites in all strata from (0.58 to 0.95) and similar values 0.10 to 0.99 were also reported earlier by Risser and Rice, 1971, and 0.44 to 0.76 by Singh *et al.* 2014.

Species richness: Margalef Index (MI) and Menhinick's index (MEI)

The MI ranges from 0.86 to 4.05 and MEI value ranges from 0.48 to 1.41. MEI was minimum on DUS site for seedling strata and maximum for shrub strata on ABS, while as MI range (0.48 to 1.41) was minimum for seedling strata and maximum for shrub strata both on DUS. The shrub richness may possibly be the reason for the high MI and MEI. The earlier results for MI (0.63-2.95) and MEI (0.33 to 1.46) reported by (Gairola *et al.* 2011b) from the temperate forests of Garhwal Himalaya are someway analogous to the present study.

Berger-Parker (d) and Pielou's Equitability (Ep)

Berger-Parker index value ranged from 0.32 to 0.61 among tree, sapling and seedling layers and 0.08 to 0.15 among shrubs across four sites. Earlier findings reported by Sarkar, 2016 (0.16), Uniyal *et al.* 2010 reported value of Berger-Parker for trees (0.34 to 0.63) and for shrubs (0.12 to 0.39), moreover (Pala *et al.* 2016), find out results of (d) for trees (0.13 to 0.35) and for shrubs (0.14 to 0.25) and these findings were correlated with the current study. The values of Ep varied between (0.73 to 0.93) among three layers and for shrubs values were (0.93 to 0.99). The Ep earlier known ranges reported were 0.2 to 6.2 by (Kharkwal, 2009), 0.02 to 0.05 (Kumar *et al.* 2010).

Statistical analysis estimation

A Carl Pearson coefficient was calculated between various phytosociological attributes (Table 7).

Table 3. Phytosociological attributes of Unburnt sites (DUS and NUS) (Frequency%, Plant density, TBC and A/F ratio)

Species	DUS				NUS			
Trees	F (%)	D (trees/ha)	TBC (m^2/ha)	A/F	F (%)	D (Trees/ha)	TBC (m^2/ha)	A/F
Cedrus deodara	20	40	0.71	0.1				
Cupressus torulosa	40	100	1.15	0.0625				
Myrica esculenta	30	90	1.02	0.1	120	180	2.82	0.013
Pinus roxburghii	100	430	21.07	0.043	60	100	1.83	0.028
Pinus wallichiana					20	40	0.99	0.1
Prunus cerosoides					20	30	0.81	0.075
Quercus leucotrichophora					100	450	10.28	
Quercus serrata	20	40	0.45	0.1				
Rhododendron arboreum					130	190	4.26	0.045
Total	**210**	**700**	**24.39**		**450**	**990**	**20.99**	
Saplings (sap/ha)								
Celtis australis	20	140	0.16	0.088	25	200	0.27	0.080
Cupressus torulosa	15	120	0.21	0.133				
Myrica esculenta	20	160	0.16	0.1	70	400	0.92	0.020
Pinus roxburghii	50	500	0.68	0.05	35	220	0.75	0.045
Pinus wallichiana					20	140	0.25	0.088
Prunus cerosoides					10	80	0.26	0.2
Quercus leucotrichophora					90	760	1.51	0.023
Quercus serrata	15	80	0.10	0.089				
Rhododendron arboreum					50	360	0.79	0.036
Total	**120**	**1000**	**1.31**		**300**	**2160**	**4.75**	
Seedlings (seedl/ha)								
Celtis australis	30	280	0.001	0.078	25	300	0.03	0.12
Cupressus torulosa	10	120	0.001	0.3				
Myrica esculenta	35	320	0.001	0.065	55	380	0.089	0.031
Pinus roxburghii	100	780	0.002	0.020	25	280	0.020	0.112
Pinus wallichiana					15	180	0.012	0.2
Quercus leucotrichophora					80	880	0.283	0.034
Quercus serrata	65	640	0.001	0.038				
Rhododendron arboreum					65	420	0.08	0.02
Total	**240**	**2140**	**0.008**		**265**	**2440**	**0.51**	

Table 4. Phytosociological attributes of Burnt sites shrubs (MBS and ABS) (Frequency%, Plant density, TBC and A/F ratio).

Sites	MBS				ABS			
Species	F (%)	D (shrubs/ha)	TBC (m^2/ha)	A/F	F (%)	D (shrubs/ha)	TBC (m^2/ha)	A/F
Asparagus adscendens	15	160	0.002	0.178	60	580	0.004	0.040
Berberis aristata	40	320	0.0500	0.05	45	340	0.102	0.042
Berberis asiatica	65	800	0.2982	0.047	55	300	0.104	0.025
Campylotropis speciosa					60	280	0.001	0.019
Carissa opaca	30	240	0.0011	0.067	35	200	0.034	0.041
Cotoneaster rotundifolia	20	160	0.0371	0.1	50	300	0.151	0.030
Daphne papyracea	35	320	0.0011	0.065	60	360	0.016	0.025
Desmodium multiflorum	40	340	0.0003	0.053	95	520	0.007	0.014
Eupatorium adenophorum	80	980	0.0010	0.038	95	1000	0.005	0.028
Flemingia fruticulosa	45	400	0.0011	0.049	40	180	0.001	0.028
Himalrandria tetrasperma	50	580	0.1405	0.058	90	780	0.255	0.024
Hypericum oblongifolium	15	180	0.0006	0.2	75	320	0.001	0.014
Indigofera heterantha	30	320	0.0024	0.089	75	340	0.002	0.015
Inula cappa	15	140	0.0005	0.156	45	220	0.001	0.027
Leptodermis lanceolata	20	180	0.0009	0.113	85	360	0.012	0.012
Myrsine africana	25	200	0.0013	0.08	85	560	0.004	0.019
Phyllanthus parvifolius	20	160	0.0004	0.1				
Pyracantha crenulata	30	240	0.0060	0.067	45	260	0.134	0.032
Reinwartia indica	20	180	0.0005	0.1125	55	260	0.001	0.021
Rhus cotinus	25	280	0.0011	0.112				
Rhus parviflora					80	360	0.021	0.014
Rhynchosia rothii	20	240	0.0020	0.15	70	320	0.001	0.016
Rosa brunonii	10	80	0.0034	0.2	40	200	0.040	0.031
Rubus ellipticus	65	660	0.0042	0.039	60	380	0.013	0.026
Rubus niveus	60	260	0.0022	0.018	40	260	0.013	0.041
Rubus paniculatus					35	220	0.016	0.045
Urena lobata	35	200	0.0042	0.041	75	400	0.024	0.018
Viburnum mullaha	10	80	0.0063	0.2	50	260	0.018	0.026
Total	820	7700	0.5678		1600	9560	0.980	

Table 5. Phytosociological attributes of Urburnt sites shrubs (DUS and NUS) (Frequency%, Plant density, TBC and A/F ratio).

Sites	DUS				NUS			
Species	F (%)	D (shrubs/ha)	TBC (m/ha)	A/F	F (%)	D (shrubs/ha)	TBC (m/ha)	A/F
Asparagus adscendens	45	280	0.002	0.035	60	520	0.009	0.036
Berberis aristata	10	100	0.008	0.25	50	500	0.099	0.050
Berberis asiatica	40	300	0.164	0.047				
Campylotropis speciosa	10	80	0.001	0.2				
Carissa opaca					45	380	0.030	0.047
Cotoneaster rotundifolia	10	100	0.010	0.25	50	440	0.046	0.044
Daphne papyracea	20	140	0.001	0.088	65	480	0.025	0.028
Desmodium multiflorum	30	200	0.001	0.056	55	580	0.004	0.048
Eupatorium adenophorum	65	580	0.003	0.034	75	780	0.003	0.035
Flemingia fruticulosa	35	300	0.001	0.061				
Himalrandria tetrasperma	85	780	0.334	0.027	65	460	0.189	0.027
Hypericum oblongifolium	15	120	0.004	0.133	40	380	0.001	0.059
Indigofera heterantha	30	360	0.002	0.1	70	540	0.002	0.028
Inula cappa	25	140	0.003	0.056	55	520	0.001	0.043
Leptodermis lanceolata	20	160	0.001	0.1	40	420	0.001	0.066
Myrsine africana	35	300	0.007	0.061	75	680	0.002	0.030
Phyllanthus parvifolius	20	120	0.000	0.075				
Pyracantha crenulata	20	120	0.004	0.075	45	460	0.055	0.057
Reinwartia indica	20	180	0.0004	0.113	65	560	0.001	0.033
Rhus parviflora	20	140	0.003	0.088	50	360	0.008	0.036
Rhynchosia rothii	15	100	0.0004	0.111	45	380	0.0001	0.047
Rosa brunonii					30	300	0.0004	0.083
Rubus ellipticus	55	380	0.007	0.031	50	500	0.0018	0.050
Rubus niveus	30	260	0.004	0.072	40	280	0.0098	0.044
Viburnum mullaha	10	80	0.007	0.2	45	440	0.0096	0.054
Zanthoxylum americanum					40	280	0.0275	0.044
Total	665	5320	0.567		1155	10240	0.525	

Table 6. Diversity (H), Concentration of Dominance (CD), Simpson (D), Margalef Index (D), Menhinick Index (MEI), Berger-Parker Dominance (d) and Equitability (Ep) calculated for all the sites

	Diversity Indices	Sites & Taxa			
Strata and Parameters		MBS (6)	ABS (6)	DUS (5)	NUS (6)
Trees	Shannon (H′)	1.20	1.47	1.17	1.45
	Concentration of dominance (Cd)	0.39	0.28	0.42	0.29
	Simpson (D)	0.61	0.72	0.58	0.71
	Margalef Index (MI)	0.97	1.06	0.94	1.09
	Menhinick Index (MEI)	0.64	0.57	0.60	0.60
	Berger-Parker (d)	0.57	0.45	0.61	0.45
	Equitability (Ep)	0.75	0.82	0.73	0.81
		MBS (5)	ABS (6)	DUS (5)	NUS (7)
Sapling	Shannon (H′)	1.35	1.59	1.37	1.73
	Concentration of dominance (Cd)	0.33	0.23	0.32	0.21
	Simpson (D)	0.67	0.77	0.68	0.79
	Margalef Index (MI)	1.05	1.06	1.02	1.28
	Menhinick Index (MEI)	0.74	0.56	0.71	0.67
	Berger-Parker (d)	0.52	0.35	0.50	0.35
	Equitability (Ep)	0.84	0.89	0.85	0.89
		MBS (6)	ABS (6)	DUS (5)	NUS (6)
Seedling	Shannon (H′)	1.43	1.57	1.44	1.66
	Concentration of dominance (Cd)	0.32	0.23	0.26	0.22
	Simpson (D)	0.68	0.77	0.74	0.78
	Margalef Index (MI)	1.10	1.06	0.86	1.04
	Menhinick Index (MEI)	0.62	0.57	0.48	0.54
	Berger-Parker (d)	0.52	0.32	0.36	0.36
	Equitability (Ep)	0.80	0.88	0.90	0.93
Shrubs		MBS (25)	ABS (26)	DUS (23)	NUS (22)
	Shannon (H′)	3.01	3.15	2.92	3.06
	Concentration of dominance (Cd)	0.06	0.05	0.07	0.05
	Simpson (D)	0.94	0.95	0.93	0.95
	Margalef Index (MI)	4.03	4.05	3.94	3.37
	Menhinick Index (MEI)	1.27	1.19	1.41	0.97
	Berger-Parker (d)	0.13	0.10	0.15	0.08
	Equitability (Ep)	0.94	0.97	0.93	0.99

Table 7. Correlation between different parameters of different sites

	LF	Fire	T	Ind	H′	Cd	D	MI	MEI	d
Fire	0.000	1								
T	.776**	-.047	1							
Ind	.760**	-.028	.938**	1						
H′	.822**	.002	.985**	.954**	1					
Cd	-.846**	-.031	-.895**	-.886**	-.953**	1				
D	.846**	.031	.895**	.886**	.953**	-1.000**	1			
MI	.767**	-.043	.997**	.910**	.978**	-.884**	.884**	1		
MEI	.683**	-.038	.935**	.764**	.893**	-.778**	.778**	.958**	1	
d	-.849**	-.032	-.880**	-.894**	-.940**	.991**	-.991**	-.864**	-.739**	1
Ep	.843**	.127	.709**	.760**	.809**	-.924**	.924**	.689**	.566*	-.926**

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).
Abbreviations: LF=Life Form, T=Taxa, Ind=Individual, H′=Shannon-Wiener, Cd=Concentration of dominance, D=Simpson's Index, MI=Margalef Index, MEI=Menhinick Index, d=Berger-Parker, Ep=Equitability

The concentration of dominance was strongly negatively correlated with H′ (-.953) because the indirectly inverse proportion of Cd and H′ but Simpson's index was positively correlated with H′ (.953). Margalef Index and Menhinick's index were positively correlated with H′ (.953, .978). Berger-Parker was positively correlated with Cd (.991) and negatively correlated with H′ (-.940), D (-.991), MI (-.864) and MEI (-.739). Equitability was positively correlated with H′ (.809), D (.924) and negatively correlated with Cd (-.924).

Conclusion

The present study concludes the effect of prescribed fire on the comparative analysis of different attributes of the forest ecosystem. Our results highlight main contributing factors of fires on forests. The conifer forests responded well to the application of prescribed as the seedlings restoration was elevated after the application of burning treatment and at the same time, the effects on board-leaved forests were attainable. This presumably because prescribed burning decreases the intensity of subsequent wildfires. The maximum number of species was contiguously and randomly distributed although regular distribution was also observed in few species. Therefore our analysis was to implicit a concrete regional management plan, and the task for future perspective is how to maintain these climax communities from overwhelming fires.

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