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TRIGGERING OF SECONDARY SUCCESSION AFTER FOREST FIRE BREAKOUTS IN SHIWALIKS, NORTH-WEST HIMALAYA

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ABSTRACT

As per annotations on surface maps of Kalidhar forest range obtained periodically from an open source Google Earth using 1300 satellites, a gradual decline in the forest cover has been noticed in the last fifteen years. Thinning of forests in accordance with the satellite images reveals that forest fire breakouts in each year during the months of April-August is affecting negativity to the richness or evenness of tree species in the area. However, it is pertinent to reveal that the prescribed functioning of the forest ecosystem after forest fire is lacking in the proposed study area. The post-fire regeneration index of *Pinus roxburghii* (dominant species) and other plant species has been studied to find out the level of auto-succession in both post-fire regeneration sites and reference site. Patterns of succession deduced from the observations made in sample plots on these sites showed that regeneration in post-fire degraded sites was comparatively higher.

Key words: Kalidhar forest, *Pinus roxburghii*, Auto- succession, Regeneration.

Introduction

Plant succession begins just as soon as a land area capable of supporting plant life is formed. Nudation or formation of a bare area (newly formed area that was occupied previously by a community but has been cleared off by any of the processes like fire, drought, flood, wind, snow) is the initial cause of succession, and is considered as the initial step of ecological succession. In the early days, researchers considered fire as a destructive agent with few or no beneficial aspects. The development of prescribed or controlled burning as a tool in silviculture, fire hazard reduction and fire management, however, has caused a re-evaluation of the effect of fire on the forest. This re-evaluation has lead to the realization that the effect of fire on forest ecosystems is complex and may often be entirely beneficial.

Trends in the secondary succession started after fire and depends on several factors, such as species composition in the initial community (Hanes, 1971), fire severity (Trabaud and Valina, 1998) and the season in which fire occurs (Martin, 1990). Slope was also found to be an important factor determining natural regeneration, which was best in areas with a slope of 0-50% (Tsitsoni, 1996). Seed±source distance, vegetation height, blaeberry cover, slope and deer pellet-group density are also the factors most closely related to the number of pine seedlings and saplings during regeneration of *Pinus sylvestris* in Scotland (Scott *et al.,* 2000).

The beneficial effects of fire on forest ecosystems are classified as direct, indirect and detrimental. Therefore, a number of ecologists have been attracted towards post fire successional studies, like recurrent fires and development of a shrubby vegetation (Hanes, 1971), change in the heat regime of soil after forest fire (DeBano, 1990), effects of forest fires on atmospheric gas composition (Hao *et al.,* 1990; Scholes *et al.,*1996), soil erosion and exposure of rock beds after forest fires (Inbar *et al.,* 1998; Zimmerman *et al.,*1994), metapopulation formation and habitat fragmentation after forest fires (Cochrane, 2004). Buhk *et al.,* 2006 studied the post-fire regeneration in a Mediterranean pine forest with historically low fire frequency and supported the theory that autosuccession is not a process restricted to fire-prone areas. They proposed that fire has been only one of several selective forces since human settlement that probably led to a set of species pre-adapted against recurrent disturbance. Regeneration of bristlecone and limber pine may also benefit from natural disturbance or proactive management creating appropriately sized openings and microtopographic structure (e.g., abundant fallen logs); however, beneficial responses may require many decades to be achieved (Coop and Schoettle, 2009).

As per the surface maps of Kalidhar forest range obtained periodically through the open source Google Earth using 1300 satellites, a gradual decline in the forest cover has been noticed in the last ten years. Although the

Forest fire acts as boon and not as destructive agent as it lead to increase the diversity on the burnt site.

mentioned forest range is prone to forest fires every year during the months of April-August but not support the earlier reports like forest fire as boon for forest life (Toky and Ramakrishnan, 1983 and Inouye *et al.*, 1987). Hence, aim of present study was to understand the complex behaviour of Kalidhar forest range, in N.W. Himalaya in terms of the influence of post fire changes on regeneration capacity in forest range.

Material and Methods

Study area

Kalidhar forest range at the boundary of Jammu and Rajouri districts of J&K state, India, flanked between geographical co-ordinates N33°02$'$59.50$''$ E74°45$'$04.46$''$ to N32°58$'$28.21$''$ E74°24$'$35.44$''$ with altitudinal range of 304-1143m asl is represented by typical subtropical vegetation. At lower altitudes vegetation is dominated mainly by shrubs (*Zizyphus jujuba* Mill., *Carica aphaca* L., *Punica granatum* L., etc) with a few herbs (*Rhoeo spathacea* (Sw.) Stearn, *Stellaria media* Cirillo, *Taraxacum officinale* F. H. Wigg., *Geranium wallichianum* D. Don, etc) and lower plants like bryophytes (*Asterella pathankotensis* and *Plagiochasma appendiculatum* Lehm. and Lindenb.) and pteridophytes (*Adiantum capillus-veneris* L. and *Cheilanthes farinosa* Sw.). On moderate elevation these shrubs are found to be associated with broad-leaved (*Grewia asiatica* L., *Melia azedarach* L. and chir pine (*Pinus roxburghii* Sarg.) communities.

Mountains in the range are inhabitated by Gujjar and Bakarwal tribes. They seasonally migrate from lower altitudes to higher in summer and descend to the lower altitudes in the winter season. Some of them supplement their income from agriculture and forestry also. The pastoral economy of Gujjar-Bakarwals depends mainly on the availability and utilization of extensive seasonal pastures that leads to the seasonal migration of the Bakarwals with their herds from the Siwaliks to the Middle and Greater Himalaya in summers and downward movement in winter season.

Fig. 1: Kalidhar Forest range in outer Himalaya, Jammu and Kashmir, India

A total of six sites (five post-fire degraded sites and one reference site) were geo-referenced using GPS instrument for collecting the data (Fig. 1).

Sampling units

05 sampling units of 10m^2 plotted at five post fire degraded sites were geo-referenced using GPS instrument. The sampling units were plotted after extensive survey of the forest with respect to ecological aspects and altitudinal ecocline. Similarly, one reference sampling unit of same size has also been plotted in the forest and geo-referenced. Each sampling unit of 10m^2 was shaped to grid by dividing the sampling unit in 100 sub-grids of 1m^2 size, out of which 10 sub-grids were selected randomly for data collection (Fig. 2).

Ash quantity: Randomly ten gridlets of 1m^2 within the major grid of 10m^2 were selected for collection of ash samples from post fire degraded areas. The ash samples were collected in polythene bags from each gridlet separately and each bag was sealed in the field and carried to the laboratory for determining the amount of the ash with the help of the below given formulae:

Amount of ash at one gridlet (A) = X^1

Mean amount of ash at 10 gridlets (B) = $\dfrac{X^1 + X^2 + \ldots\ldots X10}{10}$

Mean amount of ash at 1 grid (C) = B X 100

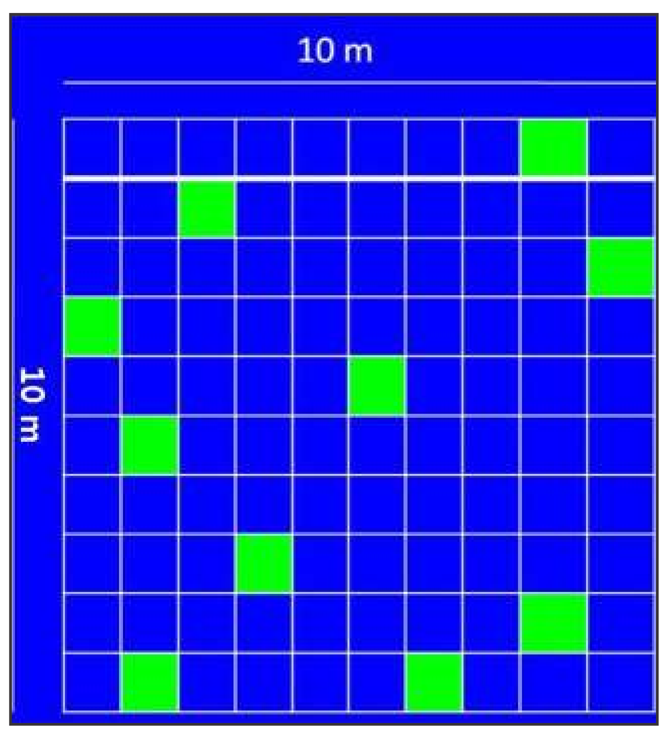

Fig. 2: Sampling unit of 10m^2 grid with 10 randomly selected gridlets

Regeneration index

Regeneration index of *Pinus roxburghii* and other plant species was calculated at each site. For this, 60 gridlets (10 for each site) of 1m^2 were selected randomly inside a 10m^2 grid and seedlings were classified according to their heights, in three classes (2-4cm; 4-6cm and 6-10 and >10cm). Regeneration index was then calculated according to formula given by Tsitsoni (1996):

Regeneration index (RI) = Number of seedlings/m^2.

Regeneration indices were then compared for both post fire degraded sites and reference site.

Observations

According to present observations, mean regeneration indices of *Pinus roxburghii* and other plant species showed a lot of variation in both post-fire degraded and reference sites. Regeneration index of *Pinus roxburghii* was found to be between 2-4.4m^{-2} and for other species, values obtained were between 49.3-233.4m^{-2} for post-fire degraded sites and for reference site, regeneration indices obtained were 1.2 and 34.4m^{-2} for *Pinus roxburghii* and other plant species, respectively (Fig. 3 and 4; Table 1). Thus, regeneration index was higher in post-fire degraded sites than in reference site.

In addition to this, anthropogenecity caused by nomadic people i.e., Gujjars and Bakarwals, also contributes in lower values for regeneration index for *Pinus roxburghii* in post- fire degraded sites as these groups prefer mountaneous habitats due to their preferable geo- climatic conditions. These groups depend on forests for their livelihood; like pastoralism and also other minor forest products like gums, resins, dyes etc. Need of timber wood for their day-to-day activities is the main reason for depletion of pine trees in the range. During the study, it was observed that these tribes burn the trees from the base of trunk and fell down the pines, which is affecting negatively the ecological conditions of the area and large scale depletion of pines in the forest.

Fig. 3: Seedlings of *Pinus roxburghil* and other species

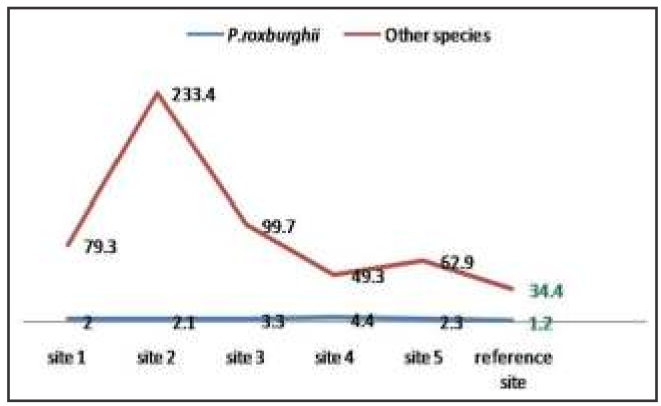

Fig. 4: Regeneration indices of *Pinus roxburghil* and other species

Mean amount of ash quantified at five different sites was found to be between 6.4-7.5kg/grid (10m^2) which was found to be appropriate for auto-succession of *Pinus roxburghii* and other plant species in the area (Table 2).

Table 1: Showing regeneration indices.

Site		Quadrats with no. of seedlings of different plant species										Mean regeneration index (seeding/m^2)
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
Reference site	*Pinus roxburghii*	3	0	0	2	0	1	2	0	0	4	1.2
	Other plant species	42	25	49	22	33	24	38	53	33	25	34.4
Site 1	*P. roxburghii*	0	0	4	2	0	5	2	0	4	3	2
	Other plant species	27	30	40	58	33	23	62	191	151	178	79.3
Site 2	*P. roxburghii*	2	4	3	0	2	4	2	3	1	0	2.1
	Other plant species	226	286	282	195	169	233	329	345	100	169	233.4
Site 3	*P. roxburghii*	3	5	0	3	6	6	0	0	7	3	3.3
	Other plant species	188	144	79	50	139	61	95	67	60	114	99.7
Site 4	*P. roxburghii*	11	4	3	0	7	0	11	0	0	8	4.4
	Other plant species	37	32	36	41	46	22	53	61	72	93	49.3
Site 5	*P. roxburghii*	1	4	2	5	0	3	0	5	1	2	2.3
	Other plant species	44	89	58	187	47	31	73	35	28	37	62.9

Table 2: Showing quantity of ash collected at five post fire degraded sites.

Site	Amount of ash in 10 Quadrats (in gm)										Mean amount of ash in 1 gridlet (in gm)	Mean amount of ash in 1 grid (in kg)
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10		
1	35	40	27	90	56	64	120	67	61	195	75.5	7.55
2	110	160	46	73	57	40	23	65	19	98	69.1	6.91
3	50	95	122	74	80	106	60	20	30	106	74.3	7.43
4	60	44	98	99	37	09	108	91	56	38	64	6.4
5	26	88	102	86	31	44	64	46	111	105	70.3	7.03

Discussion

Trabaud *et al*. (1985) observed 0.1 seedlings m^{-2} of *Pinus halepensis* during the first 5 years after fire and in the next 5-15 years, it increases to a peak of 1 seedling m^{-2} and then again decreases to a value of 0.1 seedling m^{-2} in next 15-30 years after fire. Zagas (1987) studied Aleppo pine regeneration in Mount Pateras, Attiki (Central Greece), and found 8.7 to 18.5 seedlings m^{-2} during 2 years after fire. Thanos *et al*. (1989) also reported a regeneration index of 0.30 seedlings m^{-2} within 15 months for *P. brutia*, after forest fire. This value according to them, is high enough that leads to complete natural regeneration. The post-fire natural regeneration in Aleppo pine (*Pinus halepensis*) in Kassandra forests accounts between 0.60-14.26 seedling m^{-2} (Tsitsoni, 1996; Zagas, 1987). Here, slope was found to be an important factor in determining natural regeneration. Lowest values were observed at the upper position and higher descending the hill side, but, regeneration was best in areas with a slope of 0-50%. Spanos *et al.* (1999) studied the natural post-fire regeneration of *Pinus brutia* in two 40–60-year-old forests of Thasos island, Greece and reported that mean regeneration was very high (2–6 seedlings m^{-2}), at initial phase but, significantly fall. The regeneration index ranged from 0.006 to 20.4 pines/m^2 has also been reported, indicating that forest fire can act as boon for regeneration (Pausas, 2004). Further it is revealed that regeneration was high in forests with large amounts of branches on the floor, northern aspects, high pre-fire basal area and on terraced slopes. Under present study regeneration index for *Pinus roxburghii* was found to be between 2-4.4m^{-2} and for other species, values obtained were between 49.3-233.4m^{-2}. Thus, we can say that these values are high enough for the auto-succession or natural regeneration of plant species in the area when compared with the above studies.

Conclusions

From the above observations, it can be concluded that regeneration capacity of *P. roxburghii* and other plant species was higher in post-fire degraded sites which confirms that forest fires are not responsible for the depletion of above mentioned pine trees. This depletion is only due to the continuous exploitation of only *P. roxburghii* mostly by tribes such as Gujjars and Bakkarwals for various purposes like timber, fuelwood, resins and so on. These people and a number of other rural people directly fell these pines for fulfilling their economic needs. Overall diversity was also comparatively higher in post-fire degraded sites. Therefore, from this study, it is clear that forest fires act as boon and not a destructive agent as they lead to increase in diversity of plants and therefore provide variety of habitats.

शिवालिक, उत्तर पश्चिम हिमालय में वनाग्नि लगने के बाद द्वितीयक अनुक्रमण की रोक

पल्लवी शर्मा एवं हरीश चन्द्र दत्त

सारांश

1300 सैटेलाइटों का उपयोग करके एक ओपन स्रोत गूगल अर्थ से समय-समय पर प्राप्त कालीधार वन रेंज के सतह मानचित्रों पर व्याख्याओं के अनुसार गत पन्द्रह सालों में वनावरण में क्रमिक ह्रास देखा गया है। सैटेलाइट इमेजों के अनुसार वनों के विरलन ने दर्शाया कि अप्रैल-अगस्त महीनों के दौरान हर साल होने वाली वनाग्नि क्षेत्र में वृक्ष प्रजातियों की समृद्धता अथवा समानता के लिए नकारात्मकता प्रभावित करती है। तथापि, यह बताना प्रासंगिक है कि वनाग्नि के उपरान्त वन पारितंत्र की विहित प्रक्रिया का प्रस्तावित अध्ययन क्षेत्र में अभाव है। *पाइनस रॉक्सबर्घाई* (प्रधान प्रजाति) तथा अन्य पादप प्रजातियों की आग के बाद पुनर्जनन तालिका का अध्ययन किया गया ताकि आग के बाद पुनर्जनन स्थलों और संदर्भ स्थल दोनों में स्व-अनुक्रम के स्तर का पता लगाया जा सके। इन स्थलों में नमूना भूखण्डों में किए गए प्रेक्षणों से व्युत्पन्न अनुक्रम के पैटर्नों ने दर्शाया कि आग के बाद निम्नीकृत स्थलों में पुनर्जनन अपेक्षाकृत उच्च था।

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