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Impact of Forest Fires and Shrinking Water Sources on the Elephants of Rajaji National Park, North - West India

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Abstract: Every year wildfires in Rajaji National Park, north-west India destroys more than 250 hectares of landscape encompassing tall grasslands and mixed forests. This is not only making a negative impact on wild species, but also causing a drastic impact on elephant's seasonal movements. This study evaluated the impact of three fire seasons in 2007, 2008 and 2009 on the elephants of Chilla and Haridwar forest ranges. The 2008 forest fire burned 95 (0.64%) hectare of the Chilla forest followed by 2007 (75 hectare, 0.50%) and 2009 (60 hectare, 0.40%) whereas the 2007 fire burned 120 hectare (1.40%) of Haridwar forest followed by 2009 (105 hectare, 1.23%) and 2008 (95 hectare, 1.11%) fires. Scarcity of natural water during dry periods is another major factor which is affecting elephant's movements within their home range. Chilla and Haridwar forests are currently facing water scarcity as far the elephant distribution is concerned, most of the perennial water sources have shrinked or remaining are on the verge of it, whereas before 2002 all of these water sources were fulfilled with tremendous water. Our review of available evidence suggests that wildfires and shrinkage of natural water sources have caused a catastrophic decline of free-ranging elephants from the Chilla and Haridwar forest ranges. All of these data support the importance of protecting the Rajaji National Park and its adjoining protected habitats as an important elephant range, linking different protected areas in north-west India.

Key words: Asian Elephant % Wildfire % Shrinking water sources % Rajaji National Park % Conservation % North-West India

INTRODUCTION

Fire causes profound changes in the habitat; this has important implications for the survival, population size and composition of plants and animals [1]. In the Rajaji National Park and its adjoining protected habitats, every year wildfires leave a devastating impact on the landscape, affecting flora, fauna and local climate. The most affected part considered is the corridors present in between different forests. Although wildfires may be both of natural and anthropogenic origin, the limited studies on this aspect suggest that in Shivalik foothills fires are entirely of anthropogenic origin. During 1999 forest fire has strucked the forest of Garhwal and Kumaun Himalaya and engulfed the precious forests over 5000 Km^2. An equally devastating forest fire took place in 1995 in Kumaun, Garhwal and Himachal Pradesh forests and destroyed nearly 3000 Km^2 area, the damage caused to vegetation, wildlife and ecology was colossal and irreparable [2]. Maximum numbers of fires were observed near the areas which are adjoining to human settlements, near to Gujjar shelters, near to villages, near to agricultural lands, near to religious places inside the forest and, especially in forests which are being traditionally used by local people for collection of fuel wood and fodder. Forest fire and felling of fodder species are considered to be important influences, as far as frequent movement of elephants is concerned and both factors greatly affect the structure and composition of the plant communities in the Rajaji National Park area [3].

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Fig. 1: Lightning is felling over to Motichur forest, Rajaji National Park during 2007

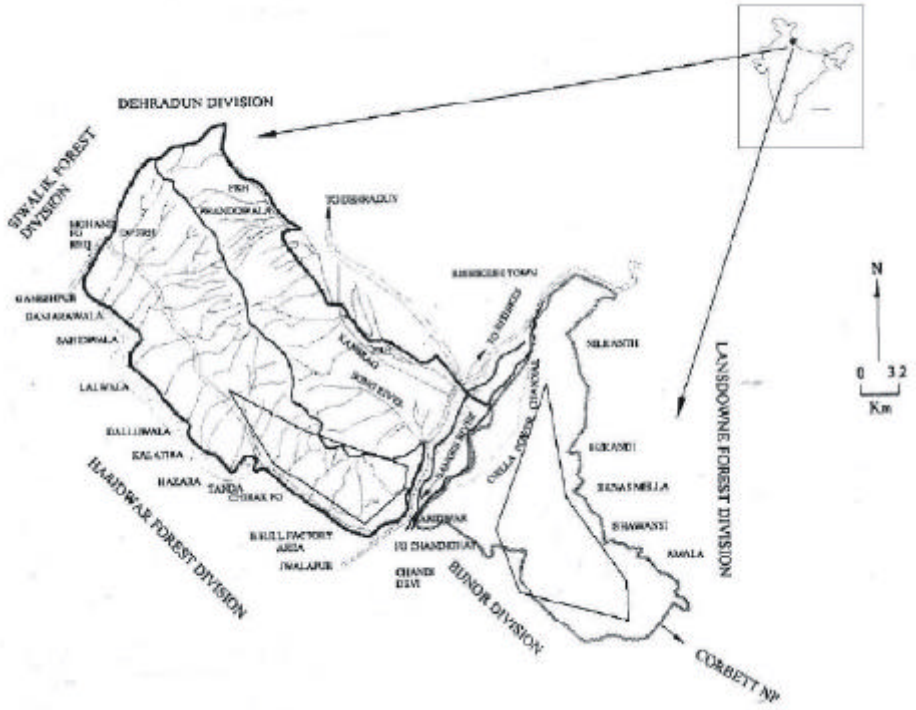

Fig. 2: Wildfire affected areas in Chilla and Haridwar forests of the Rajaji National Park during 2007-2009

Lightning is considered to be one of the major causes of natural fires and wildlife mortality in most of the ecosystems, but till date no such incident was found, which caused wildfire and elephant mortality through lightning. During May 2007 lightning was observed as it felled over the Motichur forest of the Rajaji National Park, but our post-assessment revealed that incident has not caused any hazardous impact over the forest (Fig. 1). Lightning is reported to be another cause of forest fire and its scars can be observed on many trees besides, fire caused by the friction of dry bamboo stalks in the mixed deciduous and bamboo forest is another cause of forest fire in Huay Kha Khaeng Wildlife Sanctuary [4].

Fig. 3: Wildfire at Haridwar forest during 2007

Table 1: Status of affected forests through wildfires in Chilla and Haridwar forest, Rajaji National Park during 2007-2009.

	Area affected through wildfire (hectare)			Elephant's status (from March to May, average values)			% of forest burned		
Forest	2007	2008	2009	2007	2008	2009	2007	2008	2009
Chilla	75	95	60	105 elephants in groups & 09 adult male	97 elephants in groups & 07 adult male	74 elephants in groups & 04 adult male	0.5	0.64	0.4
Haridwar	120	95	105	01 tusker's movement was observed	14 elephants in groups & 02 adult male	05 elephants in group & 02 adult male	1.4	1.11	1.23

Wildfires not only make a huge impact on mega-fauna of any ecosystem, but also make an impact on other groups living within like rodents, reptiles, amphibians and avian species. Among the three types of forest fires (i.e. ground fire, surface fire and crown fire) it is mainly surface fire that are found in this region, though these sometimes turn into crown fire due to the prevailing terrain conditions. Rajaji National Park falls under sub-tropical moist deciduous forest type and the period from mid-March to June is supposed to be forest fire months. During the last three years at some of the places impact of wildfires inside the Rajaji National Park has restricted the seasonal traditional movement of elephants within their home range. Forest fire was one of the most important factor, which has forced the elephants to replace their winter home ranges to some extent. Here, we reported on the status and impact of forest fire (Fig. 2) and shrinking perennial water sources on elephant's seasonal movements. Such reports are highly required to know the status and our competence in illustrating success and failures of wildlife habitat management besides in conservation of an endangered mega-herbivore species.

Assessment of Wildfires

Field Observations after 2007 Fire Season: In between March and June 2007, 75 hectare of Chilla forest was completely burned and out of them 40 hectare falls under corridor for elephant movement towards Lansdowne forest division. Besides, about 04 hectare of grass land was also destroyed during the same period and the most affected species were *Saccharum spontaneum* and *Saccharum munja*. Haridwar forest accounted for highest number of fire cases during 2007 and 120 hectare forest was burned entirely during fire season (Table 1, Fig. 3). About 30 hectares of Kharkhari forest was destroyed during fire season. It was observed after examining the situation that all of these fires were originated due to anthropogenic activities. Study revealed that several important fodder species were affected along with grasses and animal leaved the area for a long period of time.

Fig. 4: Wildfire at Chilla forest during 2008

Our assessment just after the fire concluded that all the wild animals' even herbivores has leaved the forest for few months.

Field Observations after 2008 Fire Season: The estimated wildfires during 2008 were 95 hectare and an accidental fire on Gohri forest ran out of control and burned a large area of Chilla forest. About 140 hectare of Gohri forest near to Kandakhal village was entirely destroyed due to fire (Fig. 4). As per our post-fire assessment 12 honey hives, 07 termitoriums, 05 burrows of porcupine and 04 nests of vultures near to fire area were found burned completely. Haridwar forest was the extreme affected part as compared to other forests (95 hectare) and on an average 70 hectare of forest was entirely burned upto the tree canopy. Most of the affected forest falls under elephant corridors, which consists of Ranipur, Bilkeshwar and Kharkhari forests. Elephants specially use this forest at the onset of monsoon and leave near to late winter.

Field Observations after 2009 Fire Season: Least fires were observed during 2009 at Chilla forest, only 60 hectare forest was burned and out of that about 25 hectare was of *Tectona grandis*. Whereas Haridwar forest accounted for highest number of wildfires during 2009, on an average 105 hectare forest was entirely burned and maximum number of fires was observed near to areas which consists anthropogenic activities (Table 1). Haridwar forest is one of the important habitat for *Muntiacus muntjak* (Barking deer) in Rajaji park but no single deer was found after the fire of 2009. Besides, tremendous fire of Shyampur forest has diverted the elephants to some other pockets and very rare movements of bull elephants were observed in this part.

Impact on Movement of Elephants: During 2007 fire season the Shyampur forest, which is adjoining to Chilla forest burned extensive and several fodder species were affected due to tremendous fire and elephants leaved some forest pockets and shifted to adjoining forest of Chiriapur (Haridwar forest division) and some pockets of Chilla and Laldhang (Lansdowne forest division) forest. Just after wildfires heavy flood occurred and most of the grasslands were entirely destroyed and elephants migrated in upper forest regimes, especially those lies above the altitude of 400 meter above sea level. Returning of elephants was found to be delayed by three months towards lower landscapes near to riparian corridors. On the other hand, Haridwar forest was affected severely and after wildfires only one adult male elephant's movement was observed in entire forest range (8,526.1 hectare). During the same period elephant's movement was found more near to Kansrao forest specially along the river Suswa and Song. Natural water was only observed in Rawli river whereas Kharkhari forest was completely dried.

Again in 2008 fire has affected the Chilla and Haridwar forest. In eastern part of river Ganges upper landscape of Gohri forest was imprisoned entirely with extreme fires and some part of fire ran out of control and moved towards Chilla forest besides, heavy winds have also promoted the fire to spread quickly. Fire was continuously observed for

Fig. 5: Elephant group bathing in a waterhole at Rawli forest.

a week and it destroyed about 140 hectare of crucial habitat, however during the same period elephants were not utilizing that forest, but the impact of fire was so strong that some patch of Mundal and Kasaan forest were directly affected through these fires. At the same duration elephants moved out from affected forests and shifted towards Khara, Shyampur and Chilla forest. Observations indicated that one group of elephants consisting of 11 individual didn't performed movement during monsoon and they stayed at Chilla forest for whole of the monsoon and winter season whereas their movement was also partially observed in Shyampur forest. Bilkeshwar, Kharkhari and Ranipur forests were accounted highest for these fires in Haridwar forest and fires were continuously observed near about 10-11 days. Movement of only a group of 14 elephants and 2 male elephants was observed in Rawli, Chirak and Harnol forests (Fig. 5). An immediate effect of fire on elephant's habitat is a drastic reduction in food availability, grasses are totally burnt and the green shoots of most shrubs and young trees are also ashed leaving only bare stems [1]. Wildfire is also one the prime factor, which sometimes forces the elephants to move outside from favourable forest pockets besides; forest fire sometimes causes irregularities in elephant's seasonal movement in their traditional corridors, which connects different biological areas [5].

In 2009 Chilla forest had least wildfires and a group which was performing movements at Luni and Rawasan forest was shifted towards Laldhang forest (Sigaddi beat) and elephant's movement was entirely restricted in that part. However, water scarcity was another major hindrance observed in that season as far elephant's distribution was concerned. Adjoining forest of Haridwar division was also severely affected during this period and about 170 hectare forest was entirely destroyed during said period. Elephant's movement was more observed near to east Ganga canal, river Ganges and other water sources (Fig. 6,7) whereas some portion of Siddh shroath was also severely affected due to tremendous fires. This water stream is one of the most important and crucial corridor for elephant's movement as this site consists of *Dendrocalamus strictus* and adjoined with river Ganges.

Haridwar forest accounted highest for the wildfires during 2009. As per our assessment a group consisting five individuals and only two bulls were performing movements in Haridwar forest during that period. Currently Haridwar forest is facing huge water scarcity and natural water is only available at some portions of Ranipur rao and Rawli rao. However, Kharkhari forest is the largest beat and all the perennial water sources (Bagrau, Sukrau, badapani and chotapani) were completely dried presently. Elephant's movement is more common during monsoon whereas before 2002 elephants utilized this forest round the year and large groups were observed in this forest specially near to Bagrau and Nauranga water sources.

As per the assessment carried out by Forest Survey of India in 1999 on forest fires in Uttarakhand state, Haridwar forest accounted for 119 Km^2 (20.34%) fire-affected forest out of total forest area of 585 Km^2. A total of 146 annual fires in RNP area in between 1996-2002 has affected 540.71 hectare of forest cover [6].

Fig. 6: Elephant group at east Ganga canal, Shyampur forest, Haridwar forest division

Fig. 7: Elephant's herd at Luni river, Rajaji National Park

Sometimes, burning cigarettes, biddies, matchsticks and electric fence are the causative agents of forest fire, but sometimes fire also took place naturally. During the very period when the upper surface of the land is too much hot the dry grasses like *Eulaliopsis binata* and *Neyraudia arundinacea* due to highly inflammable nature sometimes catch fire on account of minor negligence of human beings around. Few of the villagers also instigate this fire with the wrong perception that after burning of old vegetation new seedling of the trees comes up quickly. The fire occurring in the moist deciduous forest of Muttodi wildlife range is mainly due to deliberate fires set by the fringe villagers and can be attributed to the dead bamboo plantations [7]. Gatherers of non-timber forest products start fires to clear litter, grass and undergrowth on the surface floor to facilitate access to the forests. In pursuing small game, rural people start fires to drive the animals from their hiding places. For preparing agricultural land after harvesting or clear cutting of industrial plantations, local farmers usually start fires without having any control over them.

Incidentally, the conflict between local people and forestry officials appears to be a cause of forest fire [4]. These fires may cause irregularity in the movement

pattern of elephants and their movement could be increased towards adjoining forests and human habitation areas. The reasons for migration of elephants can be annual fire, drought, non-availability of fodder, paucity of drinking water and absence of cool green shades in their respective areas. Forest fire is also one a factor to force the elephant's movement to a separate area where fire had not been so extensive. Wildfire if spread extensively than the movement of wild animals also restricts to the same area for some time [8]. In south-eastern Ceylon, most fires occur during the period of the south-west monsoon, when a dry steady wind blows continuously during the daytime and extensive areas are burned almost every year and approximately 50-75 percent of talawa in the region of Bulupitiya and Nilgala were burned during 1967 - 1969 [9].

Notably one stretch of the Haridwar forest is entirely attached with human habitation with more than eight villages situated along the boundary of the park area with majority of the villagers totally dependent on local forest resources for their livelihood. It is pertinent to mention here that in Haridwar forest maximum number of wildfires occurred in the same forest year by year. To a major extent illegal persons are responsible for these fires as they destroy the remains of illicit logged trees by burning them which further aggregates the forest fire. Apart from this as they burn the trees animal species such as deer move away from the fire zone area and the poachers easily prey them. Some of the perennial water sources were also affected due to these huge fires.

Shrinking Perennial Water Sources: Chilla forest is one of the most vital habitat as far elephant's distribution is concerned. Presence of several natural water sources further ensures the presence of elephants round the year. But, one worrying fact is that during last decade majority of the perennial water resources are shrinking rapidly. Irregular monsoon rainfall and changing climatic conditions are making drastic negative changes in the ecosystems. Despite Ganges, Mitthawali and Rawasan are two other perennial rivers which flow in between the Chilla forest and strengthen the distribution of fauna. But during the past one decade water flow was decreasing slowly while rains promotes the rate of water flow to more extent during monsoon and one to two months later to it. Hazara is another perennial source of water, but it too has dried up in some of the places due to improper management practices, however this is utilized by elephants during extreme dry periods. Same is the case with Luni, Rawasan and Pandowali water sources, all of whom are dependent upon rain water besides, cattle of local inhabitants lay in these water holes during day hours (Table 2). Dayara rau is only the source, which was found in its natural condition and is one of the best habitat for tiger, sloth bear and elephants. All the artificial water sources (Soni, Kunao and others), which are linked with irrigation canal of Chilla hydro-electric power plant are currently impure for drinking purpose and elephants and other animals are utilizing these sources only for their bathing needs.

Table 2: Status of natural water sources in Chilla and Haridwar forest ranges with their status during 2000-2001 and 2007-2008.

S. No.	Name of water Source	Forest	Perennial/annual	Status during 2000-2001	Status during 2007-2008	Current status
Chilla Forest (Rajaji National Park)						
1.	Luni river	Luni	Annual	Huge water during monsoon	Adequate water during monsoon	Water present during monsoon
2.	Mitthawali shroath	Khara	Perennial	Tremendous water & flow to a long stretch	Less water present & flow to a small stretch (only near to Mitthawali rest house)	-
3.	Hazara shroath	Chilla	Perennial	Fulfilled with water	Less water available	Slowly drying
4.	Ghasiram shroath	Chilla	Annual/perennial	At some point water was present	Water available only during monsoon	-
5.	Mundal shroath	Mundal	Annual	Water available only during monsoon & wet season	Water present only during monsoon & wet season	-
6.	Gara shroath	Mundal	Annual/perennial	Water present at most of the places	Only in some spots water was available	Drying
7.	Chor Pani shroath	Luni	Perennial	Tremendous water flow	Less water available	Drying
8.	Rawasan shroath		Rawasan Perennial	Tremendous water flow	Less water available	-
9.	Hathi kund, Rawasan	Rawasan Perennial		Adequate water annually	Dried, water available only during Dried monsoon	
10.	Water pond, Luni	Luni	Perennial	Adequate water annually	Dried, water available only during Dried monsoon	

Table 2: Continued

11.	Sain shroath	Khara	Perennial	Fulfilled with water	Water available only during Monsoon & wet season	-
12.	Dayara Rau	Luni	Perennial	Fulfilled with water	Fulfilled with water	-
13.	Pandowali shroath	Rawasan	Perennial	Fulfilled with water	Water available only during monsoon	Dried
14.	Soni shroath	Mundhal	Annual	Water available only during	Water available only during	-
Haridwar Forest (Rajaji National Park)						
1.	Naraunga shroath	Kharkhari	Perennial	Fulfilled with water	Dried	Dried
2.	Bada pani shroath	Kharkhari	Perennial	Running water	Less water as compared to 2000-2001	Only one water point was present
3.	Sukh rau shroath	Kharkhari	Annual	Small water bodies at short distance	Water present only in internal zones	Dried
4.	Bag rau shroath	Kharkhari	Annual	Water available (recharged ground water)	Water decreasing	Shrinking
5.	Gaurikund mandir shroath	Mayapur	Perennial	Small water points available	Water level is continues to shrink/shrinked	Shrinking
6.	Dhak shroath	Mayapur	Perennial	At two points water available	Only one water body present unpurified	Dried
7.	Jhabri shroath	Mayapur	Perennial	At four points water available	Shrinked	Shrinked
8.	Aam shroath	Mayapur	Perennial	Water in small quantity available	Water sources shrinked, water present only during monsoon	Shrinking
9.	Hathikund / jamun shroath	Bilkeshwar	Perennial	Water available in between	Water available but fragmented hillock's ridges	Shrinking
10.	Rawli rau	Rawli	Perennial	Tremendous water was present	Water present in very less quantity	Water available
11.	Aandheri shroath	Chirak	Annual	Water present at short distance	Less water is available	Water available in less amount
12.	Harnaul rau	Harnaul	Annual	Sufficient water was present	Shrinking	Water available in internal zones
13.	Mittha shroath	Ranipur	Perennial	Unpurified water was present	Water shrinking & dried during hot period	Shrinking
14.	Ranipur rau	Ranipur	Perennial	Water was available through	Dried during dry period	Less water

Fig. 8: Historical monument: well constructed before 1877 at Ranipur forest, this is now a day's part of Rajaji National Park. Notably, 1.5 meter ground water level decreased during last five years

Fig. 9: Elephant dig out the water from a dry river bed at Kharkhari forest. Elephant's footprints and dung piles are clearly noticeable

Haridwar forest comprises of many wells, which were constructed before the park officially come into existence with the purpose of maintaining water availability, especially during dry months. Historical evidences suggested that these wells were constructed before 1877 adjoining to forest roads and raos (seasonal water streams). It was observed that the water level has decreased in all the wells and as per our assessment; about 1.5 meter of the water level has decreased during the last six years (Fig. 8). This area is currently facing the scarcity of water and fodder species as far the elephant presence is concerned. Most of the perennial water sources (Ranipur water stream in Ranipur forest beat, Bagro, Sukro, bara pani and chota pani in Kharkhari forest beat and hathi kund in Bilkeshwar forest beat) have shrinked to date, whereas before 2002 all of these water sources were filled with tremendous water (Table 2). Similarly, Nauranga water pond in Kharkhari forest beat, Dhak and Jhabri water sources in Mayapur forest beat and Harnol water source in Harnol forest beat have dried up completely whereas before 2001 elephants utilized these sources throughout the year as this forest is a connecting corridor for elephant movement towards Motichur, Kansrao and Dholkhand forest range (Fig. 9).

Presently, elephant's movement is quite rare in all of the forest beats of the Haridwar forest range, only solo bulls and sometimes small groups of 3-7 elephants were observed moving within this forest stretch. As per our review of the study, elephants start utilizing this forest area at the onset of monsoon (from the month of July), when due to extreme rains all the water bodies get refilled with tremendous water leading to spontaneous regeneration of the fodder species along with natural vegetation of the area. Besides, bamboo seedlings also start growing considerably in this part of the park. Increasing rate of forest fires may be harmful as far long-term survival of Asian elephant is concerned and we believe that some detailed studies are required to come up with scientific management suggestions to protect Shivalik landscape so that the objectives of 'Project Elephant' could be ensured.

Recommendations for Wildfire and Water Management in Rajaji National Park: As maximum numbers of wildfires are man-made, therefore, it is recommended that regular patrolling of forest should be done, especially near to areas, which are adjoining to villages. Besides, workshops should be organized in each village before fire season to motivate the local people and to search their livelihood requirements and alternatives. In most of the places conflict between forest officials and local people was observed and it should be needed to minimize by including them in each and every policy related to forest conservation with the approach of community participation.

In the forests where inflammable grasses like *Eulaliopsis binata* and *Neyraudia arundinacea* are present, proper monitoring and control burning should be done with scientific approach. At the same time elephant's movement and requirements should be properly monitored. Actual measurement of fire affected areas should be done, which will be helpful in

management of forest resources and it is also recommended that post-fire assessment of the burned areas should be worked out so that ground-based data can be achieved on wildlife mortalities.

In areas where fire took place every year, litter should be separated at short distances and may be burned controlled. As Rajaji National Park area falls under sub-tropical moist deciduous forest type, therefore, thick layer of litter is placed during spring, which is responsible for quick spreading of fire. It is also recommended that during heavy winds, sensitive forest stretch must be monitored. As most of the local people utilize local forest resources, therefore, if efforts are made to provide them substitute and include them in forest management practices their indigineous knowledge will definitely help us in controlling wildfires to some extent.

Natural water sources specially small water discharge points should be managed and cleaned on regular basis. Large water reservoirs may also be constructed during monsoon at spots where elephant movement is common after rains. For this proper scientific techniques should be implemented so that elephants can easily use the resources. Artificial water holes must be created, spread within the park area at short distance. For solving the problem water uplifting pumps can be used to uplift the well water during day hours, which will help during dry period. At Chilla forest some ponds can be created and linked with Ganga canal but it requires proper maintenance too then only it would be effective.

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