

Forest Fires

Origins and Ecological Paradoxes

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K Narendran currently works at the Centre for Ecological Sciences, Indian Institute of Science, Bangalore. He has been intrigued by the phenomenon of forest fires and is keen on looking at the historical and ecological aspects of forest fires. He is involved in mapping forest fires in the Mudumalai Wildlife Sanctuary. His major interests lie in ecological applications of remote sensing and geographical information systems, and would like to work on questions of ecological relevance at the landscape level.

Forest fires have occurred across the globe at various times in the past. The sources of these fires have been both natural and anthropogenic. Forest areas in North America, South and S E Asia, Australia, Africa and Amazonia are prone to the incidence of fires regularly. Forest fires occur almost on an annual basis in the deciduous forests of Southern India. However the extent of these fires depends on various factors such as the frequency of human disturbances and the climate of the region. These fires are thought to have impacts on the ecology of plants and animals in the region.

Introduction

Of late, forest fires have captured the attention of people worldwide. Over the last few years there have been devastating fires in the forests of South East Asia, Amazon and the Rocky Mountains of the USA. In many parts of the world fires are common, frequent and in some cases devastating. Such fires have not only led to threats to the biological diversity of these forests, but have also caused large-scale human suffering in neighbouring lands, due to pollution of the environment. This article traces the origins of forest fires, their history and their occurrence in different parts of the globe, more so in south Indian forests, and the ecological consequences of such fires.

Natural Forest Fires

Fire occurring naturally have been known ever since the evolution of land plants some 350 to 400 million years ago. The first evidence of a wild fire in the world dates back to the early Carboniferous era (approximately 390 MY ago). 'Wildland

fires,' as they are commonly known today, occur at varying frequencies, in different parts of the globe. Natural causes of forest fires are usually lightning strikes or burning coal seams. Lightning strikes when the lower portion of clouds becomes negatively charged and sufficient electrical potential has built up compared to the positively charged ground. During lightning an arc of electrically charged atomic particles, called electrons, passes from the cloud towards the ground, carrying a current of as much as 60,000-100,000 Amperes. When lightning comes in contact with dry litter, dead and fallen logs or dry canopy it could ignite a natural fire. In Australia, in the interior of the state of Queensland, the drought prone grasslands of the Mitchell Plains experience repeated natural fires from lightning strikes, these fires are not accompanied by rain and hence fire in these ecosystems has greater bearing on their ecology.

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Fires may occur naturally also, from burning coal seams below forested areas. Natural heat production within the core of the earth is only partly understood. However it is clear that some areas on the Earth have a higher flow of heat from below the surface. Most such locations are associated with the movement of tectonic plate boundaries where mountains are being uplifted and volcanic island arcs forming. It is likely that, in such areas, heat from within the Earth could be transferred to the charcoal layers above, from there onto the peat and other vegetation in the soil and finally when it comes in contact with forest litter it would develop into a natural forest fire. Ironically, in regions usually thought of as cool and wet, forest fires do occur naturally from time to time originating from charcoal layers found towards the base of peat as in the Western Highlands of Scotland.

Humans have long utilised fire as a means of altering their environment. The first evidence of the use of fire by hominids dates back 1-1.5 MY ago. Information from the measurement of charcoal in dated sediment cores has shown correlation between the rate of burning and human settlement. The practice of cultivation that dates back to 7000 BC could have largely contributed to man-made forest fires in earlier times.



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Forest Fires Worldwide

Devastating fires have occurred in many parts of the world. Most of these fires have been caused through human activities, including incendiary and to a small extent by natural sources of ignition. Severe forest fires have occurred in many countries in Asia, Africa, Europe, North America, South America and Australia. Many of the forest fires that occurred during the years 1997 and 1998 have been linked to a drier climate and have been attributed to events such as ENSO (El Niño Southern Oscillation). *Table 1* summarizes the occurrence of forest fires in different parts of the globe, their extent and their causes.

Forest Fires in the Indian Subcontinent

The first ever forest fire in India occurred about 200 million years ago coinciding with the time of evolution of early mammals on the Earth. This is based on an analysis, of charred fossil log remains of a late Triassic era forest fire in the South Rewa Gondwana basin of Madhya Pradesh, by the Geological Survey of India. Fires occur on a regular basis in many parts of India. Fires are frequent along the Himalayan foothills and also in the deciduous forests elsewhere. The pine forests of the Himalayas are highly susceptible to fire. The debris of pine accumulates as it takes a long time to decompose; the intervening period is one of high fire risk. In the deciduous forests of southern India, leaf shedding begins early in the year and by April the ground below is covered with large amounts of litter. This pattern in leaf shedding is common in the Mudumalai, Bandipur and Wynad wildlife sanctuaries, which have substantial areas under the deciduous forests. The biomass generated by many grasses such as *Themeda cymbaria* and *T. triandra* also contributes significantly to the combustible material of these forests. Humans are responsible for most of the fires here. Often the forest tribes light fires, during the collection of non-timber forest products, to make way within the densely grown patches of grasses and shrubs. Fires also do occur due to human negligence. Fires set



Country	Year of Fire	Causes	Burnt Area	Source
North America (Yellowstone National Park)	1988	Human, climate variations, lightning	> 250,000 ha	Ecological Monographs, 1997.
Israel	1995	Incendiarism	8,153 ha	IFFN-15
Mongolia	1996	Human	3 million ha	UNEP
Canada	1997	Human, lightning, others	620,471 ha	NRC, Compendium of Canadian Forestry Statistics, 1998
Brazil	1997	Human, climatic variations	3.3 million ha	INPA, UNEP
S-E Asia	1997	Human, climatic variations	4.5 million ha	UNEP
Indonesia	1997	Human, climatic variations	750,000 ha	WWF, UNEP
Russian Federation	1998	Human, climatic variations, lightning	2 million ha	UNEP, UNDAC, National Forest Fire Centre of Russia
Greece	1998	Human	100,000 ha	WWF

WWF: Worldwide Fund for Nature

UNEP: United Nations Environment Programme

UNDAC: United Nations Disaster Assessment Committee

NRC: Natural Resources Canada

IFFN: International Forest Fire News

INPA: Amazon National Research Institute

Table 1. Major forest fires in different countries across the globe.

on farmlands, to clear agricultural residues, sometimes spread into forests.

The forest departments in different parts of the country undertake controlled firing along fire lines of 5-10 m width in areas prone to fire due to human negligence. All forms of vegetation are pulled down along this fire line. Streams and rivers, agricultural areas and roads within the forest also obstruct the progress of wildfires.

Impact of Forest Fires

Forest fires are classified as crown fires, surface fires and ground fires on the basis of their intensity. The occurrence and intensity of fire in a forest depends on the topography, weather (precipitation and humidity, temperature and winds) and the forest type. These factors are popularly known as the 'fire environment' in the USA. A long dry season will provide a significant amount of flammable material. This coupled with gusty winds at the time of a fire could greatly enhance the intensity and extent of a fire.

The vegetation type is a decisive factor in forest fires. In the Mudumalai Sanctuary, the tropical dry deciduous forests are more susceptible to fire (see *Figure 1*) than the moist deciduous and dry thorn forests. While the moist deciduous forests receive higher rainfall, the dry thorn forest has very low rainfall and hence an insignificant amount of combustible matter. The dry deciduous forests have a longer dry season of about 5 months

and relatively large amounts of burnable matter in the form of litter and grass biomass. The species composition of a forest can also be decisive in forest fires. In the Mudumalai Sanctuary, the northeastern portions having a high density of *Shorea roxburgii* have the highest fire incidence than the rest of the forest – 7 times during the 11 years of recorded fire data available. We need to understand further whether such domination

Figure 1. A forest fire in the Mudumalai Wildlife Sanctuary



of *S. roxburgii* is a consequence of repeated fires, which have eliminated other species. Grasses having both perennial as well as annual life cycles can be seen in the Mudumalai Sanctuary. However, grass species with perennial life cycle predominate those with annual life cycle. The latter dry up after flowering and seeding and then form an acute fire hazard by means of their dead shoot material. Interestingly many of the perennial grasses have 'adapted' to an annual life cycle, perhaps as a consequence of the dry season and fire pattern in these forests. The question arises whether fire is a selective force leading to the spread and maintenance of these annuals and annual life cycle among perennials.

Apart from leading to monospecific forests, frequent fires could also lead to stands where most trees are even aged; they mature simultaneously and thereafter decline together. This could have a possible impact on the ecological diversity of these forests due to the lack of many more ecological niches, that are a feature of uneven-aged forests.

Fires directly affect many reptiles; there have been observations of the Indian rock python (*Python molurus*) bearing fire scars in the forests of the Mudumalai Sanctuary. Many ground-nesting birds could also be affected. Birds such as the yellow-wattled lapwing (*Vanellus malabaricus*) (Figure 2) build nests on the ground and lay eggs within them; in the event of a fire, the eggs could be charred. The ground-nesting songbird bobwhite quail of the USA, however, breeds more than once a year and hence can still reproduce successfully in the event of destruction of its eggs in a fire. It is believed that eggs are relatively safer from predation when in the ground than on the treetops.

Destruction of the microflora and microfauna in the top soil and litter layers in a forest by fire could have impacts on the organic decomposition and soil fertility in a forest. Although populations of these organisms could potentially build up quickly, a confounding factor is that, their recovery parallels that of the macroflora.



Figure 2. A hatchling of yellow-wattled lapwing.

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Not all impacts of fire in ecosystems are direct; there are some indirect impacts too. Post-fire outbreaks of insect and fungal attacks also do happen. In New Zealand the *Sirex* wasp had done immense damage to plantations; while it attacked forests that had not been under fire, a recent burn greatly enhanced its establishment and development. Sal heartwood borer (*Hoplocerambyx spinicornis*), a beetle, is associated with the sal forests (*S. robusta*) of Madhya Pradesh. In 1997, over one-sixth of the total Sal forests in Madhya Pradesh had been infested. In one of the most affected districts, about 800,000 trees had been attacked. It is interesting to note that the insect attack began in 1995 and assumed epidemic proportions in 1997. There are contradictory viewpoints about sal infestation by this beetle. Whereas one view attributes the condition to the lack of fire the other considers disturbances by humans, grazing or fire to be responsible for the outbreak of the epidemic. There also occurred large-scale mortality of adult trees of *S. roxburghii* at Mudumalai during the early 1990's. The cause of the mortality has been attributed to an unidentified stem boring cerambycid beetle. Incidentally this part of the forest has the highest fire frequencies in the whole sanctuary.

Beneficial Impacts

Regeneration of trees benefit from forest fires. For example in the Scottish highlands, some tree species produce vast quantities of seeds, but regeneration seldom occurs here. The litter layer in these woodlands prevent the regeneration, by creating conditions for an artificial drought, whereby the seeds are unable to grow a root system quickly enough to make contact with the underlying moisture reserves in the mineral soil. A fire would 'thin out' the litter layer, creating conditions necessary for regeneration. Fire enhances the productivity of ecosystems by releasing chemicals and nutrients locked up in the old herbage. This promotes growth of new shoots providing forage for herbivores. It has also been noticed in some forests that the dispersal pattern of herbivores within forests is associated with the presence or the absence of forage, which is indirectly associ-

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ated with the fire pattern in the forest.

Fire in a forest can be likened to a double-edged sword and herein lies the paradox. On the one hand it causes mortality of species in forests creating conditions wherein exotic species and weeds could proliferate and colonise parts of the forest. In the Mudumalai Sanctuary the undergrowth also features the exotic weeds such as *Chromolaena odorata* and *Lantana camara*. Incidentally their distribution is predominant in the disturbed areas, be it human, grazing or fire. On the other hand, fire randomly removes all plant growth in its path and hence is also widely used by foresters to clear the weeds.

Certain indirect effects of fire are found to be beneficial. For example in Georgia, USA, the brown-spot fungus spends part of its life cycle on the undergrowth shrubs of the forest and another stage on the trees. By burning the undergrowth at the appropriate time of the year the fungus can be prevented from completing its life cycle on the nearby trees, thereby preventing any destructive effect on these forests.

Stephen Pyne in his book *World Fire* compares the significance of fire in the forest to Nataraja, the Lord of Dance. The drum represents the rhythm of life; the torch, death; the wheel of flame, the mandala of birth, death and rebirth that fire epitomizes and makes possible. In this confrontation of opposites, the dance replaces the dialectic; Shiva holds them separate, and does not reconcile both drum and torch. Considered ecologically, Nataraja thus expresses in graphic language the great polarity of India, the annual alternation of wet and dry seasons. India's biota, like Shiva, dances to their peculiar rhythm, while fire turns the timeless wheel of the world.

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Suggested Reading

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- [2] Stephen J Pyne, *America's Fire Management on Wildlands and Forests*, Forest History Society, North Carolina, 1997.
- [3] Stephen J Pyne, *World Fire: The Culture of Fire on Earth*, Henry Holt and Company, New York, 1995.