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Effects of wildfires on flora, fauna and physico-chemical properties of soil-An overview

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Abstract: Fire is one of the most destructive threats faced by our forests. Fire is good servant but a bad master. The fire season starts in March/April continues up to June. Wildfires destroy not only flora (tree, herbs, grassland, forbs, etc.) and their diversity but also considerable long term negative impact on fauna including wild endangered species. Repeated fires can convert some shrub-lands to grass and fire exclusion converts some grassland to shrub-land and forest. Fires affect animals mainly through effects on their habitat. The extent of fire effects on animal communities generally depends on the extent of change in habitat structure and species composition caused by fire. Fire can also influence a physico-chemical property of soil including texture, color, bulk density, pH, porosity, organic matter, nutrient availability and soil biota. Drought, disease, insect infestation, overgrazing or a combination of these factors may increase the impact of fire on an individual plant species or communities. Common effects include plant mortality, increase flowering, seed production and numerous communal affects. Fire affected area showed reduction in species diversity both in flora and fauna. In a social context, fire directly affects people, property and infrastructure, thereby directly affecting the health and livelihood of individuals and communities.

Keywords: Diversity, Flora, Fauna, Habitat, Wildfires

INTRODUCTION

Forest fires are considered to be a potential hazard with physical, biological, ecological and environmental consequences (Jaiswal *et al.*, 2002). Majority of wildfires are initiated by nature as well as by man itself. People cause fires accounts 98% of the all fires, while natural factors are responsible for the remaining 2%. Of the people caused fires 23% was classified as arson, 27% as negligence and carelessness and 50% as unknown (Neyisci, 1985; Mol and Kucukosmanoglu, 1997; Mustafa, 2009). A total of 8,645 forest fire incidences have been reported during 2004-2005; 20,567 during 2005-2006; 16,779 during 2006-2007; 17,264 during 2007-2008; 26,180 during 2008-2009; 30,892 during 2009-2010 and 13,898 during 2010-2011, respectively in India. Central India including Madhya Pradesh is highly prone to forest fire followed by state likes Maharashtra, Chhattisgarh and Odisha (FSI, 2012). Fire can change plant composition, structure, diversity (Jhariya, 2011; Jhariya *et al.*, 2012; Jhariya, 2013; Kittur *et al.*, 2014a & b), destroy biomass, organic matter and influence the physical and chemical properties of soil including the loss or reduction of structure and soil organic matter, reduced porosity and increased pH (DeBano, 1990; Certini, 2005; Jhariya, 2014; Jhariya *et al.*, 2014). As per Raj and Jhariya (2014) fire is a big disaster in the forest causes a loss of natural resources, depleting of soil biomass resulting loss of various mobile nutrient. Impact of forest fire is varies from vegetational structure of forest community, availability of fuel load, frequency, intensity and fire return interval of that forest. Globally, biomass fires are burning between 3-4.5 million Km^2 per year, this is area equivalent to India plus Pakistan or more than half of Australia (Chatenoux and Peduzzi, 2012). However, impacts from biomass fires are numerous and severe. They include loss of soil cohesion from heat, which then accelerate soil erosion (from wind or rain), it destroys complex ecosystems and thus has a significant impact on biodiversity, it emits GHG, and biomass fires are responsible for 17.4% of GHG global emissions (Solomon *et al.*, 2007). Fire encouraged fire-tolerant tree species and discouraged fire-sensitive species as reported by Ivanauskas *et al.* (2003). Fires may also play a significant role in regulating ecosystem productivity and diversity by promoting mineralization of nutrients stored in organic matter and allowing the invasion of rapid growing early successional species (Busse *et al.*, 1996; DeBano *et al.*, 1998; Boerner *et al.*, 2009). Soil provides numerous essential ecosystem services such as primary production (including agricultural and forestry products); regulation of biogeochemical cycle (with consequences of the climate); water filtration, resistance to diseases and pests and regulation of above ground biodiversity (Jhariya and Raj, 2014). Fire leads to important change in physical, chemical and biological properties of soil, which are relevant for the future productivity and sustainability of ecosystem (Neary *et al.*, 2005). Wang *et al.* (2012) reported that fire increases C and N availability and increase microbial activity, which consequently decreases the potential rates of C sequestration. The extent and duration of these effects on soil properties depend on the intensity and residence time, fire severity (Certini, 2005). Large and damaging wildfires have occurred in Australia (Bradstock *et al.*, 2009), Canada (Wang *et al.*, 2010), China (Casanova *et al.*, 2008), throughout the Mediterranean basin (Leone *et al.*, 2009), Siberia (Achard *et al.*, 2008), Southeast Asia (Khandekar *et al*., 2000) and the United States, particularly in Alaska, the southeast and west (Littell *et al.*, 2009). Fires effect is generally depends upon the presence of fire hazard materials i.e. accumulation of fuels, moisture content and ignition incidence. Fuel accumulation is generally depends on the production and decomposition of ignitable material, which varies among the vegetation and forest types. Kittur and Jhariya (2012) reported that duffs litter and wood litter in both high fire and medium fire zones in the post-fire season was decreased. While in low fire and non-fire zones the fuel load was increased due to protection from fire in moist deciduous forest of Achanakmar-Amarkantak Biosphere Reserve. Fire influence nutrients status of soil by burning of organic matter. While making fire line and fuel-breaks are most remarkable method for fire-suppression in several forests. But some research indicates that fire has been part of Indian ecosystems for several millennia and that fire prevention has lead to the proliferation of invasive species, which ironically has increased the fire frequency in ecosystems (Hiremath and Sundaram, 2005). The purpose of this paper is to review the effect of wildfire on flora, fauna and various property of soil, which are important in maintaining healthy ecosystem.

EFFECTS OF WILDLIFE ON FLORA

Fire damages the tree, shrubs and plants. Globally, more than 350 m ha of forests was burned in 2000, equal to 6% of the world's geographical area (FAO, 2007). The extent of damage depends on the species, age, intensity of fire and vegetation types.

EFFECTS ON FORESTS

Fire enter forests through in-cendiarism and accidental fires (Kodandapani *et al.*, 2008) and introduced by various indigenous communities to aid in the collection of non-timber forest products (Narendran *et al.*, 2001; Saha, 2002). The extent of damage and response of tree to fire is depends upon the fire parameter including intensity, severity, soil heating, season of burn, residence time and time since last fire. In addition, numerous physical and climatic factors (e.g., fuel condition, weather, slope, and aspect) as well as biological factors (plant morphology and physiology) also influence post-fire effects on plant communities. Indian forests are broadly classified into 16 types (Champion and Seth, 1968). Of these, large area of tropical deciduous forests is under intense pressure due to recurrent fires. Of the six vegetation types, dry deciduous forest shows significantly high burnt area, followed by thorn forest, broadleaved forest, dry savannah, Scrub and grasslands (Krishna and Reddy, 2012). Seasonally dry tropical forests are considered to be the most threatened from natural fires, land use change and escaped fires following slash and burn agriculture during the dry season (Murphy and Lugo, 1986a; Kauffman *et al.*, 2003). Fire is also effect on biomass and carbon accumulation by directly reduce biomass and carbon stored in seasonally dry tropical forests (Kauffman *et al.*, 2003; Van der Werf *et al.*, 2003). As per Jhariya *et al.* (2014) forest fire have significant impact on biomass and carbon storage pattern on tree species while the shrubs produce higher biomass in the area where fire is more common or high severity as compare to protected site due to reduction of competition due to open canopy in tropical dry deciduous forest.

According to Vargas *et al.* (2008), carbon stored in belowground fractions could rapidly be lost if forests are disturbed and the thin soil is lost by fire or erosion with a potential carbon loss between 120 and 150 Mg Cha^{-1} in a mature forest. In addition, fires smoke has direct impact on the surface energy budget and increase atmospheric temperatures (Wang and Christopher, 2006) and produce feedbacks on the evaporation processes, cloud formation and precipitation patterns that could affect the hydrologic cycle at regional scales (Menon *et al.*, 2002; Allen and Rincon, 2003). Fire also influences the pattern of litter-fall and nutrient input in forest. Dezzeo and Chacon (2006) have worked on effects of fire on litter-fall and nutrient input in forests of Gran Sabana, Southern Venezuela and reported that total annual litter-fall was 5.19 Mg ha^{-1} $year^{-1}$ in the tall forest (tall primary forest), 5.65 Mg ha^{-1} $year^{-1}$ in the medium forest (slight fire affected forest) and 3.93 Mg ha^{-1} $year^{-1}$ in low forest (strong fire affected forest). Result shows that annual litter-fall values of the tall and medium forests did not differ significantly between them, but were significantly higher than the annual litter-fall value for the low forest. Also between tall and medium forests, the annual input of nutrients was similar with the exception of Ca, which was significantly higher in tall forest and low forest showed significantly lower annual inputs of N and P, and a significantly higher input of K, in compared tall and medium forests. Broad leaved species are more vulnerable than the conifers due to corky bark. Resin tapped tree are severally affected by fire than the non-tapped trees.

According to Chandra (2005), high resin content in sub-tropical pine region and dry condition in the tropical region have been a major cause of fire spreads in India. Fire also influences the richness and diversity of tree seedling species (Jhariya and Oraon, 2012a) and it may causes killing of both root-crown re-sprouters and root -sprouters. The decline of species richness in time after forest fire might be caused primarily by the elimination of some early species which were over topped and shaded out by rapidly growing fire hardy species. In high fire zones more than 44% seedling population decreased after fire season, it will adversely affect the forest stratification in future. Fires have negative impacts on native plant diversity, with varying effects on species and ecosystems including the potential for localized extinction (Kittur *et al.*, 2014b). Fire has positive effect on the plant diversity in the Oak forest (Bakhtar *et al.*, 2013**)**. Saha and Howe (2003) reported that, diversity was also significantly higher among seedlings in the fire-excluded plots than the burned plots, amounting to a 28% reduction in diversity in tropical dry forest in Mendha Forest of central India. Characters including thick bark, fire-stimulated sprouting, germination or seed dispersal, resistance to rotting, modified seedling structure and thick heat-resistant buds, which show fire tolerating capacity of the tree species (Myers, 1990; Abrams, 1992; Bond and Van Wilgen, 1996; Wade *et al.*, 2000).

Lodgepole pine has a hard coated seeds or serotinous cone, open to release seed in the presence of heat of fire. In India, about thousand hectares of forests of south western Himalayan region (Uttarakhand) are burned every year by the forest fires. The vulnerability of the Indian forests to fire varies from place to place depending upon the type of vegetation, climate and season of fire. The coniferous forest in the Himalayan region comprising of fir (*Abies* spp.), spruce (*Picea smithiana*), *Cedrus deodara*, *Pinus roxburghii* and *Pinus wallichiana* etc. is very prone to fire. Various regions of the country have different normal and peak fire seasons, which normally vary from January to June. In the plains of northern and central India, most of the forest fires occur between February and June. In the hills of northern India fire season starts later and most of the fires are reported between April and June. In the southern part of the country, fire season extends from January to May. In the Himalayan region, fires are common in May and June (IFFN, 2002). Physiographic factors, i.e. elevation and slope aspect across different forest types is also influence the extent of fire. Joshi *et al.* (2013) studied on effects of fire in relation to aspects on number of seedling, sapling and biomass stock in Oak and Pine mixed forests of Kumaun central Himalayas, India. They reported that those studied sites where fire frequency was regular (every year) the number of sapling and seedling count was 360 individual ha^{-1} and 370 individual ha^{-1} in south-eastern aspect, while this number increased to 610 and 370 individual ha^{-1} for the north-western aspect where fire occurred once in a five year. The forest tree biomass and carbon also decreased in south-western aspects (9.47 t ha^{-1} and 38.54 t ha^{-1}) than north-western site (62.54 t ha^{-1} and 49.93 t ha^{-1}), where fire frequency is every year. On southern aspects of pine forests in Garhwal Himalaya, frequent fires are common. This is due to the high inflammability of igniting material due to a low water content and high surrounding temperature. Moreover, the forests growing on the southern aspects are generally exposed to harsh climatic conditions and are prone to various natural disturbances like wind fall, wild fire, etc., which hinder accumulation of large amount of biomass on these aspects (Sharma *et al.*, 2011).

According to Jhariya (2014) fire have negative impact on carbon storage, carbon stock, net production and potential C sequestration in a seasonally dry forest ecosystem. Site productivity is also influence by the consequence of wildfire. Productivity is maintained by the presence of essential nutrients including N, S, P, K, Ca etc, which can be altered by fire. Klock and Grier (1979) reported that detrimental effects of fire on the long term site productivity may be greater in forest regions lacking significant vegetative N-fixation. Also fire can reduce Nitrogen status, which results in lower net primary productivity (NPP) and carbon storage. Thornley and Cannell (2004) reported that loss of carbon on combustion of about 500 kg C ha^{-1} $year^{-1}$ represented about 17% of the NPP (3000 kg C ha^{-1} $year^{-1}$) in Boreal forest. Rocha *et al.* (2013) reported that total NPP for control plot was higher (10.36±0.64 Mg C ha^{-1} $year^{-1}$) than burn plot (8.80±0.62 Mg C ha^{-1} $year^{-1}$) in dry southern limit of Amazon rainforest (Brazil). Forest biomass burning is also influence emission of CO_2 in environment, which causes greenhouse effects. Tropical deforestation provides a significant contribution to anthropogenic increases in atmospheric CO_2 concentration that may lead to global warming. So, forest plays a lead role for maintaining the CO_2 level, C sequestration and protects the ecosystem from global warming. Badarinath and Vadrevu (2011) reported that, 2,414 Km^2 area has been estimated to be burnt annually in forested area including closed broad-leaf deciduous forest, closed needle-leaf evergreen forest, closed to open broad-leaf evergreen/semi-deciduous forest, closed/open mixed broadleaf/needle-leaf forest, mosaic forest/grassland/shrub-land and open broad-leaf deciduous forest in India. The CO_2 emissions averaged across seven years were ~6.34 CO_2 Tg/yr from biomass burning of these forest types. Susceptibility and vulnerability to wildfire is also depends on type of forest. As per report of IFFN (2002) maximum frequent fire (50%) was reported in north-eastern region as compared to minimum (5%) in Dry deciduous. Also, maximum occasional fire (60%) was reported in Moist deciduous forest in comparison to lowest (35%) in Dry deciduous forest. It was shown in Table 1.

EFFECTS ON SHRUBS

Morphological characteristics including crown size and shape, height, branch density, ratio of live to dead crown material, crown base location with respect to surface fuels and total crown size are determine a shrubs vulnerability to fire. In general small buds and branches, due to their small mass and high surface area to volume ratios, are more susceptible to lethal heating than large buds. Bark thickness, composition, cracks and moisture content is also determining the protecting quality of bark and fire impacts on shrubs stem. Fire can also cause root mortality. According to Sheuyange *et al.* (2005), frequent fires reduced shrub cover temporarily and promoted herbaceous cover. However, the frequent fires positively influenced the herbaceous and tree species. When canopy disturbance and surface fires occur in tandem or relatively close together in time, the increase in light can contribute to the development of a recalcitrant understory layer (Mallik, 2003, Payette and Delwaide, 2003). Jhariya and Oraon (2012c) censured lianas and shrubs in four sites (High, medium, low and non-fire zone) of tropical forest ecosystem of Chhattisgarh, reported that density of lianas and shrubs was varied from 1120 to 2480 individuals ha^{-1} during pre-fire season and 1920 to 3360 individuals ha^{-1} at the time of post-fire season. The total 11 species were recorded during pre-fire season whereas it had increase after the fire (20 species). The forest fire in addition to the intermittent canopy structure provides favorable habitats for the development and high abundance.

The potential of lianas and shrubs to regenerate well naturally where the fire events and/or higher anthropogenic disturbances are common (Rodgers *et al*., 1986; Kumar and Thakur, 2008; Sahu *et al.*, 2008; Mishra *et al.*, 2008; Jhariya and Oraon, 2012c). Various reasons are reported by different workers which supports to lianas and shrubs growth like fire derived nutrient deposition (Asner *et al*., 1997; Dawson *et al*., 2002; Chen *et al*., 2010; Jhariya, 2010), availability of tree-fall gaps resulted from the natural and/or anthropogenic disturbance (Putz, 1983; Laurance *et al.*, 2001; Schnitzer and Bongers, 2002; Schnitzer and Bongers, 2011; Schnitzer *et al.*, 2012), there may be less competition due to open canopy (Perez-Salicrup *et al*., 2001; Gianoli *et al*., 2010; Schnitzer *et al*., 2012) because fire causing damage to sensitive species which resulted killing of the trees and new growing ones (Jhariya, 2013). The decline of species after forest fire might cause elimination of some early species which were over topped and shaded out by rapidly growing woody plants, especially resprouters (Miller, 2000).

Table 1. Susceptibility and vulnerability of Indian forests to wildfire (IFFN, 2002).

Type of forest	Fire frequent (%)	Fire occasional (%)
Coniferous	8	40
Moist Deciduous	15	60
Dry Deciduous	5	35
Wet/Semi-Evergreen	9	40
North-Eastern Region	50	45

EFFECTS ON GROUND VEGETATION

Burning alone can result in increased forbs abundance (Wienk *et al.*, 2004) graminoid abundance and under story species richness (Busse *et al*., 2000; Laughlin *et al*., 2004). Both Herbivores and fire frequency together drive forest-grassland dynamics in savannas (Holdo *et al.*, 2009). The herbs number, density, diversity increase after fire because of reduction in number of tree species and permit more to more light in the ground floor. Jhariya and Oraon (2012b) studied the impact of forest fire on herbaceous vegetation of four sites (High, medium, low and non-fire zone) in Bhoramdeo Wildlife Sanctuary situated in Chhattisgarh, India and reported that fire cause increased in species number (19) and density during pre-fire (112000 to 668000 ha^{-1}) and species number (30) and density (230000 to 510000 ha^{-1}) during post fire season. Also the herb layer showed higher density after post-fire in high and low fire zones, whereas decreased in medium fire zone due to change in season, the density of herb layer also increased (40.03%) after post-fire in non-fire zone. The areas or sites facing forest fire or other biotic disturbances supports more herbaceous vegetation as compared to undisturbed one due to the lower competition for various resources (Jhariya and Oraon, 2012b; Jhariya *et al*., 2013). The herbaceous vegetation increase after fire events because of general reduction in tree cover that brings more sunlight to the soil and for growing understorey or herbaceous cover (Moretti *et al*., 2002; Sheuyange *et al.*, 2005; Keith *et al.*, 2010). Azizi *et al.* (2006) also stated that the fire mainly affects the undergrowth vegetation, and highest species diversity in moderately disturb ecosystem than in undisturbed ecosystems (Connell, 1978; Decocq *et al.*, 2004).

EFFECTS ON WILD ANIMALS

Fire has influenced composition, structure and landscape patterns of animal habitat. Wildlife may be affected by fire both through direct mortality or habitat alteration (Lyon *et al.*, 2000b). Some fires alter the vegetation structure of forest, which is work as shelter and hiding cover for wild-animals and vegetation structure spatially arranged all the resource needed to live and reproduce. Dead wood on the ground is an essential habitat component for many birds, small mammals and even large mammals, including bears

(Bull and Blumton, 1999). Fire cause large dead logs on the ground, harbor many invertebrates and are particularly of ants; they also provide shelter and cover for small mammals, amphibians and reptiles. Ground-nesting birds could be killed prior to fledging (Reinking, 2005) and forest floor arthropods in the egg or larval stages may be more vulnerable to loss (Niwa and Peck, 2002). Dark-eyed juncos (*Junco hyemalis*) often choose nest sites in unburned patches within prescribed fire units (Sperry *et al.*, 2008). Amphibians are also likely to be more active with the moister conditions under which prescribed fires are typically conducted (Pilliod *et al.*, 2003). The longer term responses of many bird species are thought to be due primarily to structural changes of vegetation or changes to food resources, as affected by fire severity (Huff and Smith, 2000; Kirkpatrick *et al.*, 2006).

EFFECTS ON SOIL PROPERTY

Fire can influence physical and chemical properties of soil.

Effects on physical properties of soil: Soil physical properties are those characteristics, process, or reactions of a soil that are caused by physical forces that can be described by, or expressed in, physical terms or equations (SSSA, 2001). It can increase the soil pH (Aref *et al.*, 2011), however significant increase occurs only at higher temperature and fire can also cause increase in bulk-density of soil because of collapse of aggregate and clogging of voids by the ash and dispersed clay minerals; as a consequence, soil porosity and permeability decreases (Certini, 2005). Jhariya (2014) stated that forest fire have a significant impact of soil physical properties like texture, bulk density, moisture regime etc. Fire can also influence the soil water repellency (WR). High surface temperature 'burn' off organic materials and create vapours that move downward in response to a temperature gradient and then condense on soil particles causing them to become water repellent (Letey, 2001). As a result of increased hydrophobicity (water repellency), infiltration rate to be decreases and increased runoff that often results in increased erosion (DeBano, 2000). Ekinci (2006) reported that wildfire can increased soil pH, electrical conductivity (EC), available P and K, organic N content; reduced CEC, porosity, urease activity, total organic carbon (TOC) and soil water content. But Aref *et al.* (2011) reported that electrical conductivity (+/-) significantly decreased from 2.13 in unburned sites to 1.1 dS m^{-1} in burned sites in Al Hilia Forest (Saudi Arabia). The component of soil texture (+/-) is also affected by nature and duration of fire. Nardoto and Bustamante (2003) reported that percentage of sand, silt and clay varied from burned to unburned site at the depth of 0-5cm in Cerrado *Stricto sensu* sites. According to him, except of clay%, percentage of sand and silt are increased from unburned site (15%, 11%) to burned site (21%, 13%) respectively but the value of clay decreased from unburned site (74%) to burned site (66%). Also reported that bulk density increased from 0.64 to 0.67gcm^{-3} and per cent of total porosity decreased from 76.0 to 75.6. Aref *et al.* (2011) reported that fire did not affects soil texture and this was indicated by the fact that sand, silt and clay (%) were not significantly different when burned locations were compared with normal ones in Al Hilia Forest (Saudi Arabia).

Effects on chemical properties of soil: Forest fire can influence the availability of organic carbon and soil nutrient dynamics (Jhariya, 2014). Globally, forests are the most important carbon pool in terrestrial ecosystems (Dixon *et al.*, 1994), containing 66-80% of all carbon stored in above-ground biomass and 45% of that found in below-ground terrestrial pools (Dixon and Turner, 1991; Waring and Running, 1998). Soil organic matter (SOM) represents the third largest terrestrial carbon pool, with a global estimated total of 1526 PgC (Lal, 2004). Total and partial destruction of soil organic matter is generally depending on fire severity, intensity, dryness of the surface organic matter (OM) and fire type and other factors like soil moisture, soil type and nature of burned materials. Nabatte and Nyombi (2013), reported that mean soil organic matter content in the burnt plots was lower (4.593%, range 2.6-6.1%) than that of the unburned plots (5.11%, range 2.8-8.2%), implying that burning decrease the organic matter content. Low intensity prescribed fire usually results in little change in soil carbon, but intense prescribed fire or wildfire can result in a huge loss of soil carbon (Johnson, 1992). Fire effects on organic carbon (+/-) of mineral soil range from no effect (Johnson and Curtis, 2001; Certini, 2005) to a loss of 60% (Bormann *et al.*, 2008). Nutrient status (+/-) of soil is also influence by occurrence of fire. Effects of fires on soil organic C and total N was highly variable and controversial. Some studies demonstrated that fires significantly decreased soil organic C or total N (Mabuhay *et al.*, 2003; Zhang *et al.*, 2005; Nabatte and Nyombi, 2013), increase (Boerner *et al.*, 2004) and neutral effect or little effect of fire (Wilson *et al.*, 2002; Knoepp *et al.*, 2004). Also burn soil has low mean phosphorus content (5.77 mg Kg^{-1}, range 1.1-29.6 mg Kg^{-1}) than un-burnt plots (6.34 mg Kg^{-1}, range 1.2-39.2 mg Kg^{-1}) (Nabatte and Nyombi, 2013) and remains unchanged (Neff *et al.*, 2005). Ammonium (NH_4^+) and nitrate (NO_3^-) are the inorganic forms of nitrogen that originate during the burning (Certini, 2005). Because of high temperature, soil macro-nutrients (+/-) are loss through volatilization as a result of wildfire. The behavior of micronutrients, such as Fe, Mn, Cu, Zn, B, and Mo, with respect to fire is not well known because specific studies are lacking (Certini, 2005). Garcia-Marco and Gonzalez-Prieto (2008) has reported that prescribed fire cause short-term changes in the soil micro-nutrient availability, increasing that of Mn and Zn and decreasing that of Fe and Co; they found no effect on Cu availability. The most significant short-term effects of the wildfire are the increases in the soil solution concentrations and /or leaching of mineral forms of N, S and P (Murphy *et al.*, 2006). Wildfire can also influence the C/N ratio (+/-) in somewhat extent. Prescribed burning reduced the thickness of the forest floor and caused a low C/N ratio (Hogberg *et al.*, 2007). Badia and Marti (2003) reported that C/N ratio, soil organic matter content and nutrient availability all increased after burning.

Effects on biological properties of soil: Fire can affects biological organisms including invertebrates and micro-organism (soil bacteria, mycorrhiza) in direct and indirect way. Soil dwelling invertebrates play an important role in litter decomposition, carbon and nutrient mineralization, soil turnover and soil structure formation (Neary *et al.*, 1999). Fire generally affects abundance, species composition, instant mortality and habitat alteration of soil dwelling invertebrates. Soil microbial biomass (+/-) is a potential source of plant nutrients and a higher level of soil microbial biomass is an indicator of soil fertility and soil health. This microbial biomass of soil is defined as the part of the organic matter in the soil that constitutes living smaller microorganisms. The soil microbial biomass carbon (+/-) comprises 1-3% of total organic carbon in soil (Jenkinson and Ladd, 1981). Fire in tall grass prairie has been found to reduce both SMBC and SMBN (Ajwa *et al.*, 1999) but can be increase SMBC via a long term increase in root production (Ojima *et al.*, 1994; Fynn *et al.*, 2003).

Fire results reduction in micro-organism biomass, which play an important role in nutrient cycling and energy flow in forest ecosystem. Effects of fire on soil microbial biomass may be positive (Mabuhay *et al.*, 2003; Liu *et al.*, 2007), negative (Choromanska and DeLuca, 2001; Rodriguez *et al.*, 2009), or neutral (Rutigliano *et al.*, 2007). Jhariya (2014), found considerable site to site variability in the amount of microbial biomass carbon associated with the soil sampling depth, season and different fire regimes as well. These all the fire sites differed in the quantity and floristic composition of the vegetation. The numbers of tree species affect the availability and biochemical composition of organic matter inputs in soil (Leckie *et al*., 2004). Changes in soil microbial biomass induced by fire have been noted to be more complex. The forest fire significantly decreased microbial biomass C, which was in agreement with some previous reports (Grady and Hart, 2006; Waldrop and Harden, 2008; Campbell *et al*., 2008; Rodriguez *et al*., 2009; Swallow *et al*., 2009; Sun *et al*., 2011). Otsuka *et al.* (2008) reported that community structure of soil bacteria in post-fire non-climax forest several years after fire can be more heterogeneous compared with that in unburned climax forest. Campbell *et al.* (2008) also reported that burning treatment caused a significant reduction in soil carbon sources and therefore altered the soil microbial community structure.

Conclusion

Fire is a natural ecological disturbance factor in forest and these forests plays an important role to maintain ecosystem structure and their function and provide services include carbon storage, production of O_2, production of biomass (timber, fire wood) and production of pharmaceutical products. Wildfires create a myriad of environmental, social and economic impacts. Wildfire impacts includes total acres burned, cost of fire suppression, damage to homes and structures, alteration of wildlife habitat, damage to watersheds and water supply, damage to public recreation facilities, evacuation of adjacent communities, tourism impacts, damage to timber resources, destruction of cultural and archaeological sites, costs of rehabilitation and restoration, public health impacts, transportation impacts. To save the forest from scourge of fire is thus a central responsibility of forest managers in this country. From conservation point of view, maintaining and sustaining these all forest types is important as they harbor high biodiversity of not only plant species, but are also a preferred habitat for several wild animals. From management perspectives a participatory approach should incorporate for betterment of environmental conservation and ecological stability. Use of controlled fire, fire lines, fuel breaks, fuel load removal and mapping of fire sensitive areas are key principles to minimize fire risk. Remote sensing and GIS is novel techniques for detection and monitoring systems for fire prediction and it must become an integral part of fire management.

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