Chapter-2

REVIEW OF LITERATURE
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The vegetation has always been recognized as most prominent and characteristic aspect of the landscape. Its complexity at any place is always determined by climatic, edaphic, physiographic and biotic factors. Therefore, structure and functions of vegetation in relation to its environment forms the basis for complete understanding of the dynamics of an ecosystem. The floristic composition is one of the major distinguishing characters of the community because each of the species of the community has not only its own ecological amplitude but also its particular relationship to the environment and to associate species. Thus, the nature of the plant community at a place is determined by the species that grow and develop in such environment. The relevant literature on the effect of forest fires on floristic dynamics, soil properties and socio-economic aspect are being reviewed under the following heading:

2.1 Forest Fires and Floristic Dynamics

2.1.1 Trees, Shrubs and Herbs

As the floristic composition vary with season, consequence of biotic and abiotic factors, so it cannot be used only for studying the stratification and population structure. In order to recognize the complete composition and functions of any ecological unit, it becomes essential to study the phytosociological characteristics along with floristic composition.

Garren (1943) shows better increase of herb growth including wild legume in Slash Pine region by burning of both forest and other range in southern United States. Oosting (1944) reported that on comparison with unburned area, over storey trees on the area of surface fire had a basal area 5 per cent lower, but there were facts that the number of herbs had been affected immediately after the fire, the changes were all provisional. There were little difference between burned area and unburned lands. *Smilex spp.*, *Viburnum acerifolium*, *Aesculus neglecta* and *Euonymus americanus* were found only in unburned area where as *Lonicera japonica*, *Rubus spp.*, *Rhus capallina* and *Smilex spp.* were seen in burned areas. The only exception was an increase of Poison Ivy and Virginia creeper on the surface of fire area in even aged, 35 years
stand of old field Loblolly Pine (*Pinus taeda*) in the New Hope Division (Orange Country, North Carolina of Duke forest.)

Little and Moore (1949) found that the depth and continuity of the forest floor of all types of stands in the Pine-Oak forests of Southern New Jersey was reduced due to prescribed burning. Also it was observed that shrubs were killed back and reduced in amount. Areas periodically controlled burned, regularly damage by the fires caused marked decrease in the density of shrubs, these being substituted in part by herbs. Prasad (1949) reported that no significant loss of growth in respect of diameter in burned area was found as compared with that of unburned areas in *Pinus longifolia* forests. Shepherd *et al.* (1951) found that in Pond Pine stands, fire may be essential for regeneration. Immediately after an intensely hot fire, 2250 seedlings / acre were established, with a further 1700 / acre in the next year.

Buell and Cantlon (1953) revealed that occurrence of prescribed burning had a remarkable effect on the lower vegetation layers in the New Jersey Pine region. Cover of *Gaylussacia baccata* was only about 3 per cent in the plots burned annually and approximately 40 per cent in the control. With more frequently burning there was a rather rapid reduction in the debris. There was a great decline in shrub layer. Cover of *Gaylussacia baccata* was only 0.5 per cent in the annually burned plots and 14 per cent in the control. In general, the herbaceous layer increase in cover of angiospermous herbs was only 0.3 per cent in controlled while in the annually burned plots it was 5.5 per cents. The bracken fern, *Pteridium aquillinum* was a single herb which the sampling designated to have higher cover values in the less frequently burned plot.

Horton and Kraebel (1955) documented two types of covers: the temporary cover of annual herbs, perennial herbs, and short lived shrubs; and the permanent shrub cover consisting of shrubs which made up the mature brush cover. Seedlings also developed from Chamise seeds which germinated after the fire. Individuals of other species, such as Hoary leaf ceanothus were killed completely by fire but most of the other seedlings developed. Some species of the enduring cover, such as Chamise, after fire sprouted vigorously from the root crown. A few seedlings of woodland *Chaprall spp.*, e.g. *Prunus ilicifolia* and *Rhamnus crocea* appeared on the plot after the fire in the Chamise Chaparral of Southern California.
Martin (1955) reported that shrubs and herbs appeared during the first two year were all of sucker geneses developed from seeds which were surviving in the soil in Spruce-Birch-Oak Maple site in Nova Scotia. Lay (1956) suggested that fire increased Viburnum molle, Callicarpa americana and herbs in summer and winter burnings in Pine forests of East Texas. Lotti (1956) revealed that the Baberry was more susceptible to control than any of the important shrub or hardwoods in coastal plain Loblolly Pine forests. Winter or dormant season fires killed almost a small number of Baberry stems. Although 90 to 60 per cent respectively of Sweetgum and Baberry were killed with four annual fires. The difficulty was the kill back and the regardless resprount of few hardwoods such as Sweetgum, above one inch (Diameter at breast height) DBH. Similar development were followed in mortality among other hardwoods. Blackgum (Nyssa sylvatica M.) suffered a kill of about 40 per cent over the 4 year burning period.

Hodgkins (1957) reported that legumes, euphorbs and composites enhanced in density in first season after burning but instantly returned to normal shrubs. Vine increased by third growing season, hardwoods under 6 feet height decreased but returned to normal by third season, and grasses cover varied oppositely with that of trees, shrubs and vines in the Loblolly shortleaf Pine forests of the upper coastal plain of Alambama. Uggla (1957) found that vegetation recurring after the fire was Deschampsia flexuosa, Vaccinuim spp., Epilobium, angustifolium, and Ribes idaeus (already present in a few months) for the first few year followed by Pleurozium schreberi and Hylocomium splendens in Pine and spruce stands.

Brown (1960) found that due to fire there was decrease in species and the species reproducing by the seeds had been greatly reduced by fire in Rhode Island Forests. The intolerant sprouting species capable of surviving fire, including Quercus velutina, Quercus alba and Quercus cocccinea were the major occupant of the burned areas. These three species predominated in all size classes, shows that species composition would remain Oak indefinitely. The important constituents of unburned stands were Oaks, but other species including Fagus grandfolia, Betula lenta, Pinus strobes, Tsuga canadensis and Bentula lutea generally occurred in all size classes. It was possible that in future, these species would increase in the overstorey.

Potter and Moir (1961) found that species present in the unburned stand, not elsewhere, were Disporum Trachycarprum, Ranunculus abortivus, Viburnum edule, Disporum
trachycapuram, Ranunculus canadense, Mentha arvensis and Anemone canadense in deciduous woods, Turtle Mountains North Dakota. An adjacent burned stand on similar topography and soil contained the same species of trees but their significance was diverse. Quercus macrocarpa was reduced from second to fourth, Ulmus americana from fifth to seventh and Populas tremuloides exceeded Quercus in importance percentage by fifth times. The alter in relative density between unburned and burned stands were Quercus macrocarpa (16 to 3 per cent), Populas tremuloides (38 to 70 per cent), Franxinus pennsylvanica (13 to 10 per cent ) and Betula papyrifa (10 to 6 per cent). Relative basal areas changed as follows: Quercus macrocarpa (24 to 2 per cent), Populas tremuloides (38 to 85 per cent), Franxinus pennsylvancia (8 to 3 per cent) and Betula papyrifa (13 to 7 per cent). The most evident influence of the fire was a change in relative foliage cover of Corylus spp. from 56 per cent in urban stands to 80 per cent in burned stands.

Dansereau (1960) reported that the species composition is one of the major characters of plant community. Phyto-sociological examination of a plant community is the first and foremost basis of the study of any portion of vegetation as it is a requirement to the understanding of community structure and organization. While discussing the significance of species diversity, Odum (1963) stressed that the number of species reflects the gene pool and adaptation potential of the community. Species diversity is a very useful factor for comparing two communities especially to study the influence of biotic disturbance or to know the state of succession and steadiness in the community. The plant climate of the site and also to a certain extent the effect of biotic operations is revealed by the classification of vegetation in the various life form classes (Raunkiaer, 1934).

Cocharane (1963) reported that sclerophyll forest vegetation was uncovered in bush fire, the trees were defoliated and rarely entirely burned, but the shrubs layer was entirely razed and reduced to ashes. Eucalyptus oblique and Eucalyptus baxteri were outstandingly resistant to bush fires in the mount Lofty Ranges, South Australia. The erect, branchless lower stems and thick fibrous bark of the stringly bark gums were shielding adaptations against bush fires, enabling the tree to virtually remain unaffected by a fire. A dynamic development of adventitious shoots from dormant buds, usually throughout the entire length of the trunk was rapid falling in bush fire consequently the original structure and composition of the tree stratum was preserved. Fire succession was restricted to the scrub strata.
Plants that can resist or endure fire have certain adaptive characters that afford the greatest fire-survival probability and due to their thick bark these plants protects the cambium from the heat of the fire (Gill and Ashton, 1968; Hare, 1965; Martein 1963; Vines, 1968) and they tend to be tall, minimizes the possibility of crown fire due to their height. Navesh (1975); Trabaud (1987) studied that wildfires are an important characteristics of Mediterranean ecosystems and many species have evolved strategies that permit them to survive periodic fire. Brown, (1976); Montgomery and Cheo, (1971) reported that in conifers, density varies to a smaller extent among populations of a given species and considerably among species in different geographical locations. Conifers have surface to volume ratios in the neighbour level of 54 to 99 cm².

Grelen (1976) reported that endurance and growth were high for all plots and were impervious by burning. Cover of hardwoods and shrubs over 6 feet high on burnt plots (2 per cent),was considerably less than on unburned plots (4 per cent),but differences in cover under 6 feet high were not significant in a young Slash Pine plantation, Louisiana. Gill (1975) chooses the example of Acacia Cyclops, originally originated in Western Australia and later spread to South Africa to illustrate this fire-related trait. Taylor (1977) revealed that this plant has become a problem of particular attention with respect to the conversation of native species in the gap of wood region. This species stress large amounts of seed in the ground (up to 250 x 106/ ha) and is propagated rapidly by fire at the expenses of native flora.

Huston (1979) and Denslow (1985) found that the disturbance promotes the co-existence of species at small scales by reducing the supremacy of strong competitive species, thereby increasing overall richness. According to Rundel (1981) the long needles in conifers and in some species with comparable leaf structure produce a fine ventilated litter that eases ground fires, thus preventing undue fuel build-up that could encourage crown fires or lethal cambium damage. Frequent fire helps maintain fire adaptation species and ecosystems such as Pinus roxburghii forests. In communities with a low soil nutrient content fire may lead to the rapid decomposition and recycling of minerals. Under such circumstances, natural selection may have lead to a structural and chemical composition that supports high flammability and thus helps maintain a variety of stages and species in the community.
Rundel (1981) suggests that assuming that fire adapted plant species may present reproductive modifications (Sprouts from root systems, serotinous cones and fire encouraged germination) and anatomical adaptations for survival (thick bark, epicormic buds). Such species may have developed structural and chemical modifications that can have a biological effect on natural fire frequency. Abrahamson (1984) revealed that species diversity increased significantly after fire on inadequately drained sites, but there was no alter at better drained sites. Fire did not initiate succession on these sites, with species resprouting soon after fire on resisting fire.

Malik and Gimingham (1985) observed that the most susceptible to fire was Junipurus communis, which was killed by 800°C treatments and which made only meager regrowth after exposure to 600°C. All the Ericaceous spp., notably Erica tetralix, sprouted vigorously after burning. Anemone nemorosa, Campanula rotundifolia, Lotus corniculatus, Lathyrus montanus, Potentilla erecta and Trientalis europaea obsessed underground perennating organs which escaped the effects of fire and from which new vegetative shoots can develop quite rapidly under appropriate conditions.

Thomas and Agee (1986) found that tree mortality was recorded 1, 2 and 4 years after the fire. Both large and small pines continued to die after 1 year while white Fir mortality remains in smaller size classes of mixed conifer forest composition at Cater Lake, Oregon. All the plots were subjugated by white Fir before and after the fire and mortality in the first year (mainly as direct result of fire) was concentrated in the smaller size classes for all tree species. Approximately two-thirds of white Fir mortality occurred in the first year. Insects were important reason for mortality after 1 year.

Keeley (1987) found that some of the woody dominants with widest increase of the Chapparal also had seeds with no inborn germination requirement for fire. Heteromeles arburofolia, Prunus ilicifolia, Cercocapus betuloides and Quercus dumosa, or at least most of the seed germinate readily, as Rhamnus crocea, Rhus integrifolia and Rhus Californica.

Malanson and Trabaud (1988) found significant differences in result between plots of different ages, between burns of different durations but season was the dominant variable in all analysis; resprouted density and growth were much greater following burning in late May than after burning early in October in Quercus coccifera stand in Southern France. Other than season,
in prefire canopy structure that most affected resprouted vigour prefire stem density and woody and foliar biomass seems to be essential variables. Swamy and Ramakrishnan (1988) revealed that in successional fallows, plant vigour was declined with age in unburned plots but stable in burnt plots. The biomass and nutrient share to seeds was higher in burned than unburned 8 year old plots. *Mikania micrantha* was adapted to survival after fire in slash and burn agriculture (Jhum) in north eastern India.

Haraharap and Sutisna (1989) found that there was a remarkable decline in density of all species over ten years, with only three species (*Teramnus labiallis*, *Ficus hirta* and *Cynodon dactylon*) having an importance value greater than 10 per cent. Two of these species (*Eupatorium palensens* and *Gleichenla linearis*) also had high importance values at another site (*Sibatuloting*) where regular fire occurred in *Pinus murkusi* stand at Darmaga. Morneau and Payette (1989) reported that species diversity (Shannon index) was low 4 year fire and then declined and stabilizing at low value in old growth woodlands of boreal in Northern Quebec.

Rebertus *et al*. (1989) observed that primary fires apparently had a several immediate effects on the pattern of surviving *Quercus laevis*: (1) more random to regular pattern at large scale (2) increase in clumping intensity; and (3) decrease in the scale of maximum clumping, i.e., smaller clump sizes. These changes were fairly reliable except small *Quercus laevis*, which did not display an increase in clumping intensity after fire. Random mortality suggested that random eradication of *Quercus laevis* was not substantially changed that prefire pattern in *Quercus laevis* spatial pattern in Florida Sandhills. The surviving *Quercus laevis* was observed in more discrete, isolated clumps after initial fires.

Vlok and Ronde (1989) observed that the responses of the grasses, shrubs and trees were more pronounced than those of the herbs and ferns. The first burn created most of the vegetation changes, with repeated burning having less impact on the most species and growth forms. After many burns, the understorey had changed from a shrub community to a short even cover of a grass community. Thothurst (1990) reported that spring and autumn burning after one year encouraged an increase in bracken density, however cover only increased after the autumn fires but there was reduction in open Eucalyptus forest in west central Victoria.
Anderson and Schwegman (1991) observed that 15 years after the last one, annuals and perennial prairie species responded positively to burning as did two shrubs, Prairie Willow (*Salix humilis*) and Silky Dog Wood (*Cornus amomum*). In the absence of fire, shade-tolerant to moderately shade tolerant and mesophytic tree species including Sugar Maple (*Acer saccharum*), Paw Paw (*Asimina triloba*) and woodland herbs appeared on site. Species diversity tended to be highest after end of burning, when composition and abundance were in flux with declining abundance of fire adapted species and increasing abundance on woodlands plants. For woody stems 8.9 cm dbh, diversity was the lowest following burning, when prairie Willow and Silky Dog Wood had high density of stems as an outcome of resprouting.

Chesterfield *et al.* (1991) revealed that there was a decline in the number of species with time in unburned controls and an increase in all burned plots. The greatest increases occurred in the longer rotation burns (6 years) and the least in the short rotation (3 years) spring burns and alternative spring and autumn burned plots. It has been observed that considerable changes in species numbers showed that herbs species generally increased with fire, though a few decreased in the absence of fire. Some obligate seeders and roots stock species increased with fire, a few in the absence of fire. Some bulbs, predominantly orchids, decreased with fire, a few increased, and in the absence of fire the numbers of bulbs intact. Only four species changed significantly in number as a result of season of burning. Two root stock species *Agonis parviceps* and *Dampiersa spp.* enhance in the spring burned plots and decreased in the autumn burned plots. One of the herbs, *Senecio spp.* decreased in the spring burn plots and increased in the autumn burned plots in the Eucalyptus forest ecosystem of South Western Australia.

Chesterfield *et al.* (1991) also observed that establishment of sclerophyll species was greatly condensed by profile growth of herbs, particularly *Cynoglossum latifolium*, *Calystegia marginata*, *Siegesbeckia orentalis*, *Stelleria flaccid* and *Urtica incise* after the most recent fire in warm temperature rainforest at Jones Creek, East Gippsland, Victoria. Although, *Armenia spp.* indicated some tolerance to fire by producing coppice.

Swezy and Agee (1991) observed that mortality of *Pinus Ponderosa* greater than 20 cm diameter at breast height was lower in unburned areas (6.6 per cent) than in burned areas (19.5 per cent), and early season burn had over 30 per cent mortality in old growth *Pinus ponderosa*
Douglas Stands at Crater Lake National Park. Waldrop and Brose (1992) observed that fire of low and medium low intensity gave rise to plentiful regeneration but might not have killed enough of the over storey to prevent shading in mountain pine (*Pinus punges* Lamb.) stand. High intensity fires killed almost all over story trees but might had destroyed some of the seeds. Fires of medium–high intensity might have best choice; they killed over storey trees and permitted abundant regeneration. Irwin et al. (1994) observed that the production of perennial herbs averaged twice that on control, while production of annual herb shows little difference in two years post burn in south central Wyoming mountain shrub community.

Kuhry (1994) stated that peat surface fires did not affect the long term undergrowth development of Sphagnum-dominated boreal peat lands vegetation response such as species composition changes in moss cover, if any, is generally restricted to a few decades after the event. Accumulation rates in Sphagnum-dominated boreal peat lands with increasing fire frequencies decreased significantly in Sphagnum dominated peat lands in western Boreal Canada. Turner et al. (1994) reported the pre fire and post fire analysis of sample plots shows that the fire top killed woody understorey vegetation. Changes also occurred in coverage of forest floor components, after fire, leaf litter and shrubs were reduced while grasses and forbs increased. Overall stand density and diversity were enhanced in Mission Teja State park.

Hruska and Ebinger (1995) suggested that 21 herbaceous species showed significant changes in frequency after the fires in savanna restoration in East-central Illinois. The shrubs *Rubus flagellaris* increase significantly while *Rosa multiflora* and *Rubus allegheniensis* decreased significantly following the fires. Seedlings of *Pinus serotina* decreased significantly in frequency and density, even saplings of *Pinus serotina* decreased considerably in density after the fires. Individuals > 3m tall of *Quercus alba, Quercus velutina, Quercus imbricaria, , juglens nigra, Liriodendron tulipifera* and *Liquidambar styraciflua* were fire resistant (when >1 m tall).

Abrahamson and Abrahamson (1996) reported that floristic composition and community structure of post burn stand changed away from those of the preborn stand on long unburned Florida sand pines scrub. However, this shift did not restore the populations of narrowly endemic scrub herbs. Instead, the change toward xeric hammock, characterized by the perseverance of woody understorey species, the unsuccessful re-establishment and pine as canopy dominant, the
near absence of most herbs. Ducey et al (1996) stated that only Aralia nudicaulis and Quercus alba illustrated statistically significant decrease in density while as most species increased in density and frequency after fire. Overall, 29 species increased in the density following fire, while 8 declined. However, diversity and equitability measure were depressed on the moderately burned sites, due to fast regrowth of Kalmia latifolia in a kalmia-dominated Oak forest, New England.

Henning and Dickmann (1996) observed that except for loss of a few trees due to crown fire early in the study when few loading were high the pine overstorey was minimally affected by fires at any return interval. Compared with unburned plots, fire had no consequence on total species richness of per cent cover of ground flora < 1.4 m tall, but species composition shifted Black Cherry (Prunus serotina) seedling enhance in the two shortest fire intervals. Although per cent cover of grasses, bracken fern (Pteridium aquillinum) and Rubus spp., appeared to increase following fire, the clump distribution of vegetation and inter plot variability in overstorey density obscured the statistical significance of these trends. Species richness and density of stands in the woody understorey (< 1.4 tall but < 10 cm diameter at breast height) decrease abruptly as burning interval decreased and number of burns increased in mature Red Pine stands.

Schwartz and Heim (1996) observed that the impact of fire on Acacia Petiolata, understory forbs, shrubs and saplings was strongly depressed in the unit burned in the growing season (May) and moderate in the unit burned in the dormant season (March). After three years, Acacia Petiolata had not recovered to preborn densities in the growing season burn unit. Likewise, densities and richness of native herbaceous species continued below preborn values in the growing season one unit after three years. Growing season and dormant season burns uniformly and strongly reduced shrubs and sapling densities relative to control unit.

Semwal and Mehta (1996) observed that Myrica esculenta, Lyonia ovalifolia (tree), Crataegus crenulata, Rhus Parviflora (shrub) and Chrysopogon aciculanus, Heteopogon contortus, Arundinella nepalensis (grass), Desmmodium micophyllum, Cotalaria albida, (Legume) and Anaphalis ssp; Ajuga parviflora, Micromeria biflora (other non-leguminous forbs) had been identified as fire resistant species present in Chir Pine (Pinus roxburghii Sarg.) forests of Garhwal Himalaya. The various changes in the Himalayan forests are appearing in
their structure, density and composition due to global warming (Gaur, 1982), uncontrolled lopping and felling of trees for fuel wood, fodder and grazing (Bargali et al. 1998; Kumar et al. 2004 ;)

Che et al. (1997) found that species diversity and evenness index were 1.05 and 0.70, and 1.32 and 0.83 in the cut end and uncut burned sites, respectively and 0.22 and 0.63 in the unburned site. The dominance index was 0.15, 0.06 and 0.96 in the cut, uncut and unburned sites, respectively. Corresponding degree of succession was 343.19, 747.47 and 674.34. The index of similarity was 0.66 among cut and uncut sites, 0.50 among unburned and cut sites, and 0.61 among unburned and cut sites. Kruger and Reich (1997) observed that fire substantially decreased the tree regeneration density while grasses and sedges became the most profuse vegetation on the burnt plots in northern Red Oak (Quercus rubra) in south western Wisconsin.

Saharjo and Waterable (1997) suggested that the reason why there was no natural regeneration under Acacia mangium after burning were: (1) The highest temperature reached 1 cm under the soil surface was $76^0$ C. At this temperature germination per centage was mainly low because the heat supplied could not break seed dormancy of Acacia manguim in a plantation in the south Sumatra, Indonesia. (2) The temperature at the soil surface exceeded $150^0$ C, as it did with distinctive fuels and fuel loads, no germination occurred. Whittle et al, (1997) found that six unique species including Salix ssp; Viola adunca Diervilla, Lonicera, and Rubus allegheniesis were found solely within the burned sites. Whereas only one species, Linnaea borealis was exclusive to unburned areas. Fire severity levels were associated with the occurrence of buried seed species such as Salix spp. and Voila adunca, while most vegetative species presented independent of severity. The abundance of deeply buried vegetative reproducing species including Prunus, pumila, Vaccinuim angustifolia, Ptereridium aquillinum, Vaccinuim myrtillodes, Kalmia angustifolia and the seed species Pancicum xanthophysum and Carex hougtonii varied significantly with fire severity.

Kularatane et al (1998) found that structure difference at each site included (1) a decrease in the density of fire tolerant species (2) an overall increase in the density in each of the girth classes of vegetation (3) an increase in the density of individual per hectare and (4) an increase in the density individual of the fire susceptible species. The floristic changes experienced included
(1) a trebling of species at site 1 (32-90), doubling at site 2 (43-85) and an increase by only by 9 species at site three (60-69), (2) a larger increase in the number of shrubs and climber at site 1 and 2 than site 3, while the number of tree species explained only a small change. Overall these changes showed that floristic diversity changed considerably during early stages of succession, but more slowly as succession progressed Adina cordifolia, Anogeissus latifolia and Mitragyna parviflora continue to at sites 1 and 2, but that on the whole, these species were absent from site 3 in Victoria Randenigale Rantembe Sanctuary.

Linder et al (1998) observed that tree mortality for smaller pines and spruces, of DBH (Diameter at a breast height) <10 cm, was over 80 per cent in the burned parts of the reserve for larger pines of DBH 10-30 cm, mortality showed a decreasing trend with increasing diameter, from 14 per cent in 10-20 cm class to 1.4 per cent in the 40 to 50 cm class. However, pines of DBH 30 cm had significantly higher mortality (20 per cent), since a high proportion of them had open fire scars holding cavities, caused by fungi and insects in an old growth Scots pine Forests in Northern Sweden.

Doyle et al. (1998) suggested that species present in the unburned forest added 55-74 per cent in severely burnt areas and 91- 100 per cent of the understorey cover in the moderately burnt areas. Species richness was found less in the severely burnt stand and has increased during the 17 years of succession. While sprouting is the primary mechanism for understorey plant establishment in the moderately burnt areas, most species appeared to have grown seeds in severely burnt areas of Waterfalls Canyon fire in Grand Teton National park. Haywood et al (1998) reported that burning every three years support Schizachyrium scoparium, which is often dominant grass on long leaf uplands in the West Gulf Coastal Plain of the USA.

Huddle and Pallardy (1999) observed that survival of seedlings in burnt plots was less significant than the control plots. Survival of seedlings in low fuel plots of Quercus rubra was significantly greater than either that of Acer rubrum or of Quercus alba subject to the same burning treatment. Survival of seedlings in the high fuel plots (6.5 per cent) was about half of that in low fuel plots (12.1 per cent) although differences was not statistically significant in Oak Hickory forest of the Eastern United States.
Rikhari and Palni (1999) studied the fire effects on ground flora dynamics of forest ecosystem and found that species richness and diversity were higher under burnt sites (species richness =25, Shannon-Wiener index = 3.68) as compared to unburnt sites (species richness =9, Shannon-Wiener index = 2.66). Fire as a disturbance agent plays a vital role in *Picea spinulosa*, *Pinus wallichiana* and *Pinus roxburghii* forests (McKinell, 2000). These forests become extremely vulnerable to fires when they are located on dry sites. Pure stands of *P. wallichiana* and *P. roxburghii* forest are destroyed by fire every year, though the matured stands of latter are more resistant to fire than the former.

Cain and Shelton (2000) observed that survival and growth of resprouting rootstocks were compared with controlled seedlings of short leaf pine (*Pinus echinata* Mill.), Southern Red Oak (*Quercus falcate* Michx.) and white Oak (*Quercus alba* L,) through one growing season after burning. Although 100 per cent of the oak and 99 per cent of the pines were top killed by fire, survival of resprouting rootstocks exceeded 95 per cent for all three species in the year after the winter burn. For southern red Oak, season of burning did not pessimistically affect (P>0.05) the growth of sprouts during the year after burning. No pine resprouted following the summer burn, but rootstock of survival of Oak averaged greater than 65 per cent. Compared with controls, winter burns reduced (P<0.01) mean height and ground line diameter of short leaf pine develops through the next growing season.

Gibbons *et al.* (2000) suggested that tree with a fire scar were likely to have short standing life compared to trees without fire scar in southern Australia. Tree retained on northern aspect, regardless of the type of slash burn, showed relatively higher rates of mortality. Tree retained on sites with relatively high stand basal area of living eucalyptus experienced relatively low mortality. Welch *et al.* (2000) found that there was no pine seedlings present in the tree burn ground layer. On all sites, burning top killed some over story and mid story fire intolerant species such as Sassafras, Red Maple, and White Pine. Numerous sprouts of these species appear in the post burn under story and ground layers. Under story and ground layer species richness were significantly higher (two times preburn values) following most burns. All three burn significantly condensed canopy basal area (20-30 per cent) and ground layer cover (40-70 per cent) but increased under storey density (two time preburn values) in table Mountain Pine (*Pinus pungens*) and Pitch Pine (*Pinus rigida*) stands.
Srivastava (2002) reported that *Acacia mearnsii*, *Cytisus scoparius*, *Eupatorium glandulosum*, *Lantana camara* and *Ulex europaeus* have become menace in Western Ghats and have replaced the valued flora at places. Fire is the one of the factor dependable for such species, which is not only depleting under growth but also facilitating the germination of some weeds in Natural Forests of Tropical India. Bruce and Servant (2003) found that despite the relatively high fire intensity the fire at both sites largely succeeded in improving the conditions of the field layer for wood land grouse. The majority of dense moss layer was also killed off by the burning, and in some places was visibly consumed by the fire. This was also likely to make slightly more favourable micro-sites for tree seedling establishment in pinewood forest in Scotland. The majority of the Rank Heather was killed by the fire and was being succeeded by vigorous regeneration of *Vaccinium* spp., mainly in the wood land site where blueberry had rapidly become the dominant part of the field layer.

Danthu *et al.* (2003) reported that the only species to manifest an improvement in germination capacity, under certain selective experimental fire conditions, and in relation to the non scarified control were *Acacia sieberiana*, *Acacia seyal* and *Acacia raddiana*. This finding implied that in dry savanna areas, it was impossible to regard fire as an accessory to reforestation or natural regeneration of these species in West African acacias. Anderson *et al* (2003) reported that in African savannas the fire is important in determining the composition and structure of these ecosystems. Keeley (2003) observed that on the vast majority of grasslands, burning recommendations might altered species composition was inappropriate for community restoration because it also inhibited native annual plants in California ecosystems. Annual seeds and perennial basal buds typically survived the fire to regenerate the following springs. However, fire in springs destroyed seed crops, favoring the perennials, which resprouted from basal buds. Spring burning therefore shifted the balance from annual exotic grasses to native cover, but only on sites where perennial bunch grasses were present in California ecosystems.

Brown and Peet, (2003); MacArthur and Wilson (1967) reported that in order to examine the role of processes such as immigration, extinction and survivorship that constrain changes in species richness at a local community level, a comparison of pre and post-disturbance
communities is essential. Matthew et al. (2006) found that the effects of fire on species richness must be measured in terms of severity of disturbance, the spatial grain of observation and the capacity for dispersal of the species present in the surrounding landscapes. He also observed that the role of competition decreases after fire because light availability increases and competitive asymmetries between growth forms with large size differences are condensed. Fire mediates the responses of forest to climate change, either by accelerating species turn over or by selecting for fire adaptive species (Ovespeek et al., 1990). In the same way change in species composition may alter fire occurrence by changing the concentration and arrangement of flammable fuel (Bond and Keeley, 2005).

2.2 Forest Fires and Edaphic Factors

2.2.1 Soil Characteristics

The studies on performance of forest ecosystems without knowledge of soil characteristics are likely to prove meaningless. Thus the importance of soil characteristics should be taken into consideration.

Fuller et al. (1955) observed that fire has the potential to induce major changes in soil, as it speeds up the normal method of mineralization of organic matter. In a severe ground fire, colloidal organic matter in the surface mineral layer may be destroyed, accompanied by a loss of structure and reduction in porosity. Lutz (1956) reported that extent of loss of organic matter vary with intensity and frequency of fire in Alaska. Scotter (1964) has documented the successional sequence of plant invasion after fire in forested winter range in Carbon in northern Saskatchewan. In most cases forest fires remove the organic layer and exposed mineral soil provides a more favorable microsite than peat for successful establishment of seedlings. Soil temperature also increases when the insulating organic layer has been removed (Lutz, 1956; Scotter, 1964).

Sanit et al. (1972) reported that differences between soil physical properties were in general insignificant. But N, P and K content, organic matter were significantly different (between burnt and unburnt plots) in teak plantation at Lampang. William (1974) stated that nitrate and phosphate were substantially higher in the first rainfall at the burned area after the burn, but not in the subsequent rains. Biologically available N and P in the litter are apparently
not increased directly by burning. But a rise in soluble nitrate and phosphate occurred sometime after the burn and is probably volatized and could exercise important effects on the productivity in a South Carolina Pine forest.

Reports of lower nitrogen content followed burning are frequent. In Florida, Barnette and Hester (1930) reported an estimated annual loss of 27 pounds of nitrogen per acre when land was burned annually. In New Jersey, Lutz (1934) found slightly lower nitrogen content in frequently burned soils as compared with unburned soils. Finn (1934) reported loss of nitrogen by leaching in experiments in which sand and loam soils placed in boxes were covered with organic matter and burned. Hetsch (1980) reported that the oxidation of humus layer and the needle caused a rise of pH in the upper 10 cm of the soil and an increase in soluble K and N. Leaching was high, especially of K. The increased solubility of P leads to a decrease in P concentration in the upper soil layer with time. Over 4 year there was a loss of mineral nutrients from the burned humus layer in Scot pine stand.

Covington and Sackett (1986) reported that generally, $\text{NH}_4^+$ and $\text{NO}_3^-$ concentrations were higher on plots repeatedly burnt than on unburnt controls. However, plots not burnt for 3 to 4 years had concentrations similar to among treatments. It was concluded that a frequent periodic burning can be used to enhance N availability in south western Ponderosa Pine forest. Kutiel and Naveh (1987) reported that 14 months after the fire organic matter and nutrients in the burnt soil were less than those of the unburned, except total P which significantly higher in the upper, burned, soil layer than in the unburnt. Tryon (1948) reported increase of Phosphorus with addition of charcoal to clay, loam and sand, while Lutz (1956) observed no significant change in phosphorus content in pitch pine soils of New Jersey after burning, as did Isaac and Hopkins (1937); Fowell and Stephenson (1933) in the Douglas-Fir region, and LeBlanc (1954) in Quebec.

Rashid (1987) reported that the pH increased sharply in the burned surface soils (0-5 cm) taken months after the fire and dropped only by half a unit over 14 to 21 months. However at greater depth (15 cm), the burnt soil was more acidic than the adjacent unburned soil up to nine months following the fire and thereafter its pH rose only slightly above that of the unburned soil. There was sharp rise in the concentration of organic carbon, total and mineral nitrogen in
addition to in vitro mineralization activities in the burnt surface soil collected five months five months after the fire in a Mediterranean oak forest of Algeria.

Fujita (1988) reported that chemical analysis including analysis of total nitrogen and total carbon of samples from burned and unburned areas were compared. The amounts of exchangeable Nitrogen, exchangeable K and available P increased after burning but decreases to about the same values as those found in unburnt samples by autumn in the secondary oak forest in northeastern part of Japan. Fernandez et al. (1991) reported that loss of structure was observed in the most affected soil (nearest the fire). Burning increased soil pH in all the profiles. Some alteration in the minerals of the clay and sand fractions occurred in the top (5-cm) in Pine forests. Kutiel and Shaviv (1992) reported that nitrification rate in the soil burnt with plants was similar to rate of that in the unburned soil. Maximum value obtained after 12 weeks were also similar to those obtained to unburnt soil, despite the large amounts initially found in the burnt soil.

Boyer and Miller (1994) reported that burning reduced available soil moisture holding capacity and macropore space and increased the bulk density of surface soils, and also reduced the moisture holding capacity of subsurface soils in young leaf Pine stands, Alabama. Bauhus et al. (1993); Creighton and Santelices (2003); Giacomo (2005); Ekinci (2006) reported that fire is capable of exerting serious effects on soil properties. Legleiter et al. (2002); Wondzell and King (2003) observed that light fires encourage accumulation of litter on surface soil. Dumontet et al. (1996) reported that the C, N and P contents of the soils surface layer was greater 1st year after fire and declined in soil as time since the last fire increased. After 11 years, the soil nutrient content and the size of microbial biomass were still lower than the neighboring unburned site suggesting that fire have a long term effect on soil microbial properties of pine forest soil from a Dunal Mediterranean environment.

Hernandez et al. (1997) reported that all burnt soils had higher contents of available P and K, while their total content of organic C was lower than those of unburnt soils in Mediterranean Pine forest soils. Isaac and Hopkins (1937) reported that in Douglas-Fir regions, Available potassium was increased with burning. Kivekas (1939) and Lutz (1956) also reported increase in Available potassium with burning. Saharjo and Makhi (1998) reported that immediately after burning there was an increase in soil cations of potassium, but one year after
burning potassium, pH, organic carbon and total nitrogen, decreases significantly. The only exception was available phosphorus, which increased in the *Acacia mangium* plantation. Marafa and Chau (1999) compared the soil chemical properties of a new burnt site and an old burnt site on upland soil in Hong Kong. Repeated fires raised soil pH by 0.27-0.33 units but reduced total exchangeable acidity by 85 per cent, total Kjeldahl nitrogen by 75 per cent and total phosphorus by 66 per cent of the new burned site against the old burned site.

Ellingson *et al* (2000) reported that slash burning resulted in dramatic but short term increase in organic nitrogen and soil pH. Mineral Nitrogen pool in surface soils (0-10 cm) increase from 9-44 kg ha⁻¹ in the low severity treatment and from 18-57 kg ha⁻¹ in the high fire severity treatments. This was due to increase in soil NH₄-N; NO₃-N concentrations were lowered by fire. Surface soil pH increased 1.1 units following the low severity fires and 2.3 units following the high severity fires. Soil pH remained elevated in the perturbed sites for the duration of the study. Immediately after the initial slash fires, and nitrogen mineralization was higher in the burnt plots compared to adjacent undisturbed forest in a Mexican tropical dry forest.

There are five principal global C pools. The oceanic pool is the largest, followed by the geologic, pedologic (soil), biotic and the atmospheric pool. Soil organic matter (SOM) represents the third largest terrestrial carbon pool, with a global estimated total of 1526 pgC (Lal, 2004). The most intuitive change soil experience during burning is loss of organic matter (Certini, 2005). The organic horizon is critical component of ecosystem sustainability in that it provides a protective soil cover that mitigates erosion, aids in regulating soil temperature, provides habitat and substrates for soil biota and can be major source of readily mineralizable nutrients (Neary *et al*., 1999).

**2.3 Forest Fires and Socio Economic Behaviour**

Fire has always been a natural, regular occurring and part of plant succession that permits the rejuvenation of some plant population and creates a mosaic pattern in the plant communities that develop over a time and vary with location. However, man’s appearance on the scene distributed this balance of nature. Humans used and abused fire for agriculture, religious, and personal needs. This in combination with cutting, grazing and farming activities followed by the
abandonment of many areas scared much of the plant life that exists in ecosystem today (Chandler et al., 1983). Other natural phenomena may also have caused fires such as volcanic eruption, spontaneous combustion (Viosca, 1931), and sparks produced in rockslides (Hennicker-Gotleir, 1936).

Recent ecological literature has begun to address the impacts of fire exclusion on forest ecosystems in the American West (Keane et al., 2002; Collins et al., 2011). However, while there are many studies of the social impacts of wildfire on human communities, there are virtually no studies of the social impact of wildfire exclusion. There is an overlap in these issues in that fire exclusion leads to larger catastrophic wildfires over time.

The human mastery of fire set in motion a wave of transformation of the world's forests. Long before the introduction of agriculture, the flora and fauna in many parts of the world had already been strongly affected by human interference with the aid of fire (Goudsblom 1992). Some of the best documented examples of the impact of human induced fire on forests come from North America. Pyne (1982) and Axelrod (1985) argue that in North America fires set by humans expanded the prairies, and reduced the woodlands and forests. They also claims that American Indians burned parts of the ecosystems in which they lived to promote a diversity of habitats and to increase the "edge effect" which gave the Indians greater security and stability. Their use of fire differed greatly from European settlers who burnt to create greater uniformity in ecosystems.

The role of fire in human society ranges from acceptance and use as a land management practice to fear of its threat to lives, property and livelihoods. Even societies that use fire as a land management tool often greatly fear fire when it is perceived as “out of control.” In some ecosystems wildfire has natural selection significance, and the human use of fire as a land management tool may have longstanding cultural significance (Myers 2006; Pyne 1982; Yibarbuk 1998; Goldammer and De Ronde 2004). Evidence suggests that human induced fires accelerate the trend of ecosystem transformations caused by climate change in the long term (Kershaw et al. 2002).

Forest products used in India others than timber, are rarely managed based on systematic concepts and scientific knowledge (Singh, 2008). But the accessibility and the supply of many
products need a certain amount of management to ensure the supply in the required form, e.g., the fuel wood taken from forest can be either collected as dead branches or by the removal of smaller trees. As the latter is prohibited and in many areas the forest contains many thorny species that make the forest difficult to penetrate. The management for fuel wood comprises the collection of dead wood as well as providing access to the forest. Both can be achieved by setting the forest on fire (Schmerbeck and Seeland, 2007).

Man has used fire as a tool for hunting and to create pasture land worldwide for nearly 50,000 years (Bowmann et al., 2009) and for India it is assumed that fire was used in the same way in prehistoric times (Pyne, 1994). Fire removes the remaining negromass of the past season shoots, provides easily available nutrients and leads therefore to the production of fresh new shoots uniformly on big areas. At the same time the establishments of unwanted plant species that limit the supply of the fodder plants are mitigated.

Furthermore, in the face of increasing costs of firefighting, fire severity and decreasing fire intervals more effort has been paid in involving local communities as resources in fighting fires (Everett & Fuller, 2010). Local communities can play key roles in fire prevention and response. Local community involvement can also mitigate negative social impacts of fires by increasing community capacity. With their longstanding and sophisticated cultural practices, ties to the land, traditional ecological knowledge, political standing and increasing political and economic capacity, it is imperative that Karuk expertise and leadership in forest management be acknowledged not only as an issue of legal rights or social justice, but for the health and wellbeing of ecosystems and non-Native human communities alike, especially in the face of climate change.