ECOLOGICAL ANALYSIS OF THE EFFECTS OF DISTURBANCE ON STRUCTURE AND FUNCTION OF FOREST ECOSYSTEM.

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CERTIFICATE

I the undersigned certify that the thesis entitled **'Ecological Analysis of the Effects of Disturbance on Structure and Function of Forest Ecosystem'** submitted by Neizo Puro for the degree of Doctor of Philosophy in the department of Botany, Nagaland University embodies the record of the original investigation carried out by him under my supervision. He has been duly registered, and the thesis presented is worthy of being considered for the Ph.D degree. This work has not been submitted for any research degree in any other university.

Dated: 28/11/02
Place:Lumami

(N.S.Jamir)
Supervisor of Research

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Chapter – I

INTRODUCTION

INTRODUCTION

Forest ecosystems are the natural habitat of many varied plant and animal species. It is rich in biodiversity and highly productive. These forests are continuously influenced by many ecological factors and disturbances. Disturbance is an event that causes a significant change from the normal pattern of functioning in an ecosystem. Space, time and magnitude are the three important dimensions in the study of the effect of disturbance of ecosystem. The disturbances can be of different types i.e abiotic and biotic. Natural abiotic disturbances can be of a periodic/ seasonal or occurrences after a long interval of time. Some of these disturbances can be catastrophic in nature such as windstorms, cyclones, hurricanes, earthquakes, land erosion, drought, fire or pollution induced etc. These disturbances may have along term effect on the forest community whereby the response of the forest regrowth and establishment may be hampered. Men and animals cause biotic disturbances. Animals disturb the community mainly in the form of herbivory and trampling. One of the major disturbances caused by men is the traditional agricultural practice such as Slash-and-Burn (jhum) also known as shifting agriculture.

Apart from this practices, logging, random extraction of natural resources as well as use of fire as a management tool also bears an impact on the forest ecosystems. These disturbances can be at regular time intervals, because of which forest regrowth is adversely affected and the maturity of the developing forest ecosystem is considerably delayed. The rich flora and fauna of the ecosystem is also drastically affected by these disturbances. The above ground vegetation as well as the soil nutrients is also depleted, thereby affecting the overall productivity of the forest ecosystem. Disturbances play a central role in determining the distribution and abundance of tree species in forests (Pickett & White. 1985). Much emphasis is given on the structure and function of forest ecosystem, which is determined by the plant component more than any other living component of the system (Richards,1996). Many workers also concluded that botanical composition and structural organization of the forest communities váries according to plant's responses to different environmental conditions.

Factors like species richness, their dispersion, density and dominance determine the community structure. Different life-form composition described by Raunkiaer(1934) is used to describe communities of different climatic zones. Any deviation from this normal life-form of phytoclimatic zone is considered as an indicator of alteration in vegetation either due to biotic or edaphic. One of the major for the loss of forest cover is shifting cultivation practiced by the people inhabiting the tropical forests. Lanly (1982), reported that forest cover loss due to deforestation accounts for 70% in Africa, 50% loss in Asia and 35% in the America. Grainger(1992) discussed the three major consequences of tropical deforestation and they are (i) reduced diversity of species and genes, (ii) Changes affecting local and regional ecosystems, and (iii) changes affecting global ecosystems.

Nagaland has a total area of 16579 sq.km. The topography is very severe full of hilly ranges, which break into a wide chaos of spurs and ridges. The altitude varies between 194 meter and 3048 meters. Most of the thousand and odd villages stand at 1 – 2000 meters high. The total population of Nagaland is 1209546 according to 1991 census. Out of which 73.38% are engaged in agriculture. The status of the forest area in Nagaland is shown in the table below:-

Classification of forest area (Area in hectares)

1999 – 2000

Particular	Forest area	% of total forest
1. a) Reserved Forests	8,583.00	1.0
b) Purchased land	19,247.00	2.3
2. Protected Forest	50,756.00	5.9
3. Wild life sanctuary	22,237.00	2.6
4. Village forest		
a) Virgin accessible		
+		
b) Virgin nonaccessible	4,77,827.00	55.4
5. Degraded forest	2,84,280.00	32.9

Total forest	8,62,930.00	100

Source: *Chief conservator of forest*. Govt. of Nagaland.

The present study is undertaken in Lumami in the district of Zunheboto. The total forest status in Zunheboto district is shown in the table below:

Year	Total forest	Proposed Reserved	Protected forest	Forest degraded
1999-2000	18,685.50	40.00	645.50	18,000.00

Total % of degraded forest in Zunheboto = 96.33%

Source: *Chief Conservator of forest*. Govt. of Nagaland

As shown in the table the total percentage of degraded forest area in overall Nagaland is considerably high (32.9%). It is more alarming to see the degraded forest area in Zunheboto district (96.33%). It can be noted that at this rate of forest degradation the entire forest community will be completely destroyed as well as deplete the soil nutrient. The major cause of forest degradation is due to shifting agriculture. At such a rate of forest degradation, it is a threat to the loss of biodiversity and survival of the people and the environment. The people of this area completely depend on this farming system that puts a lot of pressure on land without allowing enough time for the land to regenerate and reclaim the fertility of the soil. Therefore, a study on such a condition is important so as to analyze the ecological impact on this forest ecosystem and its consequences, which will create more awareness to the people concerned. This study is the first ecological research done here in this part of the country. Forest community structure, stratification, floristic composition, abundance, density, dominance are some of the parameters considered in this study. Studies on productivity through litter fall and the content of nutrients particularly. Nitrogen, Phosphorus and Potassium in soils as well in the vegetative structure is also considered. Physico – chemical characters of the soil are also studied. All these parameters were studied for a period of two years. This study aims to analyze the community structure and the soil status in the two forest types i.e the undisturbed and the disturbed forest stands. In this study field, disturbances caused due to other factors like drastic climatic changes were not observed. However, disturbances due to logging and felling of trees for firewood contributed to disturbances in the forest stand. It was also observed that the forest area serves as a complete sustenance to the people. However, over exploitation of the natural resources has already created an adverse impact on the forest ecosystem and also altering the soil nutrient status.

Shifting agriculture or slash- and –burn (local name jhum) is a traditional agricultural practices and a primitive way of cultivation. Processes involved in this cultivation are as follows. Forest area is cleared by felling of trees and plants in a dry season particularly in the winter season. When the cut trees are dried, it is burned with the help of a slight wind. After which the soil is cleared and the seeds are sowed. Cleaning and weeding is done at frequent intervals. The land is cultivated for a year and he land is left as a fallow land. The cycle returns after a period of few years. The land that is left uncultivated as fallow land provides a substratum for the regeneration of pre-existing species as well as enables other new species to establish in this land. However, the success of this succession will also depend on the physico-chemical properties of the soil. It has been observed by many workers that shorter the cycle of cultivation, the regeneration and succession of plants are impaired. It is also reported that if the fallow land is left for considerable period of years, forest ecosystem may develop and reach a mature stage but this is not so in this case of study. Fire, which is a tool for this cultivation, also acts as a major disturbance on the forest stand. It burns the felled trees but also affects the physico-chemical properties of soil as well as kills the soil microorganisms.

However, there are also reports that fire also helps in breaking the dormancy of certain plant species and help sprouting of species. Disturbance can also create canopy openings that provide opportunity for tree recruitment and the scale, intensity and spatial pattern of tree mortality defines the consequences of disturbance for forest vegetation composition. Hence, a clear understanding of forest dynamics is not possible without a comprehensive understanding of the disturbances of forest ecosystem.

Chapter – II

LITERATURE REVIEW

LITERATURE REVIEW

Forest ecosystems are influenced by disturbances of varying scale. A few of the disturbances noted are, the woody plants which suffer frequent physical damage (Aide 1987; Clark & Clark 1991). Catastrophes such as hurricanes affect the resprouting of woody plants and are well documented by Walker (1991); Yih et al. (1991); Bellingham et al. (1994). Effect of tornadoes on forest have been also documented by Glitzenstein & Harcombe (1988); Peterson & Rebertus (1997). Large scale disturbances on forests due to logging were studied by Gorchov et al (1993); Pinars & Putz (1996). Fire is also a factor that affects the forest ecosystems and is also studied by Williamson et al. (1986); Kauffman(1991). Fire, however is also used as a management tool in managed agro-ecosystems but a large scale outbreak of fire causes damage to the forest ecosystems. Mild fire may have an advantage to certain plants to break dormancy and sprouting but an intense fire destroys the plant community. Traditional cultivation processes such as slash and burn also has an impact on the natural vegetation and its composition of the forest ecosystems. Studies on this effect has been undertaken by Sampaio et al.

(1993); Miller & Kauffman (1998). Studies of damage and mortality rate of trees by catastrophic windstorms in the pacific and Caribbean's variously known as cyclones and hurricanes was carried out by whitmore (1974, 1989); Walker et al (1991); Everham & Bookaw (1996). Whitmore and Burslem (1998) also reviewed the impacts of drought, fire, landslides and earthquakes in a variety of tropical forests. Their studies suggest that the tropical rain forests are non- equilibrium plant communities and the community composition may be influenced strongly by rare, but large scale disturbance events. It is important to understand how the forests recover from the long-term of the communities to such disturbances. Vandermeer et al. (1996) reported that, forest recovers primarily by regrowth of damaged stems or release of shade tolerant seedlings pre-existing under the canopy then to change in response to disturbance when regrowth occurs by recruitment of pioneer species. A more general outcome of the recovery of forest due to disturbances as observed by Walker (1991); Yih et al. (1991); Bellingham et al. (1994); Zimmerman et al. (1994) is that short-term recovery of forest structure takes place by re-sprouting of damaged stems and branches. The prevalence of resprouts among the stems damaged by hurricanes was studied by Yih et al. (1991); and Boucher et al.

(1994) and proposed a direct model of forest recovery, in which species dominate before dominant in the first year after disturbance will be the same as the species which were dominant before the disturbance. As in the process of forest regeneration, on abandoned agricultural fields, shade-tolerant species might become established and grow up beneath the canopy of the pioneers and the forest gradually revert to its original composition. Roth (1992); Smith et al. (1994); Baldwin et al. (1995) found that hurricanes are common in many areas characterized by mangroves, and these large scale initiating disturbances are known to influence the regeneration dynamics of such forests. Paijmans & Rollet (1977); Smith (1992); Smith et al. (1994) also reported that small-scale disturbances also are common in many mangrove forests. Lightning has also been identified as a common disturbance agent in many mangrove forests and studies on this affect of lightning has been done in Papua New Guinea (Paijmans & Rollet, 1977), Australia (Smith, 1992), Malaysia (Anderson, 1964), Panama (Smith 1992) and Florida (Craighead (1971); Odum et al (1982); Smith et al (1994). Although the mechanism by which lightning causes group tree mortality is not known, Anderson (1964); Bruenig (1964); Paijmans & Rollet (1977); Smith (1992), reported that the effect of lightning is almost always to kill groups of trees in a 20-30 m diameter circle and the trees remain standing dead for several years. Ruth et al,(2000) observed that the species composition of neotropical mangrove forests probably depends in part on the balance between large-scale and small-scale disturbances.

Current concern over the consequences of destruction and degradation of tropical forest has resulted in a growing interest on the effects of habitat disturbance on tropical forest communities. In temperate communities, species abundance distribution has been used to detect ecosystem disturbance (Jane K.Hill & Keith C.Hamer 1998). However, Nummelin (1998) claims that species abundance models cannot be used to detect tropical forest disturbance. Undisturbed tropical forest may not necessarily be at equilibrium (Blau 1980), but disturbed habitats may be at equilibrium if the perturbation is maintained, however this needs further study. Jane k.Hill & Keith C.Hamer (1998) suggests that species abundance models are a powerful tool for describing community structure and encourages the wider use of these of these models in tropical ecosystems. Kremen (1992); Kremen et al (1993) observed that insects particularly butterflies respond rapidly to forest disturbance and species abundances models of insects may be particularly powerful as indicators of tropical forest disturbance.

In some forests, the disturbance regime is characterized by frequent, small-scale gap formation, where the forest is constantly turning over and, at any one time a significant proportion of the landscape is in a recently disturbed state (Raunkle 1982). Other forests however are affected by large, infrequent disturbances with return times of decades. These disturbances include catastrophic fires (Heinselman 1973), floods (Duncan 1993), hurricanes (Foster & Boose 1995), earthquakes (Veblen et al. 1992) and volcanic eruptions (Turner et al. 1997). Because these disturbances tend to be severe, and to impact over a large areas, they may have a dominant influence on the pattern and function of forest (Garwood et al. 1979; Foster et al. 1998; Turner & Dale, 1998). Despite their significance this infrequent disturbances in the dynamics of forested landscapes can be overlooked if the disturbances occurred sufficiently long ago where their impact has been obscured by forest regrowth (Andrew et al. 2001).

Evergreen broad-leaved forest, which is found widely in humid areas at mid-latitude in the northern hemisphere, is also the natural vegetation of the warm-temperate zone in East Asia, where it is dominated by the families Fagaceae, Lauraceae and Hamamelidaceae (Kira 1991; Tagawa 1995). One of the natural disturbances was found to be occurrence of high frequency typhoons (Naka 1982; Yamamoto 1992 a ; Bellingham et al., 1996). Masahiro et al. (2001) studied on the response of forests to disturbance and reported that both composition and structure of the forest changed in response to disturbance- related effects on canopy dynamics. Canopy state changed remarkably and when canopy trees died, canopy gaps were formed by strong typhoon as observed in 1997, which improved understorey light conditions and are likely to have favoured new recruitment over mortality but competition, gap closure or new small-scale disturbances may then have caused increased mortality. According to Nakashizuka et al. (1992); Runkle (1998,2000); Marod et al.(1999);Masahiro et al., (2001);Lieberman & Lieberman (1987);Swaine et al. (1987), tree mortality is sometimes but not always size dependent. In addition, the proportion of mortality related to disturbance was higher in the uppermost layer. Small trees may be more vulnerable to shade under the closed canopy or by other falling stems and thus showed greater mortality, whereas larger trees might be senescent, which showed reduced vigour and also less tolerant of natural disturbances, but the medium sized trees were favoured. Mortality due to disturbance therefore appears to depend on tree size, and probably depends on the disturbance regime. Tropical rain forests are characterized by a complex vertical structure (Ashton & Hall, 1992; Richards, 1996). This creates heterogeneity in environmental factors such as light level, CO_2 concentration and humidity (Aoki et al., 1978; Yoda, 1978). Of these, light environment has the greatest effect on the growth rate of trees as observed by Clark & Clark, (1992). In mature tropical forests most of the tree species were found to be late successional as shade-tolerant (Hubble & Foster, 1986). Fox (1976); Bazzaz and Pickett (1980) Augspurger (1984a,b,c); Rao and Singh (1985); Khan and Tripathi (1989), Houle (1992); Tripathi and Khan (1992); Rao (1992); Ashton et al.(1995); Canargo and Kapos (1995); Hart (1995); Itoh (1995); Rao et al .(1997) reported that the survival of tree seedlings to a great extend depend on the moisture, temperature, light regime, microsite, heterogeneity, nature of soil and competition from the established species in the surrounding vegetation.

Soil enzymes play an essential role in catalyzing reactions necessary for organic matter decomposition and nutrient cycling. Ladd and

Butler, (1972); Dalal, (1975); Tabatabai, (1977); Speir, (1977) concluded that soil enzyme activities are greatly affected by organic matter content of the soil and also are often used as indices of microbial and soil fertility (Kumar Jha et al., 1992;Dick & Tabatabai, 1992; dick, 1994). Dick, (1994);Tabatabai, (1994), reported that soil enzymes are also involved in energy transfer, environmental quality and crop productivity. Microbial biomass is the la bile portion of the organic fraction in soils and serves as both an important source and sink for plant available nutrients as observed by Jenkinson and Ladd, (1981);Garcia and Rice, (1994). Management practices e.g crop rotation, mulching, tillage and application of fertilizers and pesticides may have diverse effects on various enzymes and microbial activities of soil (Ladd, 1985; Dick et al., 1987; Tabatabai, 1994). Dick et al., 1988a,b, observed changes in enzyme and microbial activities could alter the availability of nutrients for plant uptake, and these changes are potentially sensitive indicators of soil quality (Dick, 1994). Many studies have reported significant correlations among soil enzyme activities, microbial biomass and various soil properties (Tabatabai, 1977; Speir et al., 1980; Frankeberger and Dick, 1988; Perucci et al., 1984; Dick et al., 1988 a, b). Dick et al. (1988,a) found a string correlation between dehydrogenase activity and microbial biomass C (MBC). In a long- term study on the effects of residue management on enzyme activities, Dick et al.(!988,b) found significant correlation between burning of the residue and acid phophatase activity in the top 20 cm of soils, but weak correlations with several other soil enzymes. The authors attributed these weak correlations to the fact that the burning effect on microbial populations was confined mostly to the top 2.5 cm of the soil profile, and mixing the upper 20 cm of the soil by plowing may have elevated this effect. Studies on the effect of long-term prescribed burning on enzyme activities in a forest ecosystem found that microbial bomass is significantly correlated with acid phosphatase, b-glucosidase, arylsulfatase and urease activities (Eivazi and Bayan, 1996). Ajwa et al.(1999) observed that the decrease in inorganic N concentrations in the burned (fertilized and unfertilized) treatments was due to greater plant N uptake associated with greater plant biomass in tall grass prairie soil. Garcia & Rice (1994) found out that microbial activity was a regulator of the soil N dynamics in the prairie soil. Net mineralization increased inorganic N at the beginning of the growing season, and the N returned to the soil upon plant senescence at the end of the growing season was conserved by microbial immobilization. Studies on the effect of burning on N and C budgets in the Konza prairie found an increase (14%) in inorganic N after the first year burning and a decrease (8%) after repeated burning (Ojima et.al.1990). Garcia and Rice (1994) also reported an increase in inorganic N immediately after burning. These studies attributed the increase in inorganic N to enhanced N mineralization due to higher soil temperature after the removal of detritus following burning. Ajwa et al. (1999) based on their studies on tallgrass prairie soil related to burning and nitrogen fertilization showed that long-term burning and N fertilization of tallgrass prairie soil has diverse effects on surface soil (0-5cm) enzyme activities, and some enzymes are more sensitive indicators of disturbances in pristine ecosystems than microbial biomass. Long-term burning appears to alter the rate of organic matter turn over and therefore, affect microbial biomass and the production of enzymes. Because many soil enzyme and microbial N are immediately responsive to soil disturbances or restoration, they can be used as indices of environmental stability and soil quality for sustainable management.

According to Laurie et al. (1999) microbial dynamics partially control forest productivity. Following forest cutting, microbial biomass may reflect changes in the forest floor environment. Fahey and Hughes (1994) reported that forest floor serves as rooting zone for up to 40% of the fine roots in lower montane forest stands. Gosz et al. (1976) also reported that forest floor is a major storage component for ecosystem organic matter and nutrients and according to marks and Bormann (1972); Marks (1974), forest floor plays an important role n ecosystem recovery following disturbance. Nutrients needed for forest growth and maintenance are bound in the forest litter and released through decomposition by microorganisms. Microbial mineralization and immobilization therefore affect nutrient availability and ultimately forest productivity (Parkinson, 1979; Zak et al.1990). Forest harvesting alters the amount of soil organic matter (Federus, 1984; Mattson and Smith, 1993). Soil temperature, soil moisture and pH (Bormann and Likens,1979), all of which affect microbial biomass activity(Harvey et al. 1980; Hendrickson et al 1985; Entry et al. 1986). Laurie et al. (1999) found in their study that active microbial biomass in young stands was quite similar to that in the oldest stands and higher than that in mid-success ional stands. Therefore they suggested that similarity between young and old stands suggests that the greatest changes in conditions affecting microbial activity in the northern hardwood forest occur in mid-succession. They also concluded that the differences in microbial biomass at different stages of forest succession and identified forest floor moisture content as the environmental factor that most frequently explained variation in microbial biomass. The mineralization of soil organic matter depends on its nature and abundance, and on climatic factors, in particular temperature and humidity, which condition mineralization processes through their effects on microbial activity in soil. In temperate deciduous forests, all these factors will clearly vary the course of the year (Leirus et al.1999). Increase in the atmosphere concentration of green house gasses are leading to progressive global warming (Folland et al, 1990). Trabalka (1985); Moore& Roulet (1995), predicts that over the next century the global mean equilibrium temperature will increase by between 1.4 and 4.0°C, depending on the planetary zone. If global warming continues, edaphic processes may be accelerated, especially biological processes. Raich and Schlesinger (1992) suggest that this would affect the geochemical cycles of biophiles in the soil. And according to Bouwman and Sombroek (1990); Raich and Schlesinger (1992); Davidson (1994) this will lead to release of greenhouse gases such as CO_2, CH_4 and N_2O.

Since the products of organic matter decomposition include greenhouse gases, this process will have a positive feedback effect on global warming. It is widely believed that increase in ambient temperature due to global climatic change will decrease the organic matter content of soils and soils and increase the emission of greenhouse gases from them (Leiros et al, 1999). Schleser (1982); Paustian et al.(1995) predicts that the most effected region will occur at middle and high latitudes, where the largest temperature changes are expected.

Soil organic matter mineralization affects soil fertility and is conditioned by many factors e.g type of soil, humus layer quality and moisture content (Merila and Ohtonen, 1997), temperature (Wildung et al. 1975), irradiaton (Wen et al. 1997), tillage and soil texture (Franzluebbers & Arshad, 1997) and profile depth (Rovira & Vallejo 1997). Due to its importance and complexity it is a widely studied process (Bekku et al 1996; Pomazkina et al. 1996). Forests of the world play an important role in sequestering and storing carbon in terrestrial ecosystems (Sampson, 1995).

When natural ecosystems are altered, the organic matter turnover is modified and can alter both productivity and community structure of ecosystems (Pastor & Post 1986), because of its influence on the supply of nutrients to plants (Berg & Tamm 1991). Alteration of the ecosystems has an influence on the composition of organic matter in the humus layer (Wardle, 1992) and on soil structure. Smaling (1993) observed that, population pressures have precluded fallow opportunities and resultant continuous cultivation has led to the depletion of soil organic matter (SOM) and nutrients. Mwaura and woomer (1999) reported that farmers of the central highland have access to fertizers but usually lack sufficient capital to apply them at recommended rates. Jane et al.(1999) basing on their studies concluded that a decline in soil organic matter due to continuos cultivation was observed in humic nitosol at Kabete, Kenya. They found out that additions of manure were more effective than crop residue retention or addition of fertilizers as a means of offsetting soil organic matter decline, but best protection against soil organic matter loss was achieved by combinations of inputs which results in better crop performance and the formation and quality of soil organic matter.

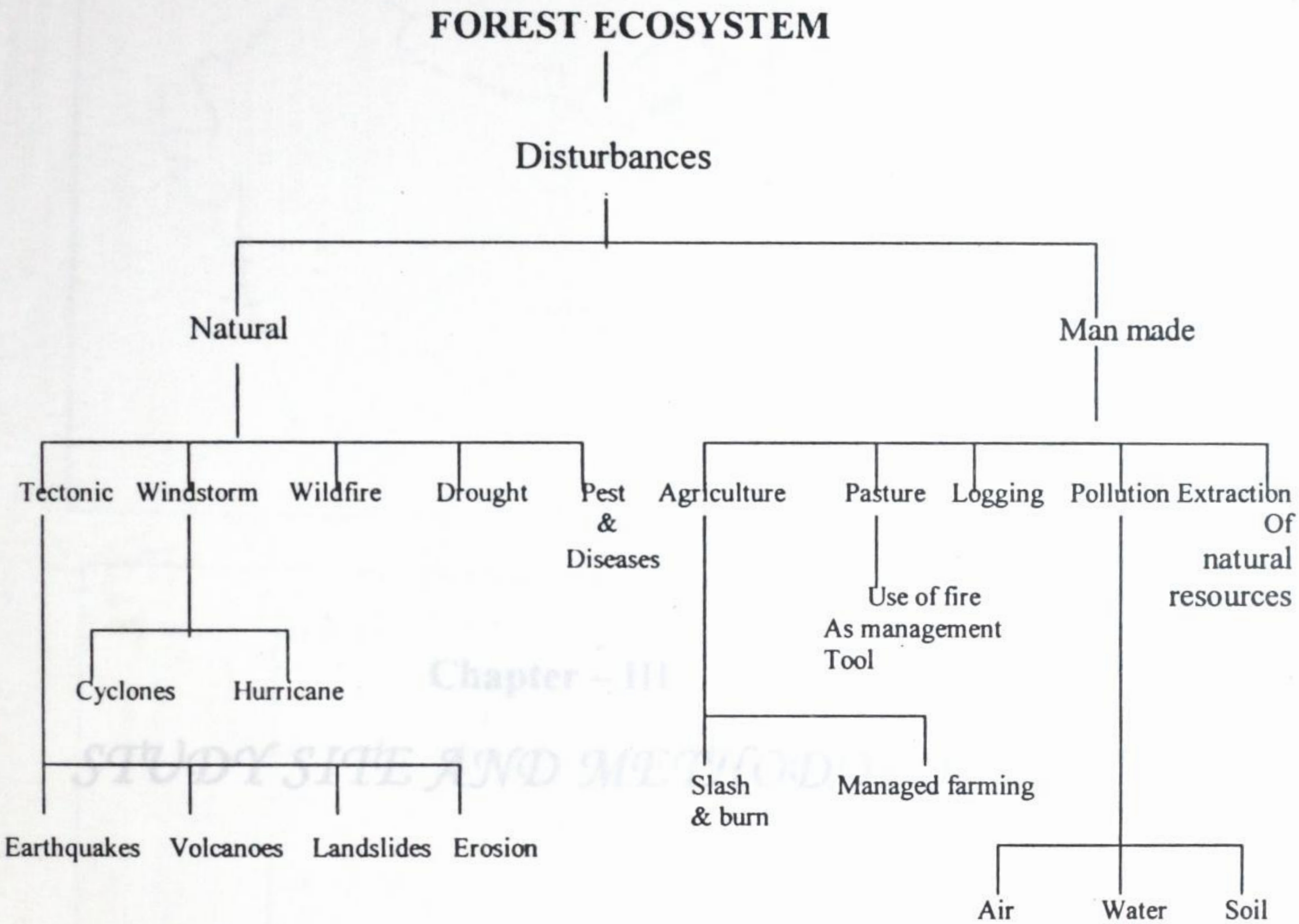
Nutrient cycling and energy flow in terrestrial ecosystems are tied to the turnover of organic matter in soil. Smith and Paul (1990) stressed on the need to understand the microbial processes for the management of farming systems, particularly those that rely on organic inputs of nutrients.

Bolton et al,(1985);Anderson and Domsch (1989);Doran (1987); Powlson et al. (1987); Nannipieri et al (1990) and Kirchner et al. (1993) made a general observation on studies on farm management systems on microbial population dynamics and different tillage practices and concluded that such studies showed a development of a larger microbial biomass in soils receiving cover crops and manures than in the same soils receiving only mineral fertilizers. Gunapala and scow (1998) estimated the microbial biomass and activity and showed that these variables are almost always significantly higher in soils of organic and low input than the conventional farming system. They also observed that, though management of the farming systems differs in many ways, the most important factor differentiating the microbial communities in the different farming systems is the amount of C entering the system.

Martin and Scott (200) noted that the atmospheric nitrogen (N) deposition has become one of the most important agents of vegetation change in densely populated regions. They determined that the relationships found between N depositions, available soil N and forest expansion suggest that even comparatively low rates of N deposition may accelerate the expansion of forest into temperate grasslands. Vitousek et al. (1997) observed that terrestrial eutrophication caused by nitrogen deposition changes species composition and lowers diversity over wide areas. Bobbink et al (1998) also reported that high amounts of deposited nitrogen are correlated with the increase of tall species in nutrient poor European grasslands and heathlands. Kellman & Carty (1986) noted that due to their height, trees and shrubs can intercept more airborne particulate N than grasses and they should therefore benefit most from N deposition. Bert et al. (1997) also noted that fertilization also increases the water-use efficiency of wody invaders. Wilson and Tilman (1991) reported that deposition of N may decrease competition for N and increase competition for light and may give further advantage to tall or fast growing trees. Wilson (1998) therefore noted that increased deposition rates might result in a self-maintaining positive feedback that allows trees to establish in grasslands. According to Chapin (1980); Berendse (1983); wedin and Tilman (1990); Olff et al.(1994) species composition, species diversity and primary productivity of terrestrial ecosystems are strongly affected by the rates at which limiting nutrients such as nitrogen (N) are supplied. Swift et al. (1979) observed that the supply rate of N depends largely on mineralization i.e the microbial- mediated conversion of organic N to inorganic forms (NO_3^- and NH_4^+). Van Brumen (1993) also noted that mineralization is regulated by both abiotic and biotic factors. Wedin and Tilman (1990) found that N mineralization was higher when plots contained early rather than late success ional faster growing species. Berendse (1998) contended that increased biomass turnover, resulted in the accelerated increase in N mineralization. Tanja and Frank (2001) observed that plant species could affect soil nitrogen mineralization rates. Overall, species from high fertility habitats increased N mineralization and nitrification more than species from low fertility habitats. Parkinson and Paul (1982) suggested that the microbial biomass could supply a large proportion of crop N requirements. However Hassink et al. (1993) suggested that microbial activity, rather than the size of the microbial biomass was a better indicator of N mineralization, particularly in sandy-textured soils. Jenkinson (1990) partitioned the capacity of a soil to supply N into two compartments; firstly N which is immediately available for plant uptake and secondly the amount of N potentially available from mineralization of organic matter. Puri and Ashman (1998) in their study showed that soil moisture in combination with temperature gave the best correlation with gross N mineralization rates. They also showed that decline in soil moisture content corresponded with significant decline in mineralization and increased soil moisture corresponded the rise in mineralization rates. In a condition where soil temperature declined rapidly and when soil moisture contents were stable the mineralization rates were significantly depressed.

Litterfall and decomposition ~~and decomposition~~ from trees is considered to be an important factor contributing to soil quality (Wedderburn and Carter,1999). Nutrient flow is influenced by the timing, quantity, quality and decomposition rate of litter. Quantity of litter entering the system varies from a pulse to continuous fall through out the year depending on the species. Swift et al.(1979) reported that high quality (high N,low lignin) will decay and release nutrients quickly whereas that of low quality (low N, high lignin) will decay slowly. Anderson and Domsch(1978); Visser and Parkinson(1992); Wardle (1993) reported that microbial activity assist in comparing rates of decomposition from the different functional types. Wedderburn and Carter (1999) reported that the main difference between deciduous and evergreen species was in the patterns of litter fall rather than in terms of decomposition or litter quality. They also reported that litter of N-fixers did not necessarily have a higher N concentration. They suggested that chemical components of litter were better predictors of nutrient release than was broad functional type classification and of the chemical components measured in their studies, lignin values were found to be best for predicting the decay rate of litter. Melillo et al (1982) also investigated the use of lignin- N ratio to determine decomposition and nutrient release. Christine Conn and Dighton (2000) reported that decomposition of oak leaves is slower than that of pine needles or of oak in combination with pine needles. Pine needles represent a source of easily mobilized phosphorus while oak leaves easily serve as a phosphorus sink. Both litter types immobilize nitrogen, but this immobilization is significantly greater in pine than oak. Litter quality differences influence the turnover of organic matter in the pineland ecosystem. They also found that ectomycorrhizal community structure also responds to patches of resource diversity. Alison and John (2000) reported that dissolved forms of carbon and nitrogen plays a significant role in forest nutrient cycling, particularly the role of dissolved organic carbon as an energy source for microbial metabolism. They also reported that forest litter is an important source of dissolved organic carbon to the forest floor and lower soil horizons. They observed that the flux of dissolved organic carbon from litter to soils can vary widely depending on the species present, and nitrogen availability does not appear to alter the flux of dissolved organic carbon from litter, however increased N availability does increase the dissolved organic nitrogen flux thereby decreasing leachate dissolved organic carbon to dissolved organic nitrogen ratio.

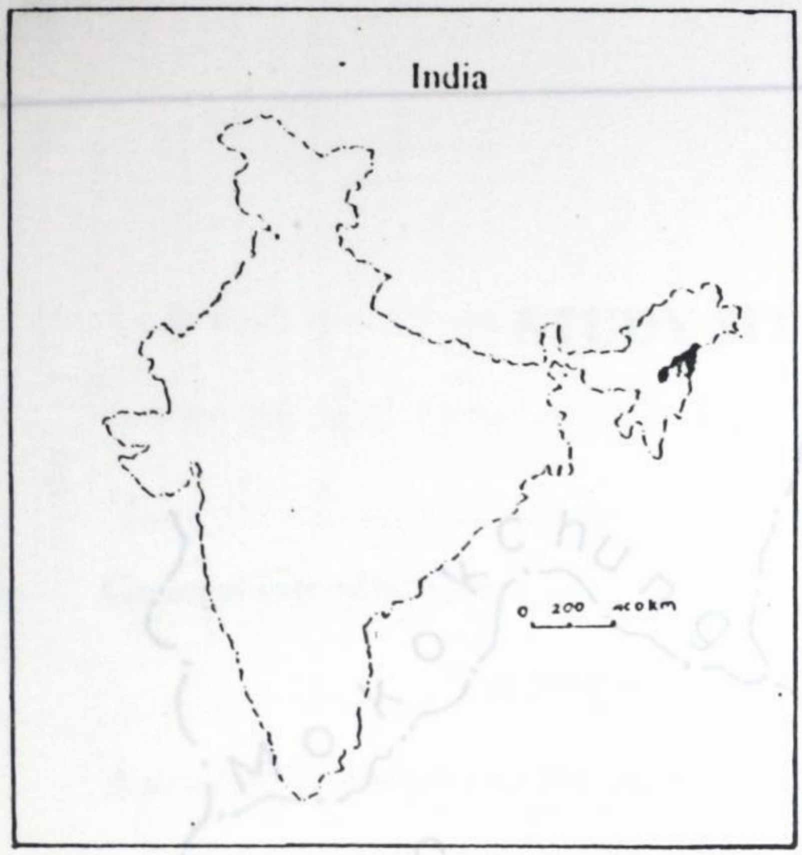
In North-East India studies were carried out on jhum cycles and its effects on soil, effects of fire on the early phase of secondary succession after slash and burn agriculture (Ramakhrishnan & Toky, 1983; Saxena & Ramakhrishnan, 1984; Kuswaha et al. 1983). Khan (1986); Rao (1992) and Barik (1992) studied the regeneration of tree species along disturbance gradient in the sub-tropical wet hills forest of Meghalaya. Ramakhrishnan and Toky (1983) reported that the first few years in the development of vegetation cover herbaceous species showed a marked reduction from 7 to 16 years old stand. Arunachalam (1996) reported that the presence of seedlings and saplings of the climax community of oak in the 7-year-old stand has a faster rate of vegetation recovery and this may be attributed to favorable climatic conditions. Soil moisture content (SMC) seems to have seasonal variation with lower soil moisture content in surface layer during dry winter and spring seasons could be result of higher evapotranspirations from the soil surface and percolation and infiltration of water to the lower depths (Tiwari et al, 1992). Temporal changes in soil pH have been reported by Mishra and Ramakrishnan (1983) in 'Jhum' fallows of different ages. However, Pandey and Singh (1984/1985) reported that the pH as such may not be the main factor associated with revegetation of acidic soils. Soil moisture content, soil organic matter, total nitrogen and available phosphorus increased in older stands while percentage pH showed a reverse trend (Arunachalam 1996). Tawnenga et al.(1997)also demonstrated that due to slash burning soil acidity, carbon and nitrogen is depleted but elevates phosphorus and cations. In order to reduce the demand for forested land for Jhum, second year cropping may be a innovative choice and will also lengthen the Jhum cycle substantially (Tawnenga et al. 1997).



Schematic representation of the major disturbances on forest ecosystem

Chapter – III

STUDY SITE AND METHODOLOGY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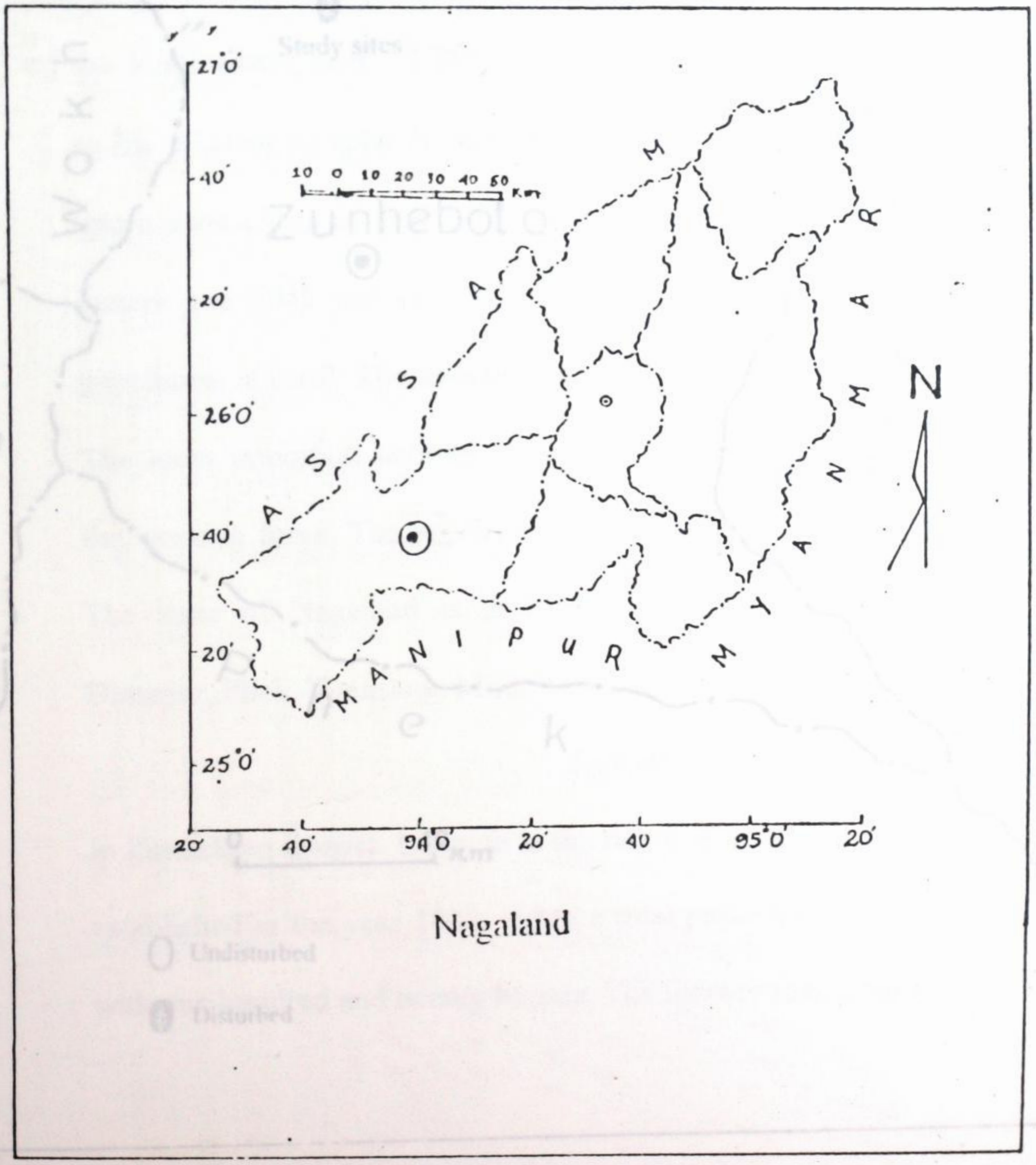
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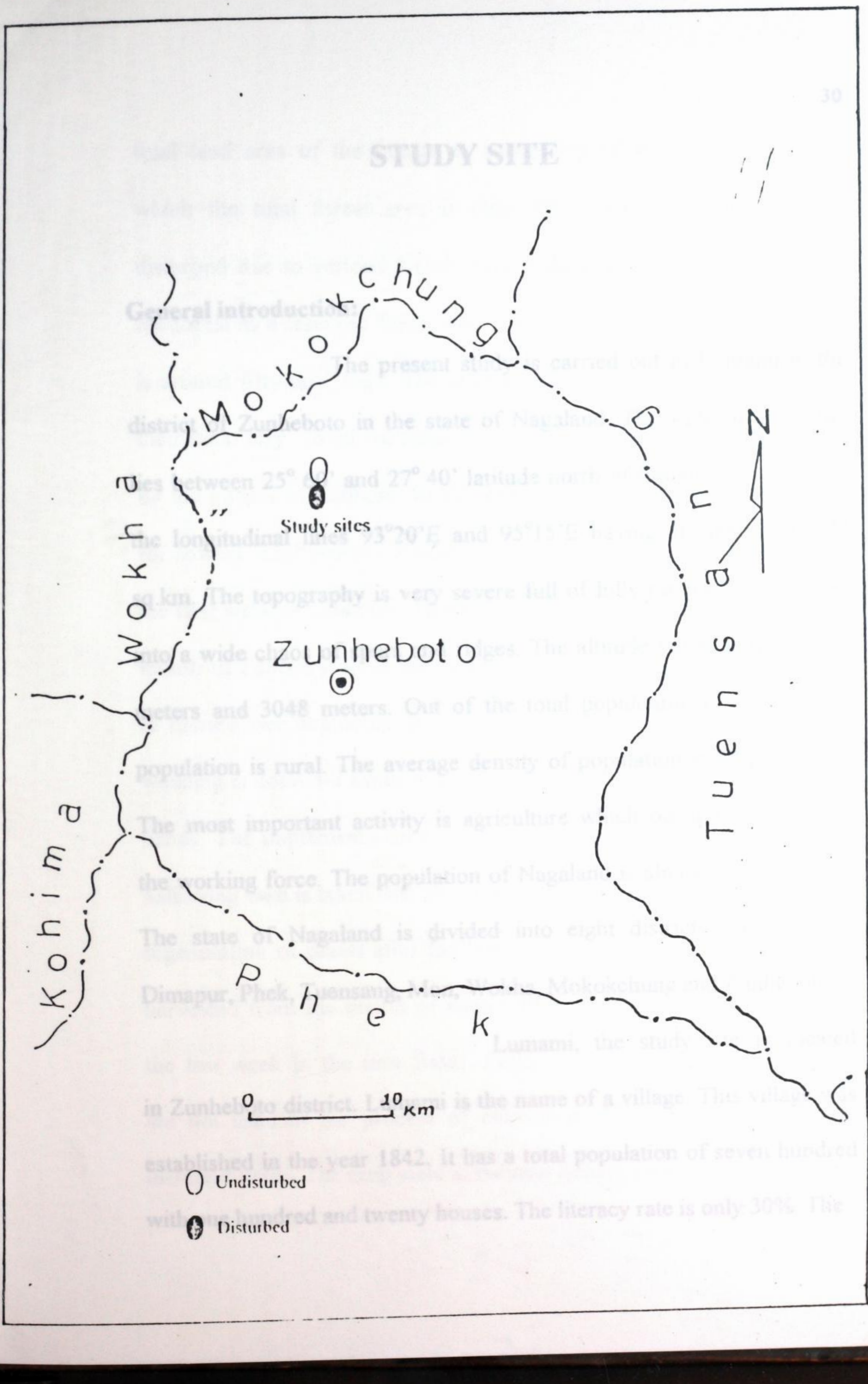
Mokokchung
Wokha
Kohima
Zunheboto
Tuensang
Phek
N
Study sites
0 10 Km
Undisturbed
Disturbed

STUDY SITE

General introduction:

The present study is carried out in Lumami in the district of Zunheboto in the state of Nagaland. The state of Nagaland lies between 25° 60' and 27° 40' latitude north of Equator and between the longitudinal lines 93°20'E and 95°15'E having an area of 16579 sq.km. The topography is very severe full of hilly ranges, which break into a wide chaos of spurs and ridges. The altitude varies between 194 meters and 3048 meters. Out of the total population, 82.78% of the population is rural. The average density of population is 73 per sq.km. The most important activity is agriculture which occupies 73.38% of the working force. The population of Nagaland is almost entirely tribal. The state of Nagaland is divided into eight districts viz: Kohima, Dimapur, Phek, Tuensang, Mon, Wokha, Mokokchung and Zunheboto.

Lumami, the study site is located in Zunheboto district. Lumami is the name of a village. This village was established in the year 1842. It has a total population of seven hundred with one hundred and twenty houses. The literacy rate is only 30%. The total land area of the village is approximated at 3000 acres, out of which the total forest area is only 150 acres, which is constantly disturbed due to various factors. The village maintains a small part of the forest as a reserved forest since 1949, which at the time of the study is around fifty-one years. The villagers totally depend on cultivation as their main stay. Jhum cultivation is the only major agriculture practiced by the people of Lumami. In this practice the forest is cut and cleared for sowing. This process is normally done in the month of November to the first week of February. These cleared forests are being burned in the month of February up to the middle week of March. . Sowing of seeds is carried out beginning from the last part of March. Cleaning and weeding is done 3-4 times in a cultivated year, which is mostly done by hands. The implements used are mostly dao, spade, and akhwo. While hallowing care is taken that all roots are not removed so as to enable the regeneration of plants after the land is left as fallow land. The field is harvested from the month of august first week in the old fields and in the last week in the new fields. Fertilizers, pesticides and weedicides are not used in the process of cultivation. The crop yield differs in different fields. The crop yield in the new field is found to be lesser than in the old fields. A good harvest also depends on the time of sowing, late sowing produced low yield whereas timely sowing produced good and higher yield. The major crops cultivated are paddy (*Oryza sativa*) of three varieties (yonglo, khulhoghi and khatighi). Out of which yanglo (local name) gives a very good yield. Millet, maize, chilli, beans (gancharg, mengeng, asii, kholakhiti, awu) of various types are also cultivated. After the cultivation the land is left as fallow land. The return or cycle of jhum cultivation is in two types i.e. (a) 60- years return in some parts and (b) the same area is cultivated continuously for 2-3 years. Forestland not only serves as agriculture land but also produces timber, firewood and materials of economic and aesthetic values. The local people were completely dependent on this forestland for their livelihood and so far they have been found to be self-sufficient.

The present study seeks to find the effects of disturbance on the forest ecosystem by means of studying the parameters of the structure and function of the forest ecosystem and the fallow land. A fallow land of three years was selected as a study plot and investigation. The nearest available forest area was also selected as a study plot. This forest is a reserved forest kept by the village headman. In these study fields, both community analysis and soil characteristics were considered. All relevant data were collected in four varying seasons over a period of two years.

Climate:

Nagaland as a whole has a varied climatic conditions. This may be attributed to the altitudinal differences. The general climatic condition as observed, ranges from warm sub-tropical to cool and temperate type on the hilly areas. Lumami, situated on the lower altitude generally has a warm and humid temperature conditions. The months of June to August experience the highest temperature conditions (29^o-32^0C). These months also receive the maximum of rainfall. Humidity is also recorded at an average of 80 % during these months. Winters begin from the month of November upto the early February and have a fairly warm temperature conditions (20^oC). It is also observed that there is scanty rainfall during these months. Springs and autumn experiences a fairly pleasant weather. A brief windy period is also observed in the month of March and April. Generally, Lumami experiences a warm humid climatic condition most of the year and a dry spell in the winter months.

The four seasons in a year are as follows-

Spring season: - March- April

Rainy season: - May –August

Autumn season: - September-October

Winter season: - November-February

Different microclimatic variables were taken into consideration during the period of study.

Altitude: - Altitude was measured using an altimeter. It measured at 1100m above sea level.

Temperature: - Temperature was recorded with a thermometer and the results are shown in the Tab.1, Fig: 1

Rainfall: - Average rainfall was recorded as per the source of the directorate of soil and water conservation, Govt. of Nagaland. The results are indicated in the Tab2, Fig: 2.1 & Fig: 2.2.

Humidity: - Atmospheric humidity was recorded with a hygrometer and the seasonal variation is shown in the Table.3, Fig: 3.

Light intensity: - Digital lux meter was used to record the solar influx in the two fields in different varying seasons.

Table: 1

Sl.No	Months	Temp °C 2000	Temp °C 2001
1.	January	20	21
2.	February	23	24
3.	March	23	23
4.	April	30	28
5.	May	29	29
6.	June	31	34
7.	July	32	30
8.	August	27	27
9.	September	26	26
10.	October	25	24
11.	November	25	25
12.	December	21	22

Monthly temperature variation

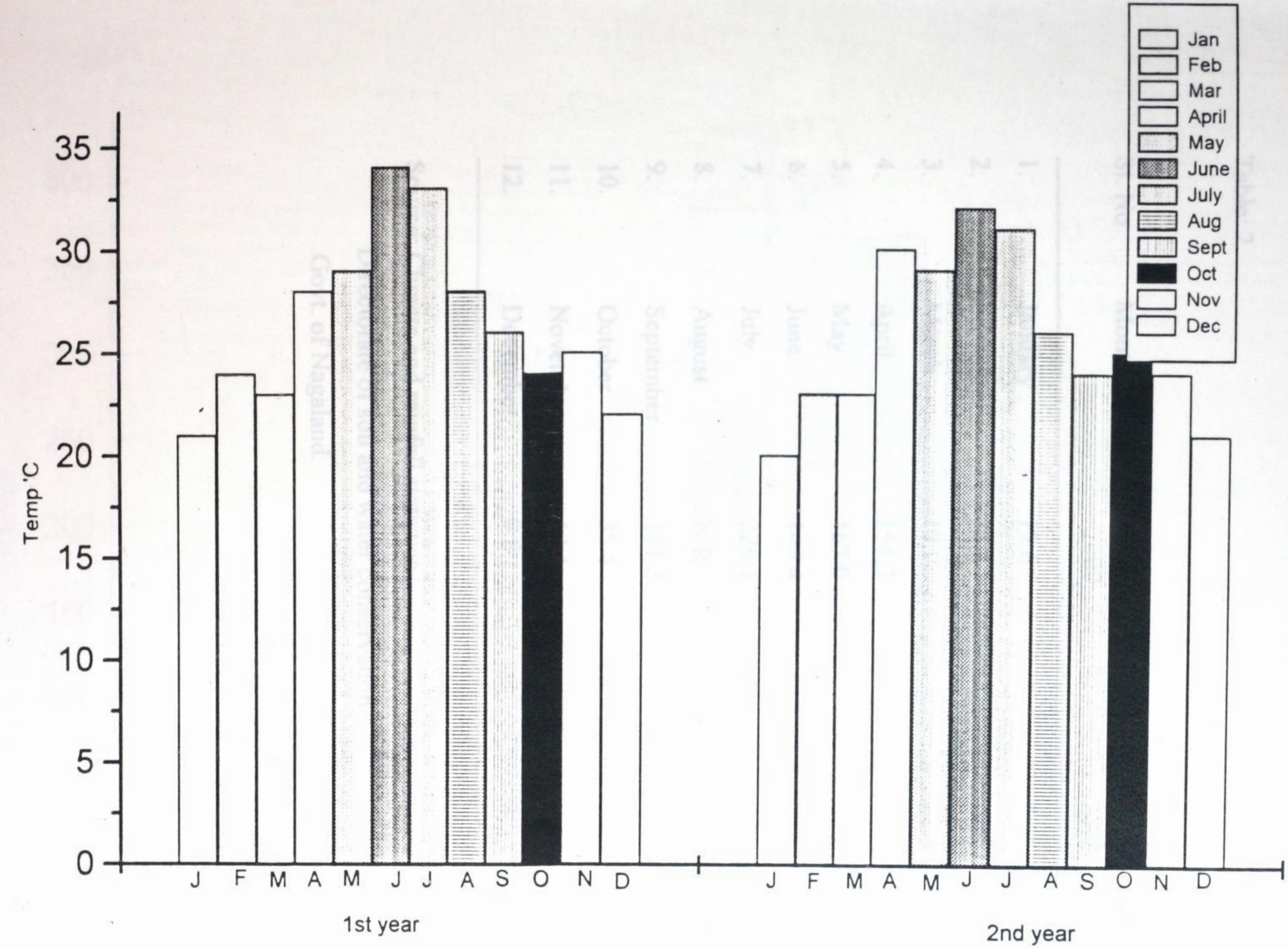

Fig: 1 Temperature variation

Table: 2

Sl. No	Month	Rainfall in (mm) 2000	Rainfall in (mm) 2001
1.	January	19.6	5.2
2.	February	15.8	0.5
3.	March	10.0	22.4
4.	April	154.3	6.8
5.	May	167.0	181.7
6.	June	143.4	273.6
7.	July	229.1	268.5
8.	August	N.R	403.8
9.	September	141.2	368.8
10.	October	35.4	233.1
11.	November	57.4	9.1
12.	December	0.8	4.5

Source: Climate and rainfall statistics

Directorate of soil and water conservation

Govt. of Nagaland.

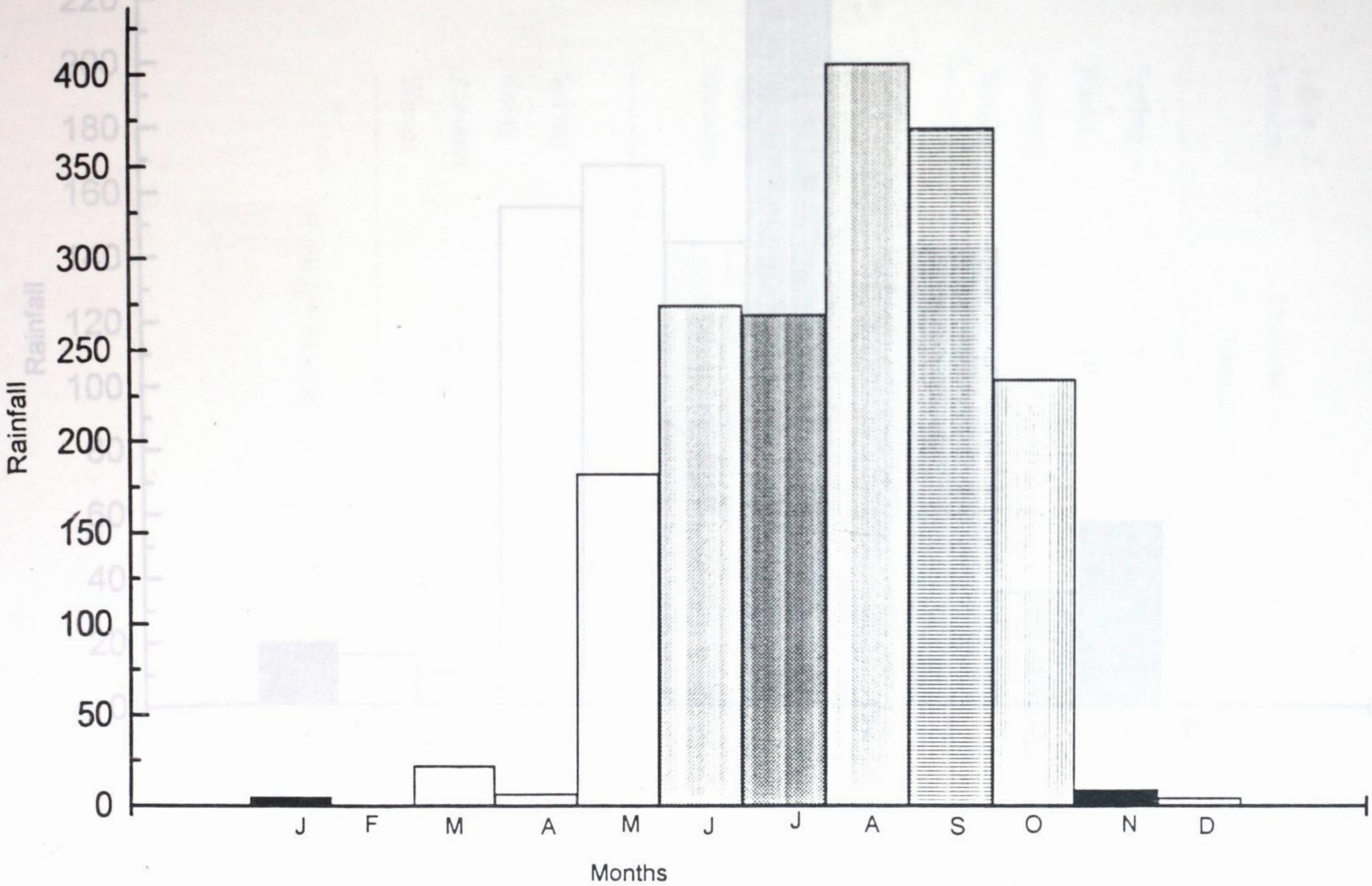

Fig:2.1 Rainfall during the 2nd year of study

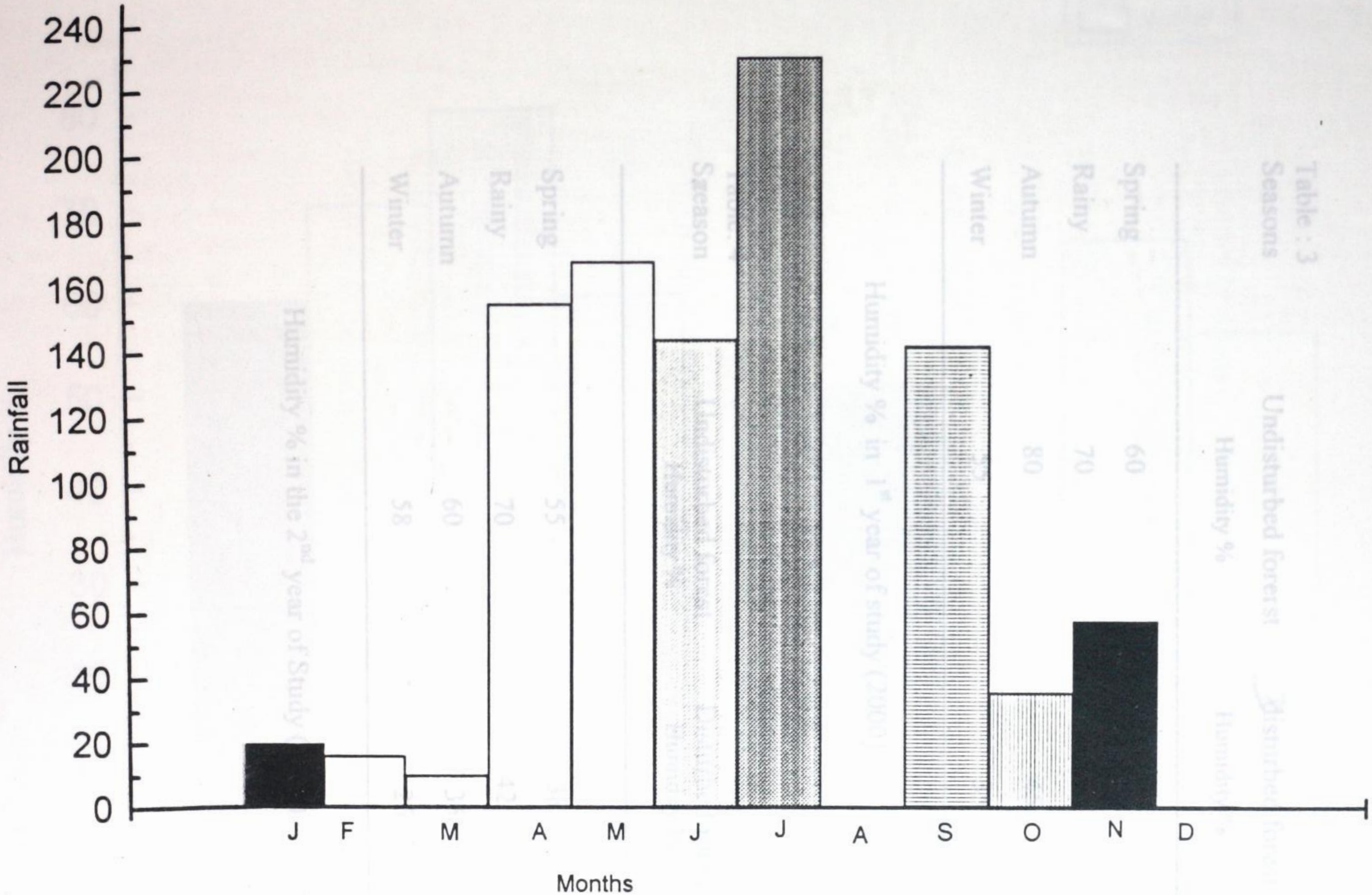

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Fig:2.2 Rainfall during the 1st year of study

Table : 3

Seasons	Undisturbed forerst Humidity %	disturbed forest Humidity %
Spring	60	50
Rainy	70	42
Autumn	80	45
Winter	55	35

Humidity % in 1st year of study (2000)

Table: 4

Season	Undisturbed forest Humidity %	Disturbed forest Humidity %
Spring	55	38
Rainy	70	42
Autumn	60	35
Winter	58	26

Humidity % in the 2nd year of Study (2001)

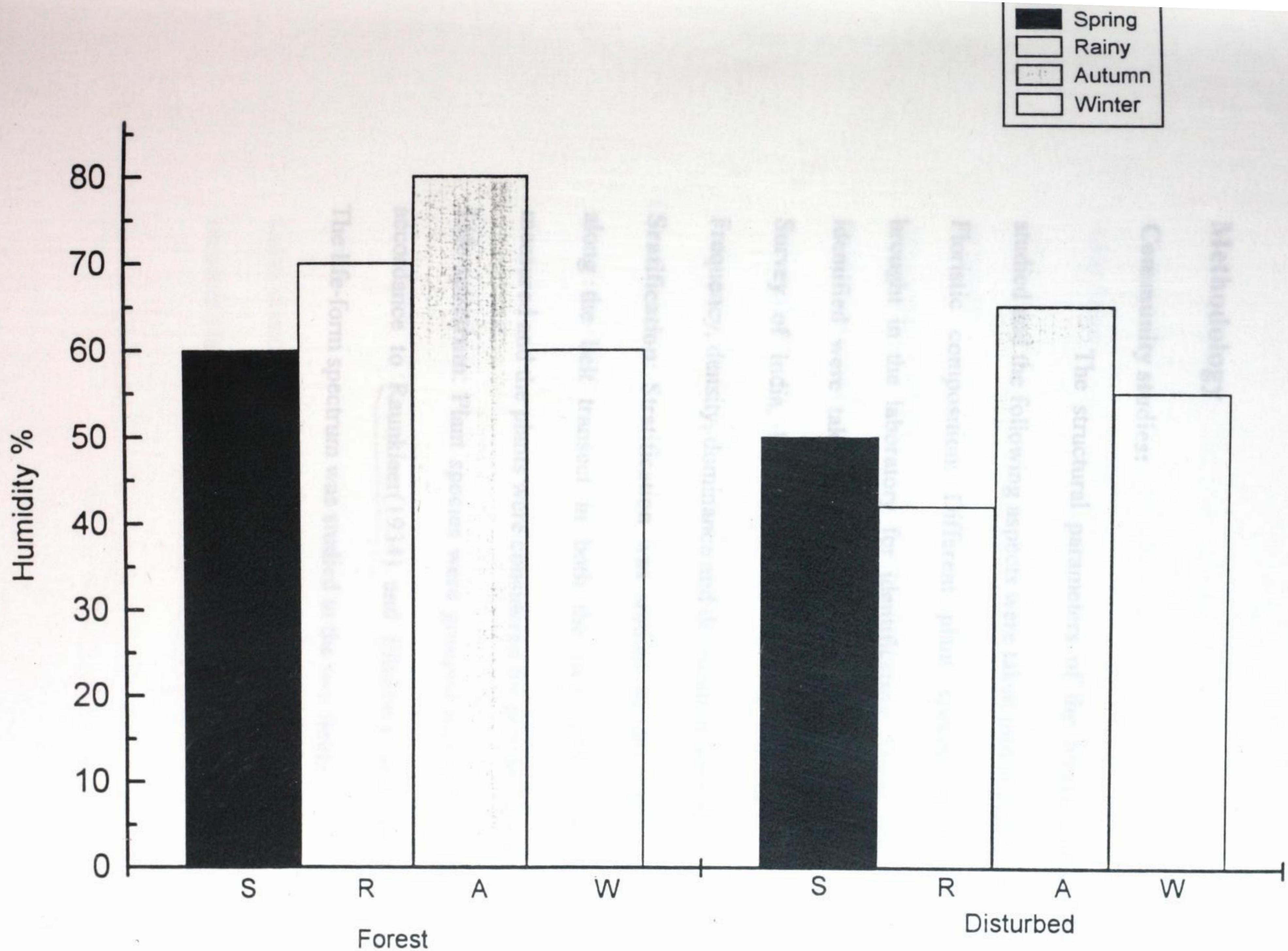


Fig:3 Humidity % in Forest and Disturbed area in the 1st year of study

Methodology

Community studies:

The structural parameters of the forest communities were studied and the following aspects were taken into consideration.

Floristic composition: Different plant species were collected and brought in the laboratory for identification. Those that could not be identified were taken to other laboratories like NEHU & Botanical Survey of India, Eastern Circle, Shillong for further identification. Frequency, density, dominance and distribution were also studied

Sratification: Stratification was studied by drawing profile diagrams along the belt transect in both the two fields. Tree heights were measured and the plants were considered for profile diagram.

Life-spectrum: Plant species were grouped into different life-forms in accordance to Raunkiaer(1934) and Ellenberg and Muller Dombois. The life-form spectrum was studied in the two fields.

Life-form		Identifying characters (Position of perennating buds from the ground)
Megaphanerophyte	-	above 30m high
Mesophanerophyte	-	8- 30m high
Microphanerophyte	-	2-8m high
Nanophanerophyte	-	up to 2m high
Chaemephytes	-	up to 0.3m high (low woody plants to herbs)
Geophyte	-	underground
Theophyte	-	in the seed form
Epiphyte	-	plants growing on other plants
Liana/climber	-	mechanically dependent on other plants

Species richness and Index of similarity:

Species Richness was calculated by adopting Whittakers diversity (D) (Whittakers 1960, 1975)

$$D = S/\log N$$

Where, S = No. of species in a sample, and

N= Total no. of individuals in the sample.

Sorensen's Index of similarity:

$$IS_s = 2\ c/a + b \times 100$$

Where, a = number of species at site A,

b = Number of species at site B, and

c = Number of species common to site A and site B.

Frequency, density, basal cover and abundance:

A quadrat of (10x10) were randomly laid to study the phytosociological parameters of the species. Frequency, density, basal cover, abundance and importance value were calculated according to Misra (1968)

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats of occurance of a species}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Density (Plants ha}^{-1}\text{)} = \frac{\text{Total No. of individuals of a species}}{\text{Total No.of quadrats studied}}$$

Basal cover (m^2 ha^{-1}) = Density x tree basal area

$$\text{Abundance} = \frac{\text{No.of individuals of a species}}{\text{No.of quadrats of occurance of the species}}$$

Shanon and Wiener index of diversity

$$H = - \Sigma \left[ni/N \left(\log 2\ ni/N \right) \right]$$

Where

ni = importance value of i^{th} species

N = Importance value of all the species.

or

$$H = - \Sigma\ Pi \ln Pi$$

Where Pi = Proportion of the number of the i^{th} species.

Soil characteristics

Soil samples from the study site were collected at two varying depths (0-10 and 10-20 cm). The soil samples were brought to the laboratory and the plant debris and roots were separated. The soil samples were mixed to make a composite sample. Soil pH was determined electrometrically by a digital pH meter. Soil moisture content was also determined by gravimetric method. Organic carbon was determined by rapid titration method (Walkley and Black 1934). Total Kjeldahl nitrogen was determined by Kjeldahl method (Allen et al. 1974). The soil samples were collected in different seasons over a period of two years and the results were obtained and discussed.

Soil texture: To evaluate the soil texture, the soil sample was examined under hand lens and felt between thumb and fingers in dry as well as moist state and texture is judged with the help of a key. The soil was found to have a relatively even mixture of different grades of sand, silt and clay. It has a gritty feel, yet fairly smooth and slightly plastic. Squeezed when dry, formed a cast and when moist the soil cast can be handled quite freely without breaking. The soil was found to be loamy in texture.

Soil moisture content: Soil samples from the study plots at different depths were brought in the laboratory. Weight of the fresh soil sample was taken and then kept in an oven at 105°C for 24 hrs for drying. The final dry weight was taken. The soil moisture content was calculated by the following formula and expressed in percentage.

$$\text{Soil moisture (\%)} = \frac{FW - DW}{DW} \times 100$$

Where, FW= fresh weight of soil

DW= dry weight of soil sample

soil pH: Soil samples from different study plots were brought to the laboratory. From each sample of varying depth, 10 gms of soil was added with 25ml of distilled water. The soil sample was stirred with a magnetic stirrer for about 5-10 minutes and the reading was taken with the help of a digital pH meter which was previously standardized with standard buffer solution. The pH readings are shown in the table.

Determination of total nitrogen:

Kjeldahl's digestion method was followed to determine the total nitrogen in plant tissue as well as soil and litter as described by Mishra (1968). 0.2 gm air-dried plant samples and 1 gm of soil sample of powdered and sieved (0.2mm mesh) was taken in 100 ml microkjeldahl flask. To it, 6ml Concentrated H_2So_4 for soil sample and 3ml H_2So_4 for plant samples were added and ½ tab of kjeltabs for plants and 1 tab for soil were also added. The digestion was carried out in a digestion unit. After the solution appeared to be green in co lour the digestion was stopped and flasks were allowed to cool. The content was diluted with 50ml dist. water in a volumetric flask.

Distillation was done in Kjeldahl distillation set, with 10ml digested solution and 10ml of 40% NaOH. Distillation was continued for 15-20 minutes and the distillate was cooled in a beaker with 5ml Boric acid indicator (100g boric acid in 10ltr of dist.water + 100ml bromocerol green i.e 100gm in100 ml methanol + 70ml of methyl red i.e 100gm in 100ml methanol). The distillate was collected in the beaker (about 50ml) and titrated against N/14 HCl. Percentage of total nitrogen was calculated by the following formula.

$$N\% = \frac{\text{T- blank x solution volume (ml)}}{10^2 \text{ x aliquot volume x air-dried sample wt.}}$$

Determination of total phosphorus

For the estimation of total phosphorus the wet triacid digestion procedure was followed as suggested by Allen (1974). 3 gm of air dried sieved soil/.2gm plant material and 30 ml of 0.5 M $NaHCO_3$ were added in a bottle. To it 100ml of Olsen's reagent was added. The solution was shaken for 30 minutes on a rotary shaker. Then the solution was filtered through No.44 filter paper.

Phosphorus was analysed by Molybdenum blue method (Jackson, 1973). The sample solution was prepared and diluted with double distilled water up to volume. 0 to 15 ml of working standard was pipetted into 50 ml volumetric flasks to give a standard range from 0 to 0.03 mg P. 5ml of aliquot sample solution was pipetted out and transferred to 50ml volumetric flasks. 2ml of ammonium molybdate and 2ml of stannous chloride reagents were mixed and total volume was prepared up to 50ml by adding double distilled water and left for 30minutes. The optical density of the solution was measured on a spectrophotometer at 700nm wave length and converted into known units through standard calibration curve and calculated into percentage phosphorus by the following formula,

$$P\,\% = \frac{C\ (mg) \times \text{solution volume}\ (ml)}{10 \times \text{aliquot}\ (ml) \times \text{sample weight}\ (g)}$$

Determination of Potassium

Potassium was determined by flame photometer method (Allen et al.1974). 3gm of air-dried sieved soil/. 2gm of plant material was taken in a 500 ml conical flask. 250 ml of ammonium acetate was added. This solution was shaken in a rotary shaker for 1hr and kept overnight. After which it was shaken again for 5min and filtered through filter paper No.44 and the first 20-30 ml were rejected. This solution was stored in an extraction bottle for the determination of Potassium in a flame photometer and converted into a known unit through standard curve and percentage potassium was calculated as per the following formula:

$$K\% = \frac{C\ (ppm) \times \text{solution volume}}{10^4 \times \text{sample wt (g)}}$$

Determination of soil organic carbon

Soil organic carbon was determined by rapid titration method (Walkley & Black 1934). 0.5 gms of soil sample (air-dried sieved soil) were taken in a 500ml conical flask and 10ml of $K_2CR_2O_7$ and 10 ml of conc H_2SO_4 were added. The system was kept as such for ½ hr. Then 200ml of dist. water was added and subsequently 10ml of Orthophoric acid,1/2 ml of DPA indicator and 0.2 gm NaF were added. The solution was shaken well and titrated against ferrous ammonium sulphate. Soil organic carbon was calculated by the following formula:

$$\% C = \frac{[10 - (\frac{T \times 10}{\text{Blank}})] \times 0.3}{\text{Soil weight (gm)}}$$

Chapter – IV

VEGETATION

Diagram: 1. Profile diagram of undisturbed forest

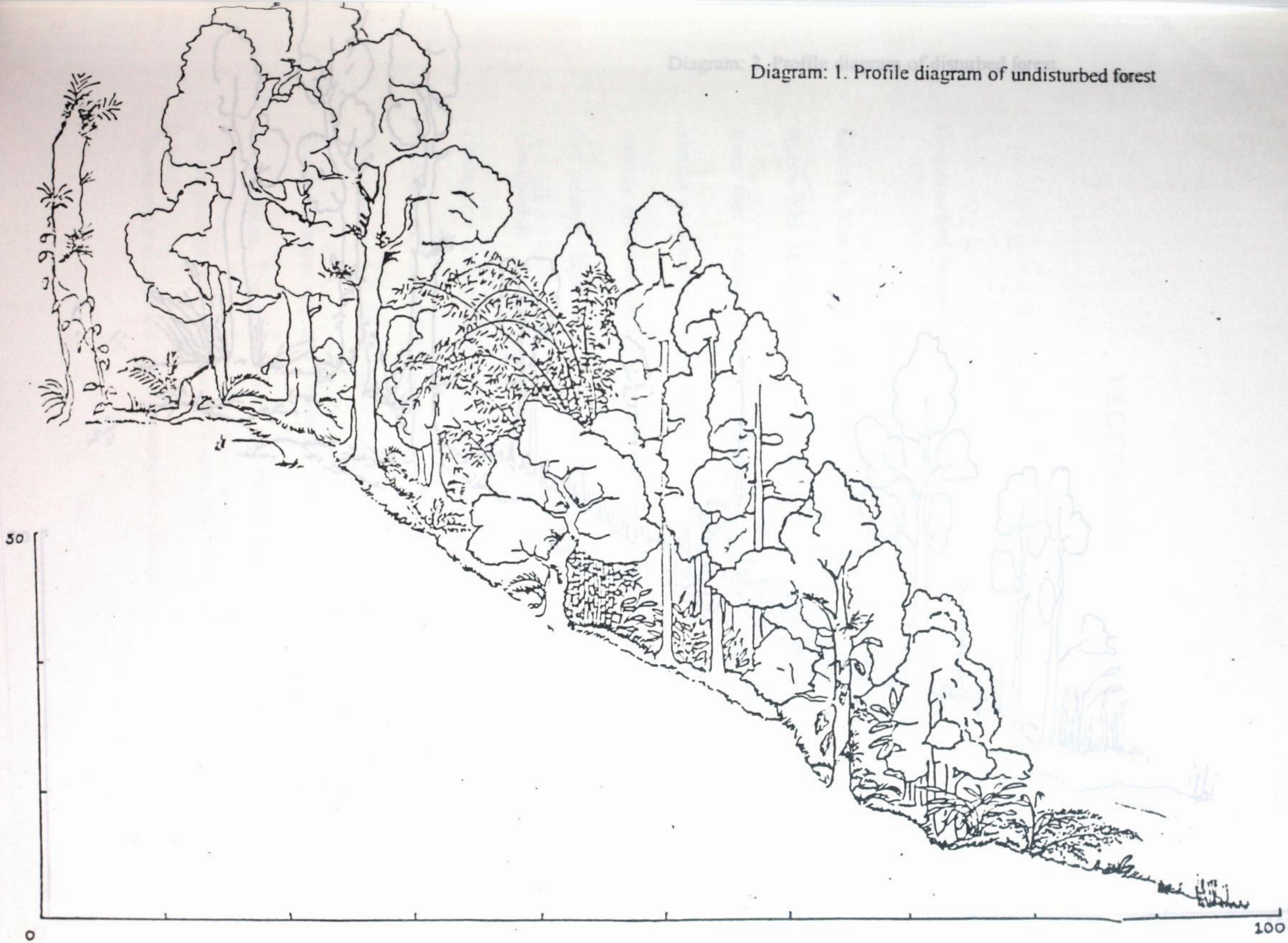
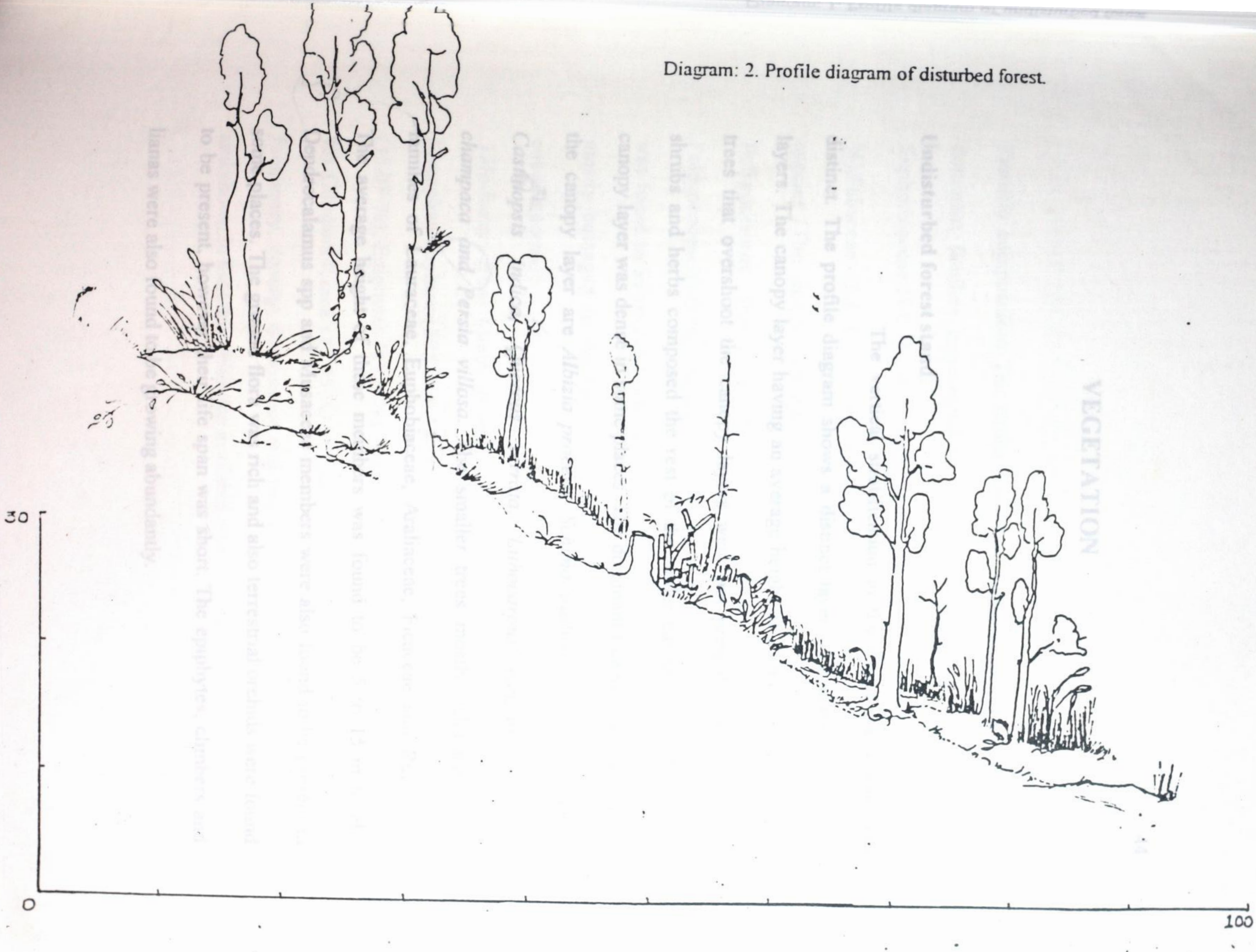


Diagram: 2. Profile diagram of disturbed forest.



VEGETATION

Undisturbed forest stand:

The vertical stratification in the forest stand was very distinct. The profile diagram shows a distinct layer of 2 (two) to 3 (three) layers. The canopy layer having an average height of 20m or more. Emergent trees that overshoot the canopy layers were not present. The small trees, shrubs and herbs composed the rest of the under canopy layer. The under canopy layer was dense in some places. The dominant tree species that formed the canopy layer are *Albizia procera, Schima wallichii, Alnus nepalensis, Castinopsis indica, Quercus serrata, Lithocarpus elegans, Michellia champaca and Persia villosa.* The smaller trees mostly belonged to the families of Lauraceae, Euphobiaceae, Araliaceae, Ficaceae and Rubiaceae. The average height of these members was found to be 5 to 15 m height. Dendrocalamus spp and Musaceae members were also found to be present in some places. The ground flora was rich and also terrestrial orchids were found to be present, however their life span was short. The epiphytes, climbers and lianas were also found to be growing abundantly.

Floristic composition: **The forest stand has a rich floristic composition.** 61 dominant families represented the total flora. Family verbenaceae (4.0%), Euphorbiaceae (4.0 %), Fagaceae (2.4 %), Lauraceae (0.8 %), Theaceae (2.4 %),Fabaceae (2.4 %), Apocynaceae (3.2 %) comprised most of the tree species. The shrubs and herbs comprised mostly of Asteraceae (4.8 %), Polypodiaceae (6.4 %), Poaceae (6.4 %), Zingiberaceae (4.8 %), Polygonaceae (1.6 %), Minispermaceae (1.6 %). Above all Pteridophytic flora was found to be very rich with a representation of about 16 families. Climbers mostly belonged to the family Smilacaceae, Verbenaceae, Pteridaceae and cucurbitaceae.

Life-form: The forest stand recorded a high species percentage of Mesophanerophtes (30.0 %), Chamaephytes (26.98 %), Microphanerophytes (15.07 %), Epiphytes (14.0 %), Nanophanerophytes (7.1 %), Epiphytes (14.0 %), Climbers /Liana's (7.75 %) and geophytes (1.5 %).

Frequency, density, domonance and Importance Value Index are worked out and shown in the table. With the available data, Sorensons index of similarity was worked out as 41.48 % and Shanons index of species diversity was worked out as 2.2520.

Disturbed forest stand

The disturbed area was not well stratified as the undisturbed stand. The profile diagram showed a stratification of two layers with tree species scattered here and there and without a canopy formation. The tree species present were the species that were left uncut while clearing the forest and the stumps that survived forest fire. *Quercus serrata*, *Erythrina stricta, Albizia procera, Schima wallichii* were found to be the dominant species present in the disturbed area i.e. the fallow land. *Eupatorium odoratum, E. adenoforum, Aegeratum conyzoides, Imperata cylindrica, Cyperus spp* are found to be abundantly present. Floristic composition: The floristic composition is also low in this disturbed area. Altogether a total of 30 families are recorded in this field. Out of which the dominant families are Asteraceae (18.9%), Poaceae (17.24%), Cyperaceae (5.17%), Euphorbiaceae (8.62%), Zingiberaceae (3.44%). Very few tree species are present. *Eupatorium odoratum* and *E. adenoforum* almost completely dominate than the rest of the species. It was also noted that very few epiphytes are present. However climbers like *Thunbergia spp, Dioscorea spp, Mikania micranta* are also found to be luxuriantly growing and rapidly overtops the tree and shrubs in the field.

Life-form: Chamaephytes recorded a relatively high percentage than the rest of the life forms. The different life-form recorded are as follows – Mesophanerophyte (12.9%), Microphanerophyte (4.8%), Nanophanerophyte (25.8%), Chamaephyte (33.8%), Geophyte (8.06%), Climbers (9.67%). Lianas were not recorded in this forest stand.

Frequency, density, dominance and Importance Value Index are worked out and shown in the table. With the available data Sorensons similarity index and Shanons diversity index (0.9740) are worked out.

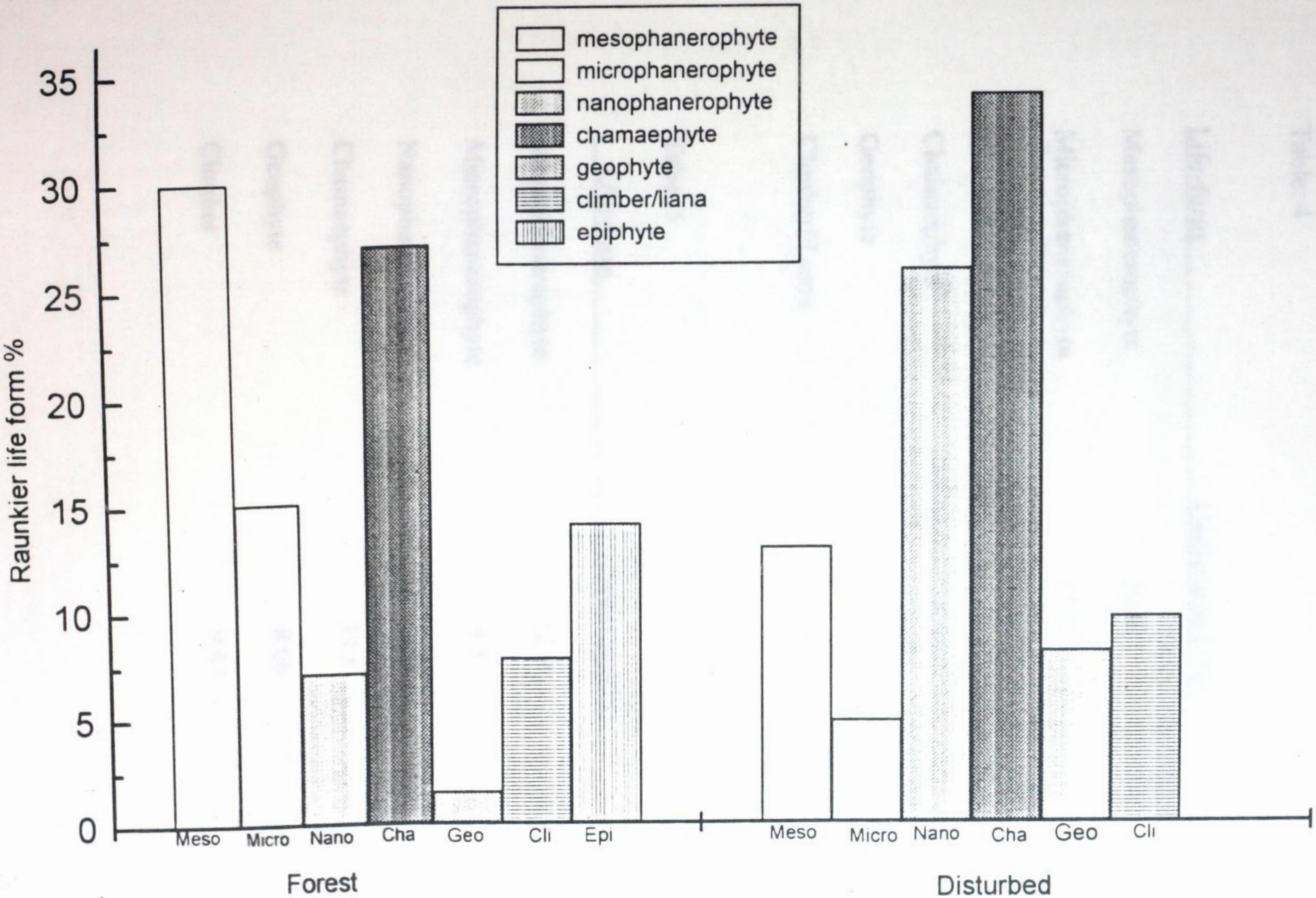


Fig:4 Distribution of life form % in forest and disturbed area

Table: 4

Life-form	Undisturbed (%)
Mesophanerophyte	30.0
Microphanerophyte	15.07
Nanophanerophyte	7.1
Chamaephyte	26.98
Geophyte	1.5
Climber/ Liana	7.75

Tabe: 5

Life-form	Disturbed(%)
Mesophanerophyte	12.9
Microphanerophyte	4.8
Nanophanerophyte	25.8
Chamaephyte	33.8
Geophyte	8.06
Climber	9.67

Table:6 Indices of Species diversity in the two Forest types of Lumami.

Index	Undisturbed	Disturbed
Shannon index of general diversity: $H = - \Sigma\ (ni/N) \log (ni/N)$ Or $- P_i \log P_i$	2.2590	0.97409
Whittaker indices of Species diversity; $D = S/\log N$	43.418	16.2341
Index of Dominace $C = \Sigma\ (ni / N)^2$	0.0606	0.1228
Sorensen's index of similarity $S = 2c/A + B \times 100$	41.489	

Table: 6.1

Frequency (%), Density(ha^{1}) and Abundance(ha^{1}) in the disturbed area.

Name of the Species	**Frequency** (%)	**Density**	**Abundanc**
Ageratum conyzoides L.	90	100	111.1
Albizia procera c.n. White Siris	10	0.5	5.0
***Ammomum* spp.**	25	12.5	50.0
***Artemesia nilagerica* (d) Pomp**	80	50.0	62.5
Artemesia vulgaris L.	40	50.0	125.0
Arundinalla benghalensis (sprin.) Druce	30	175.0	291.0
Asplenium nidus L.	10	2.5	25.0
Bauhinia variegata L.	5	0.25	5
Bidens pilosa L.	50	37.5	75.0
Callicarpa arborea Roxb.	25	2.5	10
Carex baccans Nees	70	75.0	107.14
Castinopsis indica A.D.C.	10	3.75	7.5
Centella asiatica L.	20	10.0	50.0
Costos speciosus (Koen.) SM.	15	2.0	13.33
Croton oblongifolius Roxb.	5	0.5	7.5
Curcuma zedoaria Rose	25	12.5	41.66

Cynodon dictylon Pers.	75	75.0	100.0
Cyperus spp.	80	100.0	125.0
Desmodium spp.	20	5.0	25.0
Digitaria adscendens (HBK) Henr.	25	50.0	200.0
Drymaria cordata willd.	15	7.5	50.0
Eclipta prostrata L. Hassk.	10	6.25	62.55
Eleusine indica (L.) Gaertn.	15	12.5	83.33
Emblica officinalis Gaertn.	10	0.75	7.5
Eragrostis gangetica (Roxb.) Steud.	15	10.0	66.6
Erythrina stricta Roxb.	5	0.5	5
Eupatorium adenophorum L.	100	125	125
Eupatorium odoratum L.	100	200	200
Euphorbia hirta L.	30	20	66.6
Fimbristylis dichotoma vahl.	10	7.5	75.0
Houttuynia cordata Thumb.	20	20.0	100.0
Imperata cylindrical P. Bauv.	100	200.0	200.0
Leucosceptrum canum JESM	5	0.25	5
Lycopodium aquarrosum Forst.	5	1.0	12.5
Lycopodium cernum L.	10	1.25	12.5

Macaranga indica Wt.	10	2.25	22.5
Melastoma normale L.	40	20	50
Microsorum membranaceum Ching	5	0.5	10.0
Mikania micranta H.B. &K.	25	5.0	20.0
Mimosa pudica L.	30	10.0	33.3
Mucuna bracteata DC.	25	3.75	15.0
Nephrolepis cordifolia (L) Presl.	25	20.0	40.0
Osbeckia crinita Benth.	50	25.0	50.0
Oxalis corniculata L.	25	10.0	40.0
Paederia foetida Auct	15	2.5	16.6
Panicum repens L.	70	75.0	107.14
Phyllanthus niruri L.	10	7.25	72.5
Plantago major L.	25	7.5	30.0
Pteridium equilinum (L.)Kuln.	15	6.25	41.6
Pteris spp.	5	0.5	10.0
Quercus serrata Thumb.	25	3.75	15
Rubus ellipticus (L.) SM	30	7.5	25.0
Saccharum spp.	25	20	80.0
Schima wallichii (DC) Korth.	15	1.5	10

Selaginella semicordata (wall) spring	5	0.75	15.0
Selaginella welldenovii (Desv.) Baher	5	0.75	15.0
Setaria glauca (L.) Beauv.	25	67.5	270.0
Smilax glabra Roxb.	40	7.5	18.75
Sonchus asper (L.) Hell.	20	10.0	50.0
Stephania japonica Thumb.	15	2.5	16.6
Thunbergia grandiflora Roxb.	20	3.75	18.75
Thysanolaena maxima (Roxb.) U.K	10	2.5	25.0

Table: 6.2

Frequency (%), Density (ha^{-1}) and Abundance (ha^{-1})In undisturbed forest.

Name of the species	Frequency (%)	Density	Abundance
Aegeratum conyzoides L.	5	2.5	50.0
Albizia procera c.n White siris	50	2.5	5.0
Alnus spp.	10	1.25	12.5
Alstonia(L) R.Br	10	1.0	10
Aralia L.	30	7.5	25.0
Baccaura sapida Muill.Arg.	15	1.5	10.0
Bambusa balcooa Roxb.	5	5.0	100
Bambusa pellida Munro.	5	3.75	75.0
Bambusa tulda Roxb.	5	2.5	50.0
Bauhinia purpurea (L.)	10	0.1	5.0
Bauhinia variegata L.	15	0.75	5.0
Begonia picta Sm.	15	5.0	33.3
Calamus erectus Roxb.	5	2.5	50.0
Callicarpa arborea Roxb	50	3.75	7.5
Camellia sinensis(L.) O.Kuntze	5	3.75	75.0
Caryota urens L.	15	3.75	25.0
Cassia tora L.	20	7.5	37.5
Castanopsis indica A.D.C.	75	4.25	5.66
Catheranthus roseus L.Dm	25	3.75	15.0
Chenopodium ambrosioides L.	20	2.5	12.5
Cleome viscose L.	25	6.25	25.0
Clerodendrum colebrookianum Walp.	15	1.5	10.0

Clerodendron viscotum Wall.ex Walp	15	1.0	3.75
Commalina benghalensis L.	5	1.25	25.0
Costos speciosus Koen.	20	2.0	10.0
Croton oblongifolius Roxb.	15	1.75	11.66
Curculico capitula (Lour) O.Kitz	5	1.75	7.0
Cynodon dactylon(L.) Pers.	5	1.5	30.0
Cyperus rotundas L.	5	0.75	15.0
Cyclea bicristatum Griff.	15	1.5	10.0
Datura fastuosa L.	10	7.5	75.0
Dendrocalamus gigantus Munro	5	7.5	150.0
Dendrocalamus hamiltonii Nees.	10	7.5	75.0
Dioscorea spp.	25	6.25	25.0
Dracina spicata Roxb.	10	2.0	10.0
Drynaria cordata (L.) Wild.ex Roem schult	15	5.0	33.3
Duabanga sonneratioides Buch.Ham	25	2.5	10.0
Emblica officinalis Gaertn.	15	1.25	7.5
Erythrina arborescent Roxb.	15	0.25	5.0
Erythrina stricta Roxb.	5	0.25	5.0
Euphorbia neriifolia L.	35	1.75	5.0
Eurya acuminata D.C	10	0.75	7.5
Ficus crytophylla Wall	25	2.5	10.0
Globba Clarkei L.	10	2.0	20.0
Gmelina arborea Roxb.	20	1.5	10.0
Hedychium aurantiacum Wall.	20	1.5	7.5
Hedychium coronarium Koen,	25	2.0	8.0

Hedyotes scandans Roxb.	10	0.5	5.0
Impatiens balsamina L.	5	2.0	40.0
Impatiens chinensis L.	5	5	100.0
Leea macrophylla Roxb.ex Harnem	10	2.5	10.0
Lithocarpus elegans(Bl.)Hatus ex Soepadmo	10	1.25	12.5
Litsea citrata Bl.	60	3.75	6.25
Macaranga indica Wt.	15	12.5	8.33
Michelia champaca L.	25	5.0	20.0
Mikania macranta A.B&K.	5	0.5	10.0
Musa spp.	5	1.25	25.0
Mussaenda glabra Vahl.	5	1.5	30.0
Mussaenda roxbrghii H.K.F.	10	0.75	7.5
Nephrolepis cordifolia (L.)Presl.	15	2.5	16.6
Osbeckia crinita Benth.	15	2.5	16.66
Panicum spp.	5	1.25	25.0
Piper bachmeriifolia (Mig) DC.	10	1.25	2.5
Polygonum bistorta L.	10	5	50.0
Polygonum nepalense L.	10	3.75	37.5
Pothos scandens L.	5	0.5	10.0
Quercus serrata Thumb.	75	10.0	13.33
Rhus griffithii Hk.f.	5	0.25	5.0
Rhus semialata Hk.f.	20	2.0	10.0
Rubus ellipticus Sm.	15	2.25	15.0
Schima wallichii (D.C) Korth.	9.0	8.75	9.72
Sida acuta Burm f.	10	2.0	20.0

Smilax glabra Roxb.	40	6.75	16.87
Thysanolaena maxima (Roxb.) O.K.	5	2.0	40.0

Table: 7.1 List of dominant Families represented in the disturbed area.

Families	% Ha^{-1}
Acanthaceae	9.0
Apiaceae	8.5
Aspleniaceae	8.5
Asteraceae	94.5
Caesalpiniaceae	8.5
Caryophyllaceae	8.5
Cyperaceae	25.85
Euphorbiaceae	43.1
Fabaceae	17.2
Fagaceae	8.5
Hypolepidaceae	8.0
Lycopodiaceae	8.5
Melastomaceae	3.44
Mimosaceae	17.2
Minispermaceae	8.5
Nephrolepidaceae	1.7
Oxiladaceae	8.5
Papilionaceae	13.5
Piperaceae	86.2
Polypodiaceae	8.5
Pteridaceae	8.5
Rosaceae	8.5

Rubiaceae	8.0
Selaginellaceae	8.5
Smilacaceae	8.5
Theaceae	8.5
Verbenaceae	17.2
Zingiberaceae	17.2

Table: 7.2 List of dominant families represented in undisturbed forest

Families	% ha^{-1}
Acanthaceae	5
Adiantaceae	4
Amaryllidaceae	4
Anacardaceae	8
Angiopteridaceae	4
Apiaceae	5
Apocynaceae	16
Araceae	8
Araliaceae	4
Arecaceae	9
Aspleniaceae	4
Asteraceae	24
Athyraceae	12
Balsaminaceae	8
Begoniaceae	45
Blechnaceae	4
Caesalpiniaceae	8
Caryophyllaceae	3.5
Chenopodiaceae	6
Cyatheaceae	4
Cyperaceae	4
Davalliaceae	4
Dicksoniaceae	4

Dracaenaceae	4
Euphorbiaceae	5
Fabaceae	12
Fagaceae	12
Gleicheniaceae	4.5
Hypolepidaceae	4
Lauraceae	6
Leeaceae	4
Liliaceae	4
Lindsaceae	4
Lygodiaceae	5
Magnoliaceae	4
Malvaceae	4
Melastomaceae	5
Mimosaceae	4.5
Minispermaceae	8
Moraceae	3.5
Musaceae	4
Nephrolepidaceae	4
Orchidaceae	44
Palmae	4
Papilionaceae	4
Piperaceae	8.5
Poaceae	32
Polygonaceae	8
Polypodiaceae	32

Pteridaceae	8
Rosaceae	4
Rubiaceae	12
Sinopteridaceae	4
Smilacaceae	8
Solanaceae	4
Sonneratiaceae	4
Theaceae	12
Thelypteridaceae	4
Verbenaceae	20
Zingiberaceae	24

Table: 9. List of Epiphytes , which are also threatened species.

<u>Name of the species:</u>

1. *Aerides multiforum* Roxb.
2. *Arundina graminifolia* (Don.) Hochr
3. *Calanthe spp.*
4. *Coelogyne punctulata* Lindl.
5. *Cymbidium aloefolium* (L.) SW
6. *Dendrobium corymbosa* Lindl.
7. *D. densiflorum* Wall.
8. *D. fimbriatum* Var.
9. *D. jenkinsii* Wall.ex Lindl.
10. *D. maschatum* SW.
11. *D. nobile* Lindl.
12. *D. transperens* Wall ex Lindl.
13. *Papilionanthe teres* (Roxb.) Schltr.
14. *Phaius thankervilliae* (Alton) Bl.
15. *Malaxis latifolia* Sm.
16. *Liparis viridiflora* (Bl.) Lindl.
17. *Eria spp.*

Table: 10, List of ferns that comprises the forest floor flora.

<u>Name of species</u>:

Adiantum philipense L.

Angiopteris evecta (Forst.) Hohm.

Asplenium nidus L.

Blechum orientale L.

Cheilanthes farinosa Forsk. Kaulf.

Cibotium baromtez (L.) J.Smith.

Cyathea brunoniana (Hook.) Clarke et Baker

Davallia griffithiana Hook.

Dicranopteris linearis (Burm.f) undewood var *montana* Holttum.

Diplazium esculentum (Retz.) SW.

Drymmoglossum heterophyllum (L.) Trimen

Kaulina pteropus (Blume) Nayar

Lepisorus excarvatus (Bory) Ching

Lycopodium cernuum Linn.

Lygodium flexuosum L. SW.

Lycopodium aquarrosum Forst.

Microsorum membranaceum (D.Don) Ching

Microsorum punctatum (L.) Copel

Polypodium amoenum (J.Smith) Wall ex Mett.

Polypodium microrhizoma Clarke ex Baker.

Polystichum aculeatum (L.)Roth.

Pseudodrynaria coronans (Wall.ex Mett.) Ching

Pteridium equilinum (L.) Kuln.

Pteris ensiformis Burm.f.

Pteris semipinnata L.

Pyrrosia adnascens (SW.) Ching

Sphenomeris chinensis (L.) Maxon.

Selaginalla chrysocaulos (Hoh.et Grev.) spring

Selaginella semicordata (Wall.) spring

Tectaria polymorpha (Wall.ex.Hook) Copel

Thelypteris erubescens (Wall.ex Hook.) Ching

Discussion

Natural vegetation exhibits a complex three-dimensional structure (i.e, spatial distribution of leaves, roots and stems) that influence its function both in ecosystem energetics and material cycling, and in the regulation of biotic interactions and maintenance of biodiversity. The development of this complex structure through the process of plant succession following large – scale disturbance has been the subject of numerous observational studies (Finnegan 1984). Among the conceptual models of the plant succession process is the initial floristics model, according to which all the floristics elements of the recovering plant community establish soon after a disturbance event (Egler 1954). The initial floristic model often applies in forests (Hughes & Fahey 1991), so that eventual structure and composition of the mature plant community is dictated by the initial colonization process followed by intense intra- and interspecific competition, which eliminates most individuals through time. Therefore it is important to understand plant colonization and resource competition within and populations of colonizers in order to predict the course of forest development through large scale disturbance in many forest ecosystems (Timothy et al 1998). Goldberg (1990) viewed competition as the main process in ecological organization. However competitive abilities depends on the individual responses to changing availability of resources (light, water, and nutrients). In most forest settings, competition for light is expected to be intense, but varying degrees of co-limitation by soil resources might bear an influence on the structure of the forest ecosystems (Timothy et al. 1998).

The effects of disturbance and resource availability on the abundance and diversity of herbaceous vegetation have been widely studied. In northern hardwoods, as in most forests, large-scale disturbance increases the abundance and diversity of ground vegetation by increasing resource availability (Bormann & Likens 1979, Hughes & Fahey 1991). Reiners (1992) observed that after several decades of stand development, the patterns of abundance of herbs appear to resemble those of the pre-disturbance forest.

Aber (1979) studying on the secondary succession in hardwoods observed three patterns of canopy structure i.e (1) increase in canopy height and age (2) rapid recovery of LAI after cutting (3) increasing stratification of the canopy into overstorey and understorey layers.

Changes in soil resource availability effects plant morphology and physiological performances, which in turn alters the size and structure of the populations and the composition and species structure of the overall forest community.

In the present study it was also observed that in the disturbed area, herbs, shrubs and weeds dominated the vegetation. A few reasons that could be taken into consideration are (1) Exposure to uninterrupted light influx (2) Production of more seeds (3) good fine root system (4) rapid growth etc. From overall observations it can be concluded that light-loving plants can grow well in the disturbed open fields. The species of *Eupatorium* was found to be dominant in the disturbed area whereas in the forest stand *Eupatorium* spp were not recorded. It was assumed that light influx is one of the factors affecting the size and structure of the forest ecosystem. Tree regeneration was also found to be low in the disturbed area. Trees that stand scattered in the field were already trimmed or the lower stump is left behind so as to enable the coppices to grow. These trees withstood the burning of the slash and as it survived there was less competition among the woody plants. The weeds quickly took over and grew very luxuriously. However as it is a secondary succession the pioneer flora was eliminated and soon gave way to woody species. It was generally observed that if the fallow land is kept for longer period of years, the soil system and the microclimatic variables enables the vegetation to revert back to the pre-disturbed forest ecosystem. The soil left uncultivated for long was also found to be rich in nutrients as observed in the study site and also increases in the older forest stands that is in conformity with many other workers.

The forest stand had supported rich vegetation. This may be attributed to a suitable climatic condition particularly the high percentage of humidity. The canopy gaps created here and there enabled some small trees and shrubs to grow well particularly those belonging to Euphorbiaceae members. The tree species measured an average height of 15-30 m ht. The DBH of the woody species measured from 21 cm to 244 cm. Flowering and fruiting of most of the tree members was observed before the onset of rainy season. The trees were found to be of high timber yielding quality. In the canopy gaps it was also observed that plantation of *coffea arabica* was done here and there. The herbs and shrubs as observed were shade loving and grew luxuriantly and particularly a thick vegetation of pteridophytes were observed. Small climbers such as different species of *Smilax* were found to be growing very well. Bamboos and *Musa* species were also found to be growing well in the canopy gaps, which showed almost a mixed type of forests. This type of forest is also seen in different parts of the state of Nagaland. During rainy season it was also observed that terrestrial epiphytes were growing well even though they did not last long. However parasitic plants were not found as in other tropical forests.

Soil disturbance i.e. ploughing or land preparation etc. helps in germination of weed seeds. On rough raked or rotary hoed seedbeds the resulting weed seedling populations averaged 103, 134, and 206 seedlings per square meter respectively. On the other hand compaction (which makes the soil smooth) of the seedbeds enhanced seedling emergence by as much as 60%. There are some weed species that set their seeds before the harvesting of the crop and germinate after germination of crop seeds. Soil turnover during ploughing and other land preparation operations exposes the seed to light and induces germination. These soils are usually acidic and are good for the cultivation of fruits, potatoes and rice on hill slops and terraces.

Chapter - V

Soil

Soil

The soil texture was found to be loamy and slightly acidic. The pH recorded in the undisturbed forest is about 5.9 and in the disturbed 5.0 (tab: 10). This finding corresponds with many other workers, as it has been observed that in jhum fields, soil acidity is increases. It was observed that Nitrogen and Phosphorus decreased whereas potassium increased. The nitrogen recorded at a minimum was 0.195 in winter seasons and a maximum of 0.22 in autumn seasons in the undisturbed areas (tab: 12) and a minimum of 0.18 in spring and winter and 0.19 in autumn in the disturbed area (tab: 12). The total phosphorus content in the undisturbed forest area recorded a maximum of 0.004 in autumn and a minimum of 0.002 in winter (tab: 13). In the disturbed areas the maximum recorded was 0.0025 in winter and 0.0032 in autumn season (tab: 13). Organic carbon concentration is also found to be more in the undisturbed area than the disturbed area. Particularly in the autumn season the carbon concentration is found to be high i.e 14.0 in the undisturbed area and 13.1 in the disturbed area (tab 14). The carbon/nitrogen ratio ranges from 59.02 in spring upto 61.81 in autumn seasons in the undisturbed forest area and 58.33 in spring upto 69.47 in the autumn season (tab 15).

Greenland and Herrera (1975) reported that the major storehouse of nutrients is the standing vegetation and not the soil in humid tropics. Ruthenberg (1983) also confirmed that a large fraction of nutrients freed after slashing and burning are lost, if not consumed in plant uptake, through leaching, run off and soil erosion. Burning of vegetation in shifting cultivation process chemically alters the plant nutrient supply from organic form to a mineral form in ash, major portion of which is often lost from the site in the run-off (Ahn 1974; Jha et al 1979). Destruction of organic matter in burning has several adverse effects on soil particularly on soil surface. Porosity, aeration, field and water holding capacity, infiltration and surface moisture are lowered. Tawnenga et al (1997) reported that slashing and burning of vegetation caused an increase in pH in the present study, the two main reasons being incorporation of cations freed from burning of standing vegetation, and destruction of organic matter which releases humic acid. Other workers like Nye and Greenland (1964), Lal and Cummings (1979) and Hrahsel (1988) also recorded a rise in soil pH due to burning and subsequent decline during cultivation. Moore and Jaiyebo (1963); Smith et al (1968); Rice (1974); Joachim and Kondiah (1948); White et al (1973); Kumada et al (1985); Hrashel (1988); Tawnenga et al (1997), observed that though burning intensifies nitrification due to rise in pH and surface temperature, total nitrogen declines and this reduction in total nitrogen is attributed to conversion of organic to volatile forms during pyrolysis (Debell and Rabton 1980). Joachim and Kandiah (1948); Nye and Greenland also reports that addition of ash after burning augments the available phosphorus. A general conclusion is that burning of slash lowers soil acidity, organic matter and total nitrogen, but enhances phosphorus and cations. The addition of phosphorus and cations due to burning is greater in old than young fields.

Table: 10

Period of Study	Soil type	Soil type (Cm)	Seasonal Soil pH			
			Spring	Rainy	Autumn	Winter
I[st] year	Undisturbed	0 – 10	5.5	5.71	5.97	5.84
		10 – 20	5.0	6.5	6.45	6.5
	Disturbed	0 – 10	5.4	5.10	5.5	5.13
		10 – 20	5.2	5.65	5.79	5.55
II[nd] year	Undisturbed	0 – 10	5.9	6.1	5.5	5.13
		10 – 20	6.0	6.0	5.6	5.83
	Disturbed	0 – 10	5.2	5.5	5.41	5.0
		10 – 20	6.0	5.62	5.54	5.0

Seasonal Soil pH variation in the undisturbed and disturbed forests during the two- year period of study.

Table : 11

Period Of study	Soil type	Soil depth (Cm)	Soil moisture content (%)			
			Spring	Rainy	Autumn	Winter
I[st] year	Undisturbed	0 – 10	22.20	36.13	36.00	21.6
		10 – 20	22.71	35.30	35.00	20.7
	Disturbed	0 – 10	22.83	23.58	23.58	20.0
		10 – 20	21.94	22.16	18.98	19.5
II[nd] year	Undisturbed	0 – 10	22.50	36.13	25.64	28.90
		10 – 20	22.41	36.0	24.48	26.16
	Disturbed	0 – 10	24.48	28.90	25.90	20.16
		10 – 20	25.80	26.0	24.16	18.6

Seasonal variation of soil moisture content (%) in the undisturbed and disturbed forests during the two-year period of study.

Table: 12

Soil types	Seasonal Variation			
	Spring	Rainy	Autumn	Winter
Undisturbed Forest	0.206 ± 0.0103	0.21 ± 0.105	0.22 ± 0.011	0.195 ± .00975
Disturbed Forest	0.18 ± .009	0.185 ± .00925	0.19 ± .0095	0.18 ± 0.009

Total Nitrogen concentration (%) in the two types of soils (±SE,n = 3)

Table: 13

Soil types	Seasonal variation			
	Spring	Rainy	Autumn	Winter
Undisturbed Forest	0.0031 ± 0.00016	0.003 ± 0.00015	0.004 ± 0.00015	0.002 ± 0.00012
Disturbed Forest	0.0027 ± 0.00014	0.0027 ± 0.00014	0.0032 ± 0.00016	0.0025 ± 0.00012

Total Phosphorus concentration (%) in the two types of soils (± SE,n=3)

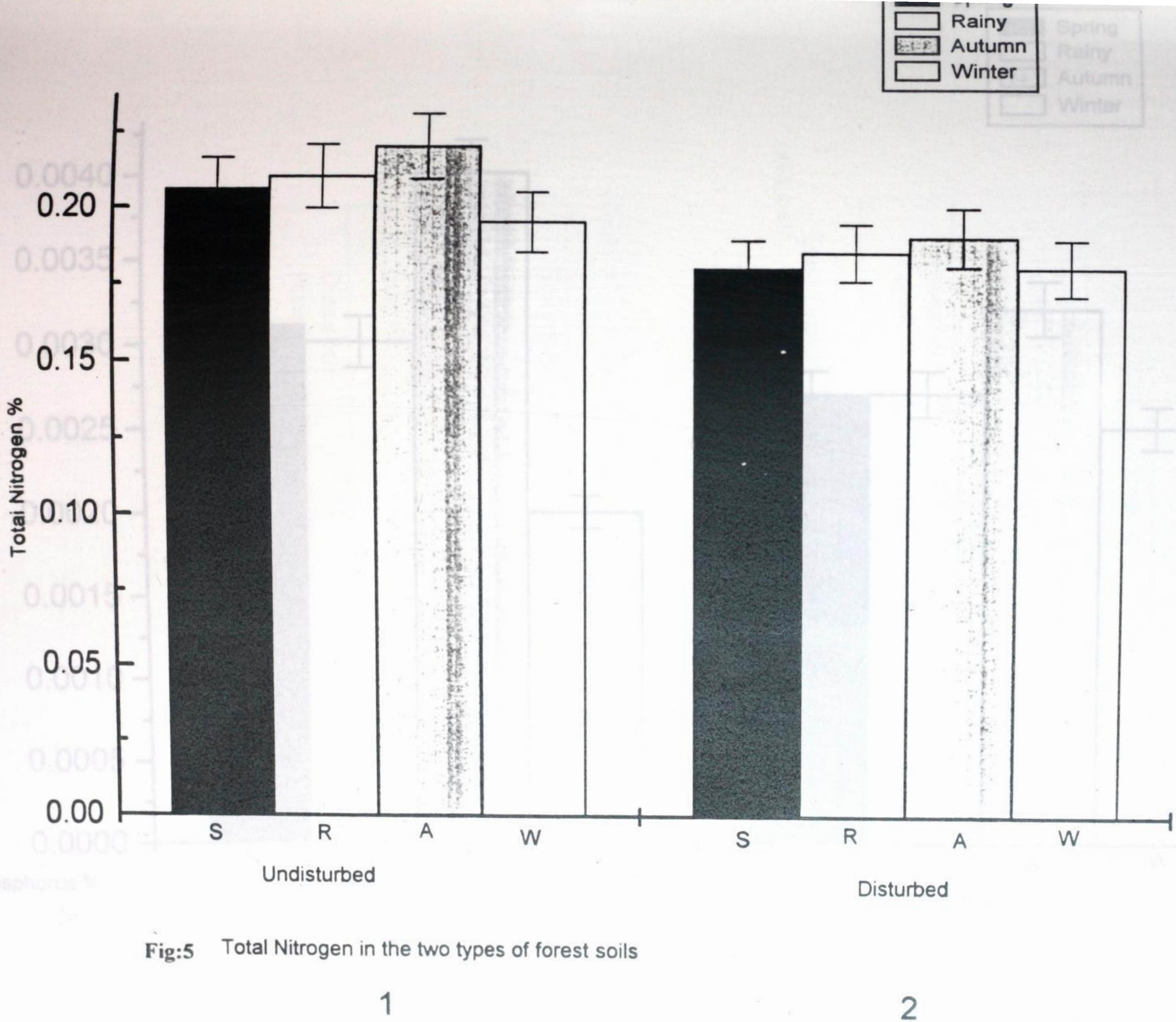


Fig:5 Total Nitrogen in the two types of forest soils

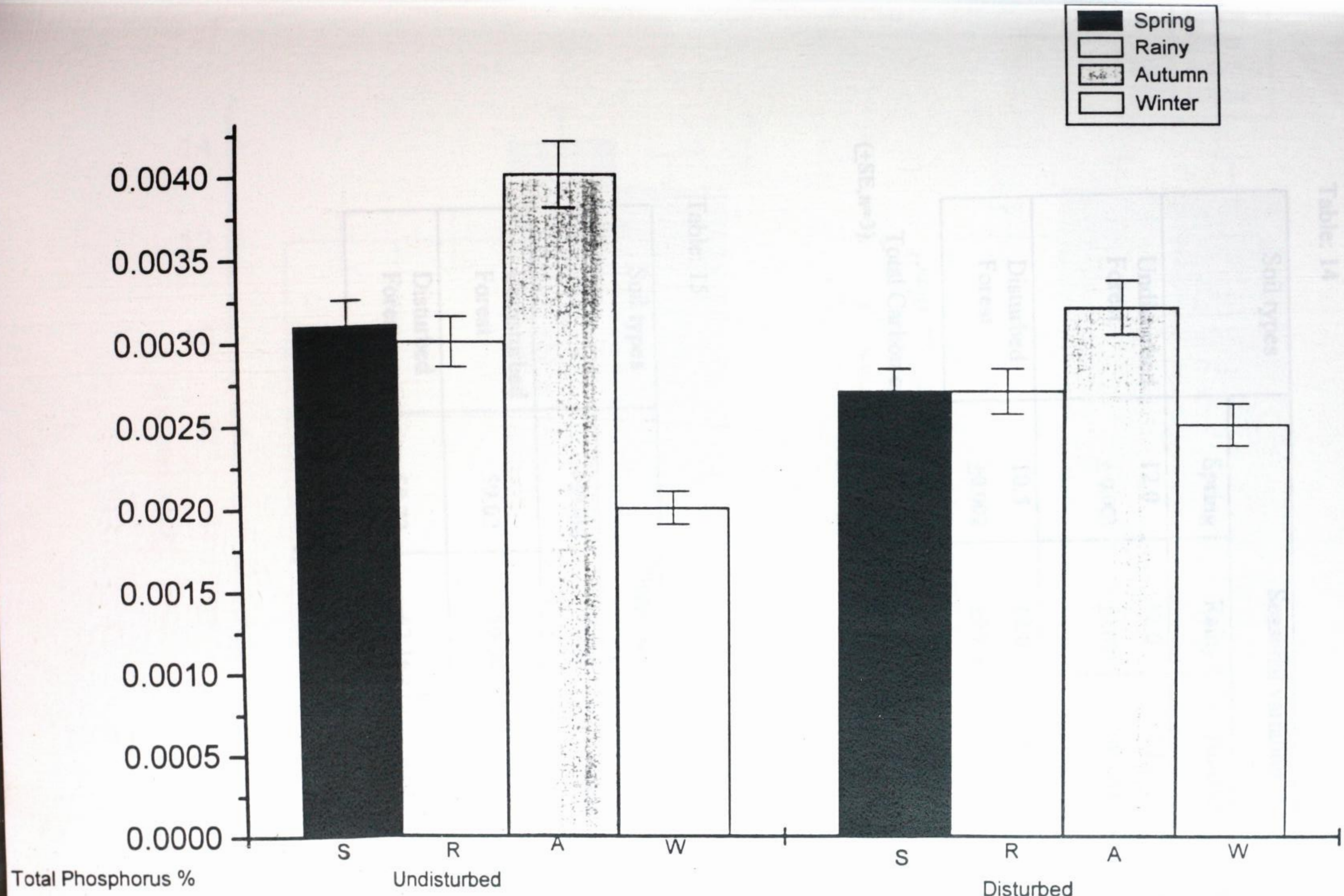


Fig :6 Total Phosphorus in the two types of forest soils

Table: 14

Soil types	Seasonal variation			
	Spring	Rainy	Autumn	Winter
Undisturbed Forest	12.0 ±0.001	12.0 ±0.001	14.0 ±0.002	13.0 ±0.001
Disturbed Forest	10.5 ±0.002	12.0 ±0.001	13.1 ±0.01	13.0 ±0.002

Total Carbon concentration (%) in the two types of soils (±SE,n=3).

Table: 15

Soil types	Seasonal variation			
	Spring	Rainy	Autumn	Winter
Undisturbed Forest	59.02	59.04	61.81	65.64
Disturbed Forest	58.33	62.162	69.47	68.33

C/N ratio in the two types of soils.

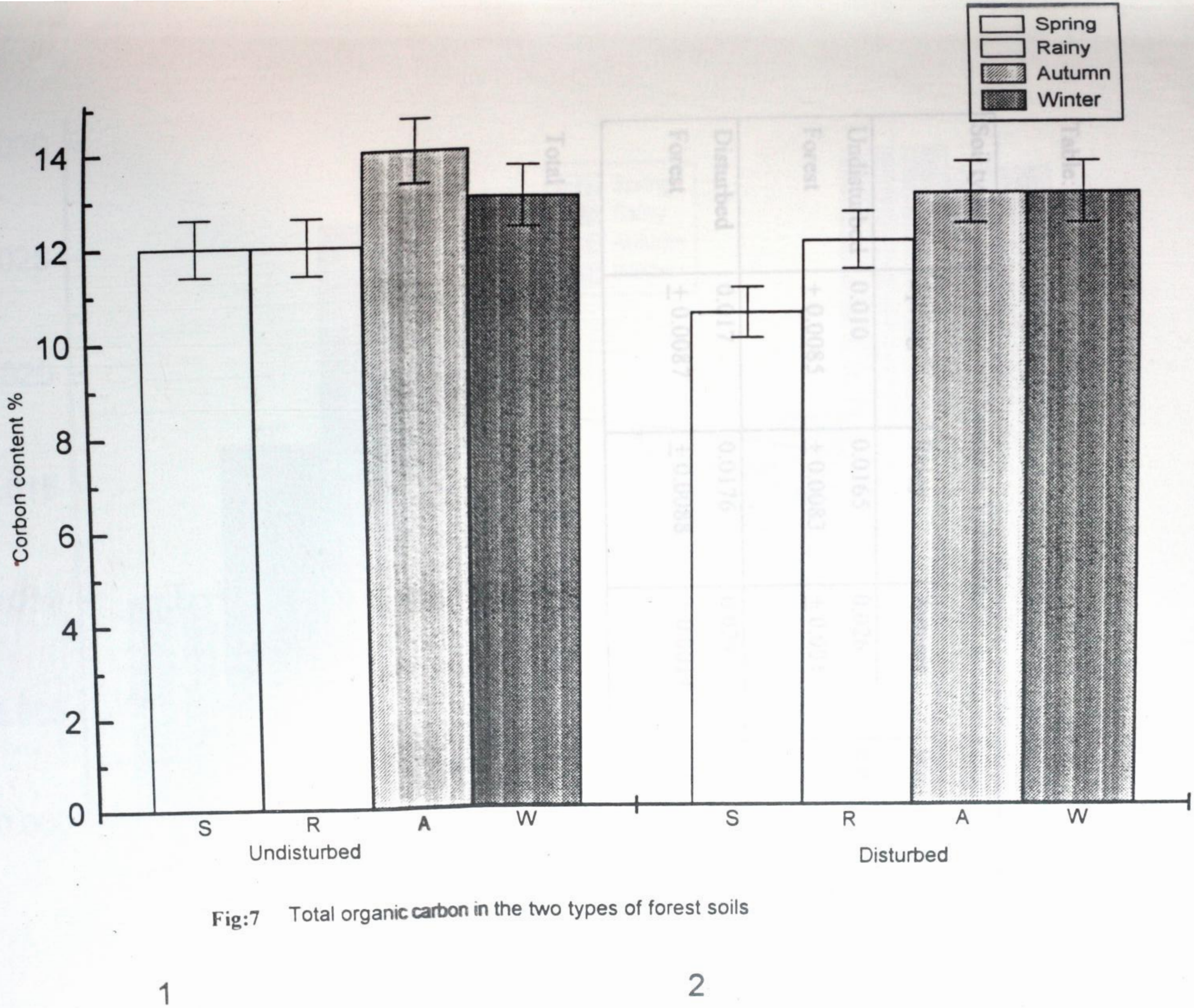


Fig:7 Total organic carbon in the two types of forest soils

Table: 16

Soil types	Seasonal Variation			
	Spring	Rainy	Autumn	Winter
Undisturbed Forest	0.010 ± 0.0085	0.0165 ± 0.0083	0.026 ± 0.0013	0.021 ± 0.00105
Disturbed Forest	0.017 ± 0.0087	0.0176 ± 0.0088	0.029 ± 0.0014	0.028 ± 0.0014

Total Potassium content (%) in the two types of soils.

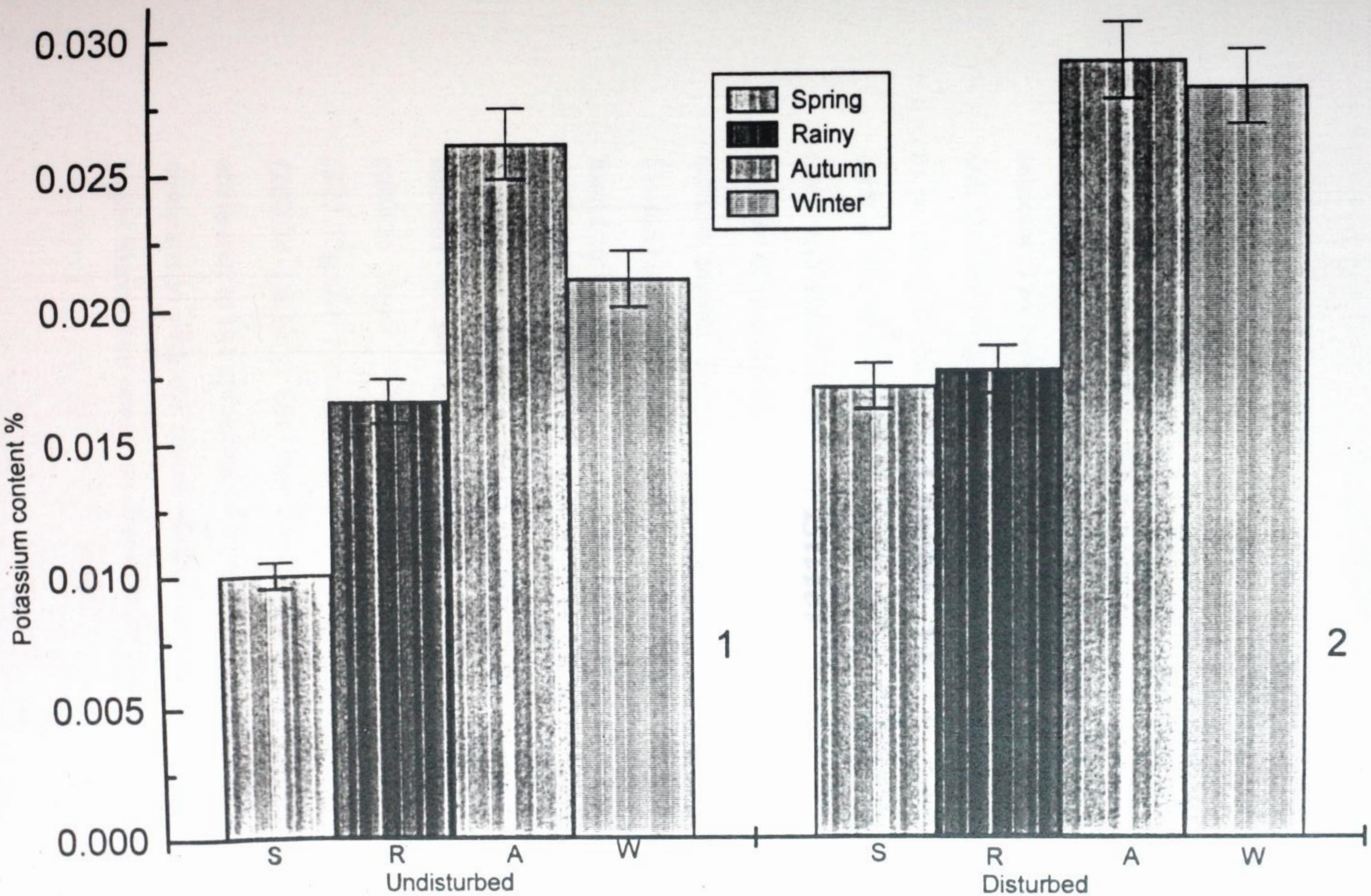


Fig:8 Total potassium content in the two types of soils

Chapter - VI

Litter

Litter

In the present study litter was collected as a composite sample over a period of two years in the four different seasons. The collected samples were then brought in the laboratory and the dry weight was taken. As observed the litter fall was found to be more in the undisturbed forest than the disturbed forest. The litter in the undisturbed forest composed of leaves and twigs of both trees and shrubs. The trees in the undisturbed forests composed of mostly of deciduous type, which shed their leaves mainly in the autumn season. Species such as *Quercus serrata, Castinopsis indica, Croton oblongifolius, Lithocarpus elegans, Aralia spp* etc were found to be dominant in the undisturbed forest. The litter fall in this species were found to be mainly seasonal and is enhanced by dry and windy seasons. Bamboos shed their leaves mainly during windy seasons. In the rainy seasons litter gets accumulated on the soil surface layer. The litter fall recorded was highest in the (225.55gm/m^2) autumn seasons and least in the spring season (200.74 gm/m^2). The low litter fall in the spring season may be attributed to the sprouting of new seedlings and new plant growth. In comparison with the spring season, autumn season has fairly dry and high temperature condition accompanied by slow wind, which may perhaps help the fall of leaves and dead twigs. The decomposition of litter could not be studied in detail and was not taken into consideration. This aspect of study needs further investigation and research in future. However it has been generally observed that litter decomposition increased as temperature became more favourable. A thick layer of litter was found to be accumulated on the forest floor during rainy and autumn seasons. Comparatively the litter accumulation on the forest floor was less in the spring seasons.

The litter fall in the disturbed forest was primarily of *Eupatorium odoratum* and *E. adenoforum* and other herbs belonging to Asteraceae family. Other major plants contributing to litter fall are members of Poaceae and Cyperaceae particularly *Imperata cylindrical.* As observed the litter fall was high in autumn and winter seasons in both the forest types. The maximum litter fall of 104.7gm/m^2 was recorded during the autumn season and a minimum of 98.7gm/m^2 during the spring season as indicated in the table 17. It was generally observed that the litter decomposition was found to be high and faster in the disturbed area than the undisturbed area. This may be attributed due to the temperature, soil acidity and moisture conditions in the particular area. However this needs further investigations. The accumulation of litter on the surface layer was more in the autumn and in the winter seasons and less in the spring seasons. Germination and new growth of plant species was found to be in the spring seasons and flowering was observed during the onset of the rainy seasons.

The decomposition of plant litter is a key process in the nutrient dynamics of forest ecosystems, and it is through this process that nutrients immobilized in the detritus are mineralized and released into the soil in a form suitable for plant uptake. In nutrient-poor ecosystems, litter decomposition becomes the controlling step of nutrient cycles and forest productivity (Flannagan & Van Cleve 1983). The second major output of the decomposition process is the formation of soil organic matter, including both cellular and humic components. The rate of accumulation of organic C in soils is a function of primary production and decomposition. An accumulation of organic Cat the soil surface is generally observed in the early stage of forest development, which at maturity, the amount of organic matter in soil tends to be more constant and it is distributed to a greater depth in the profile (Dickson

and Crochen 1953). In forest ecosystems the main source of organic matter entering the decomposition subsystem is represented by plant litter, with leaf litter accounting from 70 to 90% of total litter annual production (Stober et al.2000). The fine root system is also a major component of forest production and turnover, estimated to contribute between 20 and 26% of primary production in European beech forests (Stober et al. 2000).

The rate of decomposition is regulated by three main driving variables and their interactions: the physicochemical environment, the resource quality and the decomposer organisms (Swift et al. 1979).Aerts (1997) showed that on a global scale, climate [expressed a annual actual evapotraspiration (AET)] is the factor that can best predict first-year leaf litter decay rates. AET was also shown to be a good predictor of first-year decay of scots pine needle litter, over a transect that ranged from the sub arctic to the sub tropic climate, although other climatic variables, linked to seasonal patterns of precipitation and temperature, could explain part of the variability in the rates (Berg et al.1993). Soil pH is also an important factor for decomposition and many soil microorganisms seem to tolerate a broad range of soil pH; only pH values < 2 have been reported to strongly inhibit microbial activity (Myrold 1990).

Decomposition of plant material is largely mediated by fungi and bacteria, which have lower C/N ratios than the vegetation on which they feed. Therefore they have a high demand for N and it maybe predicted that detritus with high concentrations of N would decompose faster because of the associated faster growth of microbial populations. Hence, the C/N ratio of plant litter has often been negatively correlated with litter decomposition rates (Edmonds 1980; Taylor et al.1989). However, Fog (1998) demonstrated that such correlation cannot be generalized and that a strong distinction between resource types needs to be made, with a positive effect of N addition commonly being observed for materials with low C/N ratio, whilst the reverse is often the case for resources with high C/N ratios. Berg et al. (1982) observed that initial N litter content is an important rate-regulating factor of decomposition in the first stages of the process, while at latter stages lignin concentrations becomes a better predictor. Therefore, lignin and lignin-derived indices have often been used to quantify substrate quality, and correlated with litter decomposition rates (Melillo et al. 1982). Litter with high N concentrations may have rapid initial decomposition rates, but in later stages, high N concentration may suppress the formation of ligninolytic enzymes, enhancing the formation of recalcitrant N- phenolic complexes, and inducing a slowdown in lignin degradation and litter decomposition rates (Berg et al. 1982). Besides physicochemical parameters, decomposer community including a wide range of bacteria, fungi, protozoa and invertebrates play a major role in decomposition. Estimates of the relative contribution of fungi and bacteria to microbial biomass, using selective inhibitors in combination with substrate- induced respiration measurements, have a fungal dominance in both agricultural and forest soils (Anderson & Domsch 1975) and decomposing litter residues (Beare et al.1990). Where resource quality is low and climatic constraints are present, fungi tend to play a more important role in the decomposition process than bacteria (Dighton 1995).

Forest litter is an important source of dissolved organic carbon to the forest floor and lower soil horizons. The flux of dissolved organic carbon from litter to soils can vary widely depending on the species present. Leaching processes also important for determining changes in the carbon and nitrogen chemistry of litter. Up to 30% of carbon loss from litter occurs as dissolved organic carbon leaching. Understanding the fate of dissolved organic carbon leached from litter to soils is critical for accurate predictions of carbon balances of forest soils.

Table: 17

Forest type	Seasonal variation			
	Spring	Rainy	Autumn	Winter
Undisturbed Forest	200.74	219.54	225.55	220.55
Disturbed Forest	98.7	103.5	104.7	105.35

Litter fall in the two types of forest in different seasons.

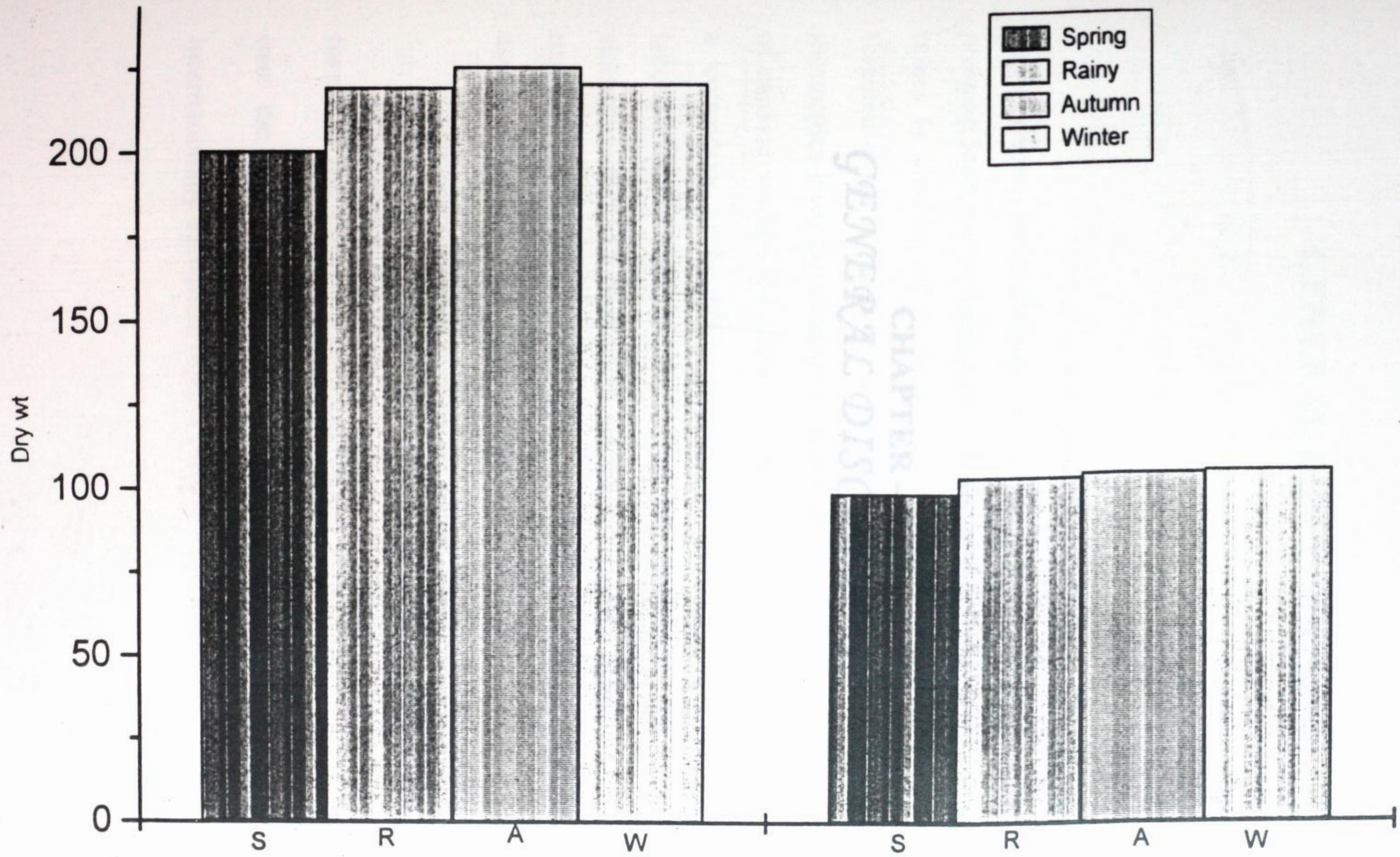


Fig:9 Liter fall in the two types of forests

CHAPTER – VII
GENERAL DISCUSSION

GENERAL DISCUSSION

Forests cover about 33 percent of global land area. Deforestation as a phenomenon is considered as the world's most pressing land use problem today. In the simplest of term, deforestation refers to clearing of forest and conversion of forested area to non-forested areas. It has been estimated that changes in the forest areas in the tropics have far outstripped those in temperate region to the extent of causing world-wide alarm as 'tropical forests provide humanity with a conucopia of benefits. Tropical forests are living museums and laboratories that have yielded only a tiny fraction of their treasures to scientific study. More than 50 percent of modern medicine come from tropical forests, includes volatile essential oils, gums, resins, tanning agents, edible oils, etc'. (World Resources, 1986).

The principal agent in the conversion of tropical forests is the slash and burn cultivation. About 250 million people all over the world are engaged in slash and burn agricultural practice. Internationally acclaimed reports (World Resources, 1986,p 93) has also pointed out that problem lies not so much with traditional shifting cultivators as with the shifted cultivators who find themselves landless in established farmlands'.

In India, the practice is followed in 228 development blocks in 33 districts of a total of 5122 blocks. The shifting cultivation remains a major practice in Arunachal Pradesh, Meghalaya, Mizoram, Nagaland, all five districts of Manipur and two districts of Assam and about 2.5 million hectares are used for this agricultural system by 500,000 tribal families in North-East India. Besides North- East India at least 14 blocks in nine districts of Karnataka, Kerala, Madhya Pradesh, Maharashtra and Sikkim, the practice is variably followed. An estimate in mid-seventeen reveal that more than 3 million people are dependent on shifting cultivation in India. About 12 percent of tribal population of India can be grouped as shifting cultivators (Bose & Thanggam, 1980)

Statewise area affected by shifting cultivation.

Sl No.	States	Area under shifting cultivation (lakh hectare)	
		One time	Annual
1.	Andhra pradesh	1.50	0.500
2.	Arunachal Pradesh	2.10	0.700
3.	Assam	1.39	0.696
4.	Bihar	0.81	0.162
5.	Madhya Pradesh	1.25	0.125
6.	Manipur	3.60	0.900
7.	Meghalaya	2.65	0.530
8.	Mizoram	1.89	0.630
9.	Nagaland	0.77	0.192
10.	Orissa	26.84	5.298
11.	Tripura	1.12	0.223
	Total	43.56	9.656

Source: Task Force report on shifting cultivation in India

Ministry of Agriculture, 1983.

Taking into consideration the views of majority of experts evaluating these processes of agriculture, perhaps it can be concluded that as long as the cycles are being long enough (20-30 years) the practice is excellent. But with the burning of forest, the virgin vegetation vanishes and bamboos, reeds, coarse grasses compete with invading weed flora to replace the evergreen vegetation of many species complex, which may offer as many as 230 tree species in single tropical forest.

Lumami, the study area which has only 150 acres of forest land area was also found to be under great pressure due to shifting agriculture. As already observed about 96% of the forest land in Zunheboto district is under degraded land which causes alarm and immediately needs measures to limit it. The entire population practically survives on this cultivation however they are not shifted cultivators. The jhum cycle in this area has two different period of return, the first cycle returns after 6 years and the second return after 20 years.

The forest of Lumami also resembles the tropical and sub-tropical forests in species richness, heterogeneity and complex organizations. The stratification layer of 3-4 layers may correspond to the characteristics of tropical forests. The presence of a high percentage of mesophanerophyte (30%) also bears similarity with tropical forests. Presence of a large no.of epiphytes may well indicate the favourable rainfall and high humidity even in the dry seasons. Below the canopy shade tolerant species grow well and in some canopy openings the invading weeds from the disturbed area established themselves.

However because of disturbance the vegetation differed in the two types of forests. Species diversity was lower in the disturbed area (0.9740) as compared to the undisturbed area (2.2520). The no.of species recorded was less in the disturbed forests (61 species belonging to 30 families) as compared to undisturbed forests (126 species belonging to 61 families). It was also found that the invading weeds completely dominated the disturbed area and slowly getting established in the complex vegetation as observed in the undisturbed forest.

Among the angiosperms recorded in the study site, majority of them belonged to dicotyledons in both the types of forests. A large no.of pteridophytic flora was also recorded. Epiphytes such as orchids were found to be abundant in the undisturbed forest however this is already a threatened species because of its aesthetic value and random extraction. Climbers belonging to Smilacaceae, Asteraceae and Verbanaceae were also found in large numbers in both the types of forests.

It is in the tropical forest again that more than 50 percent of world fauna survives. Therefore, as such the question of habitat distribution becomes rationally linked up with shifting cultivation in mountain forest. No proper estimate is available on the undescribed species of invertebrates and non-flowering plants, the number of which (in tropical forest alone) may run to 30,000(vascular plants) to 30 million insects only (Erwin,1983).

In Rao's (1974) paper on vegetation and Phyto-geography of Assam –Burma, the vegetation cover of Northeast India is typified. This region is largely formed of tertiary mountains, ' characterized by highly humid tropical climate and remarkable for wealth and diversity of vegetation and flora. Indeed over half the total number of Phanerograms, described so far from India, occur in Assam'. In the same paper Rao has provided a list of 100 species of flora, which are rare, endemic, or otherwise of scientific interest, of these 100, about 25 species have been described as new to science in recent years. Many of these floras occur in evergreen forest, some in humus covered forest floor, while other as epiphytes.

The study site also recorded large no.of epiphytes and seasonal orchids like the terrestrial orchid *Melaxsis spp.* The under canopy growth was very rich and it was observed that species of Arisaema grew very well even up to a height of 5.8ft. However all these species are threatened due to random extraction. It was also observed that this species were not recorded in the disturbed area as well. There was a drastic change of vegetation in the disturbed area.

The regions of Northeast India, Burma Southern China are considered as one of the most possible cradle by scientists engaged in tracing out the evolution and phylogeny of flowering plants. Takhtajan (1969) elucidated this hypothesis by bringing together a list of primitive flowering plants like *Magnolia, Manglietic, Euptelia, Tetracentron, Holboellia, Exbucklandia, Distylism, Alnus, Betula,* etc. which occur in Eastern Himalayans, Assam and Burma and in no other region.

The tree species that are recorded in the present study site such as Alnus, Quercus, Lithocarpus, Litsea also resemble the species in other eastern Himalayan species. Bamboo species scattered in the forest also resemble the sub-tropical mixed forests in other parts of the region. The soil characteristics also shows a similarity of slightly acidic soils with loamy textures of the other tropical forest soils.

With a brief survey of biological diversity, which can be considered as the end result of 3 billion years of evolution involving an intricate and complex mechanism of mutation, recombination and natural selection, one can look at the possible impact of land use pattern on such resource. Khoshoo (1986) pointed out that while natural extinction is a part of overall evolutionary process, the 'present wave of extinction is essentially man made' and presupposed that by the end of 20th century, 'we may well witness the elimination of about one million, out of the planet's 5-10 million species of organisms'. It was pointed out that most culturable regions are humid and in tropical areas. While 10% of the living species are now deemed to be on the verge of extinction, and thousand are vulnerable, 'the corresponding evolutionary renewals are not in sight'.

In the present study area it was observed that only a small fraction of the forest is conserved as reserved forest. However this forest area is unlike the preserved forest as sacred grooves in Meghalaya. As the land pressure increases there is always a threat that this forest will also be destroyed as there is no religious observations concerned to this forest. The loss of big trees in this forest is mainly due to extraction for timber and firewood. The proximity of the forest to the village is also a disadvantage for conservation of species.

The disturbed area showed a ability to recover after a few years if left without further disturbances. So far drastic climatic changes or other catastrophic agents were not recorded except for the anthropogenic activities. The ability of the species to recover and regenerate may indicate the favourable climatic conditions and nutrient availability in the area as it has been observed that the common species of both the areas grow very well. It may be concluded that the two forest types are of the same type but the differences caused were only due to agricultural disturbances and the disturbed area may perhaps regain its vegetation as the undisturbed forest after some few years.

It is seen that the concept of conservation is specially becoming widespread in order to combat that ever-increasing onslaught on living biota. The process of shifting cultivation is mainly practiced in the median to high rainfall zone (25-10,000 mm) and on hilly slopes, located between 100 meters to 12 meters but may extend to an altitude of 2000m. With low population density level, the extent of clearance of forest may be minimal but with tremendous pressure of forestland for other development activities and to meet demands of non- forest dwellers, the practice is bound to add as yet another dimension to retrogressive mechanism.

Today the role of forest in maintaining ground water level, preventing soil erosion and landslide, controlling flood plains, reducing air pollution has resulted in the formulation of policy emphasizing environmental impact assessment for all development projects.

The observations in this study correspond to many other workers. However this study being the first of its kind here in Nagaland needs further investigation for thorough understanding of the forest structure and function. Studies on microbial activity and its influence on litter decomposition and nutrient cycling are other factors that need further detailed research. A few suggestion that can be made may be perhaps encourage the local people to conserve more trees particularly nitrogen fixing trees like the *Alnus* trees. Increase of the jhum cycle to at least 10-15 years would enable the plant regeneration. Cultivation by means of terrace may also reduce land pressure. Jhuming which is traditionally and emotionally attached to the people cannot be immediately cannot be done away with immediately however certain constructive measures has to be taken before the rich biodiversity and soil fertility is lost completely.

Summary

Summary

The present study was an analysis of the study undertaken over 2 years period. Lumami the study site is located in Zunheboto district. The total land area of the village recorded was around 3000 acres out of which the forestland covers only 150 acres. Overall the forestland of the entire Zunheboto district records a high percentage of forestland degradation (96%). The major factor contributing to the degradation of forest was found to be due to agricultural practices such as jhuming.

The study site is at an altitude of 1100 m. The climatic condition generally is hot and humid in the summer seasons and warm and dry in the winter seasons. The maximum temperature recorded was in the month of June and July. Rainfall was also found to be high in these two months. Humidity was also found to be high ranging from a minimum of 35% to a maximum of 80% in the undisturbed forest and 26% to 50% in the disturbed forest.

The undisturbed forests comprised of many and varied vegetation. The stratification was found to be 3-4 layers (diagram: 1). The tree species were found to have a maximum height of 30m and formed a canopy without any emergent trees. The members of Fagaceae, Fabaceae, Verbenaceae &Lauraceae were found to be dominant tree species in this type of forests. The understorey vegetation comprised of rich flora of shrubs and herbs. Particularly fern flora was quite dominant in this layer. In rainy seasons, a variety of terrestrial orchids were found to adorn the forest floor. Species of *Arisaema* were also found to be growing luxuriantly during this season (pt:4). A large number of species flower at the onset of rainy seasons. Epiphytes were a common sight in these forests, even though they are the most threatened species. A large variety of climbers were also recorded, some of which were evergreen like the *Pothos spp.* In some parts of the forest it was difficult to get in because of the thick vegetation. Species of bamboos were also recorded here and there.

The diversity of flora was recorded as 2.25 (Shannon index of general diversity) and dominance index of 0.0606. The undisturbed forest recorded a 126 species belonging to 61 families. The dominant tree species listed were *Quercus serrata, Schima wallichii, Castinopsis indica, Albizzia procera, Litsea citrata, Lithocarpus elegans, Erythrina stricta, Croton oblongifolius etc.*

The soil pH recorded was 5.82 in this forest types. The soil texture was found to be loamy. Total Nitrogen, Phosphorus, Potassium and carbon varied in the different seasons (Tabl. 12,13,14, &16). Litter fall was found to be high during the autumn and winter seasons. Most of the litter fall comprised of leaves of deciduous trees (Tab: 17). The decomposition of this litter fall was found to be slower than the disturbed area.

The disturbed forest stand recorded same temperature and rainfall conditions. However the humidity ranges from 26-50% only. The soil surface was more exposed to light conditions. This study area is adjacent to the undisturbed area but differs in vegetation due to the disturbance caused by Jhuming. The forest recorded 61 species belonging to 30 families. Trees were scattered here and there and the forest here was less stratified. A thick layer of shrubs and herbs covered the entire forests (pt: 10&11). The trees were normally cut before the cultivation (pt: 12) and used as firewood or burned as slash. After the cultivation the next 2 to 3 years showed a maximum growth of shrubs and herbs. It was recorded in this study that members of Asteraceae particularly *Eupatorium odoratum* and *Eupatorium adenoforum* completely dominated the entire field (Pt:12). These species, in spite of climatic changes had a more reproductive ability and regeneration was very fast. Apart from these species, grasses like *Imperata cylindrica* grew very well and also quickly covers the area. This may be perhaps due to a very good rooting system. However this grass is also used as thatch for constructing houses and barns. Other species like *Osbeckia, Melastoma, Hedychium, Curcuma* flower at the onset of the rainy season. Tree seedlings mostly of *Schima spp.* were found to regenerate faster than the other tree species.

The Chameaphytes (up to 0.3 ht) was found to be dominant (33.8%) in these disturbed forests. Shannon's index of species diversity was recorded at 0.9740 and index dominance was recorded at 0.1228. However the index of species similarity was recorded at 41.48% that may perhaps indicate that the two types of forests presently studied were of the same type and the differences in vegetation is due to the agricultural disturbance.

The soil was also found to be almost the same with loamy texture, and pH of 5.0. The total Nitrogen, Phosphorus, Potassium, Carbon showed a variation in different seasons (Tab: 12,13,14, &16). Litter fall was also observed to be high in the autumn seasons (Tab: 17). Litter decomposition in the disturbed forest was found to be faster than in the undisturbed forests. This may be attributed to the favorable climatic and light conditions.

PHOTOGRAPHIC PLATES

Plate 1. Undisturbed forest

Plate 2. Undercanopy vegetation in undisturbed forest

Plate 3. Shrubs and herbs in undisturbed forest

Plate 4. *Arisaema spp.* in undisturbed forest

Plate 5. Thick understorey vegetation in undisturbed forest

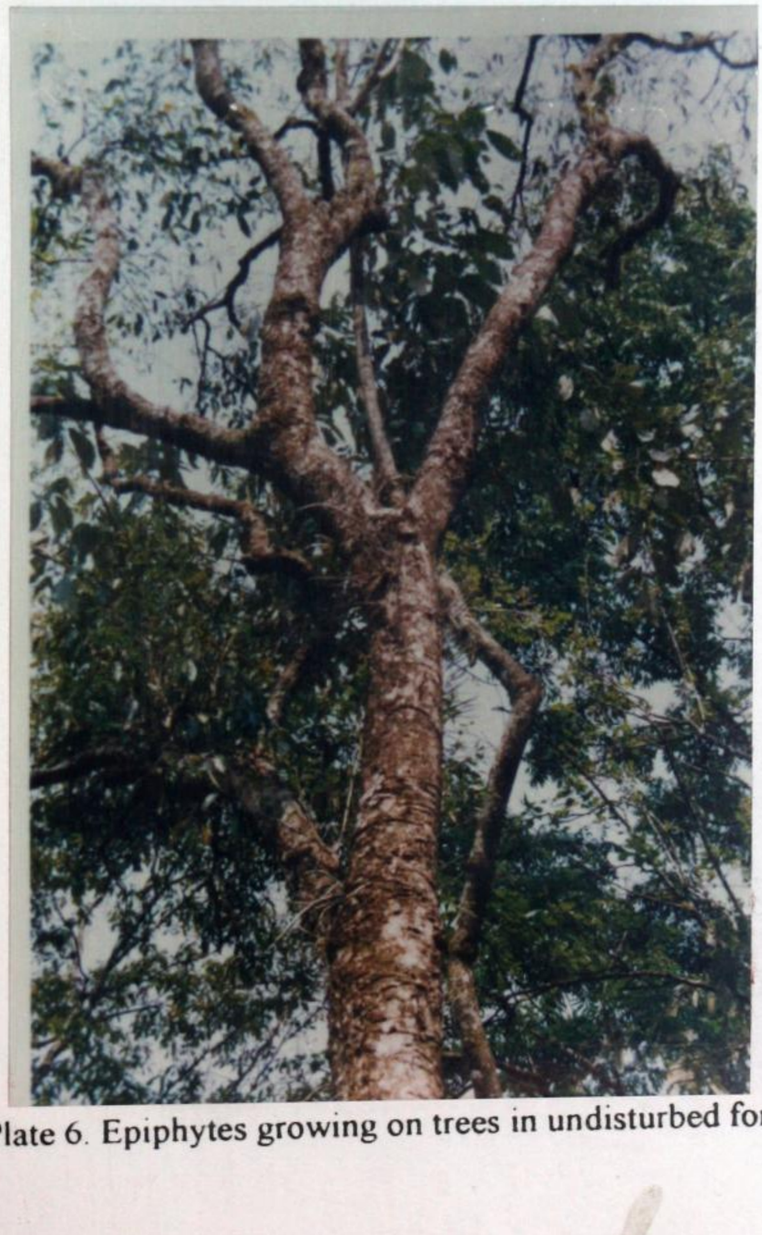


Plate 6. Epiphytes growing on trees in undisturbed forest

Plate 7. Flowers of *Sterculia spp*

Plate 8. Flowers of *Schima wallichii.*

Plate 9. Terrestrial Orchid, *Malaxis spp*.
in undisturbed forest.

Plate 10. Abandoned jhum field.

Plate 11. A thick growth of *Eupatorium odoratum*, in disturbed forest.

Plate 12. Flowers of *Eupatorium odoratum*.

Plate 13. Felling of trees for jhum cultivation.

Plate 14. Cutting trees for firewood.

Plate 15. Cleaning of soil for sowing of crops.

Plate 16. Paddy crops adjacent to undisturbed forest.

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