Chapter - VI
ANTHROPOGENIC EFFECTS ON FOREST COMMUNITY STRUCTURE

6.1 Introduction

The forest community has been playing an important role in the conservation of the flora and fauna of Manas biosphere reserve located in the foothills of eastern Himalayas in Indo-Bhutan border. The eastern Himalayan range has been identified as Indo-Burma global biodiversity hotspot (Myers et al., 2000). It also contains elements of Indo-Malayan, Indo-Chinese, Sino-Malayasian and east Asiatic floras as well as several Gondwanan relicts (Rawat and Wikramanayake, 2001). Several endangered species like Royal Bengal tiger, Asian elephant, non human primate species and avifauna have been forming niche in the forest of Manas biosphere reserve. The presence of different rare and endangered species has indicated rich plant diversity and diverse plant communities in the region. Species diversity is considered to be one of the key parameters characterizing ecosystems and a key component of ecosystem functioning (Hutchinson, 1959; Schulze and Mooney, 1994; Larsson, 2001; Loreau et al., 2002; Scherer-Lorenzen et al., 2005).

In Manas biosphere reserve, there are several turbulent river and streams that have their origin from different glaciers and lakes of Bhutan hills. The forest community has been regulating the different environmental attributes including the velocity of the river course as well as diversifies the distribution of the water availability (Bezbarua, 2007). The complex forest ecosystem has been created due to succession of the Bhabor-terai zone in the foothills and riparian grasslands in due course of the time. Despite having diverse forest types in Manas, there is an urgent need to know the

status of the forest community dynamics for managing the forest depended fauna and their habitat. Natural forest cover is shrinking in different parts of the earth due to tremendous anthropogenic exploitation. According to United Nations' Food and Agriculture Organization (FAO), world has been losing 7.3 million hectors of forests per year. A comparison between 1990 and 2005 revealed that the global forest cover having 4077 million hectors of areas in 1990 was reduced to 3952 million hectors in 2005 (FAO, 2006). Although a slight increase of total forest cover of 0.65% was observed in between 2001 and 2003, India had lost 26,245 sq. km. of its dense forest during the same period (FSI, 2003). Assam lost 3,085 square kilometres of forest cover in a span of 28 years (FSI, 2015). Since 1989, the forest of Manas biosphere reserve has been also severely influenced by tremendous illegal logging pressure during the political instability period. Several close canopy forests have been converted to open forest (Plate 11) even to degraded forests in last 20 years. The opening up of the forest by natural cause or biotic disturbance would result in change in dynamics of plant community of top layer as well as undergrowth**.** Forest dynamics in relation to logging pressure in south eastern Manitoba, Canada was studied by Kemball (2005). Canopy opening by thinning of forestry would favour in increase of undergrowth (Ratnayake, 2005). Dwarf bamboo growth produces dense undergrowth in forests especially at open sites (Toyooka et al., 1981; Noguchi and Yoshida, 2005). The canopy opening due to exploitation of forests would result in increase light intensity which subsequently changes the demography of the undergrowth vegetation. Light intensity is acknowledged as being the most important environmental factor (Lieffers and Stadt, 1994). Forest litter cover was found to be negatively correlated with emergence and mortality of shade-intolerant tree species. Understorey flora and vegetation are suitable

Plate 7: House damaged by wild elephant

Plate 8: Wild elephant herd in fringe village

Plate 9: Degraded forest in an elephant corridor

Plate 10: Water scarcity in fringe village

Plate 11: Disturbed and undisturbed forest

Plate 12: Soil degradation in disturbed forest

indicators for habitat conditions, human impact and forest dynamics, and therefore, a useful and easy tool to measure and evaluate biodiversity in order to characterize sustainable or ecosystem-based forest management (Schmidt, 2005). During logging, selective tree species have been targeted for fuel wood and timber. In absence of better timber yielding species due to continuous logging, smugglers had preferred second best timber for exploitation. Again most of the timber or non timber yielding plants also have been used as fuel wood. As a result, less important plant would play significant role in the forest ecosystem dynamics. Regeneration of forest trees in different level of disturbance in different sites of forests also significantly contributed in the forests diversity, dynamics and function. Forest dynamics in relation to regeneration of tree species was studied by European workers. European forests provide the driving force for forest dynamics and regeneration through structural change, the initiation of succession and creation of habitat diversity (Pickett and White 1985; Quine et al., 1999). Scarification greatly enhances the germination and survival of tree species relative to control areas or treatments without scarification (Mäkitalo, 1999; Karlsson and Orlander, 2000; Wurtz and Zasada, 2001), suggesting that it is an effective practice for forest regeneration and restoration of degraded forests. Intensive scarification appeared to limit the growth of many tree species (Mäkitalo 1999; de Chantal et al., 2004). It inferred that surface soil compaction increases ground hardness (Buckley et al., 2003) and results in decreased growth, probably by inhibition of root extension (Miyoshi 1978). Scarification intensity may also have a strong negative effect by removing many dispersed and buried seeds in the site (Hayashida and Koyama 1990; Sato, 1999). Plant community structure and dynamic in relation to environmental gradient was studied through multivariate analysis by Janisova (2005) and Abs el-Ghani and Marel (2005).

In India, forest community in different disturbed and undisturbed habitats has been studied in detail by different workers (Pande, 2002; Jayanarayanan and Menon, 2002; Kushwaha *et. al.* 2000; Kushwaha and Behera, 2002; Nath et al., 2004; Kunhikannan et al., 2004). The seasonal change of under growth forest dynamics has been studied by Kadir and Das (2002).

The continuing forest degradation since 1989 in Manas biosphere reserve has created loss of habitats of several endangered flora and fauna as well as wild animal population. It also resulted human elephant conflict (Plate 7,8 and 9) in the region. The necessary forest cover of wild animals is not adequate and as a result they fell as easy target to poachers. Some works on the classification of forests were made by Hajra and Jain (1975) who divided the plant community of the region as tropical semievergreen forests, tropical moist and dry deciduous forests following Champion and Seth (1968). However no works on forest dynamics has been undertaken till this study despite an urgent need to evaluate the actual damage of the region.

Considering the above needs, the present investigation has been undertaken to find out the impact of deforestation, logging pressure and other concomitant change on forest diversity and community dynamics.

6.2 Methodology

Eight numbers of belt transects of size 10meterX1000meter were laid randomly in four different experimental sites namely Daodhora RF Batabari RF, Subonkhata RF and Dihira PRF. Each site had two randomly placed belt transects**.** In each transect, nest quadrats of size 10mX10m were laid at an internal gap of 90 meters(m) for collection of data on tree species. Thus there were in total 20 permanent segments in each experimental site for the study of forest dynamics. Three quadrats of size 2mX2m were also laid in each segment to record data on undergrowth vegetation like shrubs, undershrubs and herbs. The number and cover values of each undergrowth species

were obtained by taken average of particular segment. All transects, segments and quadrates were properly marked. Data on plant species were collected in the year 2000, 2002 and 2004. Data on the number of each tree (>15 c.b.h) and undergrowth species, average basal area at breast height at 1.37m from ground level for individual tree and crown canopy cover for individual undergrowth like shrubs, herbs and under shrubs species were recorded accordingly in each segment. Average canopy cover of the forests was also visually estimated in each segment as percentage and in meter values respectively. The saplings of trees were treated as undergrowth. The ecological parameter like importance value index was evaluated from the twenty segments in each site for trees as well as undergrowths. Shannon index of species diversity was evaluated for each site. Detail procedures for importance value index, Shannon diversity index (1963) were described in the Chapter IV.

6.2.1 Statistical Analysis

All statistical analyses were carried out with the help of software MS Excel, SPSS 9.0 PC was used for finding out correlation between forest canopy cover, species diversity, dominance of tree and undergrowth. It was also used in finding relationship between different biotic and abiotic factors (longitude latitude, altitude, logging intensity, protection measure, diversity, distance from village, aspect). Secondly Analysis of Variance (ANOVA) was used for significant difference between different functional plant categories at spatial and temporal change. After performing Analysis of Variance (ANOVA), DUNCAN Post Hoc test was also performed to find out the significant difference at micro level. In case of ANOVA test, different stratified layers were separately analyzed.

6.3 Result and Discussion

The anthropogenic pressure on Daodhora reserve forest results a loss of 3.60% forest cover which was converted to agricultural field (0.34 sq km) and human habitation (0.29 sq km). Apart from encroachment, the mixed deciduous forest gradually turned to scrub forest with fast invasion of herbs and undershrubs weed species. The canopy cover turned to 5-20% in disturbed forest from a normal of 50-65% recorded in undisturbed one, while continous logging restricted the canopy height within 2-3 meters in disturbed area in the southern side of the reserve. Earlier the canopy height of mixed deciduous forest was recorded in between of 6-10 meters.

The Importance Value Index (IVI) of different dominant tree, herbs and undersurb species available in all the four reserve forests were computed. The results for Daodhora RF are presented in Table 6.1(a) and Table 6.1(b) respectively.

The human disturbance significantly changed the species diversity of Daodhora RF from 2.819 to 2.13. With fluctuation of disturbance in the region there was convertion of normal tree association *Lagerstroemia parviflora-Linnea grandis –Dillenia pentagyna to Lagerstroemia parviflora–Dillenia pentagyna-Bridellia retusa*. Due to logging pressure trees like *Alstonia scholaris, Albizzia procera, A. lebbeck, Bischofia javanica, Dillenia indica, Gmelina arobrea, Lagerstroemia speciosa, Pterospermum accerifolium* including medicinal plants *Hollarhena antidysenterica & Oroxylum indicum* were locally extinct in disturbed site of Daodhora RF.

Table 6.1(a): Status of different Tree Species in Daodhora RF (IVI value indicated)

Name of the Species	Undisturbed	Disturbed
Alstonia scholaris (L.) R. Br	2.29	0.00
Albizia procera (Roxb.) Benth.	2.18	0.00
Albizia lebbeck. (Linn.) Willd.	2.12	0.00
Bischofia javanica Bl. Bijdr.	2.43	0.00
Bombax ceiba L.	21.96	17.26
Bauhinia variagata L.	1.93	4.66
Bauhinia purpurea L.	3.95	12.94
Bridellia retusa Spreng.	17.72	29.08
Careya arboea Roxb.	4.66	7.68
Callicarpa arborea Roxb.	11.45	18.72
Duabanga grandiflora (Roxb.) ex. DC. Walp	19.11	20.77
Dillenia pentagyna Roxb.	30.09	31.60
Dillenia indica L.	3.69	0.00
Gmelina arborea Roxb.	3.63	0.00
Holarrhena antidysenterica (L.) Wall. Ex A.DC.	1.66	0.00
Linnea grandis A. Rish	31.12	20.60
Lagerstroemia speciosa (Linn.) Pers.	10.09	0.00
Lagerstroemia parviflora Roxb.	49.09	71.64
Oroxylum indicum Vent.	1.71	0.00
Pterospermum acerifolium Willd.	5.96	0.00
Sterculia vilosa Roxb.	18.78	14.79
Syzygium cumini (L.) Skeets	23.29	3.73
Terminalia bellirica (Gaertn.)Roxb.	8.53	4.38
Terminalia chebula (Gaertn.) Retz.	4.34	4.44
Toona ciliata Roem.	13.23	22.06
Trewia nudiflora L.	5.00	15.63

Table 6.1(b): Status of different Herbs and Undershrubs Species in Daodhora RF (IVI value indicated)

Name of the Species	Undisturbed	Disturbed
Alpinia nigra L.	9.63	2.81
Adhotoda vasica Nees	16.76	0.00
Ageratum conyzoides L.	17.29	23.70
Boerhavia diffusa L.	5.95	10.23
Cyperus brevifolius (Rottl.) Hassk	10.83	16.00
Clerodendrum viscosum Vent.	34.09	42.16
Costus speciosus (Roem.) Sm.	3.23	0.00
Cyanotis cristata (L.) D. Don.	3.90	3.16
Drypteris species	21.83	20.42
Chromolaena odorata	25.40	41.72
Glycosmis arborea (Roxb.) DC.	2.79	0.00
Grewia sapida L.	1.58	9.80
Leea asiatica L.	27.05	53.34
Litsea salicifolia (Nees) Hook. f.	27.71	0.00
Murraya koenijii L.	10.77	0.00
Mimosa himalayana Gamble.	4.69	25.99
Phlogocanthus thyrsiformis (Hardw.) Mabb.	7.41	0.00
Paspalum longifolium	11.79	16.44
Piper diffusum Vahl.	4.61	0.00
Piper longum L.	3.07	0.00
Calamus floribundus Griff.	16.63	0.00
Setaria palmifolia L	8.98	8.46
Solanum nigrum L.	9.93	20.60
Tabernaemontana divaricata (L.) R.Br.	9.81	0.00
Saccharum spontaneum L.	0.00	5.18
Thysanolaena maxima Roxb.	4.28	0.00

The undisturbed ground vegetation dominated by *Clerodendron viscossum, Litsea salicifolia, Leea asiatica, Chromaelaena odorata, Adhotoda vasica, Ageratum conyzoides, Dryopteris paleacea, Calamus sp.* is gradually replaced by *Leea asiatica, Clerodendron* sp. and problematic weed Chromaelaena odorata. The newly open areas due to logging recruited with weed *Chromaelaena odorata* which completely replaced the shade loving important herbs and shrubs like *Adhotoda vasica, Costus speciosus,*

Glycosmis arborea, Litsea salicifolia, Murraya koengeei, Phlogocanthus thyrsiformis, Piper diffusum, Piper longum, Calamus sp.,Tabernaemontana sp., Thysanolaena sp. The other reason of vanishing of these herbs can be related to collection of these species by different villagers for medicinal and other uses. The disturbance also changed the species diversity from 2.958 to 2.371 in the region.

Batabari reserve forest also undergoes heavy logging pressure due to its distance from administration of Manas national park, absence of active forest department and ignorance of local villagers. With encouragement of forest mafias, the villagers first cleared the forest trees and later encroached it for agricultural and settlement purpose from southern side. Already 21.37 percent of forest land has been cleared to use it as agricultural land (12.97%) and creation of new villages (8.3%). Significant amount of deciduous forest was also turned to scrub forest (12.07%) in Batabari reserve. Already fourteen trees namly *Albizia procera, Albizia lebbeck, Bischofia javanica, Bauhinia variagata, Careya arboea, Duabanga grandiflora, Dillenia indica, Gmelina arborea, Linnea grandis, Lagerstroemia speciosa, Pterospermum acerifolium, Terminalia bellirica,* were completely eliminated due to demand of timber and fuel wood in the nearby regions (Table 6.2(a)). The villagers goes for non timber plants like medicinal species *Holarrhena antidysenterica*, and *Oroxylum indicum* in absence of potential trees rsulting severe deteriotion of the surrounding enviornment and scarcity of ground water (Plate 10) in the region. Similarly the *Lagerostromia parviflora-Linnea grandis–Dillenia pentagyna–Sterculia villosa* association has been changed to *Bomabx ceiba-Dillenia pentagyna–Bridellia retusa-Callicarpa arborea* type indicating gradual shifting of non timber type of forest community in due course of time. The tree diversity changed to 2.28 from 2.84 i.e. indicating severe decrease of tree species or local elimination.

Table 6.2(a): Status of different Tree Species in Batabari RF (IVI value indicated)

***Name* of the Species**	***Undisturbed***	***Disturbed***
Alstonia scholaris (L.) R. Br	*1.78*	*4.63*
Albizia lebbeck (Linn.)Willd.	*2.25*	*0.00*
Bischofia javanica Bl. Bijdr.	*2.57*	*0.00*
Bombax ceiba L.	*20.92*	*50.71*
Bauhinia variagata L.	*2.05*	*0.00*
Bauhinia purpurea L.	*8.22*	*31.86*
Bridellia retusa Spreng.	*14.08*	*43.03*
Careya arboea Roxb.	*4.93*	*0.00*
Callicarpa arborea Roxb.	*12.09*	*33.48*
Duabanga grandiflora (Roxb.) ex. DC. Walp	*22.85*	*0.00*
Dillenia pentagyna Roxb.	*31.43*	*43.92*
Dillenia indica L.	*2.50*	*0.00*
Gmelina arborea Roxb.	*3.79*	*0.00*
Ficus hispida L.	*1.78*	*0.00*
Linnea grandis L.	*37.00*	*0.00*
Lagerstroemia speciosa (Linn.) Pers.	*10.56*	*0.00*
Lagerstroemia parviflora Roxb.	*39.14*	*19.44*
Oroxylum indicum Vent.	*1.83*	*0.00*
Premna latifolia L.	*2.47*	*0.00*
Sterculia vilosa Roxb.	*24.51*	*30.90*
Syzygium cumini (L.) Skeets	*18.33*	*5.43*
Terminalia chebula (Gaertn.) Retz.	*4.53*	*11.45*
Toona ciliata Roem.	*25.13*	*14.01*
Trewia nudiflora L.	*5.28*	*11.13*

Table 6.2(b): Status of different Herbs & undershrubs Species in Batabari RF (IVI value indicated)

Name of the Species	Undisturbed	Disturbed
Alpinia nigra L.	2.51	3.84
Adhotoda vasica Nees	18.56	0.00
Ageratum conyzoides L.	18.04	34.62
Boerhavia diffusa L.	6.19	2.29
Cyperus species	11.29	14.27
Clerodendrum viscosum Vent.	38.01	40.60
Costus speciosus (Roem.) Sm.	3.58	0.00
Cyanotis cristata (L.) D. Don.	4.11	1.86
Drypteris species	22.91	17.52
Chromaelena odorata L	26.84	54.99
Glycosmis arborea (Roxb.) DC.	3.07	0.00
Grewia sapida L.	1.64	0.00
Leea asiatica L.	29.94	76.03
Litsea salicifolia (Nees) Hook. f.	12.94	0.00
Murraya koenijii L.	12.16	3.34
Mimosa himalayana Gamble.	5.31	3.12
Phlogocanthus thyrsiformis (Hardw.) Mabb.	7.80	9.96
Paspalum longifolium L	12.32	13.46
Piper diffusum L.	4.77	0.00
Piper longum L.	3.18	0.00
Calamus sp.	19.06	0.00
Setaria palmifolia L.	9.39	2.35
Solanum nigrum L.	10.40	21.76
Tabernaemontana divericata L	11.12	0.00
Thysanolaena maxima Roxb.	4.83	0.00

Regarding ground vegetation, similar changes like Daodhora RF can be seen in Batabari also (Table 6.2(b)). The weeds like *Leea, Chromoelena, Clerodendron* becomes more dominant and turned as major component by replacing the shade loving

species like *Adhotoda vasica, Costus speciosus, Glycosmis arborea, Grewia sapida, Litsea salicifolia, Piper diffusum, Piper longum, Calamus sp, Tabernaemontana divericata* etc. In Batabari disturbance also changed the species diversity from 2.94 to 2.191 in the region.

The status of different trees and bamboo, and herbs and undershrubs species in Subonkhata RF in terms of IVI index are presented in Table 6.3(a) and Table 6.3(b) respectively. In this reserved forest also, vast encroachment for agricultural land (8.41 sq km) and human habitation (2.61 sq km) were indentified that resulted major fregmentation in the continguity of the Manas biosphere reserve in the eastern buffer zone. An area of 47.13% of the forest land were encroached for agricultural and settlement purpose. The species diversity also changed from 2.69 to 2.39 in disturbed forest. The conopy cover in the disturbed forest community found to be 5% or low from normal 50-60%, while significant decrease of canopy height to 2 meters from 5 meters occurred. The felling and smuggling of trees resulted in severe water crisis in the region and human-elephant conflict.

Subonkhata RF, the undisturbed forest community comprises of *Bombax ceiba-Lagerstroemia parviflora-Dillenia pentagyna Linnea grandis* changed to Linnea grandis-Lagerstroemia parviflora-Bridellia retusa type in due course of time. During the same period the *Albizia procera, Bauhinia variagata, Holarrhena antidysenterica, Pterospermum acerifolium, Sterculia vilosa, Syzygium cumini, Terminalia bellirica* and bamboo (wild) species were totally eleminated by the anthropogenic pressure. The ground vegetation *Clerodendrum-Litsea-Dryopteris* type is changed by the weed *Chromaelaena odorata* in disturbed habitat. Interestingly the species diversity increased in disturbed forest (2.50) in comparison to undisturbed (2.39) region. This may be due to the invasion of large number of sun loving species in open forest area with less canopy cover.

Table 6.3(a): Status of different Tree and Bamboo Species in Subonkhata RF (IVI value indicated)

Name of the Species	Undisturbed	Disturbed
Bambusa species	9.51	0.00
Albizia procera (Roxb.) Benth.	15.20	0.00
Bombax ceiba L.	54.13	23.53
Bauhinia variagata L.	4.15	0.00
Bauhinia purpurea L.	17.26	9.44
Bridellia retusa Spreng.	12.61	41.98
Callicarpa arborea Roxb.	20.78	23.21
Duabanga grandiflora (Roxb.) ex. DC. Walp	4.90	13.40
Dillenia pentagyna Roxb.	21.26	19.42
Holarrhena antidysenterica (L.) Wall. Ex A.DC.	3.17	0.00
Linnea grandis L.	23.47	53.97
Lagerstroemia speciosa (Linn.) Pers.	5.98	9.44
Lagerstroemia parviflora Roxb.	48.40	42.50
Oroxylum indicum Vent.	3.36	8.70
Pterospermum acerifolium Willd.	5.62	0.00
Sterculia vilosa Roxb.	9.46	0.00
Syzygium cumini (L.) Skeets	10.78	0.00
Terminalia bellirica (Gaertn.)Roxb.	4.15	0.00
Terminalia chebula (Gaertn.) Retz.	6.93	14.92
Toona ciliata Roem.	13.37	26.94
Trewia nudiflora L.	5.52	12.55

Table 6.3(b): Status of different Herbs and Undershrubs Species in Subonkhata RF (IVI value indicated)

Name	Undisturbed	Disturbed
Tridex procumbens L.	0.00	19.00
Xanthium sp.	0.00	2.25
Ageratum conyzoides L.	6.03	18.59
Boerhavia diffusa L.	0.00	3.21
Cyperus sp	6.58	15.65
Clerodendrum viscosum Vent.	61.76	15.16
Costus speciosus (Roem.) Sm.	5.92	0.00
Cyanotis cristata (L.) D. Don.	3.73	0.00
Drypteris sp.	39.93	17.42
Chromaelaena odorata L.	8.65	89.69
Glycosmis arborea (Roxb.) DC.	5.15	0.00
Leea asiatica L	4.13	11.24
Litsea salicifolia (Nees) Hook. f.	49.88	0.00
Murraya koenijii L.	23.23	9.20
Mimosa himalayana Gamble.	18.48	15.20
Paspalum longifolium L.	20.02	7.73
Plectarenthus sp.	0.00	3.49
Polygonum sp.	0.00	6.59
Lantana camera L.	0.00	27.76
Setaria palmifolia L	28.51	15.96
Solanum nigrum L.	11.71	12.95
Adhotoda vasica Nees	0.00	2.87
Saccharum spontaneum	6.28	6.04

Dihira proposed reserve forest also lost about 8.06% due to agricultural (0.496 sq. km.) and human habitation (0.133 sq. km.). Large number of evergreen forest gradually turned to scrub forest (42.69%) due to ongoing timber exploitation. The community structure of the forest is reflected in Table 6.4(a) and Table 6.4(b). The major tree association is comprised of *Lagerstroemia parviflora, Dillenia pentagyna, Callicarpa arboria, Linnea grandis* and *Bombax ceiba* in the undisturbed and disturbed

sites. However excess timber logging resulted local elimination of the tree species like *Alstonia scholaris, Albizzia procera, A. lebbek, bauhinia varagata, Careya arborea, Sterculia villosa.*

Table 6.4(a): Status of different Tree Species in Dihira PRF (IVI value indicated)

Name of the species	Undisturbed	Disturbed
Alstonia scholaris (L) R.Br	1.2	0
*Albizia procera (*Linn.) Willd	2.36	0
*Albizia lebbeck (*Linn.) Willd	1.2	0
Bischofia javanica Bl. Bijdr.	1.7	0
Bombax ceiba L.	25.87	39.2
Bauhinia variagata L.	3.8	0
Bauhinia purpurea L.	11.6	11.45
Bridellia retusa Spreng	31.9	55.6
Careya arboea Roxb.	12.87	0
Callicarpa arborea Roxb.	34.73	47.21
Duabanga grandiflora (Roxb.) ex DC.Walp	17.11	5.7
Dillenia pentagyna Roxb.	39.14	33.91
Linnea grandis L.	38.32	31.6
*Lagerstroemia speciosa (*Linn.) Pers.	1.98	11.43
Lagerstroemia parviflora Roxb.	34.5	35.2
Sterculia vilosa Roxb.	12.5	0
Syzygium cumini (L.) Skeets	9.56	2.3
Terminalia bellirica (Gaertn) Retz.	2.56	1.1
Terminalia chebula (Gaertn) Retz	1.11	2.7
Toona ciliata Roem.	17.19	22.6

Table 6.4(b): Status of different Herbs and Shrubs Species in Dihira P.R.F (IVI value indicated)

Name of the Species	Undisturbed	Disturbed
Adhotoda vasica Nees	38.49	7.11
Ageratum conyzoides L.	36.65	29.62
Boerhavia diffusa L.	12.87	3.98
Cyperus species	17.20	9.27
Clerodendrum viscosum Vent.	41.01	35.60
Costus speciosus (Roem.) Sm.	6.58	0.00
Cyanotis cristata (L.) D. Don.	7.11	0.00
Drypteris species	9.16	0.00
Chromaelaena odorata L.	16.37	87.23
Glycosmis arborea (Roxb.) DC.	7.76	1.00
Grewia sapida L	1.98	5.40
Leea asiatica L.	25.30	77.03
Murraya koenijii L	8.16	1.50
Mimosa himalayana Gamble.	4.32	5.60
Phlogocanthus thyrsiformis (Hardw.) Mabb.	17.20	10.96
Piper longum L.	3.18	1.00
Calamus species	15.06	1.00
Setaria palmifolia L.	5.39	0.00
Solanum nigrum L.	26.20	23.70

Analysis of variance for different tree species in disturbed and undisturbed areas of all the four reserve forests was also made and the results are presented in Table 6.5. The observed values of F were found to exceed the theoretical values and the null hypothesis may be rejected and it may be concluded that all the population means are not equal. Thus, there are significant variations in forest community structures between undisturbed and disturbed forest areas in all the four reserve forest.

The impact of human disturbance seems to be the highest in Dihira proposed reserve forest and least in Batabari reserve forest.

Table 6.5: Overall Analysis of Variance for different tree species in disturbed and Undisturbed Sites of Daodhora RF, Batabari RF, Subonkhata RF and Dihira PRF

Site		Sum of Squares	df	Mean Square	F	Sig.
Batabari	Between Groups	7417.520	26	285.289	2.666	.007
	Within Groups	2889.612	27	107.023		
	Total	10307.132	53			
Subonkhata	Between Groups	8582.238	26	330.086	3.814	.000
	Within Groups	2336.800	27	86.548		
	Total	10919.038	53			
Daodhora	Between Groups	9197.999	26	353.769	11.090	.000
	Within Groups	861.260	27	31.899		
	Total	10059.259	53			
Dihira	Between Groups	11841.926	26	455.459	15.177	.000
	Within Groups	810.253	27	30.009		
	Total	12652.179	53			

The study of the human disturbance in the four reserve forest and proposed reserve forest indicated significant loss of the tree species that resulted changed of the undergrowth vegetation dynamics. Moreover the tree forest dynamics also changed in terms of presence of different association types in the area. Forest dynamics in relation to logging pressure in south eastern Manitoba, Canada was studied by Kemball (2005). Canopy opening by thinning of forestry would favour in increase of undergrowth (Ratnayake, 2005). The canopy opening resulted increase of the heliophytic species spread to replace the sciophytic communities in all the four studied reserve forests. The

canopy opening due to exploitation of forests would result in increase light intensity which subsequently changes the demography of the undergrowth vegetation. Light intensity is acknowledged as being the most important environmental factor (Lieffers and Stadt, 1994). The vegetation change due to human disturbance is also evident in the core zone of Manas biosphere reserve and other parts of the western buffer (Bezbarua, 2004, 2007). Understorey flora and vegetation are suitable indicators for habitat conditions, human impact and forest dynamics, and therefore a useful and easy tool to measure and evaluate biodiversity in order to characterize sustainable or ecosystem-based forest management (Schmidt, 2005). During logging, selective tree species have been targeted for fuel wood and timber as indicated by the local elimination of several tree species from the areas. Bezbarua (2007).also reported similar human behavior in resource exploitation in the different parts of the core zone of Manas National Park.

6.4 Conclusion

The Human disturbances in Daodhora reserve forest resulted loss of 3.60% forest cover which was converted to agricultural field (0.34 sq km) and human habitation (0.29 sq km). The canopy cover turned to 5-20% in disturbed forest from normal 50-65% recorded undisturbed one and canopy height to 2-3 meters in disturbed southern side of the reserve from 6-10 meters. The disturbance significantly changed the species diversity of Daodhora RF from 2.819 to 2.13. The natural tree association *Lagerstroemia parviflora-Linnea grandis–Dillenia pentagyna* converted to *Lagerstroemia parviflora–Dillenia pentagyna-Bridellia retusa*. Due to logging pressure trees like *Alstonia scholaris, Albizzia procera, A. lebbeck, Bischofia javanica, Dillenia indica, Gmelina arobrea, Lagerstroemia speciosa, Pterospermum accerifolium* including medicinal plants *Hollarhena antidysenterica & Oroxylum indicum* were locally extinct in disturbed sites of Daodhora RF.

The undisturbed ground vegetation dominated by *Clerodendron viscossum, Litsea salicifolia, Leea asiatica, Chromaelaena odorata, Adhotoda vasica, Ageratum conyzoides, Dryopteris paleacea, and Calamus sp.* have been gradually replaced by *Leea asiatica, Clerodendron* sp. and problematic weed *Chromaelaena odorata*. The weed completely replaced sciophytes like *Adhotoda vasica, Costus speciosus, Glycosmis arborea, Litsea salicifolia, Murraya koengeei, Phlogocanthus thyrsiformis, Piper diffusum, Piper longum, Calamus sp., Tabernaemontana sp., Thysanolaena sp.* The other reason of vanishing of these herbs can be related to resource exploitation by villagers for medicinal and other economic uses. The disturbance also changed the undergrowth species diversity from 2.958 to 2.371 in the region.

In Batabari reserve forest, 21.37% of forest land has been cleared to use it as agricultural land (12.97%) and creation of new villages (8.3%). Significant amount of deciduous forest was also turned to scrub forest (12.07%) in Batabari reserve. Already 14 trees namely *Albizia procera, Albizia lebbeck, Bischofia javanica, Bauhinia variagata, Careya arboea, Duabanga grandiflora, Dillenia indica Gmelina arborea, Linnea grandis, Lagerstroemia speciosa, Pterospermum acerifolium, Terminalia bellirica,* were completely eliminated due to demand of timber and fuel wood in the nearby regions. The villagers goes for non timber plants like medicinal species *Holarrhena antidysenterica, and Oroxylum indicum* in absence of potential trees resulting severe degradation of the surrounding environment and scarcity of ground water in the region. Similarly the *Lagerostromia parviflora-Linnea grandis–Dillenia pentagyna–Sterculia villosa* association has been changed to *Bomabx ceiba-Dillenia pentagyna–Bridellia retusa-Callicarpa arborea* type indicating gradual shifting of non timber type of forest community in due course of time. The tree diversity changed from 2.84 to 2.28, which indicates severe decrease of tree species or local elimination.

Regarding ground vegetation in Batabari the weeds like *Leea asiatica, Chromoelena odorata, Clerodendron* viscossum becomes more dominant and turned as major component by replacing the shade loving species like *Adhotoda vasica, Costus speciosus, Glycosmis arborea, Grewia sapida, Litsea salicifolia, Piper diffusum, Piper longum, Calamus sp, Tabernaemontana divericata* etc. In Batabari disturbance also changed the species diversity from 2.94 to 2.191 in the region.

In Subonkhata RF, vast encroachment for agricultural land (8.41 sq km) and human habitation (2.61 sq km) were indentified that resulted major fragmentation in the continuity of the Manas biosphere reserve in eastern buffer zone. An area of 47.13% of forest land were encroached for agricultural and settlement purpose. The species diversity also changed from 2.69 to 2.39 in disturbed forest. The canopy cover in the disturbed forest community found to be 5% from normal 50-60% while significant decrease of canopy height to 2 meters from 5 meters had occurred. The felling and smuggling of trees resulted in severe water crisis in the region and human-elephant conflict according to local people. The undisturbed forest community comprising of *Bombax ceiba- Lagerstroemia parviflora- Dillenia pentagyna Linnea grandis* changed to *Linnea grandis-Lagerstroemia parviflora-Bridellia retusa* type in due course of time. During the same period the *Albizia procera, Bauhinia variagata, Holarrhena antidysenterica, Pterospermum acerifolium, Sterculia vilosa, Syzygium cumini, Terminalia bellirica* and bamboo (wild) species were totally eliminated by the anthropogenic pressure. The ground vegetation *Clerodendron-Litsea-Dryopteris* type is changed by the weed *Chromaelaena odorata* in disturbed habitat. Interestingly the species diversity increased in disturbed forest (2.50) in comparison to undisturbed (2.39) region. This may be due to the invasion of large number of sun loving species in open forest area with les canopy cover.

Dihira proposed reserve forest also lost about 8.06 percent due to agricultural (0.496 sq km) and human habitation (0.133 sq km). Large number of evergreen forest gradually turned to scrub forest (42.69%) due to ongoing timber exploitation. The major tree association is comprised of *Lagerstroemia parviflora, Dillenia pentagyna, Callicarpa arboria, Linnea grandis* and *Bombax ceiba* in the undisturbed and disturbed sites. However excess timber logging resulted local elimination of the tree species like *Alstonia scholaris, Albizzia procera, A. lebbek, bauhinia varagata, Careya arborea, Sterculia villosa etc.*

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