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STUDIES ON DISTURBED SHOLA FORESTS FOR EVOLVING STRATERGIES FOR THE CONSERVATION AND MANAGEMENT

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ABSTRACT

Four shola forests, namely Mannavan Shola, Pullaradi Shola, Manthan Shola and Aruvikkad Shola in Munnar Forest Division were selected to study the impact of disturbances on vegetation structure, composition and regeneration pattern, to identify the socio-economic reasons for disturbances and to evolve strategies for management of these forests. At each forest, dominance of light demanding species in all phases (seedling, sapling and mature trees) of tree community and in shrub and herb communities was recorded. In the case of the disturbed parts of Mannavan Shola, even the dominance of exotic species in tree seedling, shrub' and herb communities were recorded. Reduction in plant density and basal area, noticed in these forest patches, is generally attributed to the harvest of firewood and poles by the local people. Skewed girth class distribution of tree community with poor representation by individuals of girth class 30.1 to 90.0 cm in Mannavan Shola, Manthan Shola and Pullaradi Shola also indicates that collection of small wood and poles is a common practice from these forest patches. In Manthan Shola, cutting of large trees was even common as indicated by girth class distribution patterns. Comparison of disturbed forest patches with nearby relatively undisturbed patches indicated that they are dissimilar in terms of species composition as recorded from low similarity values recorded for each plant community. In all these shola forests except Aruvikkad shola the RISQ value is above 1.7 as against near to 1.0 in relatively undisturbed forest stands suggesting that the disturbance is intensive and thus natural recovery process would be slow. On the other hand, vegetation analysis in Aruvikkad Shola indicated that in tree seedling phase, primary species are dominant and RISQ value is near to 1.0 suggesting that the forest is recovering from the past disturbance in the absence of any fresh disturbance. Socio-economic analyses of villages located near these shola forests reveal that the people living near

Mannavan Shola, Pullaradi Shola and Manthan Shola depend heavily on forests for their livelihood. Quantity of wood collection increased due to lemongrass cultivation and at present about 65 percent of the firewood collected from shola forests is used for oil distillation. Among the threats to the management of shola forests firewood collection ranks first followed by grazing and revival of shifting cultivation. Thus the crux and the success of future management and conservation strategy depends on how one can reduce the dependency of people on the shola vegetation. Enrichment planting in disturbed parts of sholas, enhancement of firewood availability by raising energy plantations as well as developing lemongrass and firewood based agroforestry systems, reduction of grazing pressure by developing silvopastoral systems, suspension of shifting cultivation and prevention of encroachment are the major strategies identified for conservation of these shola forests. These strategies may be implemented through eco-development programmes aiming at overall development of the shola as well as people living nearby. This study also revealed the fact that Aruvikkad' Shola is at present free from disturbance due to supply of firewood from the Tea Estate Company and due to the different socio-economic background of the Estate workers. However, if the present system of firewood supply by the Estate to its workers is discontinued due to policy changes then Aruvikkad shola would face severe threat.

1.0 Introduction

The Western Ghats located in the Indian sub-continent, is one of the biologically and bio-geographically richest tracts in the world (Nair, 1997) and is considered as a mega-centre of biodiversity. Being a part of such an important region, the Kerala State is endowed with unique forest wealth with a forest cover 10,336 km^2 represented by several major forest types found in India. Apart from tropical wet evergreen, semi-evergreen, moist deciduous and dry deciduous forests, montane forests are also seen in the State (Chandrasekharan, 1960; Karunakaran, 1995). The montane forests found at an altitude above 1800 m possess a distinct vegetation type, called shola forests (Ranganathan, 1938; Nair, 1991). According to Champion and Seth (1968) shola forests are Southern Wet Montane Temperate closed evergreen forests with stunted growth of species occupying valleys, depressions, and especially in folds, pockets and the slopes of the hills and in water courses, which is usually surrounded by grass lands. These forests are of high ecological significance in protecting headwaters of rivers and conserving rare and endemic flora and fauna (Blasco, 1970). Studies conducted by several workers (Fischer, 1921; Gupta, 1962; Aiyar, 1932; Ganeshaiah et.al., 1997; Noble, 1967; Srivasthava, 1994 Jose et.al., 1994; Swarupanandan et.al., 1998) not only confirmed the ecological importance shola forests but also provided information on the structural, floristic and edaphic attributes of these forests in the Western Ghats. Even though these forests are generally located in relatively inaccessible hilly areas, many of these forests have been cleared and converted into plantations and for agricultural use. Thus, in the Western Ghat part of the Kerala State only about 70 km^2 forest area (0.74% of the total forest area of the State) is now left with under shola forests (Nair, 1991). However, conversion of these forests was discontinued in the recent past, once their ecological functions were realised to some extent. Even then these forests are still under anthropogenic pressure leading to continued habitat degradation and loss of biomass and biodiversity (Rangarajan, 1997). However, the type, degree and intensity as well as causative factors of disturbance may not be similar in all shola forests of the State. Since a range of ecological, socio-economic situations are responsible for human-induced changes in the shola forests one single approach for management is not enough and instead many approaches are to be identified. Therefore, a systematic analysis of vegetation

structure and regeneration patterns as well as the socio-economic dimensions of habitat degradation and restoration processes is necessary to develop a cafeteria of strategies for management and restoration of impacted ecosystems. Thus the objectives of the study were to:

a) analyse the impact of the type and level of disturbance on vegetation structure, composition, regeneration and ecosystem recovery processes in the shola forests,
b) investigate socio-economic issues responsible for the degradation of forests, and
c) evolve location-specific strategies for conservation and management.

2.0 Methodology

2.1 Site Selection

As already mentioned shola forests represent montane forests located at an altitude of 1800 m above mean sea level. A list of shola forests of the State was prepared based on available literature including Forest Working Plans and Management Plans. A reconnaissance survey was conducted to know the status of the shola forest whether they are disturbed or not. After personal observation, discussions with forest officials and literature survey, all shola forests of the State were categorised into disturbed and undisturbed forest (Table 1).

Table 1. Area and disturbance status of Shola forests

Division/Range	Name of the area	Area (Km^2)	Condition of the Forest
Wayanad Division	Chembra	NA*	Undisturbed
Kozhikode Division	Vellarimala	NA	Undisturbed
Attappady Division	Near Nilgiri Boundary	NA	Undisturbed
Attappady Division	Near Elival malai	NA	Undisturbed
Silent Valley National Park.	Sispara	5.0	Undisturbed
Nilambur Division	Neelimala (New Amarambalam)	NA	Undisturbed
Nilambur Division	Mukkuruthi area	NA	Undisturbed

* NA, Not available

-----Cont'd-----

Table 1 (cont'd). Area and disturbance status of Shola forests

Division/Range	Name of the area	Area (Km^2)	Condition of the forest
Marayoor Range	Mannavan shola	5.18	Disturbed
Marayoor Range	Pullaridi shola	1.6	Disturbed
Marayoor Range	Manthan shola	~1.0	Disturbed
Marayoor Range	Pampadan shola	0.8	Undisturbed
Marayoor Range	Idivara shola	0.6	Undisturbed
Marayoor Range	Upper areas of Marayoor	NA	Undisturbed
Eravikulam National Park	Eravikulam	50.0	Undisturbed
Devikulam Range	Aruvikkad	~1.2	Disturbed
Devikulam Range	Silent valley - Upper part	NA	Undisturbed
Periyar Tiger Reserve	Vellimala, Kottamala, Kalverimala, Sundermala, Upper Manalar.	NA	Undisturbed

* NA, Not available

2.2 Study area and climate

All four sholas namely are Mannavan shola, Manthan shola, Pullaradi shola and Aruvikkad shola, which showed signs of disturbance were selected to study the causes and impact of disturbance. While Mannavan shola, Manthan shola and Pullaradi shola come under Marayoor Forest Range of Munnar Division (Figure 1); Aruvikkad shola belongs to Devikulam Forest Range of the same Forest Division (Figure 2). Mannavan shola and Pullaradi shola are located at an average elevation of 1950m above msl, while the average elevation at Manthan shola and Aruvikkad shola is 1900m above msl. Mannavan shola is the largest shola in the State with an area about 5.18 km^2 and Pullaradi shola is a medium sized shola with an approximate area of 1.6 km^2 followed by Manthan shola and Aruvikkad shola. The weather data was collected from nearby weather stations. In Mannavan shola, Manthan shola and Pullaradi shola the mean annual temperature is about 20^0 C and mean annual precipitation between 2000 – 3000 mm. In Aruvikkad shola forest mean annual temperature is about 18^0 C and mean annual precipitation is 3000-5000 mm. In these forests the soil is red, sandy loam, oxysol, acidic (pH = 4.2) in reaction with 4.6% to 14% organic carbon content

Figure 1. Map of Marayoor Forest Range showing Mannavan Shola, Pullaradi Shola and Manthan Shola.

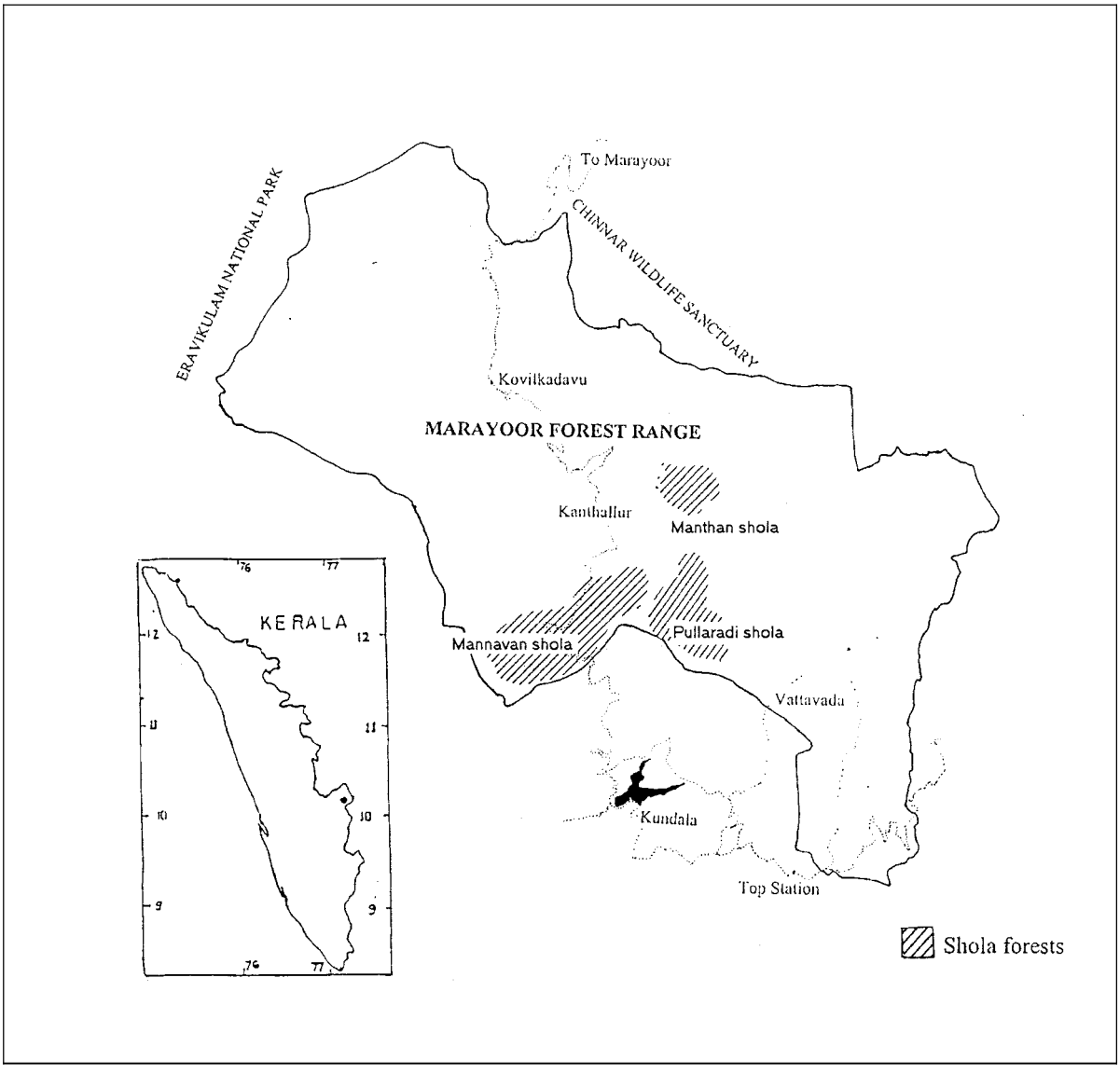
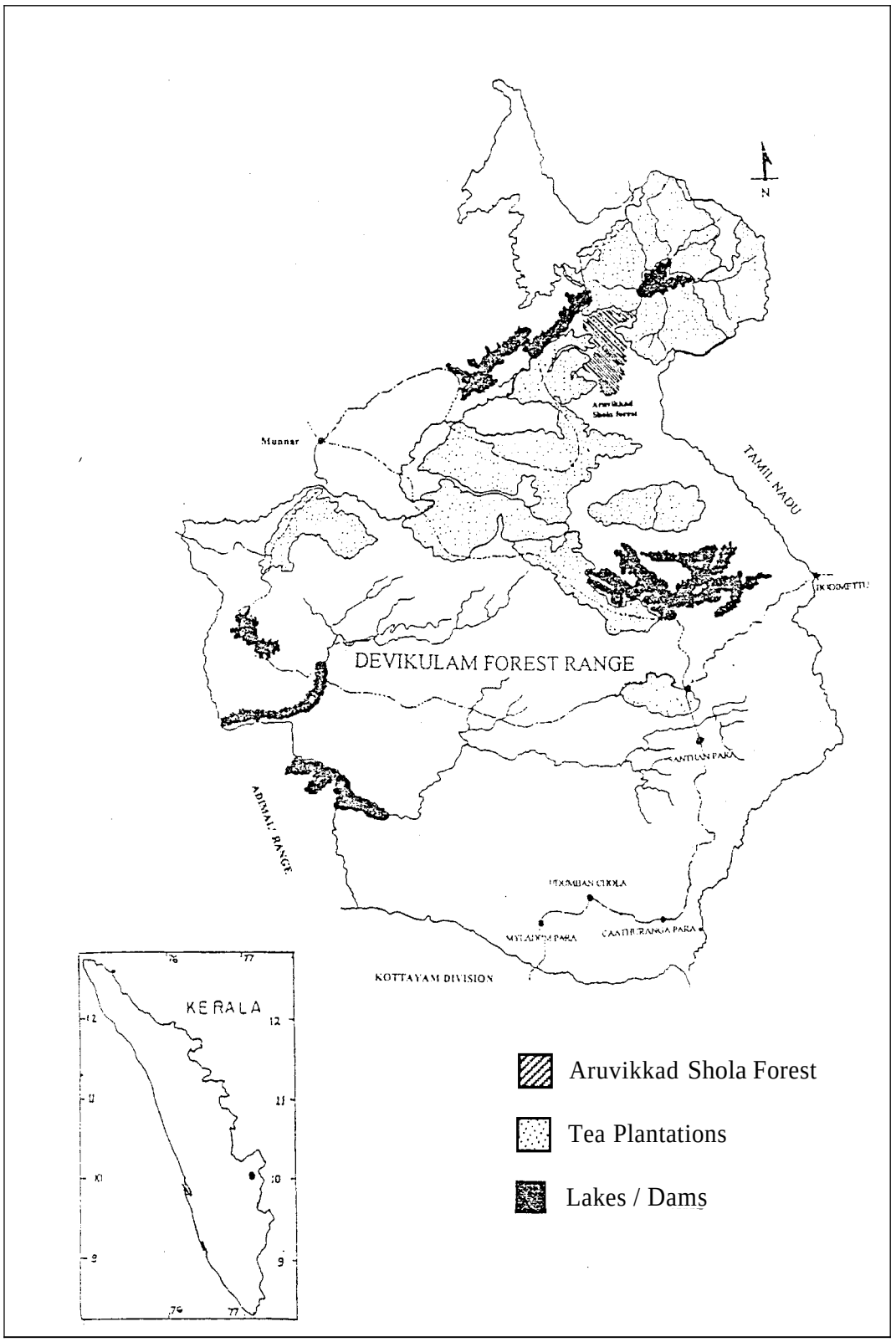


Figure 2. Map of Devikulam Forest Range showing Aruvikkad Shola.



2.3 Methods

2.3.1 Vegetation analysis

In Mannavan Shola, Pullaradi Shola and Manthan Shola, both disturbed and undisturbed areas can be clearly identified (Figures 3,4 & 5). In these forests, areas were considered as disturbed from where the local people collect firewood and poles. These areas are also often used for grazing. In both disturbed and undisturbed areas of these forests, vegetation analysis has been conducted. However, according to local people, Aruvikkad forest has not been disturbed for 8-10 years. The whole area of this forest was considered as a site recovering from past disturbances and studies on vegetation structure and composition were conducted. Since the species composition in Aruvikkad forest matches that of relatively undisturbed patch of Mannavan Shola, vegetation data collected from the two localities were compared.

2.3.1.1 Vegetation structure and composition

In undisturbed parts of Mannavan Shola, Pullaradi Shola and Manthan Shola, plots of 5 ha, 2 ha and 2 ha respectively were demarcated. Whereas, in the case of disturbed areas of Mannavan Shola, Pullaradi Shola and Manthan Shola, approximately 2 ha, 1.5 ha and 1 ha plots respectively were selected. In Aruvikkad Shola a 3 ha plot was established. Vegetation analysis was carried out in these plots by establishing randomly laid quadrats of 10m x 10m. Size of the quadrat was fixed as I0m x 10m based on the results of species- area curve investigations. The total number of quadrats in these plots vary as the number of quadrats established in each plot was restricted to cover at least 10% of the site. These 10m x 10m quadrats were used for studying mature trees (individuals with gbh more than 30.Icm) and saplings (individuals with 10.1-30cm gbh). In each quadrat, sub-quadrats of size 5m x 5 m were established for enumerating shrubs and herbs and Im x lm for tree seedlings (individual with girth 1.0- 10 cm) (Kershaw, 1973; Misra, 1968). Number and occurrence of all species in each quadrat were measured. Girth at breast height (gbh at 1.37m above ground) of all trees and saplings was also recorded. For trees with large buttresses the girth was measured from above the buttressed part. For seedlings, shrubs and herbs girth at ground level was taken.

Figure 3. Schematic map of Mannavan Shola showing disturbed and undisturbed area in the forest.

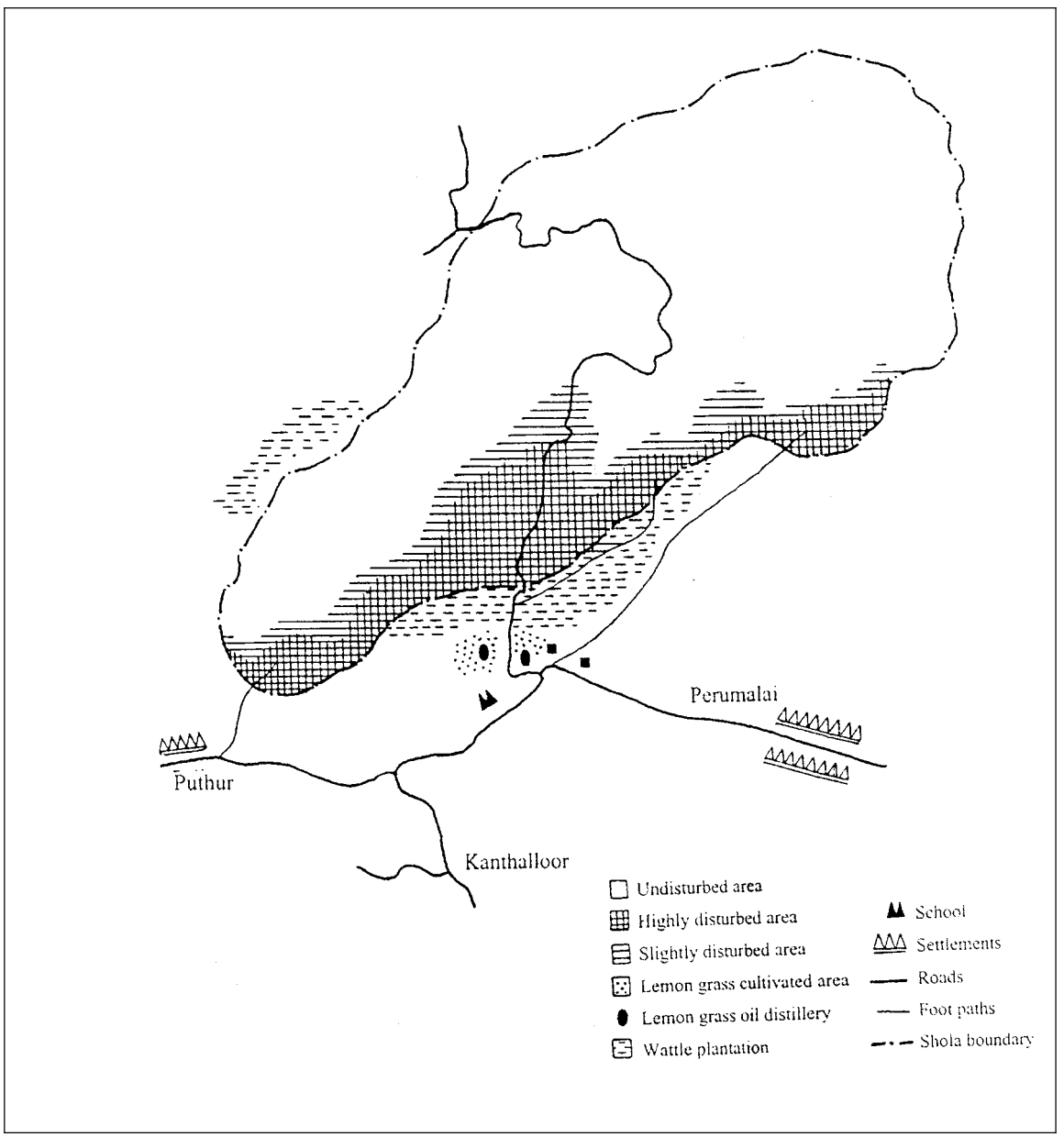


Figure 4. Schematic map of Pullaradi Shola showing disturbed and undisturbed area in the forest.

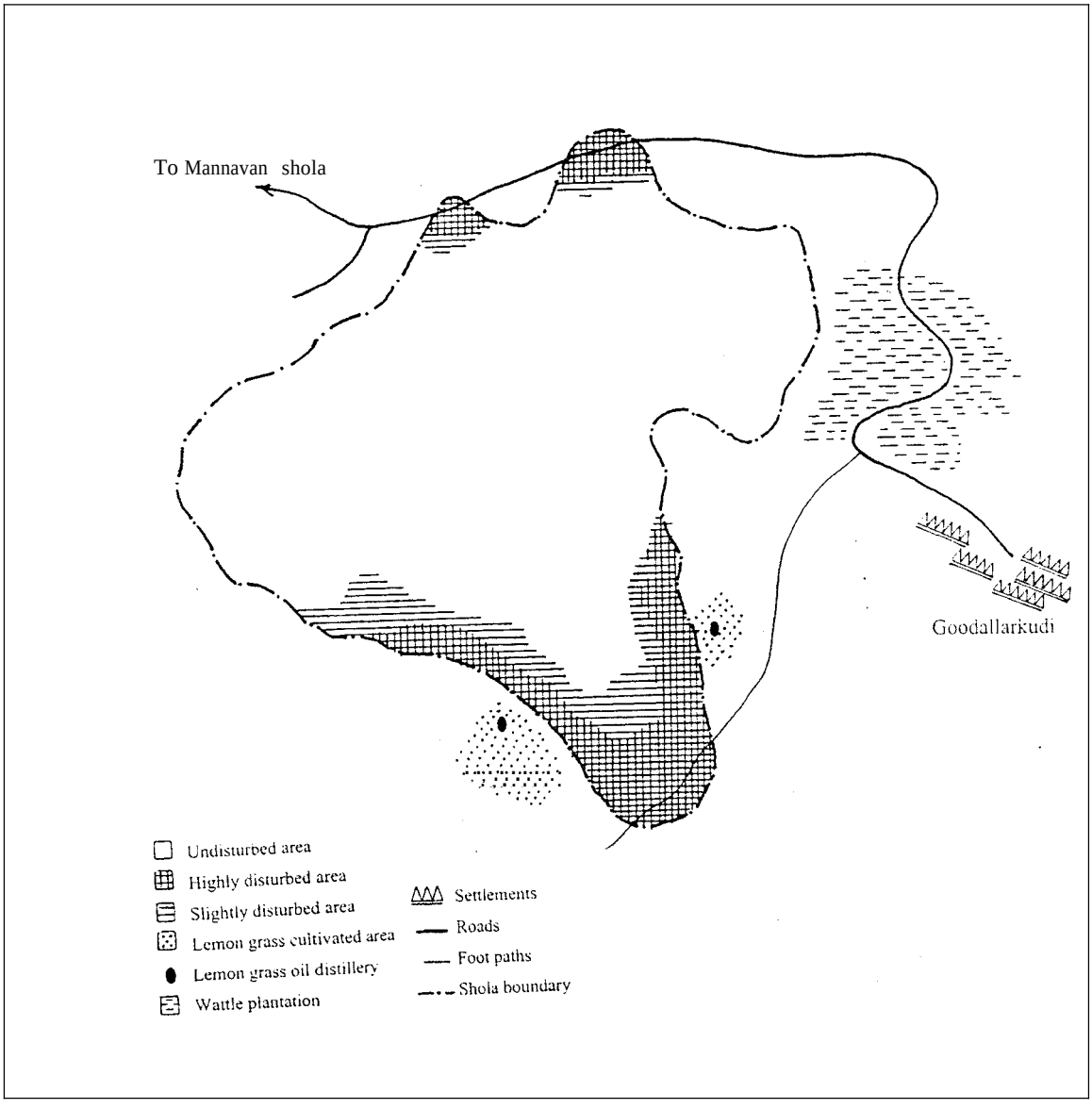
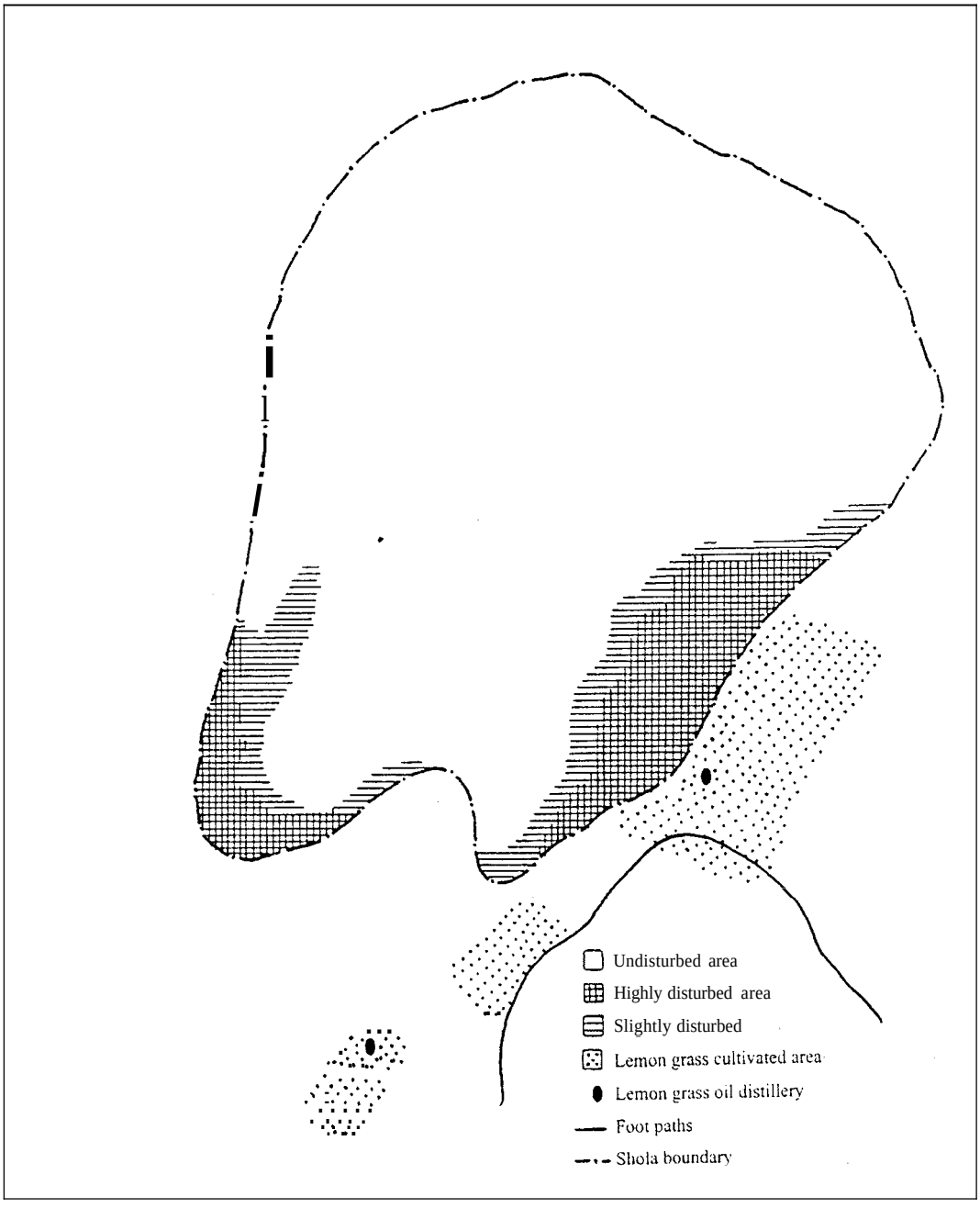


Figure 5. Schematic map of Manthan Shola showing disturbed and undisturbed area in the forest.



The vegetation data were analysed for relative density, relative frequency and relative dominance (Phillips, 1959) and the sum of values for these parameters represented by Importance Value Index (IVI) for various species (Curtis, 1959). Species diversity was calculated using a formula given by (Shannon and Wiener, 1963) as:

$$H = - \Sigma \{(n_i/N) \log_2 (n_i/N)\}$$

where, = Shannon index of general diversity, n_i = importance value index of species i, N = importance value index in the community.

The index of dominance of the community was calculated by Simpson's index (Simpson 1949) as:

$$C = \Sigma (n_i/N)^2$$

Where, C = index of dominance, n_i and N being the same as in the Shannon index of general diversity.

Sorensons's Similarity index (Mishra, 1989) was calculated for comparing the vegetation of disturbed area and undisturbed area of a given shola forest.

$$\text{Similarity index} = 2C/A+B$$

where, C = Total number of common species of disturbed and undisturbed areas of a given forest, A = total number of species in disturbed area and B = Total number of species in undisturbed area.

The quadrats established in disturbed areas of above mentioned shola forests were also used to record number and girth of recently cut or removed trees and saplings of different species.

2.3.1.2 Determination of forest stand quality

Considering the life history pattern, shola forest tree species can be categorised into primary species (shade-tolerant species), late secondary species and early secondary species (strong light demanders). Based on the available literature (Chandrasekharan, 1960: Chandrashekara and Ramakrishnan, 1994; Chandrashekara

and Sankar, 1998a; Gamble, 1928; Pascal, 1988; Rai, 1979; Rai and Proctor, 1986), species encountered in study area were categorised into three groups. Each group is given an index number, its pioneer index 1 for the group requiring a small gap for regeneration, and 3 for the group of strong light demanders with a strong canopy disturbance requirement. The procedure to determine the stand quality (Chandrashekara, 1998) followed is as given below:

$$RISQ = \Sigma\{(n_i/N) \times \text{species pioneer index}\}$$

Where, RISQ = Ramakrishnan Index of Stand Quality; n_i and N being same as in the Shannon index of general diversity. Pioneer index is 1 for the species whose seedlings establish in closed canopy area but need small canopy gaps to grow up. Pioneer index is 2 for the species whose seedlings establish in small gaps but need small to medium size gaps to grow up. Pioneer index is 3 for the species whose seedlings need larger canopy gaps for both establishment and growth.

The RISQ of a given site can vary from 1.0 (all stems, group 1 species; forest stand is undisturbed) to 3.0 (all stems, group 3 species; forest stand is highly disturbed).

2.3.2 Socio-economic analysis

The study relied on both primary and secondary data. For generating primary data a few villages, which are proximal to the selected areas were identified and subjected to a detailed study. The villages dependent on Mannavan shola are Kanthallur, Perumala, Puthur and Kolachavayil. A sample of 100 households, 25 households each from Perumala, Kanthallur, Puthur, and Kolachavayil respectively, were selected randomly for studying the problems of Mannavan shola. The village Goodallarkudi (Pillayarkudi) with totally 80 households is highly dependent on Pullaradi Shola area. Here 25 households were randomly selected. Manthan shola, which was included in the ecological study, was excluded from the socio-economic study because the socio-economic conditions in this area found similar to that in Pullaradi shola and year round visit to this area for data collection was difficult. Aruvikkad shola, which is under the Forest Department holding, is located near Tata Tea Estate, Madupetty in Munnar Panchayath. The Tea Estate, consisted of three

Divisions, viz. Central, East and West in which 380 households (143, 138 and 99 households respectively in Central, East and West Divisions respectively) are located. This shola is situated near The Central Division of the Estate and therefore, household samples were drawn only from this Division. Of the total of 143 households, 80 numbers were randomly selected for detailed investigation study. Besides 10 aged respondents from above areas were selected for collecting historical data regarding migration, socio-cultural tradition of the people, destruction of shola, etc.

The primary data were collected using a structured questionnaire. Participatory Rural Appraisals were also conducted among the people to know the major problems of the shola area. In addition to primary data, secondary data collected from the Government Offices such as the Forest Department, Panchayath Offices, etc. have been used in this study.

3.0 Results and Discussion

3.1 Analysis of vegetation structure and composition

3.1.1 Mannavan shola

Phyto-sociological studies revealed that due to disturbances the vegetation structure has altered remarkably with changes in the dominance of species (Appendix 1). *Hydnocarpus alpina, Isonandra stocksii* and *Gomphandra coriacea* dominate in the mature tree phase in undisturbed areas (Plate 1). Whereas in disturbed areas, light demanding species like *Symplocos cochinchinensis* and *Daphniphyllum neilgherrense* dominate contributing about 50 % to the total IVI of the mature trees. When the sapling phase is considered, *Mastixia arborea*, *Hydnocarpus alpina* and *Chionanthus ramiflorus* are the dominant species in the undisturbed forest area. However, in disturbed forest area light demanding species such as *Symplocos cochinchinensis*, *Maesa indica* and *Daphniphyllum neilgherrense* are dominant. These three species contribute about 60% of total IVI of the sapling population. In the case of seedling population of undisturbed plots, *Beilschmiedia wightii* and *Chionanthus ramiflorus* were co-dominant species followed by *Hydnocarpus alpina*. Apart from *Symplocos cochinchinensis* and *Daphniphyllum neilgherrense*, exotic *Acacia dealbata* is

dominant in the seedling phase of disturbed forest plots (Plate2). This suggests that disturbance in the Mannavan shola is leading to the invasion of exotic Acacias such as *Acacia dealbata* and also *Acacia melanoxylon*. However, these species have not been recorded in the sapling and mature phase not because they are not recruiting to these phases but because they are prone to be cut by the local people. The impact of disturbance is so high that some dominant species of undisturbed plots viz., *Beilschmiedia wightii* and *Isonandra stocksii* are completely absent in the disturbed plots. In the disturbed area, *Hydnocarpus alpina* is represented only in seedling stage. In the undisturbed forest plots, native species of herbs and shrubs such as *Lasianthus accuminatus, Strobilanthes homotropa* and *Ardisia rhombifolia* are in plenty. On the other hand in the disturbed plots apart from native species such as *Oplismenus* sp., *Vigna trilobata* and an exotic weed *Ageratina adenophora* are dominate. It may also be pointed out that *Oplismenus* sp. and *Vigna trilobata* are light demanding species, where as *Lasianthus accuminatus, Strobilanthes homotropa* and *Ardisia rhombifolia* are comparatively shade tolerant.

Disturbance in Mannavan shola also led to the reduction in the density and basal area of trees particularly in the sapling phase (Table 2). Even the understorey shrubs and herb community showed a drastic reduction in the stem density and basal area. Such low values for density and basal area in disturbed plots can be attributed to the collection of poles and stems of shrubs like *Strobilanthes homotropa* by the local people from these plots. However, both density and basal area of tree seedlings in disturbed area are more than those in undisturbed regions. This is due to the fact that early secondary native species and exotic species have a tendency to recruit well when canopy gaps are created. For example, it is noted that in the disturbed plot light demanding species like *Symplocos cochinchinensis, Daphniphyllum neilgherrense* and *Acacia dealbata* contributed 64% of the total basal area of seedlings. Canopy openings formed by human disturbances are known to offer favourable microenvironment for establishment and growth of such early secondary species (Denslow, 1980).

The disturbed plot in Mannavan shola is different from undisturbed plot in terms of tree species diversity. In the disturbed area, the total number of tree species was very less than in undisturbed location (Table 2). However, the number of species of

shrubs and herbs are more in disturbed plots. The similarity index value of mature trees, saplings, seedlings and shrub and herb communities is 0.250, 0.225, 0.3109 and 0.381 respectively. These values reveal that there is a significant difference between disturbed and undisturbed areas, with regard to vegetation composition. Only two species (*Persea macrantha* and *Syzygium densiflorum*) are present in all three phases in both plots. It is also clear that about 70-80% of species in the disturbed plots is not typical of the undisturbed forest plots and they represent species that prefer disturbed sites. Only 14% of total number of species recorded are present in the seedling phase in both plots. Similarly, only 7.6% of total number of species recorded are present in the sapling and mature phases in both plots.

Table 2. Basic statistics of tree, shrub and herb communities in undisturbed and disturbed plots of Mannavan shola.

Parameters	Mature trees*	Tree saplings	Tree seedlings	Shrubs and herbs
Number of species				
Undisturbed plot	44	40	34	29
Disturbed plot	20	22	35	34
Density (individuals ha^{-1})				
Undisturbed plot	567	476	12232	221538
Disturbed plot	464	226	96481	114074
Basal area (m^2 ha^{-1})				
Undisturbed plot	52.4	1.3	2.5	27.4
Disturbed plot	21.4	0.7	19.3	7.3
RISQ value				
Undisturbed plot	1.224	1.274	1.271	--
Disturbed plot	2.516	2.693	2.577	--
Species diversity index (H)				
Undisturbed plot	3.9903	3.9329	3.8929	3.8913
Disturbed plot	3.0222	3.4683	3.2983	3.5299
Species dominance index (C)				
Undisturbed plot	0.1002	0.1319	0.1065	0.0940
Disturbed plot	0.2176	0.1394	0.1953	0.1425

*Mature trees ($\geq$30.1cm gbh), saplings (gbh 10.1cm to 30.0cm), seedlings (girth $\leq$10.0cm, height $\leq$1m).

The undisturbed plot of Mannavan shola can be considered as a mixed forest patch with no major dominance of any one species as indicated by high species diversity and low species dominance values. In all phases in the undisturbed area, species diversity was more or less same which indicates the maintenance of equilibrium in diversity in this area unlike in disturbed sites, where diversity varies phase to phase. The disturbed plot of this forest shows a tendency towards the over-dominance of one or a few number of species as indicated by the low species diversity and high species dominance values.

To determine the level and intensity of disturbance in the forest, Ramakrishnan Index of Stand Quality (RISQ) was estimated. The RISQ values obtained for mature trees, saplings and seedlings were much higher in the disturbed patch than the benchmark undisturbed area (Table 2) indicating the intensity of disturbance is high and thus leading to changes both in species composition and stand structure of the forest. This analysis also reveals that since the RISQ value obtained for the disturbed site is much higher than the expected value for an undisturbed site, the rate of recovery by the forest will be slow. These values also indicate that further and repeated disturbances can lead to the arrested succession due to the dominance of exotic weeds and trees.

Detailed comparison of girth classes of all species in both the areas indicated that dominant species were represented in all the girth classes (Appendix 2). About 54% of species in the undisturbed plot do not have representation in seedling stage. On the other hand, in the disturbed plot only 27% of tree species do not have representation in seedling phase. This suggests that the closed canopy nature of undisturbed forest plots does not provide suitable microsites for many species to regenerate and recruit, whereas moderate disturbance alters the microenvironment which favours the regeneration of more number of species (Aiyar, 1932). It may be pointed out that, in general, density of trees in sapling and different girth classes in the mature phase is lesser in the disturbed plot than in the undisturbed plot (Figure 6). Complete absence of trees in the girth class between 150.1 cm and 180cm gbh in the disturbed plot also reveals the impact of intensive and prolonged disturbance in the forest.

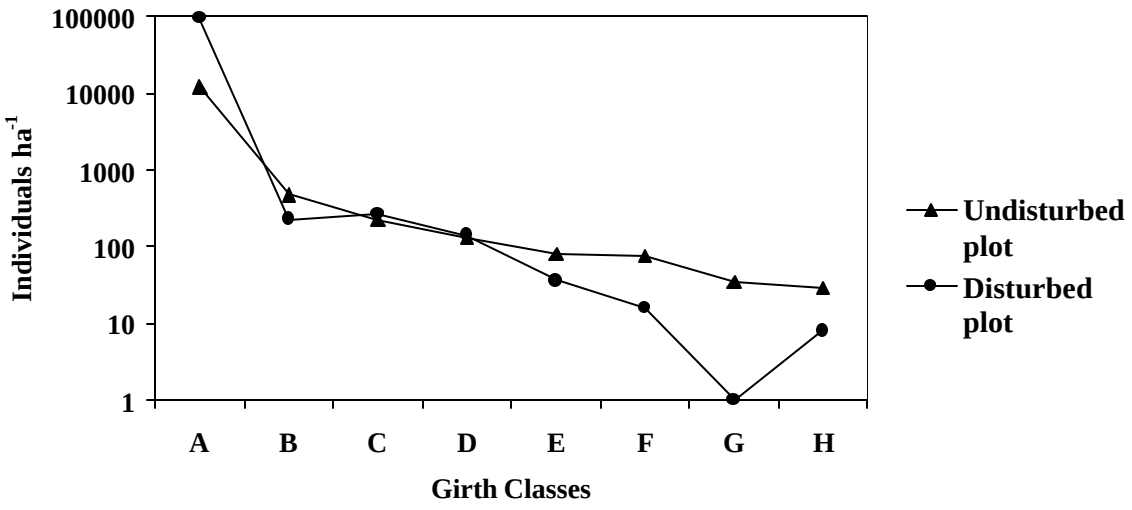


Figure 6. Density (individuals ha^{-1}, given in log scale) of trees in different girth classes in undisturbed and disturbed plots in Mannavan shola.

(A : Seedlings; girth < 10.0 cm and height < 1.0m , B: Saplings; 10.1-30 cm gbh, C- H : mature trees - C: 30.1-60 cm, D : 60.1-90 cm, E: 90.1-120 cm, F: 120.1-150 cm, G: 150.1-180 cm, H: above 180.1 cm gbh.)

Quantification was made for the density and frequency of distribution of recently cut trees in the disturbed plot. Totally 830 individuals ha^{-1} of 28 species were cut during a period of about 2 year. All these individuals belong to the girth class between 10.1 cm and 60cm gbh (Table 3). The removal of individuals of higher girth classes was not recorded. More number of individuals of *Symplocos cochinchinensis*, *Daphniphyllum neilgherrense* and *Maesa indica* were cut from the plot. In the undisturbed plot, remnants trees cut by the people were not found. Similarly, invasion of exotic species of *Acacia* in the undisturbed forest plot was not observed.

Table 3. Density and frequency of distribution of cut trees in the disturbed plot of Mannavan shola.

Species	Frequency (%) of distribution of cut trees	Density (individuals ha^{-1}) of cut trees	
		10-30 cm gbh	30.1-60 cm gbh
Symplocos cochinchinensis	80	225	95
Daphniphyllum neilgherrense	45	85	15
Maesa indica	30	50	0
Syzygium cumini	30	40	0
Litsea wightiana	25	35	5
Alstonia venulata	20	10	0
Glochidion neilgherrense	20	20	0
Acacia dealbata	15	15	0
Photinia integrifolia	15	10	10
Strobilanthes homotropa	15	30	0
Acronychia pedunculata	10	10	0
Alseodaphne semecarpifolia	10	20	10
Eurya nitida	10	10	0
Mastixia arborea	10	20	0
Persea macrantha	10	15	10
Syzygium caryophyllatum	10	10	0
Turpinia cochinchinensis	10	15	0
Viburnum coriaceum	10	10	0
Beilschmiedia wightii	5	10	0
Celtis tetrandra	5	5	0
Chionanthus linocieroides	5	5	0
Cyathea nilgiriensis	5	0	5
Neolitsea cassia	5	5	0
Rapanea wightiana	5	5	0
Saprosma foetens	5	5	0
Sarcococca coriacea	5	5	0
Syzygium densiflorum	5	5	0
Vaccinium leschenaultii	5	5	0
Total		680	150

3.1.2. Pullaradi shola

A comparative study on species composition and vegetation structure in the undisturbed (Plate 3) and disturbed plots (Plate 4) of Pullaradi shola indicated that while *Gomphandra coriacea, Persea macrantha* and *Mastixia arborea* are dominant species in the mature tree phase in the undisturbed plot (Appendix 3), *Neolitsea cassia Beilschmiedia wightii* and *Meliosma simplicifolia* are dominant in the disturbed site. Similarly, in the case of sapling phase, *Mastixia arborea, Litsea wightiana* and *Saprosma foetens* dominate in the undisturbed plot while in the disturbed plot *Alseodaphne semecarpifolia, Meliosma simplicifolia* and *Cocculus laurifolius* are more in number. The seedling population in the undisturbed plot is dominated by *Persea macrantha* followed by *Gomphandra coriacea* and *Symplocos cochinchinensis* while in the disturbed plot *Gomphandra coriacea* is dominant followed by *Celtis tetrandra* and *Cocculus laurifolius*. Dominance of early secondary species such as *Meliosma simplicifolia* and followed by *Celtis tetrandra* in the disturbed plot is a clear indication of high intensity of disturbance. Like in Mannavan shola *Lasianthus accuminatus* and *Ardisia rhomboidea,* native evergreen shrub species are found to be the dominant species in undisturbed area of Pullaradi shola. On the other hand the ground vegetation in the disturbed plot is dominated by light demanding species like *Laportea bulbifera, Oplismenus* sp. and *Achyranthes bidentata*.

Density, basal area and number of species recorded in different phases of tree community are higher in the undisturbed plot than in the disturbed plot (Table 4). Even though the density of shrubs and herbs was higher in the disturbed plot the total basal area of this community was comparatively more in undisturbed plot due to the dominance of large shrubs such as *Lasianthus accuminatus* and *Ardisia rhomboidea*. In the disturbed plot light demanding species contributed to about 47.7 % and 24.6 % of the total basal area in the seedling and sapling phases respectively. In this forest, the disturbed plot has not been invaded by any exotic tree species.

Table 4. Basic statistics of tree, shrub and herb communities in undisturbed and disturbed plots of Pullaradi shola forests.

Parameters	Mature trees*	Tree saplings	Tree seedlings	Shrubs and herbs
Number of species				
Undisturbed plot	40	39	40	54
Disturbed plot	24	17	30	43
Density (individuals ha^{-1})				
Undisturbed plot	743	1086	54304	210253
Disturbed plot	444	775	47046	284091
Basal area (m^2 ha^{-1})				
Undisturbed plot	68.68	3.11	9.34	16.48
Disturbed plot	57.23	1.58	9.26	11.28
RISQ value				
Undisturbed plot	1.623	1.636	1.615	--
Disturbed plot	1.643	1.865	1.870	--
Species diversity index (H)				
Undisturbed plot	4.5620	4.8756	4.5571	4.6141
Disturbed plot	4.1918	3.7815	4.2904	4.1289
Species dominance index (C)				
Undisturbed plot	0.0640	0.0431	0.0615	0.0587
Disturbed plot	0.0673	0.0884	0.0677	0.0903

* Mature trees ($\geq$30.1cm gbh), saplings (gbh 10.1cm to 30.0cm), seedlings (girth $\leq$10.0cm, height $\leq$1m).

The average RISQ value calculated for the tree community in the undisturbed plot is 1.624. Slightly higher RISQ value obtained to the mature tree phase in this forest plot as compared to that recorded in the relatively undisturbed plot in Mannavan shola (1.224) indicate that the former experienced disturbance in the past. Even in the seedling and sapling phases, the RISQ values are higher or equal to that recorded for the mature phase (Table 4). The reasons for such high RISQ values for the plot selected as undisturbed need to be interpreted carefully. One reason for such a

high value could be the small size of the forest, which can slow down the progressive succession subsequent to disturbances in the past. In fact, there are a few small areas randomly distributed in the plot where the ground vegetation appeared to be cleared for the reasons unknown. In addition, stray incidences of grazing have been reported. Such a small-scale random and infrequent disturbance to the ground vegetation may also be responsible for the slightly higher values for the RISQ of seedling and sapling communities in the plot. RISQ value obtained for the disturbed plot is comparatively higher than in undisturbed plot. However, such a difference is not as prominent as seen in Mannavan shola. Even the similarity index values obtained for the mature trees (0.625), seedlings (0.743) and shrub and herb community (0.508) in Pullaradi shola indicate that there is no sharp difference between the plots selected as undisturbed and disturbed. Even in the disturbed plot, a difference among mature tree phase, sapling phase and seedling phase was recorded for the RISQ values. RISQ value obtained for the mature tree phase (1.643) is much lower than those of seedling and sapling communities indicating the fact that the disturbance is a recent action that affected only the vegetation structure of the seedlings, saplings, shrubs and herbs communities.

Undisturbed plot in Pullaradi shola can be considered as a mixed forest patch with no major dominance of any one species as indicated by high species diversity and low species dominance values (Table 4). Contrary to this, the disturbed plot of this forest shows a tendency towards the over-dominance of one or few species as indicated by the low species diversity and high species dominance values.

Detailed comparison of girth class distribution of all species in both plots indicated that dominant species are represented in all girth classes (Appendix 4). In the undisturbed plot about 38% of tree species represented in all three phases i.e. seedling, sapling and mature phases. On the other hand in the disturbed plot, only 15% of tree species represented in all three phases. While 33% of species are not represented in the seedling stage in the undisturbed plot as many as only 25% species in the disturbed plot are absent in the seedling phase. This observation confirms the view that the closed canopy nature of undisturbed forest plots do not provide suitable microsites for many species to regenerate and recruit seedling, whereas moderate disturbance alter the microenvironment which favour the regeneration more number

species. It may be pointed out that, in general, density of trees in sapling and different girth classes in the mature phase is lesser in the disturbed plot than in the undisturbed plot (Figure 7).

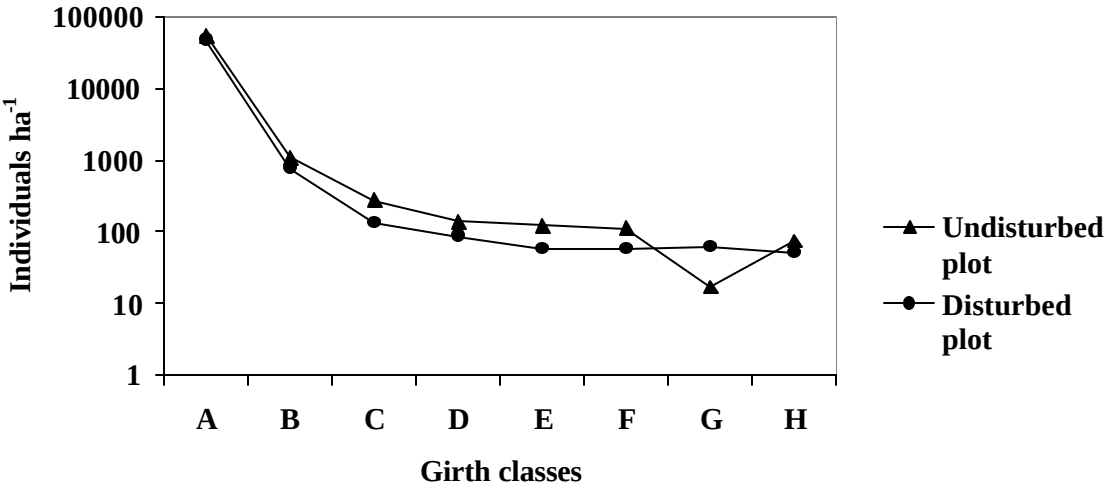


Figure 7. Density (individuals ha^{-1}, given in log scale) of trees in different girth classes in undisturbed and disturbed plots in Pullaradi shola.

(A : Seedlings; girth < 10.0 cm and height < 1.0m , B: Saplings; 10.1-30 cm gbh, C- H : mature trees - C: 30.1-60 cm, D : 60.1-90 cm, E: 90.1-120 cm, F: 120.1-150 cm, G: 150.1-180 cm, H: above 180.1 cm gbh.)

Density and frequency of distribution of cut trees and poles in the disturbed plot were quantified. Totally 930 individuals ha^{-1} belonging to 25 species cut during two year period were recorded (Table 5). All these individuals come under the girth class 10.1cm to 90.0 cm gbh. Removal of individuals of higher girth classes was not noted. In the undisturbed plot there were no signs of cut trees and poles indicating that there is no disturbance to this patch of forests in the recent past.

Table 5. Density (ha^{-1}) and frequency distribution of cut trees and poles in the disturbed plot of Pullaradi shola.

Species	Frequency (%) of distribution of cut trees	Density (individuals ha^{-1}) of cut trees		
		10.1-30 cm gbh	30.1-60cm gbh	60.1-90cm gbh
Strobilanthes homotropa	90	190	40	0
Cocculus laurifolius	50	110	0	0
Alseodaphne semecarpifolia	50	80	0	0
Rauvolfia micrantha	40	70	0	0
Sarcococca coriacea	40	40	0	0
Symplocos cochinchinensis	20	40	0	0
Meliosma simplicifolia	50	40	10	0
Celtis tetrandra	30	30	0	0
Maesa indica	30	30	0	0
Gomphandra coriacea	30	30	0	0
Glochidion neilgherrense	20	20	0	0
Meliosma pinnata	30	30	0	0
Canthium dicoccum	20	20	0	0
Acronychia pedunculata	20	20	0	0
Elaeocarpus recurvatus	20	20	0	0
Syzygium densiflorum	10	20	0	0
Actinodaphne bourdillonii	10	10	0	0
Neolitsea cassia	10	10	0	0
Murraya paniculata	10	10	0	0
Schefflera racemosa	10	0	10	0
Debregeasia longifolia	10	0	10	0
Saprosma foetens	10	10	0	0
Elaeocarpus munronii	10	10	0	0
Cyathea nilgiriensis	10	0	0	10
Antidesma menasu	10	10	0	0
		850	70	10

3.1.3 Manthan shola

In Manthan shola, *Hydnocarpus alpina* is the first dominant species in all three phases in the undisturbed plot. *Mastixia arborea* and *Cinnamomum wightii* in the mature tree phase, *Clerodendrum viscosum* and *Excoecaria crenulata* in the sapling phase and *Saprosma foetens* and *Litsea wightii* in the seedling phase followed. *Leptochilus decurrens*, *Lasianthus accuminatus* and *Strobilanthes pubescence* (Appendix 5) dominate in the shrubs and herb communities in the undisturbed plot. The late secondary species such as *Canthium dicoccum* and *Glochidion neilgherrense* and an early secondary species *Eurya nitida*, dominate the disturbed plot in the mature tree phase. In the sapling phase the early secondary species such as *Maesa indica* and *Clerodendrum* and a primary species *Saprosma foetens* are the dominant. On the other hand *Saprosma foetens* and late secondary species such as *Cocculus laurifolius* and *Canthium dicoccum* dominate the seedling phase. It may be pointed out that *Mastixia arborea* and *Cinnamomum wightii*, which are the dominant primary species in undisturbed plot were completely absent in disturbed plot. Among shrubs and herbs *Oplismenus* sp. and *Lasianthus accuminatus* and an exotic weed *Ageratina adenophora* dominated.

Disturbance in Manthan shola reduces the density and basal area of mature trees and saplings (Table 6). This can be attributed to the collection of poles and small trees as firewood. However, the understorey shrubs and herb community showed an increase in the stem density probably due to favourable microenvironment in the disturbed area. In addition, local people do not prefer many of the shrub species recorded in the disturbed plot as species suitable for firewood. However, both tree seedling density and basal area in the disturbed area are more than that in undisturbed plot. This is due to the fact that late and early secondary native species contributed as they have the tendency to recruit profusely when canopy gaps are created. For example, it is recorded that in the disturbed plot light demanding species including *Maesa indica*, *Symplocos cochinchinensis* and *Celtis tetrandra* contributed 25% of the total basal area among seedlings. Canopy openings formed by human disturbances seem to provide favorable microenvironment for the establishment and growth of such early secondary species.

Table 6. Basic statistics of tree, shrub and herb communities in undisturbed and disturbed plots of Manthan shola forests.

Parameters	Mature trees*	Tree saplings	Tree seedlings	Shrubs and herbs
Number of species				
Undisturbed plot	28	24	36	27
Disturbed plot	20	15	34	36
Density (individuals ha^{-1})				
Undisturbed plot	608	1344	51500	142167
Disturbed plot	333	985	58333	186333
Basal area (m^2 ha^{-1})				
Undisturbed plot	68.11	4.24	10.18	10.64
Disturbed plot	52.62	2.47	12.11	9.68
RISQ value				
Undisturbed plot	1.316	1.604	1.448	--
Disturbed plot	1.933	2.135	1.765	--
Species diversity index (H)				
Undisturbed plot	3.4529	3.9215	4.4175	3.5000
Disturbed plot	4.0468	3.6150	4.2779	3.8498
Species dominance index (C)				
Undisturbed plot	0.2072	0.0890	0.0678	0.1271
Disturbed plot	0.0725	0.0976	0.0897	0.1256

* Mature trees ($\geq$30.1cm gbh), saplings (gbh 10.1cm to 30.0cm), seedlings (girth $\leq$10.0cm, height $\leq$1m).

The undisturbed plot of Manthan shola (Plate 5) can be considered as a mixed forest patch with no major dominance of any one species as indicated by high species diversity and low species dominance values. However, slightly high value for species dominance in the mature tree phase than in sapling and seedling phases could be due to relatively over dominance of *Hydnocarpus alpina* with about 30% contribution to the total IVI of mature tree phase. Surprisingly, comparatively higher species diversity in mature phase was recorded in the disturbed plot than that in

undisturbed plot. This may be due to the reduction in the dominance of *Hydnocarpus alpina* and no significant dominance of any late secondary species in the plot. The disturbed plot of this forest shows a tendency towards the over-dominance of one or few species in the seedling and sapling phase as indicated by the low species diversity and high species dominance values.

The disturbed plot in Manthan shola is different from undisturbed plot in terms of tree species composition. In disturbed area, total number of tree species is generally less than in undisturbed part (Table 6). However, the number of species of shrubs and herbs are more in disturbed plots. The similarity index value of mature trees, saplings, seedlings and shrub and herb communities is 0.375, 0.410, 0.743 and 0.508 respectively. These values reveal that there is a significant difference between disturbed and undisturbed plots, except in the seedling phase.

To determine the level and intensity of disturbance in the forest, Ramakrishnan Index of Stand Quality (RISQ) was estimated. The RISQ value obtained of mature trees, saplings and seedlings were much higher in the disturbed patch than the benchmark undisturbed plot (Table 6) indicating that the intensity of disturbance is high leading to changes both in species composition and stand structure of the plot. Even in the undisturbed plot, the RISQ value recorded for the sapling phase is comparatively more than that recorded for seedling and mature phases. A similar trend is recorded in the disturbed plot also. It may be pointed out here that about 5-10 years back lemongrass cultivation in the nearby area was intensive and gradually declined due to change in landuse pattern from lemongrass cultivation to *Eucalyptus grandis* by the local people. Thus the high RISQ in the sapling phase indicate past disturbances in both plots due to intensive lemongrass cultivation. Since the RISQ value obtained for the disturbed plot is as high as and more than 1.77, the rate of recovery by the forest will be slow.

Detailed comparison of girth class distribution of all species in the undisturbed plot indicated that dominant species are represented in all girth classes (Appendix 6). In the disturbed plot, however, no such trend is observed. In the undisturbed plot about 31% of tree species represented in all three phases i.e. seedling, sapling and mature phases when in the disturbed plot, only 14% of tree species showed the same feature. The number of species represented only in the seedling stage is more in the

disturbed plot (35%) than in the undisturbed plots (23%) suggesting that the disturbance has increased the opportunity of many species to recruit their seedlings. It may be pointed out that, in general, density of trees in sapling and smaller girth classes in the mature phase is lesser in the disturbed plot than in the undisturbed plot (Figure 8).

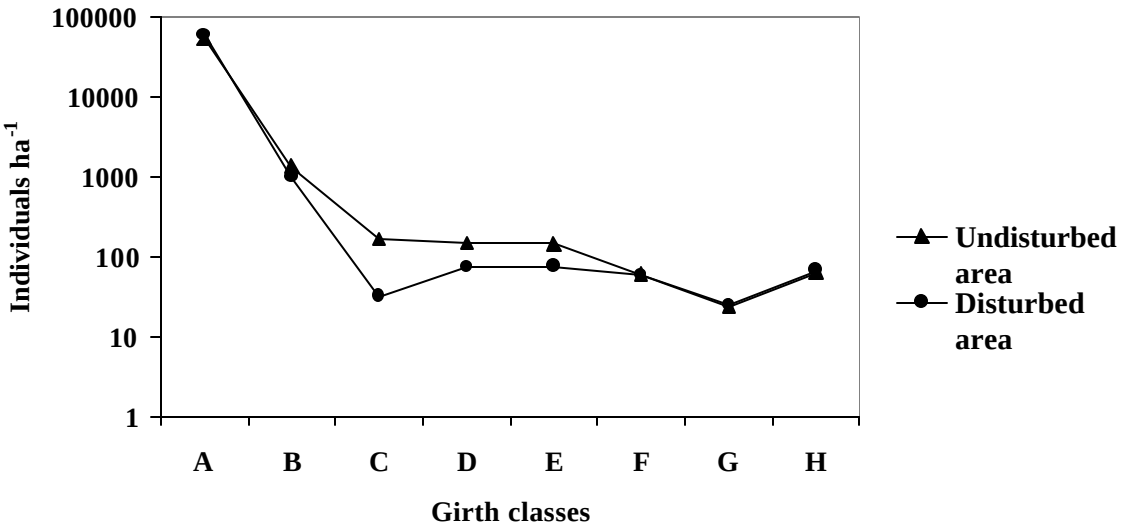


Figure 8. Density (individuals ha^{-1}, given in log scale) of trees in different girth classes in undisturbed and disturbed plots in Manthan shola.

(A : Seedlings; girth < 10.0 cm and height < 1.0m , B: Saplings; 10.1-30 cm gbh, C- H : mature trees - C: 30.1-60 cm, D : 60.1-90 cm, E: 90.1-120 cm, F: 120.1-150 cm, G: 150.1-180 cm, H: above 180.1 cm gbh.)

In Manthan shola, from the disturbed plot, totally 600 individuals ha^{-1} were found cut and removed in the two-year period. More number of individuals of *Hydnocarpus alpina*, *Alseodaphne semecarpifolia, Lasianthus accuminatus, Maesa indica, Strobilanthes homotropa* and *Canthium dicoccum* were cut from the plot. Here, even the removal some individuals of higher girth classes are also recorded (Table 7). These trees are used for the preparation of planks, which will either be used, for household furniture or for selling. Poles and trees of smaller girth classes up to 90cm gbh, which contribute to about 93% of total number of trees harvested are used as firewood for lemongrass distillation.

Table 7. Density (ha^{-1}) and frequency distribution of cut trees and poles in the disturbed plot of Manthan shola.

Species	Frequency (%) of distribution of cut trees	Density (individuals ha^{-1}) of cut trees				
		10.1-30 cm gbh	30.1-60 cm gbh	60.1-90 cm gbh	90.1-120 cm gbh	Above 120 cm gbh
Hydnocarpus alpina	40	80	10	0	0	0
Lasianthus accuminatus	30	60	0	0	0	0
Maesa indica	30	50	0	0	0	0
Strobilanthes homotropa	40	40	0	0	0	0
Saprosma foetens	20	30	0	0	0	0
Symplocos cochinchinensis	20	20	0	0	0	0
Clerodendrum viscosum	20	20	10	0	0	0
Syzygium densiflorum	10	10	0	0	0	0
Sarcococca coriacea	10	10	0	0	0	0
Persea macrantha	10	10	0	0	0	0
Mastixia arborea	10	10	0	0	0	0
Excoecaria crenulata	10	10	0	10	0	0
Cocculus laurifolius	10	10	0	0	0	0
Chionanthus linocieroides	10	10	0	0	0	0
Celtis tetrandra	10	10	0	0	0	0
Canthium dicoccum	40	10	0	20	10	0
Alseodaphne semecarpifolia	30	10	40	0	20	0
Aglaia apiocarpa	10	10	0	0	0	0
Unknown-4	10	0	20	0	0	0
Syzygium cumini	10	0	0	0	0	10
Psychotria elongata	10	0	10	0	0	0
Meliosma simplicifolia	20	0	10	10	0	0
Agrostistachys indica	10	0	10	0	0	0
		410	110	40	30	10

3.1.4 Aruvikkad shola

As already mentioned in the section Methodology, since there are no undisturbed forest plots near to Aruvikkad shola, its floristic structure and composition was compared with those of undisturbed plots of Mannavan shola. The mature tree phase of Aruvikkad shola is dominated by light demanding species *Clerodendrum viscosum* and *Syzygium densiflorum* followed by a primary species *Phoebe lanceolata* (Appendix 7). Even in the sapling phase *Clerodendrum viscosum* is dominant followed by *Phoebe lanceolata* and *Actinodaphne bourdillonii.* When the tree seedling phase is considered, *Elaeocarpus munronii, Litsea wightiana* and *Gomphandra coriacea*- all primary species are dominant. Contribution of the early secondary species to the total IVI is more in the sapling (38%) and mature (24%) phases indicating past disturbances in the plot. There is a significant difference between Mannavan shola undisturbed plot and the Aruvikkad plot as evidence by similarity index values for mature trees (0.442), saplings ((0.361), seedlings (0.455) and shrubs and herb categories (0.444). This also reveals that the disturbance in this shola forest has led to change in the species composition. The dominance of early secondary shrubs such as *Strobilanthes homotropa* and *Laportea bulbifera* and herb *Elatostema lineolatum* in Aruvikkad plot is also an indicator of disturbance. On the other hand, low contribution by early secondary tree species (18%) to the total IVI of seedling phase may suggest the fact that this forest plot is free from disturbance in recent days and is recovering. It may be pointed out that the density and basal area of all categories of trees in Aruvikkad shola are comparable with those of undisturbed Mannavan shola plot (Table 8). Higher density and basal area of tree community in the Aruvikkad plot is again an evidence for no extraction of poles and other biomass from this forest recently as well as of the forest recovery from past disturbance. Comparatively poor density and basal area of understorey shrubs and herb community in the Aruvikkad plot may be an indication of the closing up of canopy by over-storey saplings and trees.

When compared the species diversity value for different categories of trees are higher in Aruvikkad than at Mannavan shola, plot (Table 8). Contrary to this, species dominance value is less in Aruvikkad plot. High species diversity and low species dominance in Aruvikkad plot may be due to the fact the level of disturbance in this

plot is moderate which supports several species, instead any one only, to recruit individuals. In the case of shrub and herb community, species dominant index value is high in Aruvik kad plot due over-dominance of species like *Strobilanthes homotropa*.

Table 8. Basic statistics of tree, shrub and herb communities in undisturbed plot of Mannavan shola and disturbed plots of Aruvikkad forests.

Parameters	Mature trees*	Tree saplings	Tree seedlings	Shrubs and herbs
Number of species				
Undisturbed plot	44	40	34	29
Disturbed plot	(42)	(32)	(32)	(34)
Density (individuals ha^{-1})				
Undisturbed plot	567	476	12232	221538
Disturbed plot	(691)	(447)	(34688)	(157344)
Basal area (m^2 ha^{-1})				
Undisturbed plot	52.4	1.3	2.5	27.4
Disturbed plot	(49.8)	(1.7)	(5.8)	(12.7)
RISQ value				
Undisturbed plot	1.224	1.274	1.271	--
Disturbed plot	(1.934)	(2.051)	(1.706)	--
Species diversity index (H)				
Undisturbed plot	3.9903	3.9329	3.8929	3.8913
Disturbed plot	(4.4608)	(4.2406)	(4.5036)	(3.5720)
Species dominance index (C)				
Undisturbed plot	0.1002	0.1319	0.1065	0.0940
Disturbed plot	(0.0691)	(0.0865)	(0.0556)	(0.1561)

* Mature trees ($\geq$30.1cm gbh), saplings (gbh 10.1cm to 30.0cm), seedlings (girth $\leq$10.0cm, height $\leq$1m).

The level of disturbance and the present condition of the ecosystem recovery processes can be further analysed by estimating the RISQ values for mature trees, saplings and seedling phases individually. In Aruvikkad plot, the RISQ obtained for all three phases is more than those of undisturbed plot of Mannavan shola (RISQ= near 1.0) suggesting that the former plot is disturbed. The value obtained for the saplings is comparatively more than that recorded for mature trees and seedlings (Table 8). Higher RISQ values for saplings and mature trees suggest that the plot might have been disturbed in the past i.e., about more than 5 years ago. On the other hand reduction in the RISQ from sapling to seedling phase indicates that the forest is recovering from the past disturbance. This also suggests that there is no anthropogenic disturbance in recent days.

Girth class distribution of Aruvikkad shola forest shows that 40% of species was represented in all the three phases (Appendix 8). However, about 39% of the species occur in sapling and/or mature phase but absent in seedling phase. Species such as *Macaranga indica, Mallotus ferrugineus, Rapanea wightiana, Scolopia crenata* and *Viburnum* sp. are well represented in the seedling phase but their recruitment to sapling phase is generally poor suggesting the closure of canopy due to absence of recent disturbance.

It may be pointed out that, in general, no significant difference in the density of trees in sapling and different girth classes in the mature phase in the Aruvikkad plot and the undisturbed plot of Mannavan shola is recorded (Figure 9). The size class distribution curve obtained for the Aruvikkad plot shows the negative exponential growth curve as seen in undisturbed forests. Unlike in other disturbed shola plots here we have not recorded the absence of trees in any given girth class. In addition, we have not recorded any trees and poles cut from the plot since about two years. These two facts reveal that the disturbance in the past is moderate and present day management is assisting the forest recovery processes.

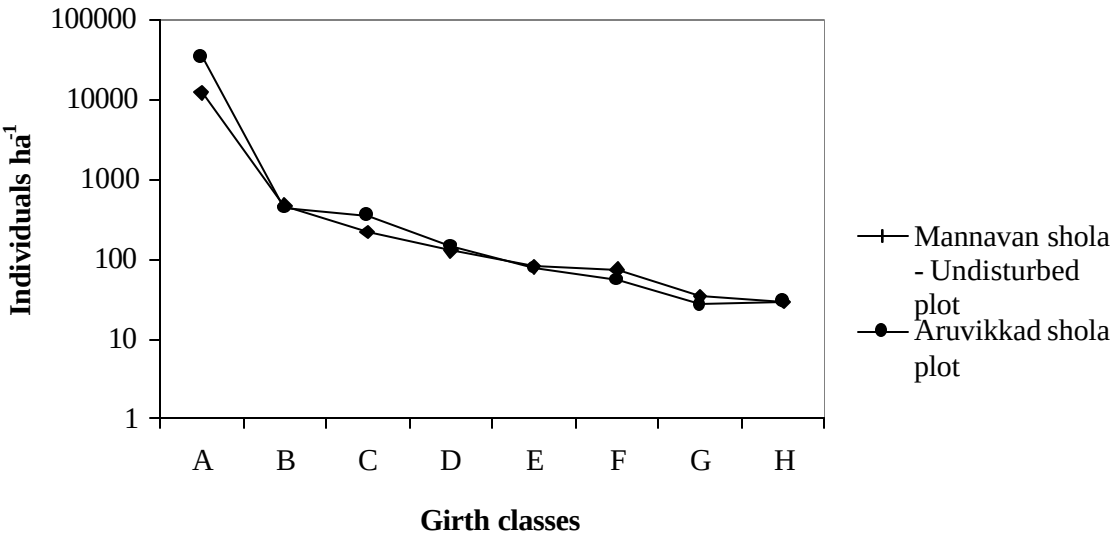


Figure 9. Density (individuals ha^{-1}, given in log scale) of trees in different girth classes in disturbed plots of Aruvikkad shola and undisturbed plots of Mannavan shola.

(A : Seedlings; girth < 10.0 cm and height < 1.0m , B: Saplings; 10.1-30 cm gbh, C- H : mature trees - C: 30.1-60 cm, D : 60.1-90 cm, E: 90.1-120 cm, F: 120.1-150 cm, G: 150.1-180 cm, H: above 180.1 cm gbh.)

3.2 Summary of vegetation analysis data

As noticed in the previous section, disturbance in shola forests made different kinds of impact on vegetation structure, composition and recovery processes. Some of the important observations made from the phytosociological point of view are highlighted in Table 9.

Table 9. Impact of disturbance on vegetation structure and composition in different shola forests.

Impact of disturbance	Mannavan	Pullaradi	Manthan	Aruvikkad
Dominance of light demanding species in different plant communities	✓	✓	✓[1]	✓[2]
Dominance of exotic species	✓[3]	✗	✗	✗
Absence of some primary species which were recorded in undisturbed plots	✓	✗	✓	✗
Reduction in the density and/or basal area of plant communities	✓[4]	✓	✓[5]	✗[6]
Increase in density and/or basal area of plant communities	✓[7]	✗	✗	✗
Low value for similarity index in different plant communities	✓	✓	✓	✓
Increase in species dominance value	✓	✓	✗[8]	✗[9]
Increase in RISQ value of tree community	✓	✓[10]	✓[11]	✓[11]
Skewed girth class distribution of tree community	✓[12]	✓[12]	✓[12]	✗
Tree cutting recorded	✓	✓	✓[13]	✗

✓[1], Prominent in herbs and shrub community.

✓[2], In seedling phase, primary species are dominant.

✓[3], Recorded in the tree seedling and shrubs and herbs communities.

✓[4], Recorded the reduction in density of herbs and shrubs due to collection of stems of species like *Strobilanthus homotropa*.

✓[5], Not recorded in tree seedling and herbs and shrub communities due to recruitment of more number of individuals of light demanding species.

✗[6], Not recorded due absence of disturbance in recent time.

✓[7], Recorded in tree seedling community due to recruitment of more number of individuals of light demanding and exotic species

✗[8], In mature tree phase, species dominance value decreased due to reduction in the dominance of *Hydnocarpus alpina.*

✗[9], In tree community, species dominance value decreased probably due to the fact the disturbance in this plot provide favour the recruitment and establishment of several species.

✓[10], Slightly high in sapling and seedling phases suggesting that the disturbance here is due to recent action.

✓[11], Slightly high in mature tree and sapling phase suggesting that the plots experienced disturbance a few years back and the recently disturbance is absent or light in intensity.

✓[12], Density of trees in sapling and mature trees of small girth classes is less indicating harvest of poles an small wood by the local people.

✓[13], Even the removal of trees of higher girths classes recorded.

3.3 Socio-economic analysis

The main driving forces behind these disturbances and degradation of forests stem from human activities. It is possible to distinguish proximate and underlying causes for the degradation. In general, over exploitation may be identified as proximate cause, while economic, socio-political and cultural factors may be the underlying ones behind the activities leading to any forest degradation (Barbier, *et.al,* 1994; Heywood and Watson, 1995). However, there is no consensus among the social scientists regarding which underlying factors are contributing more for degradation of forests. For instance, some social scientists argue that recent population pressure and expanding markets are responsible for large scale degradation of forests (Browder,1989; Black, 1989). On the other hand, some others argue that it is the

consequence of economic pressure of poverty and under development that have forced the rural population to adopt pattern of destructive exploitation of the forests (Gills and Repetto, 1988; Moench, 1989). Another school of thought strongly maintained that the root cause of the on-going disaster of deforestation lies in the radical transformation of social system of resource use (Gadgil, 1989). In the case of shola forests in Kerala, the degradation was closely linked with population increase, and changes in resource use. In this section an attempt is made to analyze how socio-economic factors are responsible for the degradation of shola forests.

3.3.1. Socio-economic conditions of the selected households

3.3.1.1 Mannavan Shola

The villages dependent on Mannavan shola are Kanthallur, Perumala, Puthur and Kolachavayil. Except tribes in Kolachavayil, all other households depending upon Mannavan shola are Tamil people who migrated from Tamil Nadu. In the selected 100 households of these four villages there are 670 persons of which male and female constitute 49% and 51% respectively. Children constitute about 20% of the population. The literacy level of the selected households is only 80 % (Table 10) as against the state average of 95%. About 20 % of the sample population have primary, 25 % secondary, 14 % high school and 8% SSLC and above levels of education The low literacy rate may be due to the predominance of Tamils and tribes in the sample and also due to lack of adequate school facilities.

Table 10. Literacy level of selected households in villages near to Mannavan shola

Education level	Male		Female	
	Number	%	Number	%
Small Children	45	14	66	20
Primary	66	20	72	21
Secondary	140	42	134	39
SSLC passed & above	42	13	26	8
Illiterate	37	11	42	12
Total	330	100	340	100

The main occupation of the people (both tribes and non-tribes) is cultivation. Vegetables and food grains like carrot (*Daucus carota*), beetroot (*Beta vulgaris*), cabbage (*Brassica oleracea*), garlic (*Allium sativum*), ragi (*Eleusine coracana*), *beans (Phaseolus vulgaris*), potato (*Solanum tuberosum*), ginger (*Zingiber officinale*) etc. are cultivated extensively in the area. Lemon grass cultivation is another important source of income of the people. There are about 295 cattle in the selected area, which provide a sizeable income to the selected households. In addition, some people get seasonal jobs, like fire-line work, road construction etc., which are undertaken by the Forest Department. About 80 % of the sample received a monthly income below Rs. 2000/-, 13% between Rs. 2000 to Rs. 3000 and only 7% above Rs. 3000/-, indicating a low per capita income and consequently low standard of living (Table 11).

Table 11. Distribution of monthly income of selected households in villages near Mannavan shola. Values in parentheses indicate the percentages to total.

Village	Monthly income (in Rs.)				Total
	<1000	1000-2000	2001-3000	>3000	
Kanthallur	8 (32)	9(36)	5(20)	3(12)	25
Perumala	12 (48)	10(40)	2(8)	1(4)	25
Puthur	14(56)	11(44)	0 (0)	0(0)	25
Kolachavayil	6(24)	10(40)	6(24)	3(12)	25
Total	**40(40)**	**40(40)**	**13(13)**	**7(7)**	**100**

People living Kanthallur and Kolachavayil earned more income than those of other areas did. It may be pointed out here that 12% of the selected households in Kolachavayil, which is a tribal settlement, earned an income more than Rs. 3000/- per month. However, indebtedness is one of the major problems of the people in the selected areas, where 54 % of the sample households are having indebtedness. The same is more among the selected households in Puthur (60%), followed by Kolachavayil (56%), Perumala (52%) and Kanthallur (48%).

3.3.1.2 Pullaradi Shola

The selected sample of 25 households has a total of 220 people, consisting of 54% males and 46% female. Children constitute about 51 % of the population. The literacy level of this settlement was found to be very low, accounting for only 50 % (Table 12). Of the total sample, 47% received primary education and less than 3% secondary education. Number of illiterates is high here partly due to their poverty and partly due to lack of school nearby.

Table 12. Literacy level of selected households in the village near to Pullaradi shola.

Education	Male		Female	
	Number	%	Number	%
Small Children	26	25	30	25
Primary	20	20	32	27
Secondary	1	0.98	2	1.7
SSLC passed & Above	0	0	0	0
Illiterate	55	54	54	45.8
Total	102	100	118	100

In the selected settlement, people are, by and large, agriculturists who cultivate a variety of crops such as garlic, ragi, carrot, beans, cabbage, ginger, etc. Majority of them cultivates in the forest areas, in addition to tiny plots owned by them. There are about 300 cattle in the settlement that constitutes another source of income of the people in the hamlets. Lemongrass cultivation, which is carried out in 142 ha, forms a yet another source of income. Another important feature of this area is that shifting cultivation is practiced in 8 ha of forest area.

3.3.1.3 Aruvikkad

The total 80 selected households consist of 378 persons of which males and females account for 47% and 53% respectively. Small children account for 7.9 %. Literacy level, particularly, level of higher education received by the people in the area is found to be higher (Table 13). For instance, 88% of the total selected population are literate with 24% have primary, 30% secondary, 21% high school and 5% SSLC and above levels of education. There are some specific reasons for higher level of education in the area. First, the Estate Management prefers educated people for job. Secondly, they also provide school facilities nearby their houses.

Table 13. Literacy level of selected households in the village near to near Aruvikkad shola.

Education	Male		Female	
	Number	%	Number	%
Small children	13	7.3	17	8.5
Primary	30	16.9	61	30.3
Secondary	65	36.7	48	23.9
High school	48	27.1	31	15.4
SSLC passed & above	8	4.5	10	5.0
Illiterate	13	7.3	34	16.9
Total	177	100.0	201	100

Most of the households have one or two members with permanent job in the Tea Estate and other adults in the households have temporary work in the Estate or other places. A few households earn additional income from sources such as cattle rearing, vegetable cultivation and trade, etc. It was reported that about 10% of the selected households received monthly income between Rs. 1000-2000, while 32% households received Rs. 2000-3000 and the rest received above Rs. 3000, indicating a higher level of standard of living.

Thus the socio-economic conditions of the people who live near Mannavan and Pullaradi sholas and those live near the Aruvikkad shola areas are significantly different. People living near the Mannavan shola and Pullaradi shola area heavily depend upon land near shola forests for their subsistence, while people in village near Aruvikkad shola are least depended on forest, as they are primarily wage earners. The first group (people of villages near Mannavan shola and Pullaradi shola) live in an unorganized manner, with highly fluctuating income and middlemen quite often exploit them. On the other hand the interest of the second group (People of village near Aruvikkad shola) is very much safeguarded by the Estate management. These differences have implications on their resource utilization and consequently the degradation of the shola areas. This will be dealt with in the following section.

3.4 Degradation of sholas

3.4.1 Resource use pattern in the past

According to some old people who were interviewed, about 5 decades ago there were hardly 10 households each located near Mannavan Shola and Pullaradi shola and depended on these two forests for their livelihood. Mainly they depended on sholas and it's neighboring areas in three ways such as shifting cultivation, collection of NWFPs and firewood. The tribal people who live nearby the sholas were basically shifting cultivators. They practiced similar shifting cultivation practices as done elsewhere in the country such as clearing of forests with slash and burn techniques, no tillage, irrigation and fertilizer application except ashes deposited during the burning, frequent shifting of field, growing of traditional annual crops, etc. In olden days the cultivation cycle was about 20-25 years. Traditional crops such as chama (*Panicum miliaceum), ragi,,* etc. were cultivated. Since there were only limited number of people who cultivated in the area, this had not altered the ecosystem much.

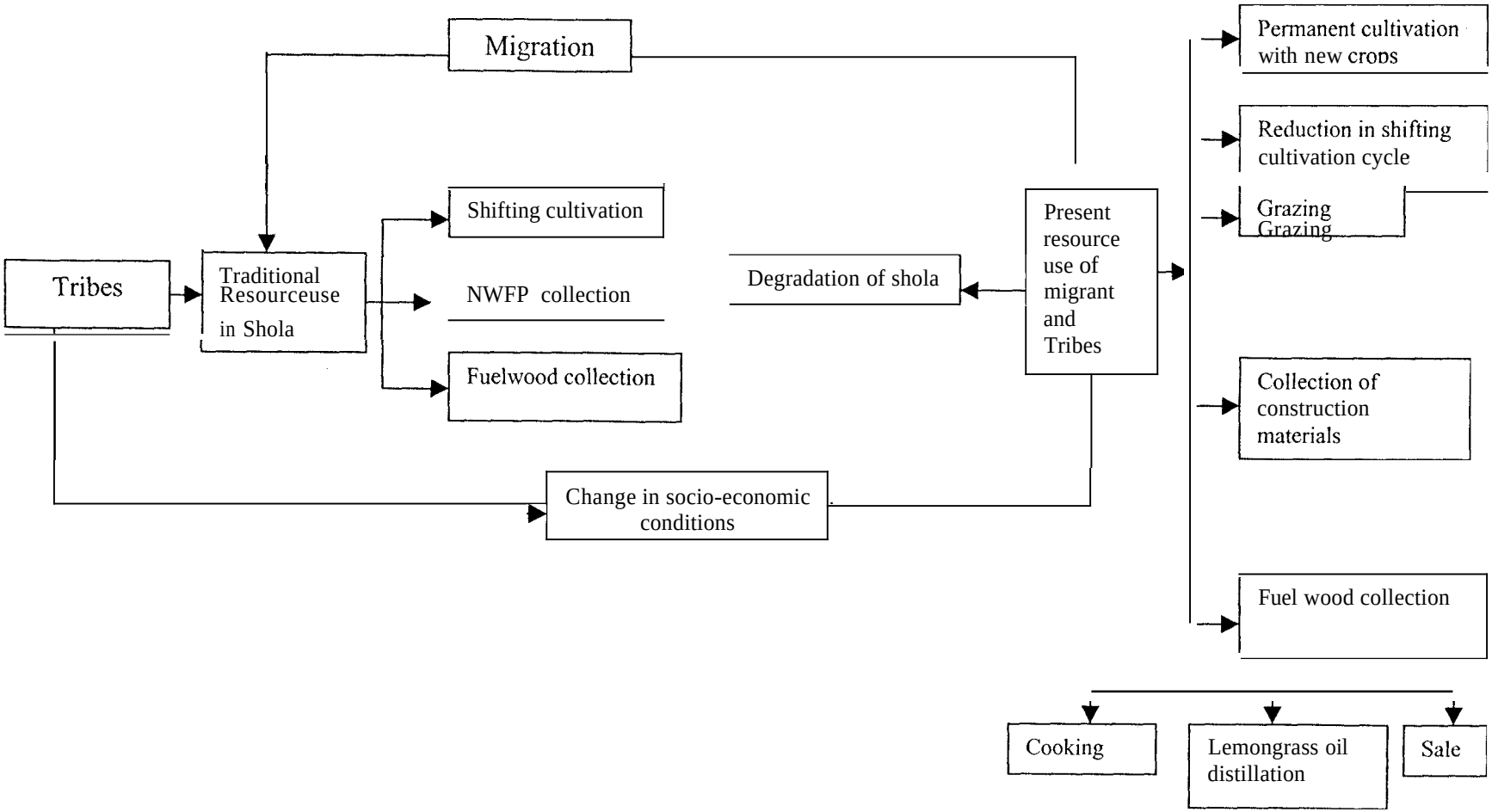
Collection of NWFPs (nonwood forest produces) was another important activity of the tribes. Since the collection of NWFPs is a seasonal activity, and honey was the major NWFP item collected by the tribes, this was not harmful to the ecosystem. Firewood, which was used mainly for cooking, is another item collected by the people from the shola. As there were only a limited number of households that

used firewood only for cooking, the firewood collection was scanty, resulting in minimum disturbance to the ecosystem. In short, the major activities of the inhabitants in olden days had not been harmful to the selected shola areas.

3.4.2 Present resource use pattern

It has been pointed out that the forest areas in the tropical countries are under severe pressure due to uncontrolled growth of population, followed by unsustainable use of forest resources. Heavy anthropogenic pressure brings out a series of changes, including structural changes that ultimately end up in degradation of forests (Ramakrishnan, *et al.*, 2000). Although this is the basis of most of the disturbance and degradation of forests, the underlying process varies from place to place. The origin of the present resource use in the shola areas dates back to early 1970 when migration of the people from the nearby Tamil Nadu state and southern Kerala began to occur. According to old people in the area, majority of the migration occurred during 1970's and 1980's. The migrant people possessed the land either by encroaching or by purchasing from the tribes at a nominal price. They introduced new crops particularly, vegetables such as cabbage, carrot, beans, etc. which are suitable to the agroclimatic conditions. They also introduced lemon grass cultivation in the areas, which is a commercial crop. This crop has both advantages and disadvantages from the point of view of conservation. The most important advantage is that it helps to prevent soil conservation. The disadvantage is that large-scale firewood is required for distillation of lemon grass oil, which resulted in extraction of more firewood from the shola areas. Rearing cattle is another important activity of the people in the areas and uncontrolled grazing resulted in poor regeneration of species. In short, population increase has brought about a significant change in the resource use, manifested by new cropping pattern, introduction of commercial crops and consequent increase in use of wood, including firewood cattle raring, shifting cultivation, etc. which resulted in degradation of shola. Such changes in the resource use by people living near shola forests such as Mannavan shola, Pullaradi and Manthan shola are depicted in Figure 10. A detailed discussion of this change and its impact on selected areas is held below.

Figure 10. Changes in resource use by villagers living near Mannavan shola, Pullaradi and Manthan shola



3.4.2.1 Food Crop cultivation pattern

As pointed out earlier, the selected area witnessed migration since 1970. The migrated farmers had not followed shifting cultivation in their new place partly because there was no adequate land and partly due to their lack of awareness of various practices of the shifting cultivation. On the other hand, they introduced a cropping pattern, which is known to them. The new cropping pattern introduced by the migrant farmers predominantly consisted of vegetables such as carrot, beans, cabbage, garlic, ginger etc. These crops are high value crops when compared to most of the crops in the shifting cultivation, and provided more income to the farmers. Lured by high profit received by migrant farmers, especially in early years, some of the tribal people also started the cultivation of these crops in their shifting cultivation areas, which reduced shifting cultivation in the study area. For instance, in Goodallarkudi, the shifting cultivation was stopped during 1970's and 1980's. As the newly introduced crops generally require more care, fertilizer and pesticide application, its cultivation is more capital intensive. Another draw back of these crops is that they are produced for the markets, which are located far-off. The prices of their products are often determined by market forces, which, according to them, are not attractive. Further, the prices of these items are highly fluctuating; for instance, the prices of cabbage varied between Rs. 2 and Rs. 15 and that of beans between Rs. 4 and Rs. 24 in a year. In the context of price fluctuations, there are instances of market interventions, to control the price as a result of which their income from agricultural activities has not been steady. There is considerable evidence that poverty among the users of natural resources in many of the least resilient ecosystem has been due to manipulation of the set of prices they face. Generally the effect of market intervention in the less developed economy has been the reduction of productive income (Warford, 1987). With a view to enhance their income, the farmers diversified their agricultural activities in two ways: grazing and cultivation of lemon grass cultivation.

3.4.2.2 Cattle grazing

It was estimated that there were about 295 livestock in the selected 100 households from four villages near Mannavan shola. On an average, each selected household possessed 3 livestock. Average number of livestock per household is more in Kanthallur village (7) and less in Kolachavayil (2), Perumala (1) and Puthur (1). In Pullaradi shola, the number of livestock is as high as 300 per selected 25 households.

Of the total livestock population, the number of cattle constitutes 77% and 81% in Mannavan shola and Pullaradi shola area respectively. It was estimated that cattle rearing provided on an average about 12% of the total income of the households. However, about 85% of the cattle in Mannavan shola and all the cattle in Pullaradi shola are sent for grazing in shola area. Both field observation and discussion with the respondents indicated clearly that some parts of the shola forests are experiencing overgrazing and also that the grazing pressure is increasing day by day. Such a raise in grazing pressure frequently has the effect of lowering the resilience of the ecosystem (Perrings and Walker, 1997). Further, increasing grazing pressure implies reduction in the proportion of palatable plants and increase in both impalatable grasses and wood plants which are susceptible to fire (Knoop and Walker, 1985). Further, overgrazing leads to undesirable alterations in the biomass (Perrings, 1989). Change in species composition including the dominance of impalatable shrubs such as *Laportea bulbifera* and *Achyranthes bidentata* as in case of Pullaradi shola and even invasion of exotic weedy species such as *Ageratina adenophora* in case of Mannavan shola could be partially due to grazing pressure.

3.4.2.3 Lemongrass cultivation

Lemongrass cultivation is another reason for degradation of Mannavan shola and Pullaradi shola. The origin of the cultivation of lemon grass dates back to 1970's when new migrant people started inhabiting this area. Around Mannavan shola, lemongrass has been cultivated in about 188 ha. Out of four villages located near Mannavan shola in Kanthallur village lemongrass cultivation is more (82 ha) followed by Perumala (48.7 ha), Kolachavayil (48.7 ha) and Puthur (7.5 ha). Near Pullaradi shola, estimated area under lemongrass cultivation is about 142 ha. In these villages, earlier the farmers undertook the lemon grass cultivation as a source of supplementary

income. But later it became a major source of income accounting for 45% of the total household income. It is generally pointed out that the lemon grass cultivation is a profitable one. The average per hectare net returns of the cultivation of lemongrass for 5 years was estimated as Rs. 37,500 (excluding the value of land) (Thomas, 2000). Another study in the neighboring area of the Mannavan shola indicated that net annual monetary benefit by lemongrass cultivation was Rs. 23,713±5,997 ha^{-1}, with monetary output/input ratio of 1.81 ± 0.14 when the cost of firewod and land was not accounted (Chandrashekara, 2000). The farmers in the study areas also indicated the profitability of the cultivation. Three reasons attributed for the profitability are: a) the price of lemongrass oil is high and less fluctuating (between Rs. 400-450 kg^{-1} during last 5 years), b) firewood required for its distillation is taken freely from the forest areas, which lowers cost, and c) wage rate is less in shola area (Rs.40 per female labor) when compared to other places (Rs. 100).

Lemon grass cultivation has both merits and demerits. In addition to a source of income, this helps to prevent soil erosion (Chandrashekara and Sankar, 1998b). But most important demerit of lemongrass cultivation is that its oil distillation takes a huge quantity of firewood for its distillation. For example, according to the cultivators, on an average, distillation of lemongrass collected in one-year period from one hectare land requires about 9,839 kg of firewood. Thus it is estimated that about 3,243 tones of firewood per year is required for distillation of lemon grass cultivated in 330 ha in the villages near Mannavan shola and Pullaradi shola.

3.4.2.4 Firewood Collection

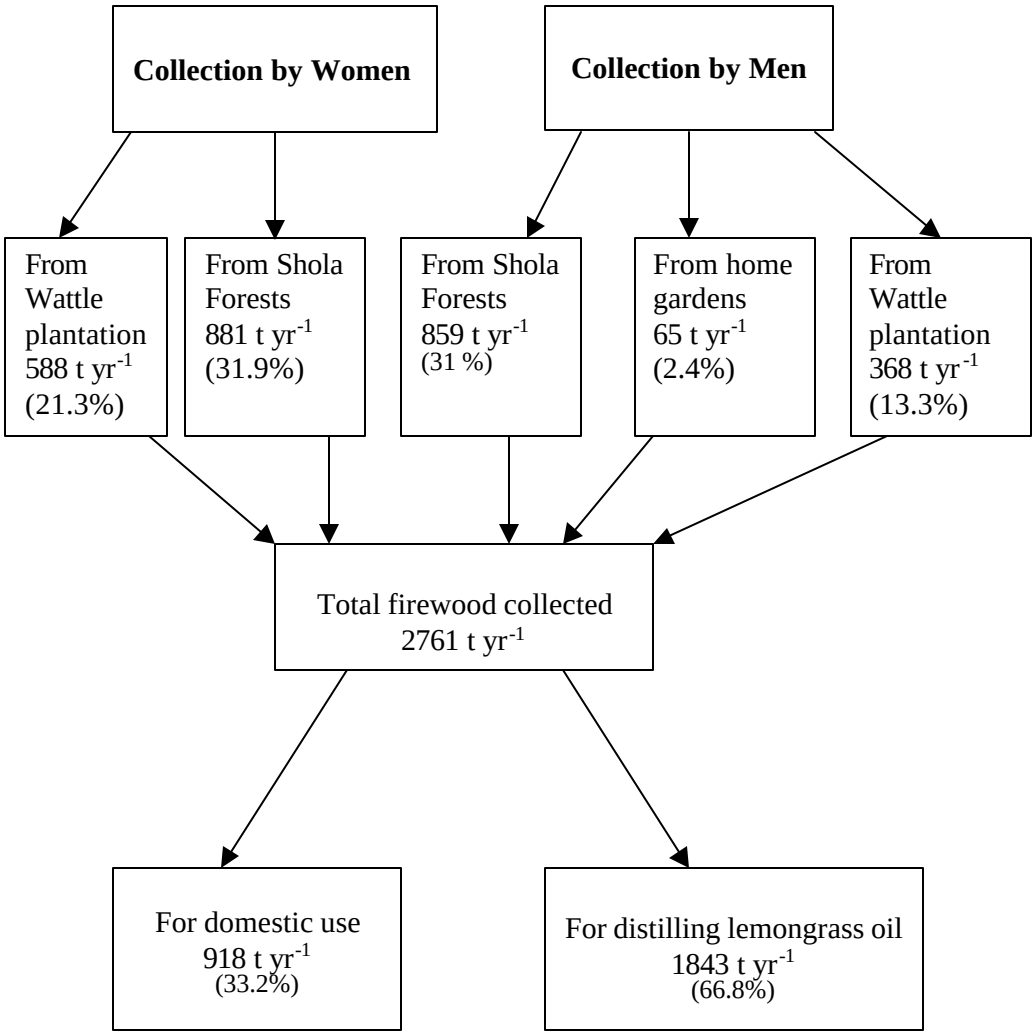
Firewood is one of the major sources of energy in rural areas in Kerala. This is particularly true in upland areas where the availability of the firewood is more. It was found that firewood constitutes the major source of energy to 90% of the selected households in the Mannavan shola areas and all the selected households in the Pullaradi shola. About 10 % of the households in Mannavan shola area use other energy sources like cow dung and LPG gas, in addition to firewood. Firewood is invariably collected from the shola areas and wattle plantations nearby it. Some of the firewood species collected from the shola forests are presented in the Table 14.

Table 14. Shola forest species collected for fuelwood by the villagers.

Scientific name	Local name
Glochidion velutinum	Chathakadamba
Isonandra stocksii	Paala
Litsea wightiana	Kodala
Meliosma simplicifolia	Kolakkatta
Meliosma pinnata	Thakiri
Neolitsea cassia	Mulakunari
Persea macrantha *Rhododendron arboreum*	Kolamamaram Aalanchi
Symplocos cochinchinensis	Kelan
Strobilanthes homotropa	Kurinji
Syzygium spp.	Njaval
Viburnum spp.	Konakara

The most preferred and widely collected species of firewood are *Viburnum* spp., *Strobilanthes homotropa*, and *Syzygium* spp. It was estimated that about 90 to 119 persons enter the Mannavan shola areas for collection of firewood, and each of them collect about 34-40 kg per day. It was also estimated that about 2768 tones of firewood is collected from Mannavan shola and nearby wattle plantation (Figure 11). Both men and women are involved in the collection of firewood, but the proportion collected by them are different. While women collect about 53% of the firewood, the rest is by men. About 62 % of the total firewood collected are from shola, 35% is from wattle plantation and rest is from homesteads. This indicate that shola constitutes a major source of firewood. Of the total firewood collected 33% is used for domestic use and the rest is used for lemongrass oil distillation. Firewood collection is mainly for self-consumption although some sell a part of their collection. However, about 10% of the total respondent stated that they firewood exclusively for sale.

Figure 11. Fuel wood collection and utilization pattern by villagers and tribes near Mannavan Shola



In Pullaradi shola, the firewood required for distillation of lemongrass oil was estimated to be 1140 m^3 of which 80% was collected from shola and rest from wattle plantation. Some of the respondents stated that collectors collect fallen trees and branches, which are available in the shola and utilize them as firewood. Then the question is whether the quantity of fallen and dead wood is enough to meet the requirement of the villagers. Thus an attempt was made to estimate quantity of fallen/dry wood available in the Mannavan shola by establishing ten sample plots of 10x10 m at 100 meter interval. It is estimated that 966$\pm$287 tonnes km^{-2} fallen and dead wood is available in the forest. Accordingly, a substantial quantity of firewood may be collected from the selected area. But the problem is that, the gatherers collect firewood only from the fringes of the Mannavan shola (Figure 5), due to variety of reasons such as inaccessibility, wildlife, etc. Since the firewood is collected only from fringes, the availability of fallen wood is usually less, which quite often, force them to cut branches and even tree for firewood, resulting in degradation. As already stated in the Section 3.1, apart from collection of stems of understorey small trees or large shrubs such as *Strobilanthes homotropa, Maesa indica, Canthium* etc., as many as 600 to 930 trees ha^{-1} were found cut from different shola forests. Such a large scale harvest of trees, which is brought about predominantly by lemongrass cultivation, is either degrading the shola or slowing down the forest recovery process. Even the collection of a large quantity of fallen and dead wood is not advisable in the context of ecological resilience of the forests. If dead wood is left to decompose within the forests, with the help of micro organism, it adds to the stock of existing humus, strengthen soil structure, enrich soil composition and retards soil loss and erosion (Roba, 2000). As sholas are confined to uplands and play an important role in watershed protection, this aspect may also be taken in to account while formulating the strategy for its conservation

3.4.2.5 Collection of timber

Cutting of timber for house construction is another factor, which contributes degradation of forests. In the study area, there has been significant increase in the construction work. For instance, during the period from 1995 to 1999, about 47 houses were newly constructed (Table 15).

Table 15. Number of houses constructed during the period 1995 to 1999 in villages located near Mannavan shola.

Village	Year	
	1995-1997	1997-1999
Perumala	6	6
Kanthallur	10	15
Puthur	6	4
Kolachavayil	1	2
Total	23	27

Number of houses constructed were more in Kanthallur than in other villages. It was estimated that about 65-70 tonnes during the period 1995-1997 and about 80 to 85 tonnes of timber during the period 1997-99 was used for house construction. It was reported that most of the timber collected from nearby shola area was done illegally.

3.4.2.6 Shifting cultivation

Shifting cultivation has been one of the important types of cultivation practiced by tribes in Kerala in olden times. Now it is confined to certain localities. Till 1960's shifting cultivation had been widely practiced in the selected shola areas, but it declined slowly during 1970's and 1980's with the introduction of new cropping pattern by the migrant farmers. Since 1990, this system has been revived and practiced in about 21ha area in Goodallarkudi settlement, near Pullaradi shola. The crops such as Finger millet, Little millet etc. are cultivated.

The shifting cultivation consists of a set of general practices such as the clearing of forests with slash and burn techniques, no tillage or irrigation or use of fertilizers other than ashes deposited during burning, shifting of fields frequently and cultivation of traditional annual crops (Hardesty, 1977). The technology used in the shifting cultivation has been developed and perfected with trial and error methods by the tribal through generations and the techniques adopted in the cultivation are scientific and suitable for the traditional agricultural settings (Muraleedharan et.al., 1993). For instance, slash and burn technique is used not only to clear the land, but also to meet the nutritional requirements of the crops (Watters, 1960). Further, mixed

cropping is employed in shifting cultivation to maximize production and income and to meet the nutritional requirements of the farmers.

As no attempt was made to study the effect of shifting cultivation on ecosystem and degradation of shola, it is difficult to say anything conclusive on this issue here. However, It is widely known fact that, when a forest is converted to a cultivable land, not only its original vegetation destroyed, but the site is subject to continuing perturbations due to fire, weeding, hoeing, etc. (Ramakrishnan, 1993). Further, if the fallow is very short degradation set in and crop yield declines (Mishra and Ramakrishnan, 1981). The respondents indicated decline in the fallow period in shifting cultivation area near Pullaradi shola. During our survey it was also indicated that many people nearby shola might involve in the shifting cultivation in future, anticipating an additional income. Needless to say this will be a threat to the degraded shola.

3.4.2.7 Illegal cutting of timber and tree fern (*Cyathea*)

The survey indicated that illegal cutting of tree from Manthan shola, Mannavan shola and Pullaradi shola was not a rare phenomenon. Outsiders with the help of people living nearby the shola did this. Cutting of tree fern *Cyathea nilgiriensis* and *Cyathea crinita*, particularly from Mannavan shola, for the purpose of decoration during the festivals and marriages is also a regular activity. Among these two species *Cyathea nilgiriensis* is often cut as it found more in the low altitude area.

3.5 Aruvikkad Shola : A Contrast

Vegetation analysis carried out in the Aruvikkad shola (Plate 7) located near the residential areas of the estate workers of the Central Division of Tata Tea Estate indicated that this forest patch is not experiencing disturbance in recent days and recovering from the past damages occurred to its vegetation. Further analysis of socio-economic aspects of the local people indicated that none of the selected households were depending on shola for meeting any of their requirements. This is primarily because the Tea Estate managers do not allow the people to enter the shola for firewood collection. Houses of the workers were also constructed by Estate and consequently, workers do not want timber for house construction. Besides this, the

Tea Estate owns a large area of plantations of fuel wood species, aiming for tea processing. The Estate managers supply the workers with firewood annually at a concession rate (Plate 8). It was reported in the survey that each family has received $3m^3$ firewood (650 kg) during that year at a price of Rs. 120 per m^3. The quantity of firewood supplied and price per unit changes annually, according to the availability. All the households have smokeless choola, which helps to reduce the consumption of firewood. In addition, about 21 % of the households have the LPG gas for cooking. It was found in the survey that higher income group owns LPG gas. For instance, about 88 % of the selected households having LPG connection fall in the monthly income category of above Rs. 2000.

3.6 Dependency on shola

It is clear from the above discussion the people living nearby Mannavan shola and Pullaradi shola depended heavily on forest area for their livelihood. This is also true in the case of Manthan shola while contrary is the case in Aruvikkad shola. Income received from different sources that is one of the indicators of level of dependency, indicates this fact. Source-wise income distribution of the selected households in the Mannavan shola and Pullaradi shola which represent the forest still under disturbance and Aruvikkad shola which represents the forest under progressive succession due to absence disturbance in recent days is shown in the Figures 12 and 13. On an average in Mannavan shola and Pullaradi shola, lemon grass cultivation provided 50% of the income of the selected household, followed by agriculture including grazing (30%), shifting cultivation (5%) sale of firewood (5%), wage from forestry work (7%) and others (3%). On the other hand in the village located near Aruvikkad shola, 90 % of the income of the people is obtained from wage labour and rest from other sources business, agriculture and cattle rearing etc. This has implication on conservation of shola forest in Kerala. As far as shola is concerned, degradation and level of dependency are closely linked that is degradation increases with increase of dependency. Thus the crux and the success of future management and conservation strategy depend on how one reduces the dependency of people on shola.

Figure 12. Sources of income of people residing in villages near Mannavan Shola and Pullaradi Shola

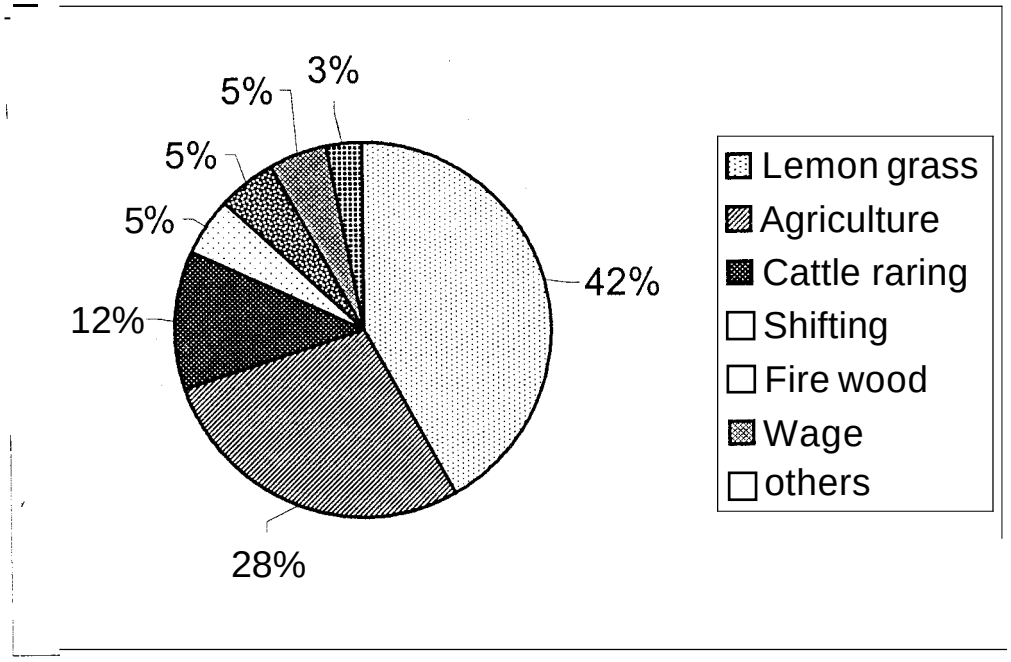
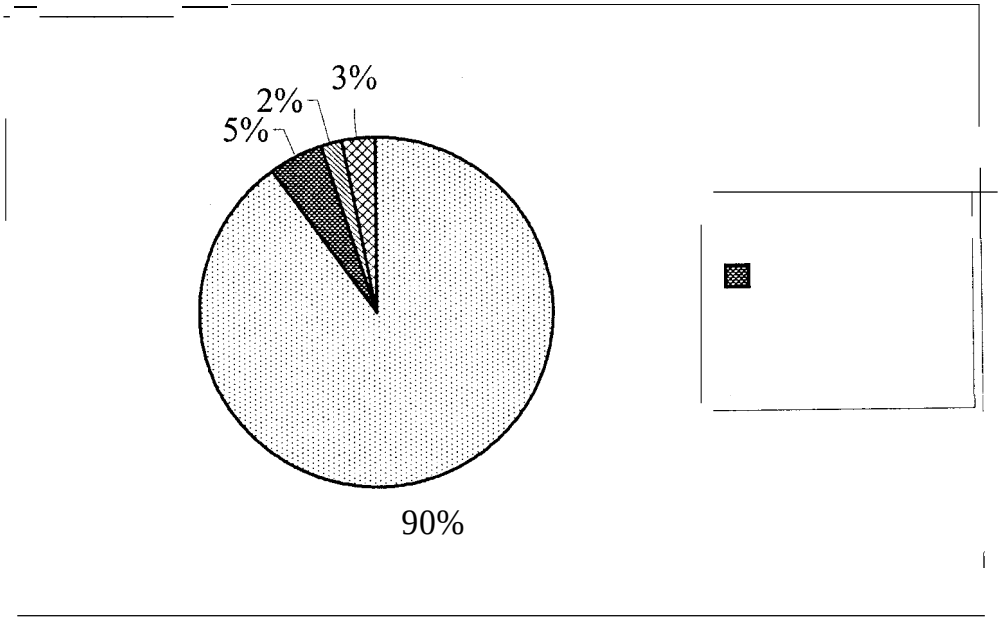


Figure 13. Sources of income of people residing near Aruvikkad Shola



4.0 Strategy for conservation of shola

Detailed studies on the vegetation structure and composition clearly indicated that all the four shola forests studied are either fully or partially disturbed. Analysis of level of disturbance and recovery process indicated that Mannavan Shola, Pullaradi Shola and Manthan Shola are disturbed much and no recovery process is operating. Socio-economic analysis has identified three major threats for the effective conservation of the sholas. These threats include firewood collection, grazing and revival of shifting cultivation. These factors may be taken into account, while formulating strategies for conservation and management of these shola forests.

4.1 Enrichment planting in disturbed parts of shola

As highlighted in the Section 3.1, due to continuous disturbance and invasion of exotic weeds, succession is either arrested or slowed down. In such a situation, attempts need to be made for enrichment planting and also assisting natural regeneration. Species that may be considered for enrichment planting in Mannavan Shola, Manthan Shola and Pullaradi Shola is given in Table 16. In case of Aruvikkad Shola, if present management system continued, enrichment planting is not required. However, here there is a scope for assisting natural regeneration mainly by weed management.

Table 16. Species suitable for enrichment planting in disturbed parts of Mannavan Shola, Pullaradi Shola and Manthan Shola

Acronychia pedunculata	*Elaeocarpus serratus*	*Neolitsea scrobiculata*
Actinodaphne bourdillonii	*Elaeocarpus munronii*	*Persea macrantha*
Alseodaphne semecarpifolia	*Elaeocarpus recurvatus*	*Rhododendron arboreum*
Beilschmiedia wightii	*Glochidion neilgherrense*	*Schefflera racemosa*
Canthium dicoccum	*Gomphandra coriacea*	*Symplocos cochinchinensis*
Chionanthus ramiflorus	*Hydnocarpus alpina*	*Syzygium cumini*
Cinnamomum sulphuratum	*Litsea floribunda*	*Syzygium*
Cinnamomum	*Litsea wightiana*	*Syzygium gardneri*
Cryptocarya bourdillonii	*Mastixia arborea*	*Turpinia nepalensis*
Cyathea nilgiriensis	*Meliosma pinnata*	*Vaccinium leschenaultii*
Daphniphyllum neilgherrense	*Microtropis ramiflora*	*Viburnum coriaceum*
	Neolitsea cassia	

4.2 Enhancement of firewood availability

In the villages located near shola forests, initially lemongrass cultivation was introduced mainly to supplement the income from agriculture, but later on it became a major source of income, In view of the low per capita income and very few avenues of income generation the idea of banning lemongrass cultivation may not be acceptable to the inhabitants. At the same time, the present study clearly demonstrated that firewood harvest and collection for lemongrass oil distillation is the major cause of forest disturbance. In this context several strategies are to be adopted to enhance the firewood base. Some of them are discussed below:

- Conversion of monocropping of lemongrass into an agroforestry system with the incorporation of tree components particularly, firewood species, may be an appropriate strategy to make the system an ecologically viable and sustainable one and this will also reduce the pressure on shola forests. Some of the species identified as appropriate to incorporate in lemongrass system are *Symplocos cochinchinensis, Syzygiuin cumini, Viburnum coriaceuni, Viburnum punctatum, Canthium dicoccuni, Eurya nitida* and *Maesa indica.*

- The study indicated that wattle plantation raised near Mannavan Shola by the Forest Department is the second largest source of firewood contributing 34.6% of total firewood collected in an year. Thus enhancement of growing stock and better management of the existing plantations with a view to provide firewood at a concession rate as done by Tata Tea Plantation to the local people near Aruvikkad Shola may be considered.

- Through PRA exercise it is learnt that villagers are ready to participate with the Forest Department and other government agencies if efforts are made to establish energy plantations in government lands near their villages and provide firewood at concession rate. Some of the species suggested by them for energy plantation include *Eucalyptus grandis, Eucalyptus globulus, Acacia dealbata, Acacia melanoxylon* and *Acacia decurrens.* It may be mentioned here that in Devikulam Forest Range, about

52 ha of mixed species fuelwood plantations were established with an intention to provide fuelwood to the local people. However, it is understood that in due course of time, local people are deprived of such a facility due to the fact that wood from these plantations have earmarked for supply to the Hindustan News Print Limited. In view of the greater damage occurring in the shola forest due to firewood collection by the local people it may be appropriate to revive the earlier system of firewood supply by raising firewood plantations near all shola forests, which are being disturbed.

4.3 Reduction of grazing pressure

Grazing is another important threat to the conservation of shola. This can be minimized by encouraging stall-feeding and making the community aware of the serious consequences of the grazing. Attempts may be made to develop silvopastoral systems with components such as fodder plants and firewood trees outside the shola areas. Grazing may be restricted to these areas. Fodder plants suitable to these area include *Desmodium intortum, Desmodium uncinatum, Trifolium repens, Dactyles glomerata* (Cock's foot grass), *Setaria anceps* (Setaria grass), *Lolium perreni* (Italian rye grass) and *Dactyles* sp. (English rye grass).

4.4 Prevention of encroachment

In many occasions, the farmers will burn more area than that can be utilised for shifting cultivation. Such an activity coupled with increase in area under shifting cultivation would lead to the forest degradation. Added to this, if the fallow period become short the crop productivity would decline slowly and consequently cultivation would be less remunerative. In this context, people may convert this land for lemongrass cultivation, which ultimately affect the conservation of shola. Recent field visits to Shola revealed the fact that encroachment to shola forest for cultivation is becoming more frequent and intensive (Plate 6). Forest encroachment and enhancement of shifting cultivation need to be strictly prohibited.

5.0 Recommendations

Many of the above mentioned strategies may be implemented through eco-development programmes aiming at overall development of the shola as well as people living nearby. These programmes may undertake plantation of firewood species, supply of inputs, increased facilities for marketing their produces, increasing availability of fodder plants and additional employment generation activities. As part of these programmes, campaigns for creating awareness for conservation and sustainable management of shola and nearby ecosystems may be undertaken. Inhabitants, especially tribes, may be employed to a greater extent in forestry related works so that pressure on shola may be reduced.

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Appendix 1. Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Mannavan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Mature trees				
Abarema subcoriacea	0 (4)	0 (4)	0 (1270.1)	0 (2.88)
Acacia dealbata	0(4)	0(4)	0(1152)	0(2.83)
Acronychia pedunculata	12(0)	9(0)	1119.8(0)	5.7(0)
Actinodaphne bourdillonii	15(0)	12(0)	390.13(0)	9.72(0)
Aglaia elaeagnoidea	2(0)	2(0)	3874.28(0)	1.25(0)
Alseodaphne semecarpifolia	7(8)	7(8)	683.68(7956.8)	5.31(8.3)
Beilschmiedia wightii	42 (0)	32 (0)	216.61 (0)	22.56 (0)
Bhesa indica	7 (0)	7 (0)	1569.33 (0)	3.93 (0)
Canthium dicoccum	2 (0)	2 (0)	3786.53 (0)	1.26 (0)
Catunaregam spinosa	2 (0)	2 (0)	3031.31 (0)	1.37 (0)
Celtis philippensis	2 (0)	2 (0)	18267.77 (0)	0.91 (0)
Chionanthus ramiflorus	41 (0)	32 (0)	161.64 (0)	25.01 (0)
Cinnamomum perrottetii	1 (0)	1 (0)	6943.97 (0)	0.65 (0)
Cinnamomum sulphuratum	10 (0)	10 (0)	610.69 (0)	6.83 (0)
Cinnamomum travancoricum	1 (0)	1 (0)	54352.69 (0)	0.44 (0)
Cinnamomum wightii	1 (4)	1 (4)	27515.7 (1613)	0.47 (3.04)
Clerodendrum viscosum	1 (0)	1 (0)	80535.72 (0)	0.43 (0)
Cryptocarya bourdillonii	1 (0)	1 (0)	5054.5 (0)	0.74 (0)
Cryptocarya lawsonii	16 (0)	14 (0)	614.33 (0)	8.8 (0)
Cyathea nilgiriensis	8 (0)	4 (0)	8593.16 (0)	2.53 (0)
Daphniphyllum neilgherrense	0 (92)	0 (48)	0 (22628.8)	0 (47.55)
Elaeocarpus serratus	1 (0)	1 (0)	1491.69 (0)	1.53 (0)
Erythrina indica	0 (4)	0 (4)	0 (414.72)	0 (2.48)
Eugenia calcadensis	1 (0)	1 (0)	32936.6 (0)	0.46 (0)
Eurya nitida	2 (0)	2 (0)	8296.16 (0)	1.02 (0)
Glochidion neilgherrense	5 (32)	5 (24)	5690.5 (12926)	2.34 (21.51)
Gomphandra coriacea	67 (0)	48 (0)	502.26 (0)	26.29 (0)
Hydnocarpus alpina	121 (0)	70 (0)	86.41 (0)	56.9 (0)
Isonandra stocksii	67 (0)	47 (0)	96.84 (0)	39.99 (0)
Litsea floribunda	1 (0)	1 (0)	54352.69 (0)	0.44 (0)
Litsea ligustrina	1 (0)	1 (0)	5954.65 (0)	0.69 (0)
Litsea wightiana	0 (8)	0 (8)	0 (2743.36)	0 (5.86)
Mallotus ferrugineus	1 (0)	1 (0)	6411.37 (0)	0.67 (0)

….Cont'd….

Appendix 1 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Mannavan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Mature trees (Cont'd)				
Mastixia arborea	60 (0)	41 (0)	609.42 (0)	22.84 (0)
Meliosma pinnata	0 (4)	0 (4)	0 (2888)	0 (3.64)
Meliosma simplicifolia	0 (24)	0 (20)	0 (12381.44)	0 (18.1)
Neolitsea scrobiculata	1 (0)	1 (0)	12785.53 (0)	0.54 (0)
Persea macrantha	10 (16)	10 (12)	414 (36984.96)	8.13 (25.03)
Phoebe lanceolata	3 (0)	3 (0)	1964.38 (0)	0.91 (0)
Photinia integrifolia	2 (0)	2 (0)	14991.55 (0)	0.93 (0)
Prunus ceylanica	1 (0)	1 (0)	12785.53 (0)	0.54 (0)
Rhododendron arboreum	0 (8)	0 (8)	0 (1851.2)	0 (5.45)
Saprosma foetens	16 (0)	14 (0)	1987 (0)	6.92 (0)
Schefflera racemosa	1 (4)	1 (4)	41017.5 (898.9)	0.45 (2.71)
Symplocos cochinchinensis	0 (188)	0 (72)	0 (81216.32)	0 (104.21)
Syzygium cumini	1 (20)	1 (20)	15094 (7684.8)	0.52 (15.05)
Syzygium densiflorum	10 (4)	10 (4)	233.9 (3461.12)	11.24 (3.91)
Syzygium gardneri	3 (0)	3 (0)	1961.59 (0)	2.08 (0)
Ternstroemia japonica	7 (0)	7 (0)	541.86 (0)	5.95 (0)
Turpinia nepalensis	6 (8)	3 (4)	1455.76 (2536)	2.9 (4.34)
Unidentified-01	4 (0)	4 (0)	2447.64 (0)	2.32 (0)
Unidentified-02	3 (0)	3 (0)	2033.16 (0)	2.05 (0)
Unidentified-03	1 (0)	1 (0)	80535.72 (0)	0.43 (0)
Vaccinium leschenaultii	0 (4)	0 (4)	0 (1152)	0 (2.83)
Viburnum coriaceum	0 (12)	0 (12)	0 (3629.44)	0 (8.57)
Viburnum punctatum	0 (16)	0 (12)	0 (8478.08)	0 (11.7)
Saplings				
Acronychia pedunculata	2 (3)	2 (3)	92.16 (60.24)	1.76 (3.82)
Actinodaphne bourdillonii	44 (0)	28 (0)	957.88 (0)	25.4 (0)
Aglaia elaeagnoidea	2 (0)	2 (0)	18.32 (0)	1.18 (0)
Alseodaphne semecarpifolia	0 (6)	0 (6)	0 (140.24)	0 (7.93)
Beilschmiedia wightii	6 (0)	4 (0)	180.88 (0)	3.91 (0)
Canthium dicoccum	0 (3)	0 (3)	0 (52.94)	0 (3.72)
Chionanthus ramiflorus	50 (0)	30 (0)	1042.42 (0)	27.94 (0)

….Cont'd….

Appendix 1 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Mannavan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Saplings (Cont'd)				
Cinnamomum wightii	0 (3)	0 (3)	0 (68)	0 (3.93)
Cinnamomum perrottetii	2 (0)	2 (0)	108.16 (0)	1.88 (0)
Cinnamomum sulphuratum	12 (0)	8 (0)	466.56 (0)	8.64 (0)
Cryptocarya bourdillonii	4 (0)	4 (0)	40.2 (0)	2.4 (0)
Cryptocarya lawsonii	14 (0)	12 (0)	360.38 (0)	9.48 (0)
Cyathea crinita	6 (0)	4 (0)	396.16 (0)	5.59 (0)
Daphniphyllum neilgherrense	0 (47)	0 (32)	0 (1363.29)	0 (58.51)
Debregeasia longifolia	0 (3)	0 (3)	0 (113.88)	0 (4.59)
Elaeocarpus recurvatus	0 (3)	0 (3)	0 (52.94)	0 (3.72)
Elaeocarpus tuberculatus	2 (0)	2 (0)	17.98 (0)	1.18 (0)
Eugenia calcadensis.	2 (0)	2 (0)	19.36 (0)	1.19 (0)
Eurya nitida	4 (0)	4 (0)	50.86 (0)	2.48 (0)
Glochidion neilgherrense	4 (3)	4 (3)	123.76 (113.88)	3.05 (4.59)
Gomphandra coriacea	4 (0)	4 (0)	242.32 (0)	3.97 (0)
Gomphandra sp.	8 (0)	6 (0)	242.04 (0)	5.43 (0)
Hydnocarpus alpina	42 (0)	32 (0)	1275.28 (0)	28.7 (0)
Ilex denticulata	4 (0)	4 (0)	265.9 (0)	4.15 (0)
Isonandra stocksii	6 (0)	6 (0)	176.12 (0)	4.5 (0)
Litsea beddomei	8 (0)	4 (0)	75.44 (0)	3.51 (0)
Litsea floribunda	2 (0)	2 (0)	173.18 (0)	2.39 (0)
Litsea insignis	2 (0)	2 (0)	2.82 (0)	1.06 (0)
Litsea wightiana	0 (12)	0 (12)	0 (242.35)	0 (15.31)
Mastixia arborea	148 (0)	64 (0)	3495.04 (0)	78.19 (0)
Maesa indica	0 (47)	0 (26)	0 (1636.71)	0 (59.06)
Meliosma pinnata	0 (3)	0 (3)	0 (76.24)	0 (4.05)
Meliosma simplicifolia	0 (3)	0 (3)	0 (124.47)	0 (4.74)
Microtropis ramiflora	10 (0)	8 (0)	339.6 (0)	7.23 (0)
Neolitsea cassia	4 (0)	4 (0)	62.12 (0)	2.57 (0)
Pavetta indica	8 (0)	8 (0)	88.56 (0)	4.86 (0)

….Cont'd….

Appendix 1 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Mannavan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Saplings (Cont'd)				
Persea macrantha	2 (9)	2 (6)	25 (284.24)	1.24 (11.27)
Phoebe lanceolata	16 (0)	16 (0)	702.96 (0)	13.81 (0)
Photinia serratifolia	8 (0)	4 (0)	77.76 (0)	3.53 (0)
Polygala arillata	2 (0)	2 (0)	84 (0)	1.7 (0)
Prunus ceylanica	2 (0)	2 (0)	23.04 (0)	1.22 (0)
Psychotria sp.	2 (0)	2 (0)	66.58 (0)	1.56 (0)
Rapanea wightiana	0 (3)	0 (3)	0 (135.53)	0 (4.89)
Rauvolfia densiflora	2 (0)	2 (0)	27.04 (0)	1.25 (0)
Rhododendron arboreum	0 (3)	0 (3)	0 (147.06)	0 (5.06)
Saprosma foetens	22 (0)	22 (0)	941.62 (0)	18.79 (0)
Schefflera racemosa	2 (3)	2 (3)	129.96 (94.12)	2.05 (4.3)
Symplocos cochinchinensis	0 (47)	0 (38)	0 (1492)	0 (63.67)
Symplocos pendula	2 (0)	2 (0)	17.64 (0)	1.18 (0)
Syzygium caryophyllatum	0 (9)	0 (9)	0 (367.06)	0 (14.12)
Syzygium cumini	0 (3)	0 (3)	0 (33.88)	0 (3.45)
Syzygium densiflorum	2 (3)	2 (3)	77.44 (94.12)	1.64 (4.3)
Syzygium tamilnadensis	8 (0)	6 (0)	90.76 (0)	4.25 (0)
Turpinia nepalensis	4 (0)	4 (0)	125.22 (0)	3.06 (0)
Vaccinium leschenaultii	2 (6)	2 (6)	134.56 (244)	2.09 (9.4)
Viburnum coriaceum	0 (6)	0 (3)	0 (92.71)	0 (5.58)
Seedlings				
Abarema subcoriacea	0 (185)	0 (2)	0 (370.37)	0 (0.84)
Acacia dealbata	0 (8889)	0 (26)	0 (17777.8)	0 (24.82)
Acronychia pedunculata	114 (0)	21 (0)	228 (0)	3.95 (0)
Actinodaphne bourdillonii	771 (0)	64 (0)	1542 (0)	18.85 (0)
Aglaia apiocarpa	200 (185)	14 (2)	576 (370.37)	5.37 (0.84)
Alseodaphne semecarpifolia	257 (741)	36 (6)	740.2 (1481.48)	8.6 (2.91)
Beilschmiedia wightii	2400 (0)	100 (0)	4800 (0)	48.87 (0)
Bhesa indica	229 (0)	21 (0)	164.88 (0)	4.64 (0)

….Cont'd….

Appendix 1 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Mannavan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Seedlings (Cont'd)				
Canthium dicoccum	0 (185)	0 (2)	0 (370.37)	0 (0.84)
Celtis tetrandra	0 (1481)	0 (11)	0 (2962.96)	0 (5.81)
Chionanthus linocieroides	0 (741)	0 (6)	0 (1481.48)	0 (2.91)
Chionanthus ramiflorus	2457 (0)	86 (0)	4914 (0)	48.4 (0)
Cinnamomum riparium	114 (0)	29 (0)	228 (0)	4.65 (0)
Cinnamomum wightii	0 (185)	0 (2)	0 (370.37)	0 (0.84)
Daphniphyllum neilgherrense	0 (15000)	0 (61)	0 (30000)	0 (46.16)
Clerodendrum viscosum	286 (185)	7 (2)	823.68 (370.37)	6.38 (0.84)
Elaeocarpus recurvatus	29 (0)	7 (0)	58 (0)	1.18 (0)
Elaeocarpus serratus	0 (741)	0 (6)	0 (1481.48)	0 (2.91)
Eurya nitida	29 (0)	7 (0)	58 (0)	1.18 (0)
Glochidion neilgherrense	0 (2222)	0 (20)	0 (4444.44)	0 (9.63)
Glochidion sp.	200 (0)	35 (0)	256 (0)	6.12 (0)
Gomphandra coriacea	57 (1481)	14 (9)	114 (2962.96)	2.33 (5.35)
Hydnocarpus alpina	1257 (185)	86 (2)	2514 (370.37)	28.87 (0.84)
Ilex wightiana	29 (0)	7 (0)	20.88 (0)	1.02 (0)
Isonandra stocksii	200 (0)	36 (0)	400 (0)	6.76 (0)
Ligustrum perrottetii	0 (741)	0 (4)	0 (1481.48)	0 (2.45)
Litsea ligustrina	29 (0)	7 (0)	58 (0)	1.18 (0)
Litsea oleoides	29 (0)	7 (0)	58 (0)	1.18 (0)
Litsea wightiana	29 (3333)	7 (19)	58 (6666.67)	1.18 (11.48)
Maesa indica	0 (6296)	0 (31)	0 (12592.6)	0 (20.81)
Mallotus ferrugineus	0 (185)	0 (2)	0 (370.37)	0 (0.84)
Mastixia arborea	800 (185)	36 (2)	2304 (370.37)	19.38 (0.84)
Meliosma simplicifolia	0 (370)	0 (4)	0 (740.74)	0 (1.68)
Murraya paniculata	57 (0)	14 (0)	41.04 (0)	2.04 (0)
Neolitsea cassia	486 (3148)	43 (22)	972 (6296.3)	12.1 (12.01)
Neolitsea scrobiculata	114 (0)	21 (0)	228 (0)	3.95 (0)
Olea dioica	29 (0)	7 (0)	20.88 (0)	1.02 (0)

….Cont'd….

Appendix 1 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Mannavan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Seedlings (Cont'd)				
Persea macrantha	600 (741)	79 (7)	432 (1481.48)	14.36 (3.36)
Phoebe lanceolata	257 (0)	29 (0)	514 (0)	6.98 (0)
Photinia integrifolia	0 (185)	0 (2)	0 (370.37)	0 (0.84)
Rapanea wightiana	29 (556)	7 (6)	37.12 (1111.11)	1.09 (2.52)
Saprosma foetens	200 (0)	43 (0)	576 (0)	8.17 (0)
Saprosma sp.	0 (185)	0 (2)	0 (370.37)	0 (0.84)
Schefflera racemosa	0 (556)	0 (4)	0 (1111.11)	0 (2.06)
Symplocos cochinchinensis	29 (37593)	7 (74)	83.52 (75185.2)	1.28 (96.19)
Symplocos macrophylla	371 (0)	43 (0)	742 (0)	10.24 (0)
Syzygium caryophyllatum	0 (1111)	0 (11)	0 (2222.22)	0 (5.04)
Syzygium densiflorum	229 (4444)	43 (30)	458 (8888.89)	7.93 (16.52)
Syzygium gardneri	0 (370)	0 (4)	0 (740.74)	0 (1.68)
Syzygium rubicundam	257 (0)	43 (0)	514 (0)	8.38 (0)
Syzygium tamilnadensis	0 (370)	0 (2)	0 (740.74)	0 (1.22)
Turpinia nepalensis	29 (0)	7 (0)	58 (0)	1.18 (0)
Turpinia cochinchinensis	0 (926)	0 (7)	0 (1851.85)	0 (3.75)
Unidentified-04	29 (0)	7 (0)	83.52 (0)	1.28 (0)
Unidentified-05	0 (370)	0 (4)	0 (740.74)	0 (1.68)
Vaccinium leschenaultii	0 (185)	0 (2)	0 (370.37)	0 (0.84)
Viburnum coriaceum	0 (2222)	0 (13)	0 (4444.44)	0 (7.8)
Shrubs and herbs				
Ageratina adenophora	385 (20741)	4 (56)	492.3 (26548.2)	0.9 (68.53)
Anoectochilus elatus	1154 (0)	12 (0)	207.69 (0)	2.24 (0)
Ardisia rhomboidea	11923 (0)	62 (0)	46738.5 (0)	31.23 (0)
Arisaema leschenaultii	769 (556)	4 (6)	1538.5 (1111.1)	1.46 (3.41)
Asparagus racemosus	0 (185)	0 (2)	0 (59.26)	0 (0.71)
Barleria involucrata	0 (370)	0 (4)	0 (266.67)	0 (1.63)
Bulbostylis densa	4231 (0)	12 (0)	761.54 (0)	3.84 (0)
Calanthe masuca	4615 (0)	23 (0)	1476.92 (0)	5.92 (0)

….Cont'd….

Appendix 1 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Mannavan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Shrubs and herbs (Cont'd)				
Carex sp.	6923 (5185)	38 (24)	553.85 (414.81)	8.82 (11.22)
Cocculus laurifolius	0 (185)	0 (2)	0 (533.33)	0 (1.36)
Coffea sp.	0 (185)	0 (2)	0 (370.37)	0 (1.14)
Coleus malabaricus	5769 (556)	19 (2)	1846.2 (177. 8)	6.03 (1.2)
Diplocyclos palmatus	2308 (0)	23 (0)	184.62 (0)	4.41 (0)
Dumasia villosa	385 (0)	4 (0)	30.77 (0)	0.73 (0)
Elatostema lineolatum	9615 (0)	15 (0)	1730.77 (0)	7.17 (0)
Eragrostis sp.	0 (1111)	0 (6)	0 (88.89)	0 (2.5)
Erigeron karvinskianus	0 (370)	0 (2)	0 (118.52)	0 (0.96)
Hydrocotyle javanica	2308 (7963)	8 (28)	184.62 (637)	2.21 (14.9)
Jasminum roxburghianum	0 (556)	0 (4)	0 (177.78)	0 (1.67)
Laportea bulbifera	2308 (0)	8 (0)	738.46 (0)	2.41 (0)
Lasianthus accuminatus	36923 (3519)	85 (15)	144738 (10133)	81.58 (20.7)
Leptochilus decurrens	25000 (0)	73 (0)	4500 (0)	23.37 (0)
Nephrolepis auriculata	1154 (0)	8 (0)	369.23 (0)	1.75 (0)
Oplismenus sp.	16538 (31667)	38 (57)	1323.1 (2533.3)	13.4 (45.77)
Passiflora leschenaultii	0 (185)	0 (2)	0 (59.26)	0 (0.71)
Pavetta breviflora	0 (556)	0 (4)	0 (1111.11)	0 (2.94)
Piper sp.	9231 (185)	50 (2)	2953.85 (59.26)	12.39 (0.71)
Polygonum chinense	0 (370)	0 (4)	0 (118.52)	0 (1.43)
Pteridium aquilinum	0 (1111)	0 (6)	0 (355.56)	0 (2.87)
Pteris quadriaurita	7692 (2407)	42 (9)	2461.5 (770.37)	10.41 (5.51)
Rubus ellipticus	385 (2963)	4 (22)	492.3 (3792.59)	0.9 (13.41)
Sarcococca coriacea	0 (556)	0 (4)	0 (1111.11)	0 (2.94)
Selaginella sp.	10769 (0)	15 (0)	1938.46 (0)	7.77 (0)
Shutteria vestita	385 (0)	4 (0)	123.08 (0)	0.77 (0)
Sida rhombifolia	0 (556)	0 (2)	0 (400)	0 (1.5)
Solanum anguivi	0 (370)	0 (4)	0 (474.07)	0 (1.91)
Solena amplexicaulis	0 (1852)	0 (17)	0 (592.59)	0 (6.66)

….Cont'd….

Appendix 1 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Mannavan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Shrubs and herbs (Cont'd)				
Strobilanthes asperrimus	3462 (5556)	23 (22)	4430.77 (7111)	6.48 (20.22)
Strobilanthes homotropa	39231 (1111)	54 (4)	50215.4 (3200)	43.73 (6.28)
Strobilanthes kunthianus	0 (185)	0 (2)	0 (133.33)	0 (0.81)
Strobilanthes sp.	0 (1296)	0 (7)	0 (1659.26)	0 (5.28)
Toddalia asiatica	1923 (2222)	15 (17)	2461.5 (4444.4)	3.96 (12.24)
Unknown-1	385 (0)	4 (0)	30.77 (0)	0.73 (0)
Unknown-2	13462 (0)	42 (0)	1076.92 (0)	12.51 (0)
Urena lobata	0 (370)	0 (2)	0 (740.74)	0 (1.81)
Vernonia bourneana	0 (3148)	0 (9)	0 (1007.41)	0 (6.48)
Vigna radiata	1538 (0)	8 (0)	276.92 (0)	1.89 (0)
Vigna trilobata	0 (15741)	0 (48)	0 (2833.33)	0 (29.88)
Wattakaka volubilis	0 (185)	0 (2)	0 (59.26)	0 (0.71)
Zehneria maysorensis	769 (0)	4 (0)	138.46 (0)	0.95 (0)

Appendix 2. Girth class distribution of trees in the Undisturbed and disturbed (in parentheses) areas of the Mannavan shola.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Abarema subcoriacea	0 (185)	0 (0)	0 (0)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)
Acacia dealbata	0 (8889)	0 (0)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Acronychia pedunculata	114 (0)	2 (3)	6 (0)	5 (0)	2 (0)	0 (0)	0 (0)	0 (0)
Actinodaphne bourdillonii	771 (0)	44 (0)	4 (0)	1 (0)	3 (0)	3 (0)	1 (0)	3 (0)
Aglaia apiocarpa	200 (185)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Aglaia elaeagnoidea	0 (0)	2 (0)	1 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)
Alseodaphne semecarpifolia	257 (741)	0 (6)	2 (0)	0 (0)	2 (8)	3 (0)	1 (0)	0 (0)
Beilschmiedia wightii	2400 (0)	6 (0)	9 (0)	11 (0)	10 (0)	9 (0)	3 (0)	0 (0)
Bhesa indica	229 (0)	0 (0)	0 (0)	3 (0)	3 (0)	1 (0)	0 (0)	0 (0)
Canthium dicoccum	0 (185)	0 (3)	0 (0)	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)
Catunaregam spinosa	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	1 (0)	0 (0)	0 (0)
Celtis philippensis	0 (0)	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Celtis tetrandra	0 (1481)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Chionanthus linocieroides	0 (741)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Chionanthus ramiflorus	2457 (0)	50 (0)	9 (0)	9 (0)	6 (0)	7 (0)	5 (0)	4 (0)
Cinnamomum wightii	0 (185)	0 (3)	1 (0)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)
Cinnamomum travancoricum	0 (0)	0 (0)	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)

….Cont'd….

Appendix 2 (Cont'd). Girth class distribution of trees in the Undisturbed and disturbed (in parentheses) areas of the Mannavan shola.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Cinnamomum perrottetii	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cinnamomum riparium	114 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cinnamomum sulphuratum	0 (0)	12 (0)	1 (0)	3 (0)	1 (0)	2 (0)	2 (0)	1 (0)
Clerodendrum viscosum	286 (185)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cryptocarya lawsonii	0 (0)	14 (0)	4 (0)	5 (0)	2 (0)	5 (0)	0 (0)	0 (0)
Cryptocarya bourdillonii	0 (0)	4 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)
Cyathea crinita	0 (0)	6 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cyathea nilgiriensis	0 (0)	0 (0)	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Daphniphyllum neilgherrense	0 (15000)	0 (47)	0 (68)	0 (20)	0 (4)	0 (0)	0 (0)	0 (0)
Debregeasia longifolia	0 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Elaeocarpus recurvatus	29 (0)	0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Elaeocarpus serratus	0 (741)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)
Elaeocarpus tuberculatus	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Erythrina indica	0 (0)	0 (0)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Eugenia sp.	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)
Eurya nitida	29 (0)	4 (0)	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
Glochidion neilgherrense	0 (2222)	4 (3)	3 (16)	2 (12)	0 (4)	0 (0)	0 (0)	0 (0)

….Cont'd….

Appendix 2 (Cont'd). Girth class distribution of trees in the Undisturbed and disturbed (in parentheses) areas of the Mannavan shola.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Glochidion sp.	200 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gomphandra coriacea	57 (1481)	4 (0)	48 (0)	18 (0)	1 (0)	0 (0)	0 (0)	0 (0)
Gomphandra sp.	0 (0)	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Hydnocarpus alpina	1257 (185)	42 (0)	35 (0)	34 (0)	28 (0)	14 (0)	7 (0)	2 (0)
Ilex denticulata	0 (0)	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ilex wightiana	29 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Isonandra stocksii	200 (0)	6 (0)	8 (0)	19 (0)	12 (0)	16 (0)	6 (0)	6 (0)
Ligustrum perrottetii	0 (741)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Litsea floribunda	0 (0)	2 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Litsea ligustrina	29 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)
Litsea beddomei	0 (0)	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Litsea insignis	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Litsea oleoides	29 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Litsea wightiana	29 (3333)	0 (12)	0 (4)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)
Maesa indica	0 (6296)	0 (47)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mallotus ferrugineus	0 (185)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)
Mastixia arborea	800 (185)	148 (0)	49 (0)	6 (0)	3 (0)	1 (0)	1 (0)	0 (0)

….Cont'd….

Appendix 2 (Cont'd). Girth class distribution of trees in the Undisturbed and disturbed (in parentheses) areas of the Mannavan shola.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Meliosma pinnata	0	0	0	0	0	0	0	0
	(0)	(3)	(0)	(0)	(4)	(0)	(0)	(0)
Meliosma simplicifolia	0	0	0	0	0	0	0	0
	(370)	(3)	(12)	(4)	(4)	(4)	(0)	(0)
Microtropis ramiflora	0	10	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Murraya paniculata	57	0	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Neolitsea scrobiculata	114	0	0	1	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Neolitsea cassia	486	4	0	0	0	0	0	0
	(3148)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Olea dioica	29	0	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Pavetta indica	0	8	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Persea macrantha	600	2	0	1	0	4	3	2
	(741)	(9)	(8)	(4)	(0)	(0)	(0)	(4)
Phoebe lanceolata	257	16	3	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Photinia integrifolia	0	0	1	1	0	0	0	0
	(185)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Photinia serratifolia	0	8	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Polygala arillata	0	2	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Prunus ceylanica	0	2	0	1	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Psychotria sp.	0	2	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Rapanea wightiana	29	0	0	0	0	0	0	0
	(556)	(3)	(0)	(0)	(0)	(0)	(0)	(0)
Rauvolfia densiflora	0	2	0	0	0	0	0	0
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)

….Cont'd….

Appendix 2 (Cont'd). Girth class distribution of trees in the Undisturbed and disturbed (in parentheses) areas of the Mannavan shola.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Rhododendron arboreum	0 (0)	0 (3)	0 (4)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)
Saprosma foetens	200 (0)	22 (0)	11 (0)	5 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Saprosma sp.	0 (185)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Schefflera racemosa	0 (556)	2 (3)	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Symplocos cochinchinensis	29 (37593)	0 (47)	0 (116)	0 (52)	0 (4)	0 (12)	0 (0)	0 (4)
Symplocos pendula	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Symplocos macrophylla	371 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Syzygium caryophyllatum	0 (1111)	0 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Syzygium cumini	0 (0)	0 (3)	0 (4)	1 (16)	0 (0)	0 (0)	0 (0)	0 (0)
Syzygium densiflorum	229 (4444)	2 (3)	0 (0)	1 (0)	1 (4)	0 (0)	2 (0)	6 (0)
Syzygium gardneri	0 (370)	0 (0)	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)
Syzygium rubicundam	257 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Syzygium tamilnadensis	0 (370)	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ternstroemia japonica	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0)	3 (0)	1 (0)
Turpinia cochinchinensis	0 (926)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Turpinia nepalensis	29 (0)	4 (0)	5 (4)	0 (4)	1 (0)	0 (0)	0 (0)	0 (0)
Unidentified-01	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)

….Cont'd….

Appendix 2 (Cont'd). Girth class distribution of trees in the Undisturbed and disturbed (in parentheses) areas of the Mannavan shola.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Unidentified-02	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	1 (0)	0 (0)	1 (0)
Unidentified-03	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unidentified-04	29 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unidentified-05	0 (370)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Vaccinium leschenaultii	0 (185)	2 (6)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Viburnum coriaceum	0 (2222)	0 (6)	0 (8)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)
Viburnum sp.	0 (0)	0 (0)	0 (4)	0 (8)	0 (4)	0 (0)	0 (0)	0 (0)
Total	97229 (96482)	692 (226)	464 (264)	256 (140)	113 (36)	75 (16)	34 (0)	37 (8)

* Size classes: A-Seedlings (girth <10.0 cm, height <1 m), B-Saplings (gbh 10.1 to30.0 cm) and C to H- Mature trees, gbh 30.1-60.0, 60.1-90.0, 90.1-120.0, 120.1-150.0, 150.1-180.0 and >180.1 cm respectively.

Appendix 3. Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Pullaradi shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Mature trees				
Actinodaphne bourdillonii	15 (6)	15 (6)	8430.8 (12013)	6.19 (5.17)
Aglaia apiocarpa	8 (0)	8 (0)	4615 (0)	3.16 (0)
Alseodaphne semecarpifolia	40 (25)	25 (19)	22172 (24272.5)	13.6 (14.9)
Antidesma menasu	8 (6)	8 (6)	19057.8 (5000)	5.26 (3.95)
Beilschmiedia wightii	28 (37)	28 (25)	40473.4 (77137)	15 (28.6)
Canthium dicoccum	20 (13)	15 (13)	6628.6 (28250)	6.62 (11.1)
Celtis sp.	3 (0)	3 (0)	2163.2 (0)	1.14 (0)
Celtis tetrandra	20 (13)	13 (13)	17169 (10512)	7.67 (7.99)
Chionanthus linocieroides	3 (6)	3 (6)	8820 (3528)	2.11 (3.69)
Cinnamomum perrottetii	13 (0)	13 (0)	12758.8 (0)	6 (0)
Cinnamomum sulphuratum	3 (0)	3 (0)	6480 (0)	1.77 (0)
Cinnamomum wightii	0 (25)	0 (25)	0 (54682.5)	0 (21.86)
Clerodendrum viscosum	3 (0)	3 (0)	3537.8 (0)	1.34 (0)
Daphniphyllum neilgherrense	3 (13)	3 (6)	1620 (3098)	1.06 (5.02)
Elaeocarpus recurvatus	3 (0)	3 (0)	4500 (0)	1.48 (0)
Elaeocarpus serratus	5 (0)	5 (0)	3206.6 (0)	2.12 (0)
Elaeocarpus tuberculatus	0 (13)	0 (13)	0 (43304.5)	0 (13.72)
Eurya nitida	3 (0)	3 (0)	387.2 (0)	0.88 (0)
Glochidion neilgherrense	8 (6)	5 (6)	2997 (5512.5)	2.43 (4.04)
Gomphandra coriacea	128 (44)	65 (38)	59276 (34588.5)	38.7 (25.9)
Hydnocarpus alpina	5 (0)	3 (0)	11274.4 (0)	2.81 (0)
Ilex denticulata	3 (0)	3 (0)	33620 (0)	5.72 (0)
Ilex sp.	20 (0)	18 (0)	17870.4 (0)	8.74 (0)
Isonandra candolleana	20 (0)	13 (0)	4443 (0)	5.81 (0)
Litsea wightiana	20 (6)	10 (6)	3020.2 (1568)	5.12 (3.35)
Mastixia arborea	55 (13)	33 (13)	48352 (19272.5)	20.88 (9.5)
Meliosma pinnata	8 (0)	5 (0)	7558.6 (0)	3.1 (0)
Meliosma simplicifolia	13 (50)	5 (44)	2391 (21273.5)	3 (26.65)

….Cont'd….

Appendix 3 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Pullaradi shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Mature trees (Cont'd)				
Microtropis ramiflora	8 (0)	5 (0)	3328.2 (0)	2.48 (0)
Neolitsea cassia	30 (50)	25 (44)	22800 (57212)	12.3 (32.9)
Neolitsea fischeri	10 (0)	8 (0)	1970 (0)	3.11 (0)
Pavetta breviflora	3 (0)	3 (0)	10580 (0)	2.37 (0)
Persea macrantha	50 (37)	30 (19)	87983.4 (49132)	25.5 (22.04)
Rapanea wightiana	8 (6)	8 (6)	1389.6 (450)	2.69 (3.15)
Schefflera racemosa	3 (25)	3 (25)	924.8 (25922.5)	0.96 (16.83)
Symplocos cochinchinensis	8 (0)	5 (0)	2848.8 (0)	2.41 (0)
Syzygium cumini	28 (19)	18 (13)	54891 (85037.5)	15.16 (22.4)
Syzygium densiflorum	0 (6)	0 (6)	0 (3612.5)	0 (3.71)
Syzygium gardneri	23 (6)	20 (6)	55790 (648)	15.09 (3.19)
Turpinia cochinchinensis	53 (0)	40 (0)	23732.6 (0)	18.41 (0)
Unknown-1	35 (13)	30 (13)	56598.2 (5730.5)	18.86 (7.15)
Unknown-3	8 (0)	8 (0)	653.8 (0)	2.58 (0)
Vaccinium leschenaultii	18 (6)	13 (6)	10519 (544.5)	6.36 (3.17)
Saplings				
Acronychia pedunculata	10 (0)	2 (0)	438.86 (0)	3.3 (0)
Actinodaphne bourdillonii	10 (0)	2 (0)	109.71 (0)	2.24 (0)
Aglaia apiocarpa	10 (0)	2 (0)	128.76 (0)	2.3 (0)
Alseodaphne semecarpifolia	10 (125)	2 (25)	109.71 (1644)	2.24 (41.38)
Antidesma menasu	19 (0)	5 (0)	780.95 (0)	6.29 (0)
Beilschmiedia wightii	48 (0)	10 (0)	1446.1 (0)	13.08 (0)
Canthium dicoccum	67 (25)	14 (6)	1782.86 (288)	17.94 (8.76)
Celtis sp.	10 (0)	2 (0)	220.19 (0)	2.6 (0)
Celtis tetrandra	19 (0)	5 (0)	168.38 (0)	4.32 (0)
Cinnamomum wightii	48 (25)	10 (6)	760.38 (512)	10.9 (10.18)
Cleidion javanicum	19 (0)	5 (0)	673.52 (0)	5.94 (0)
Clerodendrum viscosum	19 (0)	5 (0)	342.86 (0)	4.88 (0)
Cocculus laurifolius	29 (100)	7 (19)	723.81 (1356)	7.99 (32.62)

….Cont'd….

Appendix 3 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Pullaradi shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Saplings (Cont'd)				
Cyathea nilgiriensis	0 (25)	0 (6)	0 (648)	0 (11.04)
Diospyros sp.	10 (0)	2 (0)	515.05 (0)	3.55 (0)
Excoecaria crenulata	29 (0)	7 (0)	760.38 (0)	8.11 (0)
Elaeocarpus recurvatus	0 (25)	0 (6)	0 (512)	0 (10.18)
Elaeocarpus tuberculatus	0 (25)	0 (6)	0 (722)	0 (11.51)
Glochidion neilgherrense	29 (100)	7 (13)	568.38 (1708)	7.49 (31.15)
Gomphandra coriacea	48 (50)	10 (13)	1328 (1170)	12.7 (21.28)
Isonandra candolleana	29 (0)	7 (0)	1320.38 (0)	9.91 (0)
Litsea beddomei	10 (0)	2 (0)	109.71 (0)	2.24 (0)
Litsea wightiana	95 (0)	19 (0)	3180.19 (0)	27.09 (0)
Maesa indica	10 (25)	2 (6)	128.76 (392)	2.3 (9.42)
Mallotus ferrugineus	19 (0)	5 (0)	551.62 (0)	5.55 (0)
Mastixia arborea	86 (25)	19 (6)	3987.05 (512)	28.8 (10.18)
Meliosma pinnata	0 (50)	0 (13)	0 (1508)	0 (23.43)
Meliosma simplicifolia	10 (75)	2 (19)	403.05 (2794)	3.19 (38.52)
Microtropis ramiflora	10 (25)	2 (6)	403.05 (288)	3.19 (8.76)
Murraya paniculata	48 (0)	10 (0)	781.71 (0)	10.94 (0)
Neolitsea cassia	19 (25)	5 (6)	259.05 (392)	4.61 (9.42)
Pavetta breviflora	29 (0)	7 (0)	863.24 (0)	8.44 (0)
Persea macrantha	19 (0)	2 (0)	551.62 (0)	4.54 (0)
Rapanea wightiana	10 (0)	2 (0)	109.71 (0)	2.24 (0)
Saprosma foetens	86 (0)	10 (0)	2459.43 (0)	19.86 (0)
Schefflera racemosa	19 (0)	5 (0)	257.52 (0)	4.6 (0)
Symplocos cochinchinensis	19 (25)	5 (6)	790.1 (512)	6.32 (10.18)
Syzygium cumini	29 (0)	7 (0)	1326.48 (0)	9.93 (0)
Syzygium densiflorum	29 (0)	5 (0)	454.1 (0)	6.11 (0)
Syzygium gardneri	10 (0)	2 (0)	195.05 (0)	2.52 (0)
Turpinia cochinchinensis	57 (0)	14 (0)	1687.62 (0)	16.76 (0)
Unknown-1	10 (25)	2 (6)	246.86 (800)	2.68 (12.01)
Unknown-2	10 (0)	2 (0)	128.76 (0)	2.3 (0)

….Cont'd….

Appendix 3 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Pullaradi shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Seedlings				
Acronychia pedunculata	0 (227)	0 (2)	0 (454.55)	0 (1.86)
Actinodaphne bourdillonii	633 (455)	5 (5)	1265.82 (909.09)	4.17 (3.72)
Aglaia apiocarpa	253 (0)	1 (0)	729.11 (0)	1.66 (0)
Alseodaphne semecarpifolia	2278 (1591)	15 (16)	2916.46 (2036.4)	12.3 (11.78)
Antidesma menasu	2025 (0)	4 (0)	1458.23 (0)	6.53 (0)
Beilschmiedia wightii	2405 (2046)	19 (11)	4810.13 (4090.9)	15.78 (13.2)
Canthium dicoccum	253 (682)	1 (7)	506.33 (1363.64)	1.42 (5.58)
Celtis tetrandra	633 (5227)	6 (30)	1265.8 (10454.5)	4.59 (33.91)
Chionanthus linocieroides	1139 (682)	4 (5)	2278.48 (1363.6)	5.78 (4.69)
Cinnamomum wightii	1899 (1136)	15 (11)	3797.47 (2272.7)	12.52 (9.3)
Clerodendrum viscosum	0 (1364)	0 (5)	0 (3927.27)	0 (8.91)
Cocculus laurifolius	380 (4546)	4 (23)	759.49 (9090.91)	2.75 (28.33)
Daphniphyllum neilgherrense	633 (227)	5 (2)	1822.79 (654.55)	4.77 (2.08)
Debregeasia longifolia	506 (455)	1 (5)	1012.66 (909.09)	2.43 (3.72)
Elaeocarpus recurvatus	759 (227)	4 (2)	1518.99 (454.55)	4.27 (1.86)
Elaeocarpus munronii	0 (1364)	0 (9)	0 (2727.27)	0 (9.38)
Excoecaria crenulata	127 (0)	1 (0)	253.16 (0)	0.92 (0)
Glochidion neilgherrense	506 (227)	3 (2)	648.1 (454.55)	2.45 (1.86)
Glochidion velutinum	506 (0)	5 (0)	1012.66 (0)	3.67 (0)
Gomphandra coriacea	5190 (6591)	20 (23)	10379.8 (13182)	27.29 (37.1)
Isonandra candolleana	1772 (0)	13 (0)	3544.3 (0)	11.19 (0)
Litsea beddomei	633 (0)	6 (0)	1265.82 (0)	4.59 (0)
Litsea wightiana	3544 (909)	20 (5)	2551.9 (654.55)	15.87 (4.41)
Maesa indica	127 (455)	1 (5)	253.16 (909.09)	0.92 (3.72)
Mallotus ferrugineus	0 (2727)	0 (5)	0 (7854.54)	0 (16.05)
Mastixia arborea	253 (0)	3 (0)	729.11 (0)	2.07 (0)
Meliosma pinnata	253 (2500)	3 (9)	729.11 (5000)	2.07 (14.26)
Microtropis ramiflora	127 (0)	1 (0)	253.16 (0)	0.92 (0)
Neolitsea cassia	1266 (3864)	10 (23)	2531.65 (7727.3)	8.35 (25.41)
Neolitsea sp.	380 (0)	1 (0)	759.49 (0)	1.93 (0)

….Cont'd….

Appendix 3 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Pullaradi shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Seedlings (Cont'd)				
Persea macrantha	8861 (1136)	33 (7)	6379.75 (818.18)	33.89 (5.95)
Rapanea wightiana	380 (227)	4 (2)	759.49 (454.55)	2.75 (1.86)
Saprosma foetens	2785 (682)	13 (7)	8020.25 (1963.6)	17.85 (6.23)
Schefflera racemosa	253 (0)	3 (0)	729.11 (0)	2.07 (0)
Symplocos cochinchinensis	2785 (455)	19 (5)	8020.25 (1309.1)	19.92 (4.15)
Symplocos pendula	127 (0)	1 (0)	253.16 (0)	0.92 (0)
Syzygium cumini	1392 (1136)	6 (7)	2784.8 (2272.73)	7.61 (7.53)
Syzygium densiflorum	1899 (0)	16 (0)	5468.36 (0)	14.73 (0)
Syzygium gardneri	2405 (2046)	9 (11)	6926.58 (5890.9)	14.7 (15.14)
Turpinia cochinchinensis	633 (455)	5 (2)	1265.82 (909.09)	4.17 (2.83)
Unknown-1	2025 (682)	14 (7)	1458.23 (490.91)	9.84 (4.63)
Unknown-2	1899 (2727)	9 (7)	1367.1 (1963.64)	7.85 (10.57)
Unknown-3	127 (0)	1 (0)	364.56 (0)	1.04 (0)
Unknown-4	253 (0)	1 (0)	506.33 (0)	1.42 (0)
Shrubs and herbs				
Achyranthes bidentata	9367 (23182)	22 (55)	2997.47 (7418.2)	9.59 (21.86)
Ageratina adenophora	253 (5227)	3 (18)	324.05 (6690.91)	0.71 (10.15)
Alstonia venenata	380 (0)	4 (0)	486.08 (0)	1.06 (0)
Anoectochilus elatus	1266 (227)	3 (2)	405.06 (18.18)	1.24 (0.39)
Ardisia rhomboidea	10380 (0)	41 (0)	40688.6 (0)	35.87 (0)
Arisaema leschenaultii	0 (455)	0 (5)	0 (581.82)	0 (1.27)
Barleria involucrata	0 (682)	0 (7)	0 (1363.64)	0 (2.34)
Bidens pilosa	0 (227)	0 (2)	0 (72.73)	0 (0.44)
Blumea mollis	886 (0)	3 (0)	637.97 (0)	1.2 (0)
Bulbostylis densa	886 (0)	4 (0)	159.49 (0)	1.1 (0)
Calanthe masuca	633 (227)	4 (2)	202.53 (72.73)	1.01 (0.44)
Carex sp.	12278 (4091)	44 (20)	982.28 (327.27)	13.26 (4.4)
Cayratia pedata	4937 (1818)	29 (18)	1579.75 (581.82)	7.79 (3.53)
Coleus malabaricus	6582 (12727)	20 (43)	2106.3 (4072.73)	7.53 (13.73)

….Cont'd….

Appendix 3 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Pullaradi shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Shrubs and herbs (Cont'd)				
Crotalaria scabrella	380 (0)	1 (0)	121.52 (0)	0.45 (0)
Derris canarensis	253 (909)	1 (9)	81.01 (290.91)	0.36 (1.76)
Desmodium sp.	380 (0)	1 (0)	121.52 (0)	0.45 (0)
Dorstenia indica	253 (0)	1 (0)	45.57 (0)	0.34 (0)
Dumasia villosa	1139 (0)	5 (0)	364.56 (0)	1.54 (0)
Elatostema lineolatum	1139 (227)	4 (2)	205.06 (40.91)	1.25 (0.41)
Eragrostis sp.	1139 (1818)	5 (9)	91.14 (145.45)	1.38 (1.96)
Gardneria ovata	759 (0)	6 (0)	243.04 (0)	1.48 (0)
Girardinia diversifolia	253 (0)	1 (0)	506.33 (0)	0.62 (0)
Hydrocotyle javanica	4430 (35227)	13 (43)	597.47 (3200)	4.42 (20.87)
Impatiens balsamina	0 (682)	0 (5)	0 (490.91)	0 (1.27)
Impatiens cuspidata	0 (455)	0 (5)	0 (327.27)	0 (1.04)
Impatiens goughii	3671 (0)	14 (0)	4698.73 (0)	6.74 (0)
Impatiens sp.	2152 (10455)	6 (41)	688.61 (3345.45)	2.42 (11.99)
Jasminum sp.	127 (0)	1 (0)	40.51 (0)	0.28 (0)
Laportea bulbifera	3418 (50682)	8 (66)	1093.7 (16218.2)	3.46 (40.83)
Lasianthus accuminatus	7595 (3182)	37 (9)	29772 (12472.7)	27.3 (13.37)
Lasianthus sp.	886 (0)	3 (0)	1134.18 (0)	1.5 (0)
Leptochilus decurrens	20127 (11364)	54 (32)	3622.8 (2045.45)	20.15 (9.97)
Murraya paniculata	253 (682)	3 (7)	81.01 (490.91)	0.56 (1.57)
Naringi crenulata	0 (227)	0 (2)	0 (72.73)	0 (0.44)
Ophiorrhiza grandiflora	1392 (0)	5 (0)	1002.53 (0)	2.05 (0)
Oplismenus sp.	26709 (44545)	53 (66)	2136.7 (3563.64)	22.2 (27.45)
Passiflora leschenaultii	253 (0)	1 (0)	81.01 (0)	0.36 (0)
Pavetta breviflora	380 (0)	4 (0)	759.49 (0)	1.23 (0)
Phyllanthus gardnerianus	759 (1136)	4 (5)	60.76 (90.91)	0.98 (1.07)
Piper mullesua	759 (0)	6 (0)	243.04 (0)	1.48 (0)
Piper sp.	6709 (9318)	32 (27)	2146.84 (2981.8)	9.37 (9.48)
Polygonum chinense	127 (2046)	1 (18)	40.51 (654.55)	0.28 (3.67)

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Appendix 3 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Pullaradi shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Basal area (cm^2ha^{-1})	IVI
Shrubs and herbs (Cont'd)				
Pteris quadriaurita	10000 (11136)	46 (48)	3200 (3563.64)	13.72 (13.3)
Rauvolfia micrantha	4684 (7727)	20 (32)	5994.9 (5563.64)	8.99 (11.81)
Rubus ellipticus	0 (1591)	0 (9)	0 (2036.36)	0 (3.55)
Sarcococca coriacea	633 (1136)	5 (9)	1265.8 (2272.73)	1.85 (3.6)
Selaginella sp.	19114 (3636)	24 (5)	3440.51 (654.55)	14.88 (2.45)
Sinarundinaria densifolia	1266 (1136)	6 (2)	3645.6 (1454.55)	3.79 (1.99)
Solanum anguivi	0 (4091)	0 (16)	0 (5236.36)	0 (8.16)
Strobilanthes asperrimus	1899 (6818)	6 (20)	2430.4 (8727.27)	3.35 (12.81)
Strobilanthes homotropa	1013 (1364)	9 (9)	2916.46 (3927.3)	3.62 (5.15)
Strobilanthes kunthianus	380 (0)	3 (0)	273.42 (0)	0.74 (0)
Strobilanthes pulneyensis	4684 (0)	14 (0)	5994.94 (0)	8.01 (0)
Strobilanthes sp.1	2025 (0)	4 (0)	4050.63 (0)	4.01 (0)
Strobilanthes sp-2	380 (0)	1 (0)	759.49 (0)	0.84 (0)
Strobilanthes wightii	16582 (0)	22 (0)	21225.3 (0)	24.08 (0)
Tetrastigma leucostaphylum	0 (455)	0 (2)	0 (327.27)	0 (0.75)
Toddalia asiatica	1519 (2273)	13 (14)	3038 (4545.45)	4.52 (6.61)
Unknown-3	506 (0)	3 (0)	364.56 (0)	0.85 (0)
Unknown-9	0 (1818)	0 (2)	0 (581.82)	0 (1.45)
Unknown-11	0 (1136)	0 (5)	0 (363.64)	0 (1.32)
Unknown-12	1772 (0)	1 (0)	2268.35 (0)	2.41 (0)
Unknown-13	506 (0)	4 (0)	162.03 (0)	0.92 (0)
Vernonia bourneana	0 (3864)	0 (9)	0 (2781.82)	0 (5.01)
Vigna radiata	0 (1818)	0 (5)	0 (581.82)	0 (1.75)
Vigna trilobata	10000 (10000)	24 (45)	3200 (1800)	10.4 (11.05)
Zehneria maysorensis	0 (2273)	0 (16)	0 (727.27)	0 (3.52)

Appendix 4. Girth class distribution of trees in the undisturbed and disturbed areas of the Pullaradi shola. Values in parentheses are for disturbed plots.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Acronychia pedunculata	0 (227)	10 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Actinodaphne bourdillonii	633 (455)	10 (0)	4 (0)	3 (0)	5 (0)	3 (0)	0 (6)	0 (0)
Aglaia apiocarpa	253 (0)	10 (0)	3 (0)	0 (0)	5 (0)	0 (0)	0 (0)	0 (0)
Alseodaphne semecarpifolia	2278 (1590)	10 (125)	8 (0)	17 (6)	12 (13)	3 (6)	0 (0)	0 (0)
Antidesma menasu	2025 (0)	19 (0)	0 (0)	0 (0)	3 (6)	2 (0)	0 (0)	3 (0)
Beilschmiedia wightii	2405 (2045)	48 (0)	5 (0)	0 (0)	8 (0)	8 (12)	0 (25)	7 (0)
Canthium dicoccum	253 (682)	67 (25)	14 (0)	3 (6)	0 (0)	3 (0)	0 (0)	0 (7)
Celtis sp.	0 (0)	10 (0)	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)
Celtis tetrandra	633 (5227)	19 (0)	5 (0)	5 (6)	4 (0)	3 (7)	0 (0)	3 (0)
Chionanthus linocieroides	1139 (682)	0 (0)	0 (0)	0 (6)	0 (0)	0 (0)	0 (0)	3 (0)
Cinnamomum perrottetii	0 (0)	0 (0)	0 (0)	5 (0)	0 (0)	3 (0)	2 (0)	3 (0)
Cinnamomum sulphuratum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0)	0 (0)
Cinnamomum wightii	1899 (1136)	48 (25)	0 (6)	0 (0)	0 (0)	0 (13)	0 (0)	0 (6)
Cleidion javanicum	0 (0)	19 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Clerodendrum viscosum	0 (1364)	19 (0)	0 (0)	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)
Cocculus laurifolius	380 (4546)	29 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cyathea nilgiriensis	0 (0)	0 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

….Cont'd….

Appendix 4 (Cont'd). Girth class distribution of trees in the undisturbed and disturbed areas of the Pullaradi shola. Values in parentheses are for disturbed plots.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Daphniphyllum neilgherrense	633 (227)	0 (0)	0 (6)	3 (7)	0 (0)	0 (0)	0 (0)	0 (0)
Debregeasia longifolia	506 (455)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Diospyros sp.	0 (0)	10 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Elaeocarpus recurvatus	759 (227)	0 (25)	0 (0)	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)
Elaeocarpus munronii	0 (1364)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Elaeocarpus serratus	0 (0)	0 (0)	0 (0)	2 (0)	3 (0)	0 (0)	0 (0)	0 (0)
Elaeocarpus tuberculatus	0 (0)	0 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (6)	0 (7)
Eurya nitida	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Excoecaria crenulata	127 (0)	29 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Glochidion neilgherrense	506 (227)	29 (100)	5 (0)	0 (0)	3 (6)	0 (0)	0 (0)	0 (0)
Glochidion velutinum	506 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gomphandra coriacea	5190 (6591)	48 (50)	57 (6)	38 (19)	28 (13)	5 (0)	0 (6)	0 (0)
Hydnocarpus alpina	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)	3 (0)
Ilex denticulata	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0)
Ilex sp.	0 (0)	0 (0)	7 (0)	4 (0)	3 (0)	3 (0)	0 (0)	3 (0)
Isonandra candolleana	1772 (0)	29 (0)	17 (0)	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)
Litsea sp.	633 (0)	10 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

….Cont'd….

Appendix 4 (Cont'd). Girth class distribution of trees in the undisturbed and disturbed areas of the Pullaradi shola. Values in parentheses are for disturbed plots.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Litsea wightiana	3544 (909)	95 (0)	20 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Maesa indica	127 (455)	10 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mallotus ferrugineus	0 (2727)	19 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mastixia arborea	253 (0)	86 (25)	34 (7)	3 (0)	5 (0)	5 (0)	0 (0)	8 (6)
Meliosma pinnata	253 (2500)	0 (50)	3 (0)	0 (0)	0 (0)	5 (0)	0 (0)	0 (0)
Meliosma simplicifolia	0 (0)	10 (75)	10 (38)	3 (6)	0 (0)	0 (0)	0 (6)	0 (0)
Microtropis ramiflora	127 (0)	10 (25)	3 (0)	2 (0)	3 (0)	0 (0)	0 (0)	0 (0)
Murraya paniculata	0 (0)	48 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Neolitsea cassia	1266 (3864)	19 (25)	8 (19)	9 (6)	3 (0)	7 (13)	3 (6)	0 (6)
Neolitsea fischeri	0 (0)	10 (0)	0 (0)	4 (0)	0 (0)	3 (0)	3 (0)	0 (0)
Neolitsea sp.	380 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pavetta breviflora	0 (0)	29 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0)
Persea macrantha	8861 (1136)	19 (0)	10 (19)	5 (6)	8 (6)	12 (0)	3 (0)	12 (6)
Rapanea wightiana	380 (227)	10 (0)	5 (6)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Saprosma foetens	2785 (682)	86 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Schefflera racemosa	253 (0)	19 (0)	0 (6)	3 (0)	0 (13)	0 (0)	0 (6)	0 (0)
Symplocos cochinchinensis	2785 (455)	19 (25)	3 (0)	5 (0)	0 (0)	0 (0)	0 (0)	0 (0)

….Cont'd….

Appendix 4 (Cont'd). Girth class distribution of trees in the undisturbed and disturbed areas of the Pullaradi shola. Values in parentheses are for disturbed plots.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Symplocos pendula	127 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Syzygium cumini	1392 (1136)	29 (0)	8 (0)	3 (0)	3 (0)	5 (6)	0 (0)	9 (13)
Syzygium densiflorum	1899 (0)	29 (0)	0 (0)	0 (6)	0 (0)	0 (0)	0 (0)	0 (0)
Syzygium gardneri	2405 (2046)	10 (0)	3 (6)	3 (0)	0 (0)	8 (0)	0 (0)	9 (0)
Turpinia cochinchinensis	633 (455)	57 (0)	25 (0)	13 (0)	7 (0)	8 (0)	0 (0)	0 (0)
Unknown-1	2025 (682)	10 (25)	3 (0)	0 (13)	8 (0)	16 (0)	3 (0)	5 (0)
Unknown-2	1899 (2727)	10 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unknown-3	127 (0)	0 (0)	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unknown-4	253 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Vaccinium leschenaultii	0 (0)	0 (0)	7 (6)	3 (0)	5 (0)	3 (0)	0 (0)	0 (0)
Total	54304 (47046)	1086 (775)	403 (537)	226 (299)	179 (229)	170 (244)	78 (99)	125 (188)

* Size classes: A-Seedlings (girth <10.0 cm, height <1 m), B-Saplings (gbh 10.1 to30.0 cm) and C to H- Mature trees, gbh 30.1-60.0, 60.1-90.0, 90.1-120.0, 120.1-150.0, 150.1-180.0 and >180.1 cm respectively.

Appendix 5. Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Manthan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Mature trees				
Acronychia pedunculata	8 (0)	8 (0)	1430.1 (0)	3.55 (0)
Actinodaphne bourdillonii	12 (0)	12 (0)	36850 (0)	10.4 (0)
Aglaia apiocarpa	8 (0)	8 (0)	2417.9 (0)	3.69 (0)
Agrostistachys indica	16 (0)	12 (0)	7192 (0)	6.72 (0)
Alseodaphne semecarpifolia	24 (8)	20 (8)	32366 (4266.7)	13.8 (5.44)
Beilschmiedia wightii	24 (0)	24 (0)	33980 (0)	15 (0)
Canthium dicoccum	24 (50)	20 (33)	38012 (81655)	14.6 (41.1)
Celtis sp.	0 (8)	0 (8)	0 (7350)	0 (6.53)
Celtis tetrandra	4 (0)	4 (0)	2649.9 (0)	2.06 (0)
Chionanthus linocieroides	4 (0)	4 (0)	968 (0)	1.81 (0)
Cinnamomum wightii	16 (0)	16 (0)	63904 (0)	16.1 (0)
Clerodendrum viscosum	12 (0)	12 (0)	7654.7 (0)	6.13 (0)
Cocculus laurifolius	4 (0)	4 (0)	677.12 (0)	1.77 (0)
Daphniphyllum neilgherrense	0 17	0 17	0 16429	0 13.4
Diospyros sp.	4 (0)	4 (0)	5408 (0)	2.46 (0)
Excoecaria crenulata	4 (8)	4 (8)	369.92 (1536)	1.72 (5.42)
Eurya nitida	0 (34)	0 (34)	0 (29385)	0 (26.1)
Glochidion neilgherrense	8 (34)	8 (34)	15184 (18573)	5.57 (24.1)
Gomphandra coriacea	36 (8)	28 (8)	14113 (1600.7)	15.1 (5.44)
Hydnocarpus alpina	264 (8)	88 (8)	174621 (8066.6)	91.3 (6.66)
Isonandra candolleana	24 (0)	24 (0)	23925 (0)	13.5 (0)
Litsea floribunda	0 (8)	0 (8)	0 (5280.7)	0 (6.14)
Litsea wightiana	0 (8)	0 (8)	0 (3266.7)	0 (5.75)
Mastixia arborea	32 (0)	24 (0)	95940 (0)	25.4 (0)
Meliosma pinnata	4 (17)	4 (17)	29573 (39283)	6.01 (17.7)
Meliosma simplicifolia	0 (8)	0 (8)	0 (11094)	0 (7.24)
Neolitsea cassia	12 (17)	12 (17)	8263 (3712.7)	6.22 (11)
Nothopegia sp.	0 (17)	0 (17)	0 (32334)	0 (16.4)
Pavetta breviflora	4 (0)	4 (0)	591.68 (0)	1.75 (0)

….Cont'd….

Appendix 5(Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Manthan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Mature trees (Cont'd)				
Persea macrantha	20 (17)	16 (17)	48256 (46299)	14.4 (19.1)
Schefflera racemosa	4 (8)	4 (8)	16200 (68267)	4.05 (18.1)
Symplocos cochinchinensis	0 (8)	0 (8)	0 (912.67)	0 (5.31)
Syzygium cumini	4 (25)	4 (25)	898.88 (71225)	1.8 (28.9)
Syzygium densiflorum	4 (0)	4 (0)	3264.3 (0)	2.15 (0)
Syzygium gardneri	0 (25)	0 (25)	0 (75617)	0 (29.8)
Unknown-1	24 (0)	20 (0)	15736 (0)	11.3 (0)
Unknown-4	4 (0)	4 (0)	648 (0)	1.76 (0)
Saplings				
Acronychia pedunculata	16 (0)	4 (0)	216.32 (0)	3.17 (0)
Aglaia apiocarpa	16 (0)	4 (0)	250.88 (0)	3.25 (0)
Agrostistachys indica	80 (31)	12 (8)	1497.6 (553.85)	13.9 (9.12)
Alseodaphne semecarpifolia	64 (62)	16 (15)	1272.3 (708.92)	13.7 (16.6)
Beilschmiedia wightii	16 (0)	4 (0)	250.88 (0)	3.25 (0)
Canthium dicoccum	16 (0)	4 (0)	800 (0)	4.55 (0)
Celtis tetrandra	16 (0)	4 (0)	250.88 (0)	3.25 (0)
Chionanthus ramiflorus	16 (0)	4 (0)	414.72 (0)	3.64 (0)
Clerodendrum serratum	0 (31)	0 (8)	0 (553.85)	0 (9.12)
Clerodendrum viscosum	144 (123)	24 (15)	11414 (2308.9)	46.5 (29.2)
Cocculus laurifolius	48 (0)	8 (0)	1969.9 (0)	11.2 (0)
Daphniphyllum neilgherrense	16 (0)	4 (0)	216.32 (0)	3.17 (0)
Excoecaria crenulata	176 (62)	36 (15)	5219.8 (1538.5)	38.7 (20)
Glochidion neilgherrense	0 (31)	0 (8)	0 (553.85)	0 (9.12)
Hydnocarpus alpina	208 (62)	44 (15)	6682.9 (2092.3)	47.4 (22.2)
Isonandra candolleana	48 (0)	8 (0)	1349.1 (0)	9.7 (0)
Isonandra sp.	16 (0)	4 (0)	462.08 (0)	3.75 (0)
Ligustrum perrottetii	16 (0)	4 (0)	184.32 (0)	3.1 (0)
Maesa indica	48 (185)	12 (31)	913.92 (5326.8)	10.1 (55.1)
Mastixia arborea	16 (0)	4 (0)	800 (0)	4.55 (0)

….Cont'd….

Appendix 5 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Manthan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Saplings (Cont'd)				
Neolitsea cassia	16 (0)	4 (0)	250.88 (0)	3.25 (0)
Pavetta breviflora	64 (0)	12 (0)	1355.5 (0)	12.4 (0)
Persea macrantha	16 (31)	4 (8)	1076.5 (984.62)	5.2 (10.9)
Psychotria elongata	0 (31)	0 (8)	0 (984.62)	0 (10.9)
Saprosma foetens	192 (123)	40 (31)	2903 (2929.2)	35.8 (42.4)
Schefflera racemosa	0 (31)	0 (8)	0 (1664)	0 (13.6)
Symplocos cochinchinensis	64 (92)	8 (15)	2400 (1954.5)	13.4 (24.7)
Syzygium densiflorum	16 (0)	4 (0)	216.32 (0)	3.17 (0)
Unknown-4	0 (31)	0 (8)	0 (1664)	0 (13.6)
Viburnum coriaceum	0 (62)	0 (8)	0 (908.31)	0 (13.6)
Seedlings				
Abarema subcoriacea	167 (1000)	2 (10)	333.33 (2000)	1.1 (5.93)
Actinodaphne bourdillonii	1000 (0)	5 (0)	2000 (0)	5.26 (0)
Aglaia apiocarpa	1000 (1000)	10 (10)	2880 (2880)	7.48 (6.66)
Agrostistachys indica	1167 (0)	7 (0)	3360 (0)	7.37 (0)
Alseodaphne semecarpifolia	2167 (3000)	20 (20)	2773.3 (3840)	12.4 (13.4)
Antidesma menasu	0 (333)	0 (3)	0 (240)	0 (1.62)
Beilschmiedia wightii	833 (333)	7 (3)	1666.7 (666.67)	5.06 (1.98)
Canthium dicoccum	0 (4000)	0 (17)	0 (8000)	0 (17.7)
Celtis tetrandra	2333 (1667)	22 (13)	4666.7 (3333.3)	15 (9.03)
Chionanthus linocieroides	667 (667)	7 (7)	1333.3 (1333.3)	4.41 (3.95)
Cinnamomum wightii	1333 (0)	13 (0)	2666.7 (0)	8.83 (0)
Clerodendrum viscosum	1667 (1333)	17 (13)	4800 (3840)	12.5 (8.88)
Cocculus laurifolius	1167 (3667)	5 (27)	2333.3 (7333.3)	5.91 (19.2)
Daphniphyllum neilgherrense	833 (667)	7 (7)	2400 (1920)	5.78 (4.44)
Debregeasia velutinum	0 (1667)	0 (10)	0 (3333.3)	0 (8.17)
Excoecaria crenulata	3167 (667)	27 (7)	6333.4 (1333.3)	19.6
Glochidion neilgherrense	667 (1333)	7 (13)	973.33 (1706.7)	4.06 (7.11)
Gomphandra coriacea	333 (667)	3 (7)	666.67 (1333.3)	2.21 (3.95)

….Cont'd….

Appendix 5 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Manthan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Seedlings (Cont'd)				
Hydnocarpus alpina	6333 (1667)	37 (13)	12667 (3333.3)	34.7 (9.03)
Isonandra candolleana	667 (0)	7 (0)	1333.3 (0)	4.41 (0)
Ligustrum perrottetii	167 (1000)	2 (3)	333.33 (2000)	1.1 (4.22)
Litsea floribunda	0 (1000)	0 (7)	0 (1280)	0 (4.48)
Litsea wightiana	7333 (4333)	48 (27)	6560 (3120)	33.8 (16.8)
Maesa indica	333 (3000)	3 (27)	426.67 (6000)	1.97 (16.9)
Mallotus ferrugineus	0 (333)	0 (3)	0 (960)	0 (2.22)
Mastixia arborea	1000 (0)	10 (0)	2880 (0)	7.48 (0)
Meliosma pinnata	167 (667)	2 (7)	333.33 (1333.3)	1.1 (3.95)
Neolitsea cassia	3333 (1667)	23 (17)	6666.7 (3333.3)	19.4 (9.88)
Persea macrantha	833 (1667)	8 (13)	600 (1200)	4.47 (7.27)
Rapanea wightiana	167 (0)	2 (0)	333.33 (0)	1.1 (0)
Saprosma foetens	5667 (14333)	25 (50)	16320 (41280)	33.8 (71.5)
Symplocos cochinchinensis	333 (2667)	3 (17)	960 (7680)	2.49 (15.2)
Symplocos pendula	500 (0)	3 (0)	1440 (0)	3.29 (0)
Syzygium cumini	500 (333)	2 (3)	1440 (666.67)	2.84 (1.98)
Syzygium densiflorum	167 (667)	2 (7)	480 (1333.3)	1.25 (3.95)
Syzygium gardneri	500 (1000)	2 (10)	1440 (2000)	2.84 (5.93)
Syzygium tamilnadensis	333 (0)	3 (0)	960 (0)	2.49 (0)
Unknown-1	1167 (667)	12 (7)	840 (480)	6.26 (3.25)
Unknown-2	2333 (333)	8 (3)	4666.7 (240)	11.4 (1.62)
Unknown-4	500 (0)	3 (0)	640 (0)	2.5 (0)
Unknown-5	667 (333)	7 (3)	1333.3 (666.67)	4.41 (1.98)
Unknown-6	0 (333)	0 (3)	0 (426.67)	0 (1.78)
Viburnum coriaceum	0 (333)	0 (3)	0 (666.67)	0 (1.98)
Shrubs and herbs				
Achyranthes bidentata	167 (0)	2 (0)	53.33 (0)	0.5 (0)
Ageratina adenophora	0 (9000)	0 (27)	0 (11520)	0 (21.3)
Anoectochilus elatus	333 (0)	2 (0)	26.67 (0)	0.59 (0)

….Cont'd….

Appendix 5 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Manthan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Shrubs and herbs (Cont'd)				
Ardisia rhomboidea	4000 (667)	23 (7)	15680 (2613.3)	22.2 (4.19)
Asparagus racemosus	0 (333)	0 (3)	0 (106.67)	0 (0.85)
Bidens pilosa	0 (2667)	0 (17)	0 (1920)	0 (6.24)
Calanthe masuca	4500 (0)	25 (0)	1440 (0)	9.47 (0)
Carex sp.	4333 (11667)	30 (57)	346.67 (933.33)	9.31 (16.8)
Cayratia pedata	1167 (7000)	8 (37)	373.33 (2240)	2.82 (12.3)
Calamus sp.	333 (0)	2 (0)	240 (0)	0.79 (0)
Chassalia curviflora	0 (667)	0 (7)	0 (853.33)	0 (2.37)
Coleus malabaricus	667 (0)	5 (0)	213.33 (0)	1.66 (0)
Desmodium heterophyllum	0 (333)	0 (3)	0 (240)	0 (0.99)
Elatostema lineolatum	16500 (0)	25 (0)	11880 (0)	27.7 (0)
Eragrostis sp.	500 (667)	5 (7)	40 (53.33)	1.38 (1.54)
Girardinia diversifolia	0 (667)	0 (7)	0 (1333.3)	0 (2.86)
Hedyotis sp.	0 (2333)	0 (10)	0 (1680)	0 (4.68)
Hydrocotyle javanica	0 (11000)	0 (17)	0 (880)	0 (9.64)
Laportea bulbifera	12167 (9667)	37 (17)	3893.3 (3093.3)	19.5 (11.2)
Lasianthus accuminatus	8333 (5000)	43 (23)	32667 (19600)	45.2 (26.9)
Leptochilus decurrens	38667 (16333)	80 (40)	6960 (2940)	49.6 (18.6)
Murraya paniculata	167 (0)	2 (0)	53.33 (0)	0.5 (0)
Oplismenus sp.	15000 (57000)	50 (77)	1200 (4560)	21.6 (48.3)
Osbeckia leschenaultiana	0 (333)	0 (3)	0 (240)	0 (0.99)
Passiflora edulis	0 (1000)	0 (10)	0 (320)	0 (2.56)
Pavetta breviflora	1500 (1000)	13 (10)	3000 (2000)	6.52 (4.3)
Piper sp.	11333 (4000)	55 (20)	3626.7 (1280)	22.3 (6.86)
Polygala arillata	0 (333)	0 (3)	0 (240)	0 (0.99)
Polygonum chinense	0 (333)	0 (3)	0 (106.67)	0 (0.85)
Psychotria elongata	0 (667)	0 (3)	0 (853.33)	0 (1.8)
Pteridium aquilinum	0 (333)	0 (3)	0 (106.67)	0 (0.85)
Pteris quadriaurita	10167 (7333)	48 (47)	3253.3 (2346.7)	19.8 (14.3)

….Cont'd….

Appendix 5 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in undisturbed and disturbed forest plots of Manthan shola. Values in parentheses are for disturbed plots

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Shrubs and herbs (Cont'd)				
Rauvolfia densiflora	333 (0)	3 (0)	106.67 (0)	0.99 (0)
Rubus ellipticus	0 (333)	0 (3)	0 (426.67)	0 (1.18)
Sarcococca coriacea	167 (333)	2 (3)	333.33 (666.67)	0.76 (1.43)
Senecio sp.	0 (333)	0 (3)	0 (26.67)	0 (0.77)
Smilax asperima	0 (667)	0 (7)	0 (213.33)	0 (1.71)
Strobilanthes asperrimus	333 (1000)	2 (10)	426.67 (1280)	0.97 (3.55)
Strobilanthes homotropa	333 (2333)	3 (13)	960 (6720)	1.8 (10.5)
Strobilanthes pubescent	8000 (0)	13 (0)	16000 (0)	23.3 (0)
Toddalia asiatica	1500 (3333)	13 (20)	3000 (6666.7)	6.52 (12.1)
Unknown-4	500 (6667)	3 (33)	360 (13333)	1.35 (23)
Unknown-5	333 (0)	3 (0)	106.67 (0)	0.99 (0)
Unknown-7	0 (5333)	0 (7)	0 (426.67)	0 (4.43)
Vernonia bourneana	0 (3333)	0 (7)	0 (1066.7)	0 (4.02)
Vigna trilobata	833 (12333)	7 (27)	150 (3946.7)	2.05 (15.2)

Appendix 6. Girth class distribution of trees in the undisturbed and disturbed areas of the Manthan shola. Values in parentheses are for disturbed plots.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Abarema subcoriacea	167 (1000)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Acronychia pedunculata	0 (0)	16 (0)	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Actinodaphne bourdillonii	1000 (0)	0 (0)	0 (0)	0 (0)	4 (0)	0 (0)	0 (0)	8 (0)
Aglaia apiocarpa	1000 (1000)	16 (0)	4 (0)	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Agrostistachys indica	1167 (0)	80 (31)	8 (0)	4 (0)	4 (0)	0 (0)	0 (0)	0 (0)
Alseodaphne semecarpifolia	2167 (3000)	64 (62)	0 (0)	8 (8)	8 (0)	0 (0)	4 (0)	4 (0)
Antidesma menasu	0 (333)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Beilschmiedia wightii	833 (333)	16 (0)	0 (0)	4 (0)	8 (0)	8 (0)	0 (0)	4 (0)
Canthium dicoccum	0 (4000)	16 (0)	0 (0)	0 (8)	12 (17)	8 (0)	0 (17)	4 (8)
Celtis sp.	0 (1000)	0 (0)	0 (0)	0 (0)	0 (8)	0 (0)	0 (0)	0 (0)
Celtis tetrandra	2333 (1667)	16 (0)	0 (0)	0 (0)	4 (0)	0 (0)	0 (0)	0 (0)
Chionanthus linocieroides	667 (667)	0 (0)	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Chionanthus ramiflorus	0 (0)	16 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cinnamomum wightii	1333 (0)	0 (0)	4 (0)	0 (0)	4 (0)	0 (0)	0 (0)	8 (0)
Clerodendrum serratum	0 (0)	0 (31)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Clerodendrum viscosum	1667 (1333)	144 (123)	8 (0)	0 (0)	0 (0)	4 (0)	0 (0)	0 (0)
Cocculus laurifolius	1167 (3667)	48 (0)	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

….Cont'd….

Appendix 6 (Cont'd). Girth class distribution of trees in the undisturbed and disturbed areas of the Manthan shola. Values in parentheses are for disturbed plots.

	Girth Classes*							
Species	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Daphniphyllum neilgherrense	833 (667)	16 (0)	0 (0)	0 (0)	0 (17)	0 (0)	0 (0)	0 (0)
Diospyros sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (0)	0 (0)	0 (0)
Eurya nitida	0 (0)	0 (0)	0 (0)	0 (17)	0 (9)	0 (8)	0 (0)	0 (0)
Excoecaria crenulata	3167 (667)	176 (62)	4 (8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Glochidion neilgherrense	667 (1333)	0 (31)	0 (0)	0 (17)	4 (17)	0 (0)	0 (0)	4 (0)
Gomphandra coriacea	333 (667)	0 (0)	12 (8)	24 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Hydnocarpus alpina	6333 (1667)	208 (62)	76 (0)	84 (0)	80 (8)	12 (0)	8 (0)	4 (0)
Isonandra candolleana	667 (0)	48 (0)	8 (0)	4 (0)	0 (0)	8 (0)	4 (0)	0 (0)
Isonandra sp.	0 (0)	16 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ligustrum perrottetii	167 (1000)	16 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Litsea floribunda	0 (0)	0 (0)	0 (0)	0 (8)	0 (0)	0 (0)	0 (0)	0 (0)
Litsea wightiana	7333 (4333)	0 (0)	0 (0)	0 (8)	0 (0)	0 (0)	0 (0)	0 (0)
Maesa indica	333 (3000)	48 (185)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mallotus ferrugineus	0 (333)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Mastixia arborea	1000 (0)	16 (0)	4 (0)	0 (0)	4 (0)	4 (0)	8 (0)	12 (0)
Meliosma pinnata	167 (667)	0 (0)	0 (0)	0 (0)	0 (0)	0 (9)	0 (0)	4 (8)
Meliosma simplicifolia	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (8)	0 (0)	0 (0)

….Cont'd….

Appendix 6 (Cont'd). Girth class distribution of trees in the undisturbed and disturbed areas of the Manthan shola. Values in parentheses are for disturbed plots.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Neolitsea cassia	3333 (1667)	16 (0)	0 (8)	4 (9)	4 (0)	4 (0)	0 (0)	0 (0)
Nothopegia sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (9)	0 (8)	0 (0)
Pavetta breviflora	0 (0)	64 (0)	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Persea macrantha	833 (1667)	16 (31)	0 (0)	4 (0)	0 (0)	4 (8)	0 (0)	12 (9)
Photinia velutina	0 (1667)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Psychotria elongata	0 (0)	0 (31)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Rapanea wightiana	167 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Saprosma foetens	5667 (14333)	192 (123)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Schefflera racemosa	0 (0)	0 (31)	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (8)
Symplocos cochinchinensis	333 (2667)	64 (92)	0 (8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Symplocos sp.	500 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Syzygium cumini	500 (333)	0 (0)	0 (0)	0 (0)	0 (0)	0 (8)	0 (0)	0 (17)
Syzygium densiflorum	167 (667)	16 (0)	0 (0)	0 (0)	4 (0)	0 (0)	0 (0)	0 (0)
Syzygium gardneri	500 (1000)	0 (0)	0 (0)	0 (0)	0 (0)	0 (8)	0 (0)	0 (17)
Syzygium tamilnadensis	333 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unknown-1	1167 (666)	0 (0)	4 (0)	12 (0)	4 (0)	4 (0)	0 (0)	0 (0)
Unknown-2	2333 (333)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

….Cont'd….

Appendix 6 (Cont'd). Girth class distribution of trees in the undisturbed and disturbed areas of the Manthan shola. Values in parentheses are for disturbed plots.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Unknown-3	0 (0)	0 (0)	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unknown-4	500 (0)	0 (31)	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unknown-5	667 (333)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unknown-6	0 (333)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Viburnum sp.	0 (333)	0 (62)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	51500 (58333)	1344 (985)	168 (32)	148 (75)	144 (76)	60 (58)	24 (25)	64 (67)

* Size classes: A-Seedlings (girth <10.0 cm, height <1 m), B-Saplings (gbh 10.1 to30.0 cm) and C to H- Mature trees, gbh 30.1-60.0, 60.1-90.0, 90.1-120.0, 120.1-150.0, 150.1-180.0 and >180.1 cm respectively.

Appendix 7. Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in plots of Aruvikkad shola forest.

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Mature trees				
Acronychia pedunculata	3	3	1327.5	1.28
Actinodaphne bourdillonii	18	15	9423	7.41
Alseodaphne semecarpifolia	48	36	41177	22.2
Beilschmiedia wightii	9	9	10200	5.1
Canarium strictum	3	3	12273	3.48
Canthium dicoccum	27	27	58038	20.8
Celtis tetrandra	6	6	614.06	2.16
Cinnamomum sp.	3	3	280.24	1.07
Cinnamomum wightii	36	30	25210	16.1
Clerodendrum viscosum	118	45	24932	30.8
Debregeasia velutina	3	3	314.18	1.08
Elaeocarpus recurvatus	6	3	2042.4	1.87
Elaeocarpus munronii	3	3	11311	3.29
Elaeocarpus tuberculatus	33	24	31035	15.7
Eurya nitida	3	3	368.73	1.09
Garcinia cowa	12	9	1879.5	3.87
Gomphandra coriacea	48	39	29040	20.4
Grewia tiliifolia	3	3	368.73	1.09
Hydnocarpus alpina	6	6	838.06	2.2
Ilex wightiana	9	6	1599	2.79
Isonandra lanceolata	6	6	9639.8	3.97
Isonandra stocksii	9	9	3919	3.84
Litsea floribunda	3	3	535.52	1.12
Litsea wightiana	58	45	31256	23.3
Maesa indica	3	3	314.18	1.08
Mallotus ferrugineus	3	3	427.64	1.1
Mastixia arborea	12	9	22884	8.08
Meliosma simplicifolia	6	6	1420.6	2.32

….Cont'd….

Appendix 7 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in plots of Aruvikkad shola forest.

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Mature trees (Cont'd)				
Meiogyne pannosa	6	6	836.12	2.2
Neolitsea fischeri	3	3	512.97	1.12
Neolitsea cassia	15	12	3875.6	5.28
Persea macrantha	12	12	9381.8	5.95
Phoebe lanceolata	64	45	39381	25.8
Saprosma foetens	6	6	1852.6	2.41
Schefflera racemosa	6	3	5661.6	2.59
Symplocos cochinchinensis	9	9	1071.8	3.27
Syzygium densiflorum	42	36	61554	25.4
Unknown-2	3	3	1590.6	1.34
Unknown-3	3	3	350.06	1.09
Vernonia arborea	15	15	37776	12.7
Viburnum coriaceum	3	3	680.97	1.15
Viburnum punctatum	3	3	1024.2	1.22
Saplings				
Actinodaphne bourdillonii	25	22	501.75	14.6
Alseodaphne semecarpifolia	22	16	522.75	12.3
Beilschmiedia bourdillonii	9	9	200.25	5.88
Beilschmiedia wightii	9	9	115.25	5.39
Canthium dicoccum	19	19	572.25	12.8
Casearia coriacea	9	6	195.5	4.98
Cinnamomum sp.	3	3	42.25	1.82
Cinnamomum sulphuratum	6	6	199.25	4.3
Cinnamomum wightii	16	13	429.75	9.47
Clerodendrum viscosum	103	56	8319	86.6
Elaeocarpus munronii	6	6	277	4.74
Eurya nitida	6	3	233	3.61
Garcinia cowa	6	3	250	3.71
Gomphandra coriacea	19	19	760.75	13.8

….Cont'd….

Appendix 7 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in plots of Aruvikkad shola forest.

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Saplings (Cont'd)				
Hydnocarpus alpina	6	6	128	3.89
Litsea floribunda	3	3	36	1.78
Litsea wightiana	19	19	581.25	12.8
Maesa indica	28	13	671.5	13.7
Mallotus ferrugineus	3	3	64	1.94
Mastixia arborea	6	6	126.25	3.88
Meliosma simplicifolia	3	3	121	2.27
Miliusa indica	6	6	246.25	4.57
Neolitsea cassia	19	19	300	11.2
Persea macrantha	6	6	84.5	3.64
Phoebe lanceolata	44	38	1478.3	28.8
Rapanea wightiana	3	3	36	1.78
Saprosma foetens	22	22	454.75	13.7
Scolopia crenata	3	3	64	1.94
Symplocos cochinchinensis	3	3	81	2.04
Syzygium densiflorum	6	6	100	3.73
Unknown-1	3	3	64	1.94
Viburnum coriaceum	3	3	156.25	2.47
Seedlings				
Actinodaphne bourdillonii	1719	16	3437.5	16.3
Alseodaphne semecarpifolia	2813	20	3600	21.4
Beilschmiedia wightii	781	8	1562.5	7.66
Canthium dicoccum	1406	11	2812.5	12.7
Celtis tetrandra	469	5	337.5	3.57
Chionanthus linocieroides	469	3	937.5	4.05
Cinnamomum sulphuratum	1250	11	2500	11.7
Clerodendrum viscosum	469	5	1350	5.3
Elaeocarpus munronii	3594	28	7187.5	32.5
Eurya nitida	156	2	112.5	1.19

….Cont'd….

Appendix 7 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in plots of Aruvikkad shola forest.

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Seedlings (Cont'd)				
Garcinia cowa	625	3	800	4.26
Glochidion neilgherrense	156	2	200	1.34
Gomphandra coriacea	2500	22	5000	23.4
Ilex wightiana	781	5	1562.5	6.56
Isonandra lanceolata	938	8	675	6.59
Litsea wightiana	3594	33	2587.5	26.3
Macaranga indica	313	2	900	2.99
Maesa indica	313	3	625	3.06
Mallotus philippensis	156	2	312.5	1.53
Mastixia arborea	2031	8	4062.5	15.5
Meliosma simplicifolia	625	6	1250	6.13
Meiogyne pannosa	469	5	937.5	4.59
Neolitsea cassia	1563	14	3125	14.8
Persea macrantha	469	3	337.5	3.02
Phoebe lanceolata	1875	19	2400	16.1
Rapanea wightiana	625	5	1250	5.58
Saprosma foetens	313	3	900	3.53
Scolopia crenata	469	5	337.5	3.57
Symplocos cochinchinensis	781	8	2250	8.83
Syzygium densiflora	2031	17	4062.5	18.8
Viburnum coriaceum	156	2	50	1.08
Viburnum punctatum	781	6	1000	6.15
Shrubs and herbs				
Achyranthes bidentata	3750	16	1200	6.32
Ageratum conizoides	313	2	100	0.58
Alstonia venenata	469	3	600	1.37
Sinarundinaria densiflora	469	2	600	1.07
Bulbostylis densa	1719	8	550	3.02
Calanthe masuca	313	3	100	0.88

….Cont'd….

Appendix 7 (Cont'd). Density (individuals ha^{-1}), % frequency, basal area (cm^2ha^{-1}) and importance value index (IVI) of mature trees (gbh $\geq$ 30.1 cm), saplings (gbh 10.1 cm to 30.0 cm), seedlings (girth $\leq$ 10.0 cm and height $\leq$ 1 m) and shrubs and herbs in plots of Aruvikkad shola forest.

	Density (ha^{-1})	% Frequency	Total Basal area (cm^2ha^{-1})	IVI
Shurbs and herbs (Cont'd)				
Carex sp.	3906	20	312.5	6.62
Cestrum aurantiacum	1563	9	6125	7.62
Cipedessa baccifera	469	3	600	1.37
Cocculus laurifolius	2188	19	6300	9.95
Coleus malabaricus	15313	47	4900	22.6
Elatostema lineolatum	17188	47	5500	24.2
Girardinia diversifolia	4063	8	8125	10.5
Gloriosa superba	313	2	100	0.58
Hydrocotyle javanica	625	5	50	1.33
Impatiens balsamina	2031	9	650	3.6
Impatiens sp.	469	3	150	1.02
Laportea bulbifera	15469	52	4950	23.6
Lasianthus accuminatus	781	5	3062.5	3.81
Leptochilus decurrens	2500	13	450	4.34
Oplismenus sp.	8125	33	650	12
Phyllanthus amarus	156	2	12.5	0.41
Piper mollusa	7969	50	2550	16.7
Asplenium nidus	938	2	168.75	1.03
Pteris argyraea	625	2	200	0.85
Pteris quadriaurita	3125	27	1000	7.86
Sarcococca coriacea	625	5	1250	2.28
Senecio sp.	938	9	300	2.63
Spatholobus parviflorus	625	6	200	1.75
Strobilanthes asperima	2344	6	3000	5.05
Strobilanthes homotropa	53594	84	68600	104
Strobilanthes micrantha	1250	5	1600	2.95
Toddalia asiatica	1875	13	2400	5.48
Vigna trilobata	1250	6	400	2.31

Appendix 8. Girth class distribution of trees in the disturbed areas of the Aruvikkad shola.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Abarema subcoriacea	167	0	0	0	0	0	0	0
Acronychia pedunculata	0	0	0	3	0	0	0	0
Actinodaphne bourdillonii	1719	25	12	0	3	3	0	0
Alseodaphne semecarpifolia	2813	22	24	6	3	9	0	6
Beilschmiedia wightii	781	9	3	0	3	0	3	0
Beilschmiedia bourdillonii	0	9	0	0	0	0	0	0
Canarium strictum	0	0	0	0	0	0	0	3
Canthium dicoccum	1406	19	12	3	0	0	6	6
Casearia coriacea	0	9	0	0	0	0	0	0
Celtis tetrandra	469	0	6	0	0	0	0	0
Chionanthus linocieroides	469	0	0	0	0	0	0	0
Cinnamomum sp.	0	3	3	0	0	0	0	0
Cinnamomum sulphuratum	1250	6	0	0	0	0	0	0
Cinnamomum wightii	0	16	27	0	0	3	3	3
Clerodendrum viscosum	469	103	94	21	3	0	0	0
Debregeasia velutina	0	0	3	0	0	0	0	0
Elaeocarpus recurvatus	0	0	3	3	0	0	0	0
Elaeocarpus munronii	3594	6	0	0	0	0	0	3
Elaeocarpus tuberculatus	0	0	6	6	12	6	3	0
Eurya nitida	156	6	12	0	0	0	0	0
Garcinia cowa	625	6	12	0	0	0	0	0
Glochidion neilgherrense	156	0	0	0	0	0	0	0
Gomphandra coriacea	2500	19	15	18	6	0	0	0
Grewia tiliifolia	0	0	3	0	0	0	0	0
Hydnocarpus alpina	0	6	6	0	0	0	0	0
Ilex wightiana	781	0	9	0	0	0	0	0
Isonandra lanceolata	938	0	0	0	0	6	0	0
Isonandra stocksii	0	0	3	3	3	0	0	0
Litsea floribunda	0	3	3	0	0	0	0	0
Litsea wightiana	3594	19	15	24	15	3	0	0
Macaranga indica	313	0	0	0	0	0	0	0

….Cont'd….

Appendix 8 (Cont'd). Girth class distribution of trees in the disturbed areas of the Aruvikkad shola.

Species	Girth Classes*							
	A	B	C	D	E	F	G	H
	Number of individuals (ha^{-1})							
Maesa indica	313	28	3	0	0	0	0	0
Mallotus ferrugineus	156	3	3	0	0	0	0	0
Mastixia arborea	2031	6	0	3	3	3	0	3
Meiogyne pannosa	469	0	6	0	0	0	0	0
Meliosma simplicifolia	625	3	3	3	0	0	0	0
Miliusa indica	0	6	0	0	0	0	0	0
Neolitsea fischeri	0	0	3	0	0	0	0	0
Neolitsea cassia	1563	19	9	6	0	0	0	0
Persea macrantha	469	6	3	3	3	3	0	0
Phoebe lanceolata	1875	44	21	18	15	3	6	0
Rapanea wightiana	625	3	0	0	0	0	0	0
Saprosma foetens	313	22	3	3	0	0	0	0
Schefflera racemosa	0	0	0	3	0	3	0	0
Scolopia crenata	469	3	0	0	0	0	0	0
Symplocos cochinchinensis	781	3	9	0	0	0	0	0
Syzygium densiflorum	2031	6	12	12	6	9	0	3
Unknown-1	0	3	0	0	0	0	0	0
Unknown-2	0	0	0	3	0	0	0	0
Unknown-3	0	0	3	0	0	0	0	0
Vernonia arborea	0	0	0	0	3	3	6	3
Viburnum coriacea	156	3	3	0	0	0	0	0
Viburnum punctatum	781	0	0	3	0	0	0	0
	34688	447	355	145	79	55	27	30

* Size classes: A-Seedlings (girth <10.0 cm, height <1 m), B-Saplings (gbh 10.1 to30.0 cm) and C to H- Mature trees, gbh 30.1-60.0, 60.1-90.0, 90.1-120.0, 120.1-150.0, 150.1-180.0 and >180.1 cm respectively.

Plate 1. View of Mannavan shola, the largest shola forest patch in Kerala.

Plate 2. Disturbed area of Mannavan shola.

Plate 3

Plate 4

Plates 3 and 4. Disturbed part of Mannavan shola invaded by an exotic tree *Acacia dealbata.*

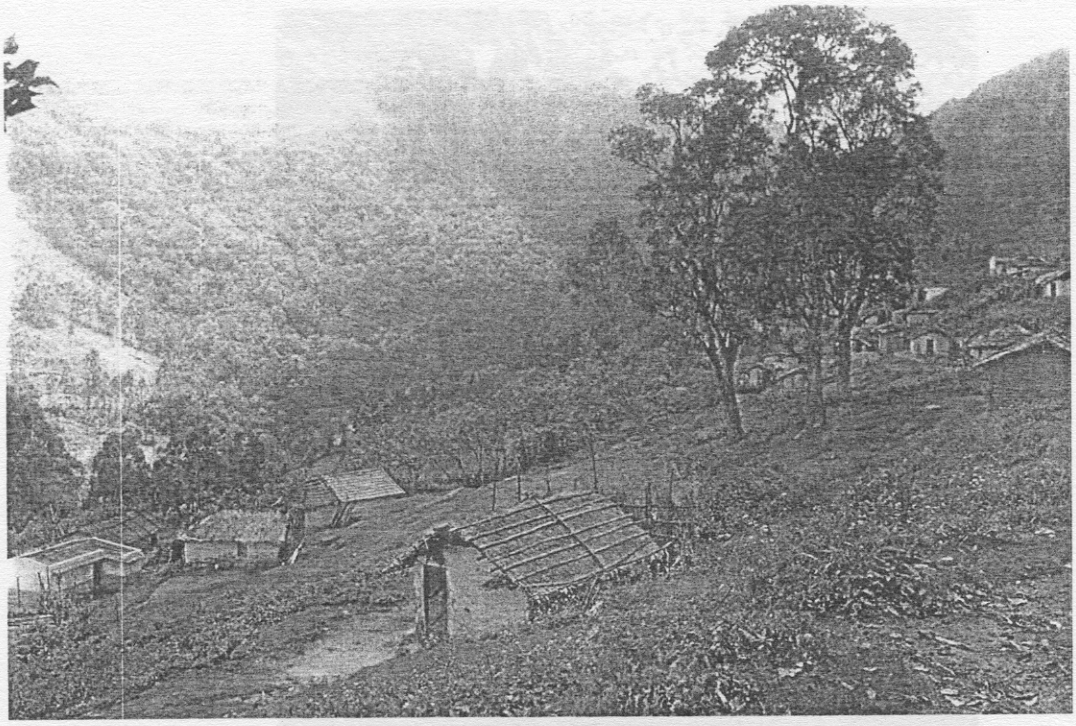

Plate 5. Settlement of Muthuva tribe at Goodallarkudi near Pullaradi shola.

Plate 6. Lemongrass cultivation area with a distillation unit near to the Pullaradi shola. Firewood required for distillation is collected from the shola.

Plate 7. Manthan shola

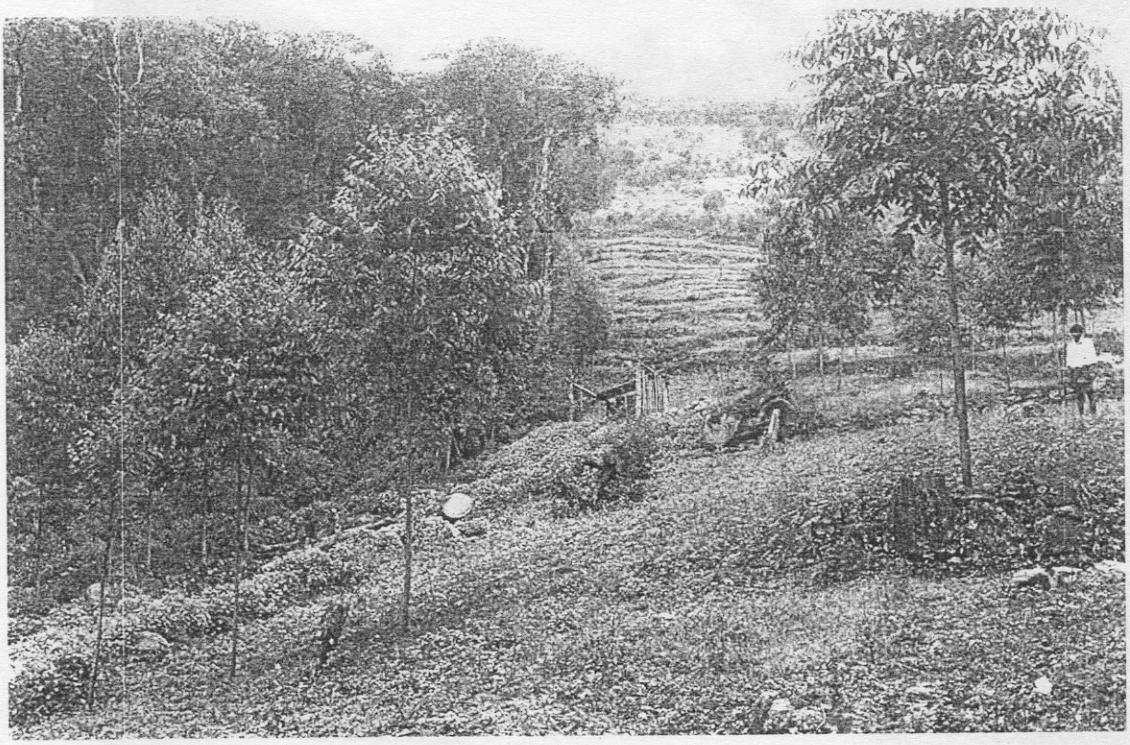

Plate 8. Part of Manthan shola disturbed by lemongrass cultivation and encroachment.

Plate 9. Aruvikkad shola adjacent to a tea estate.

Plate 10. Tea Estate workers residing near Aruvikkad shola are supplied with firewood (Eucalyptus) by the Estate Management.

Plate 11. Disturbed part of a shola forest from where firewood is collected even by branch and small wood cutting.

Plate 12. A part of shola forest being encroached for cultivation and other landuses.

Plate 13. *Cyathea (*tree fern) is collected intensively by local people from shola forests. Roads passing through shola forests are also responsible for disturbance.

Plate 14. Wattle plantations located near Mannavan shola and Pullaradi shola are helping in reducing the pressure on these forests for firewood.