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# Forests and agricultural ecosystem analysis to assess ecosystem health and to identify rehabilitation strategies in the Kerala part of Nilgiri Biosphere Reserve

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# Abstract of Project Proposal

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| Project Number | KFRI RP 455/2004 |
| Title | Forests and agricultural ecosystem analysis to assess ecosystem health and identify rehabilitation strategies in the Kerala part of Nilgiri Biosphere Reserve |
| Objectives | a. To assess the ecological and socio-economic features of agricultural practices in forest-adjacent villages/tribal settlements in the Kerala part of Nilgiri Biosphere and evolve appropriate strategies for their sustainable management.<br>b. To analyse the impact of different agricultural practices on the adjacent natural forests in terms of their vegetation structure, species composition, regeneration patterns and overall ecosystem health.<br>C. To identify suitable rehabilitation strategies for the forests affected by different cropping practices in the region. |
| Project period | May 2004 to May 2007 |
| Funding Agency | Ministry of Environment and Forests, Government of India |
| Principal Investigator | Dr. U.M. Chandrashekara |

# CONTENTS

# 1. ABSTRACT

The Nilgiri Biosphere Reserve (NBR) is the first Biosphere Reserve of India constituted under the Biosphere Reserve Programme. This Biosphere Reserve with an area of 5520 $km^2$, encompassing parts of the states of Kerala, Karnataka and Tamil Nadu forms an almost complete ring around the Nilgiri plateau in southwest portion of the Western Ghats. The Kerala part of NBR covering an area of 1455 $km^2$ is rich in biological diversity due to the presence of a wide range of biophysical and climatic conditions. However, like any other protected areas, the NBR is also facing the threat of forest degradation and natural resource depletion at a landscape level, particularly in village-fringe forests. The present study was conducted to analyse the vegetation structure and composition in village-adjacent forests and in the relatively undisturbed forests of the Biosphere Reserve and also to determine the causes and level of disturbance in the village-adjacent forests. The study was also aimed to assess the changes in cropping patterns in the villages and their impact on forest resource flow into the village landscape units. Based on the results obtained, the study also aimed to identify the forest rehabilitation strategies.

In the relatively undisturbed forests, plots were dominated by primary tree species characteristic to typical evergreen forests of the region. The girth class distribution of tree community, showing a negative logarithmic trend with clear preponderance of trees of smaller girth classes, indicated better regeneration of tree community in all undisturbed forest plots. The maximum value obtained in these plots for the Ramakrishnan Index of Stand Quality (RISQ) was 1.42 which also confirmed that the plots represent undisturbed stands.

The village-adjacent forest plots were secondary forests and experiencing different levels of disturbance. In these forest plots, litter collection and other anthropogenic disturbances have reduced the number of species in the seedling community. The litter removal from the forest floor depicted a tri-fold effect on species richness; by way of physical removal of tree propagules along with other litter materials, run-off of tree propagules in the absence of litter layer and seedling mortality consequent to soil dryness and desiccation. However, in the forest plots adjacent to villages like Kadasseri and Manikunnmala, the species number increased due to invasion of exotic species from the adjoining landuse systems. In general, the tree density in village-

adjacent forest plots was significantly lesser than that in the undisturbed forest plots. Collection of poles and fuel wood has been identified as the major causative for such a decline in tree density in the forest plots. Contrarily, in the forest plot near a village Munnadi, the tree density was more than that in the undisturbed forest plots due to high reproductive ability (through root suckers, coppice and seeds) of the dominant species such as *Xylia xylocarpa* and *Terminalia paniculata*. In some forest plots, the decline in tree density did not reduce the total basal area due to the occurrence of coppiced shoots and trees belonging to larger girth classes. Over-dominance of deciduous trees or heliophytic evergreen trees, inability of shade- tolerant evergreen species to establish and also frequent harvest of biomass of certain selected species are responsible for the low species diversity in majority of the village-adjacent forest plots. In these plots, a distorted girth class distribution curve, with a drastic decline in the number of individuals of girth ranging from 20 cm to 60 cm was noticed because they are generally harvested for using as poles and small timber. Thus, it is clear that invariably the village-adjacent forests are in disturbed status and the current challenge is to quantify the rate and degree of disturbance and habitat change to enable the stakeholders and managers of forest to plan rationally on appropriate measures of conservation and management. Therefore, three forest quality indicators- two based on vegetation parameters (Ramakrishnan Index of Stand Quality: RISQ and Index of Ecological Quality: IEQ) and one human disturbance indicator (Index of Human disturbance: IHD) were measured. A positive correlation between any two forest quality indicators suggested that they are complementary to each other and helpful to accurately assess ecological and human factors responsible for the status of the forest stand. The high value for RISQ (more than 3) is indicative of the fact that majority of the forest plots are under different stages of succession and need more time for their recovery from the anthropogenic disturbances.

Landuse and land-cover in the villages adjacent to 10 forest plots were analysed with a view to understand their impact on the forest plots. The area under agriculture ranged from 65 to 81 per cent of the total village area, dominated by farms of coconut, arecanut and rubber. Paddy cultivation, once prevalent in all ten villages is now seen in six villages only consequent to transformation of paddy fields into other landuse types. In all ten villages, fuel wood is the major source of energy for cooking. Quantity of fuel wood collected from the adjacent forest plot ranged from 3.9 to 18.9

kg $ha^{-1}$ of forest area. The litter collection from the forest floor recorded in the plot at Pattakarimba was found to be responsible for about 60% reduction in the standing litter biomass. The estimated quantity of fresh litter removed from the plot ranged from 4,440 kg to 12,316 kg $ha^{-1}$ $month^{-1}$, which was significantly more during February-March, coinciding with the summer mulching in crop lands. On an average, about 1,000 kg of free seeds/fruits $ha^{-1}$ were also removed from the forest floor in four months period and thus the tree seedling abundance in the litter collected plots was significantly low. The farming community in the village Punchavayal harvested green foliage from the adjacent forest plot with an estimated quantity of 11,720 kg $ha^{-1}$ $yr^{-1}$. In all the ten villages, livestock is an integral part of agriculture and grazing in forest plots is common with the number of Adult Cattle Units (ACUs) ranging from 3 to 78 individuals $day^{-1}$ $km^{-1}$. The forest plots at Pattakarimba and Punchavayal, where the grazing pressure by domestic animals is intense, also form the elephant corridors of the region. Therefore, low plant biomass in these plots reduces the fodder availability to elephants and other wild herbivores.

The above data indicated that despite prohibition, the resource collection in different forms, magnitude and frequency is continuing in the village-adjacent forest plots. The resultant ecological changes have profound effects on the forest species composition and structure. The precarious status of vegetation in the forest plots due to unsustainable harvest and utilisation of bioresources warrants strategic management plans on a site-by-site basis. Certain strategies and activities, i.e., reducing the forest dependence by the forest-adjacent communities, protecting forest lands and bioresources, improving human resources for managing forest plots and research and monitoring for improving forest quality have been put forth for conserving biodiversity in the village adjacent forest plots. For accelerating progressive succession in the forest plots, silvicultural practices such as, assisted natural regeneration and enrichment planting are to be adopted. Species suitable for such programmes are also listed. The need for a Village-Forest Committee, comprising of the representatives of all stakeholder groups, to each village-adjacent forest plot and a Village-Forest Committee Fund as a long-term measure to ensure continuous support for sustainable management of village-adjacent forests in the Nilgiri Biosphere Reserve has been highlighted here.

# 2. INTRODUCTION

The recognition of India recognition as one of the four mega-diversity countries of Asia is derived largely from two of its most important biodiversity 'hot spots' viz., the Himalaya including the north-eastern hills along the northern boarder and the Western Ghats in the peninsular India. During the last few decades in particular, India has accelerated its efforts to preserve this biodiversity. In this context, India has taken a positive step for biodiversity conservation by designating more than 4 per cent of the total land area of the country as Protected Areas (PAs) (IUCN, 1990). Some such areas were also brought under Biosphere Reserves. The Biosphere Reserve programme, initiated in early 1970's as an outgrowth of the Man and Biosphere programme (MAB) by UNESCO, aimed to generate alternative models of sustainable development wherever the current models are destructive of ecological processes and natural diversity. Thus, in India also several Biosphere Reserves have been established and some of the PAs formed part of these Biosphere Reserves.

Like in other parts of the developing countries, the population pressure around the forest lands is high both by forest dwelling tribal societies and by the inhabitants adjacent to forests (CES, 1990). The problem of human population is accentuated by the livestock population. In addition, very often changing pattern of man-made landuse system also exerts pressure on forest and associated biodiversity (Sankar and Muraleedharan, 1990). Since, the driving force behind these disturbances and degradation of forest systems is from human activities, it is also possible to distinguish proximate and underlying causes for degradation. In general, over-exploitation may be identified as proximate cause, while economic, socio-political and cultural factors may also be the underlying ones (Barbier *et al.*, 1994; Heywood and Watson, 1995). However, there is no consensus among the social scientists regarding which underlying factors are contributing more to the degradation of forests. For instance, some social scientists argue that recent population pressure and expanding markets are responsible for large-scale degradation of forests (Black, 1990; Browder, 1989). On the other hand, some others argue that it is the consequences of economic pressure of poverty and under development that have forced the rural population to adopt the 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 the social system of resource use (Gadgil, 1989). For instance, in the case of shola forests in Kerala, degradation was closely linked with population increase and changes in resource use (Chandrashekara *et al*., 2001).

Forest resource–based conflicts are often a product of wrong or unclear natural resource policies and unresolved socio-economic problems. A transferal in resource use, from subsistence to commercial levels results in the degradation of the forest landscape. Biodiversity loss and scarcity of resources coupled with population explosion aggravates the resource use crisis. Here, the intervention by the government to protect and conserve the resources results in a series of conflicting situations since no alternative livelihood strategies are available for the primary stakeholders (Gadgil, 1989). Local communities see these efforts as government imposed restrictions on their socio- economic systems, which affect their livelihood. These conflicts generate new kinds of management issues resulting in a total value loss of the forest ecosystem, having serious repercussions in the long run.

Natural resource management is a human activity. There is more and more evidence that if forestry is to play a key role in sustainable development, forest-dependent communities must be fully involved in both decision–making process and concrete actions concerning the land and resources they inhabit and use. The entire concept is to remove potential threats of deforestation and manage areas so as to minimize human impacts and develop sustainable management system for both village/tribal landscape and forest landscape units. This is possible only when detailed information on characteristic features of landuse pattern around the forest patches, quality and quantity of biomass flow from forest and inter-linkages between changing landscape structure and resource flow on forest structure, composition and overall health are available. Thus, a case study, aiming to assess the current conditions of the forest patches in the Kerala part of Nilgiri Biosphere Reserve and the ability of the ecosystem to recover and maintain system process and biodiversity was conducted. The purpose of the study was also to identify cases where rehabilitation is necessary, and suggest most appropriate methods available, including the species, which play a key role in the rehabilitation process.

# 3. OBJECTIVES

The specific objectives of the project were the following:

- To assess the ecological and socio-economic features of agricultural practices in forest-adjacent villages/tribal settlements in the Kerala part of Nilgiri Biosphere and evolve appropriate strategies for their sustainable management.
- To analyse the impact of different agricultural practices on the adjacent natural forests in terms of their vegetation structure, species composition, regeneration patterns and overall ecosystem health.
- To identify suitable rehabilitation strategies for the forests affected by different cropping practices in the region.

# 4. METHODOLOGY

### A. Selection of study area

The area under Kerala part of Nilgiri Biosphere Reserve (latitude 10$^{o}$50' and 12$^{o}$16'N and longitudes 76$^{o}$ and 77$^{o}$15'E), has been divided into five parts at an interval of 12' latitude. In each latitude range, two to three plots were marked to represent a gradient of altitude. In each of these fifteen plots, one forest patch was selected. In ten plots, forest patches which have a clear forest demarcation boundary and located adjacent to a village and/ or a tribal settlement were selected. However, in the remaining five plots, forest patches which do not have any history of human disturbances were selected. Thus, a total fifteen plots, located in the Wayanad Wildlife Sanctuary, Nilambur Reserve Forest and New Amarambalam Reserve Forest were selected for the study (Table 1, Figure 1).

Table 1. Forest plots established in the Kerala part of NBR for vegetation studies.

| Relatively undisturbed plots | | |
|---|---|---|
| Location | Plot Code | Altitude (m) |
| Nadukani | UF1 | 551 |
| Adakkahode | UF2 | 247 |
| Vaniampuzha | UF3 | 312 |
| Vaniampuzha-2 | UF4 | 415 |
| Chandanathode | UF5 | 849 |

| Village-adjacent forest plots | | |
|---|---|---|
| Location | Plot Code | Altitude (m) |
| Manaliampadam | H1 | 359 |
| Munnadi | H2 | 107 |
| Adackakundu | H3 | 524 |
| Parackal | H4 | 130 |
| Pattakarimba | H5 | 98 |
| Vellimuttam | H6 | 108 |
| Punchavayal | H7 | 145 |
| Appencappu | H8 | 106 |
| Kadasseri | H9 | 778 |
| Manikunnumala | H10 | 778 |


Figure 1. Location of plots established in the Kerala part of Nilgiri Biosphere Reserve.

## B. Vegetation Analysis

In each forest patch, five transects, each of 1 km length were laid. While laying transects, a minimum of 200m distance was maintained between two adjacent transects. In the village/tribal settlement-adjacent forest plots, transects were laid from the boundary between the forest and village/ settlement to the interior of the forest. In each transect, six quadrats, each of 20 m x 20 m size were established. Here also 200 m distance between two quadrats was maintained in order to avoid auto-correlation. The size of the quadrat was determined based on species-area curve. All trees (individuals with gbh more than 10.1cm; gbh: girth at 1.37m above ground) in each quadrat were marked and their taxonomic identification ascertained. Number of individuals and girth of each individual of a species were recorded. In the case of trees with large buttresses, the girth was measured from above the buttressed part. In each quadrat, one 5m x 5 m sub-quadrat was laid to study the seedling (individuals with 1.0 to 10.0 cm, height ≤1 m) community.

The vegetation data were analyzed for relative density, relative frequency, relative dominance (Phillips, 1959) and the sum of values for these parameters represented by Importance Value Index (IVI) for different species (Curtis, 1959). Species diversity was calculated using a formula given by Shannon and Wiener (1963). The index of community dominance (C) was calculated by Simpson's index (Simpson, 1949).

### C. Determination of the level of disturbance and stand quality of village-adjacent forest plots

The village-adjacent natural forest may be primary or secondary and may be experiencing different levels of disturbance. Thus, three indices namely Ramakrishnan Index of Stand Quality (RISQ), Index of human disturbance (IHD) and Index of ecological quality (IEQ) were calculated to compare the intensity of disturbances in the plots. The RISQ was calculated by following the method given by Chandrashekara (1998). Considering the life history patterns, tree species can be categorised into primary species (shade tolerant evergreen species), late secondary species (evergreen species which regenerate under medium sized canopy gaps), early secondary species (evergreen heliophytic species which regenerate in large canopy gaps or open area) and deciduous species. The pioneer index value assigned to primary species, late secondary species, early secondary species and deciduous species (and also introduced species) was 1, 2, 3 and 4 respectively. Contribution of each category of species to the total IVI was multiplied by its pioneer index value. Sum of the values obtained for four categories of species was the RISQ.

$$\text{RISQ} = \sum\{(n_1/N)\} \text{ X species pioneer index}$$

Where $n_1$ = IVI of a given category of species, N= Total IVI of species of all category and species pioneer index 1, 2, 3, and 4 for primary species, late secondary species, early secondary species and deciduous species respectively. RISQ value of a given plot can vary from 1.0 (undisturbed stand) to 4.0 (highly disturbed stand).

For calculating the IHD, all visible indicators of human disturbance in each quadrat were counted, and recorded on field data sheets. The indicators (parameters) of human disturbance in the present study included a) number of larger stumps of harvested trees (>20 cm gbh), b) number of pollarded stumps (<20 cm gbh), c) number of coppiced stumps, d) number of branch cuttings, e) number of stem debarked, f) number of vehicle tracks, and g) number of foot paths. The formulae given by Mutangah (1996) were used to calculate the IHD.

Individual parameter index value, Y = C/C max --------- (1)

where, C is parameter value in a given plot, C max is the maximum parameter value recorded.

Index of Human Disturbance Value (IHD) = (∑Y)/ N) x 100 --------- (2)

where, N= number of parameters studied.

The parameters selected for calculating the IEQ were - a) percentage of canopy opening, b) canopy area covered by lianas (in percentage of total canopy area), and c) ground area (in percentage of total area of the plot) covered by i) the grasses, ii) native weeds, iii) exotic weeds. Above mentioned equations were also used for determining the Index of Ecological Quality (IEQ) values.

### D. Analysis of landuse systems in villages

Landscape units adjacent to the selected buffer zone forest patches within 1 km range were identified and the landuse system recorded. Five transects each of 1km length were laid. In each transect, the landuse system seen at every 200 m distance was selected and the owners of the farmland were interviewed for deriving the linkages between the given landuse system and the adjacent forest patch. The questionnaire survey was also carried out to record the changes in the landuse pattern during the last 20 years (since the establishment of the Biosphere Reserve) and variation in the dependency on forests for various resource required for the crop production and land management. In addition to the questionnaire survey made by transect walk, elderly peoples' survey (senior citizen survey) was also carried out for gathering information. Secondary data on villages adjacent to the buffer zone were collected from various government departments.

### E. Resource flow analysis

At regular intervals, field surveys were conducted to quantify the amount of biomass harvested and transported from the forest plots to adjacent villages/tribal settlements.

#### i. Fuel wood collection

The quantification of fuel wood was based on the headload counting method. The data were collected by counting the headloads of fuelwood at different paths (foot path survey) through which the people traversed the forest patches in order to collect the fuelwood. The entry paths distributed in all four directions were selected randomly. The total number of entry paths selected ranged from 4 to 12 per plot, depending on the frequency and extent of fuel wood collection. After counting the headload, average weight of headload was also quantified. Based on the survey conducted for 3-4 days in a month for one-year period, quantity of fuel wood collected from each forest plot every month was estimated.

**ii. Livestock grazing**

The data on livestock grazing pressure were collected in two steps. The first step involved the collection of information from the secondary sources on the population size of livestock from the village which grazed in the forest plot. The second step involved field studies to identify grazing sites and counting actual number of livestock grazing in the plot. This exercise was carried out 3-4 days in each month for one-year period. The livestock density was calculated by converting all the livestock species into one common unit –Adult Cattle Unit (ACU) and density was expressed in terms of ACU per $km^2$.

**iii. Green manure collection**

Primary data on green manure collection were generated through questionnaire survey. Since collection is done prior to the post-monsoon season, following the foot-path survey method, headloads of green manure were counted for three to four days per month during the period from July to September. Based on the average weight of a head load of green manure, the quantity of green manure collected and transported from each forest plot was calculated.

**iv. Litter collection**

Based on field observations and PRA techniques, the forest patch was divided into two plots; namely litter collecting and non-collecting plots. In each plot, a sub-plot of 2.5 ha in size was demarked. A distance of one kilometer was maintained between litter collecting and non-collecting plots was maintained. In each sub-plot, eight quadrats, each of 5 m x 5m size were laid. Litter accumulated in each quadrat was collected and segregated into leaves, seeds/fruits and deadwood during February-March, the peak season of intensive litter collection by farmers for mulching their crops. After air-drying for a constant weight, total weight of each segregated component was recorded. Thus, the standing litter in the litter-collecting and non-collecting plots was quantified.

For quantifying the litter removed from the forest floor, the total area of the litter collecting site was calculated. Since litter collection is done from January to May, the quantification of litter removal was done for the same period. In the study site, different paths through which people traverse to collect litter were identified. The footpath survey was conducted throughout the season to count the number of headloads of litter filled sacks carried by the collectors. About 10 per cent of total number of litter sacks was weighed separately. Furthermore, every month about 10 sacks of litter were purchased from the collectors and components in each sack were segregated into leaves seeds/fruits and deadwood and the air dry weight was recorded.

To estimate the tree seedling density in the litter-collecting plot and control (where the litter is not collected) plot, twelve quadrats each of size 5m x 5m were laid. Using bamboo/wooden stakes, the boundary of each quadrat was raised to about 15 cm from the ground level. Number of tree seedlings recruited each month was counted for one year period starting from January 2005. All the established seedlings in a given month were marked in the subsequent month. These marked seedlings were monitored for their establishment.

# 5. RESULTS AND DISCUSSION

## A. Vegetation structure and composition in forest plots

Vegetation structure, species composition and ecosystem processes have been identified as essential components for long term persistence of an ecosystem (Dorren *et al.,* 2004). Measures of vegetation structure provide information on habitat conditions and ecosystem productivity and help to predict successional pathways. In fact, a comparative account of vegetation structure and composition also provides information on differences in types, severity and impacts of disturbance in any two forest patches (Davis and Mortiz, 2001). For instance, compared to natural disturbances, man-made disturbances in a forest ecosystem could severely alter the vegetation structure and composition (Chandrashekara and Ramakrishnan, 1994). In this context, studies conducted on vegetation structure and composition in the forest patches located adjacent to the human habitation and in the relatively undisturbed forests in the Kerala part of NBR has special relevance. In terms of dominant species composition, forest patches bordering the human habitation are distinct from those in the undisturbed forests of the Biosphere Reserve. For example, in the undisturbed plots, evergreen species like *Knema attenuata, Myristica malabarica, Syzygium densiflorum, Baccaurea courtallensis, Diospyors bourdillonii, Cullenia exarillata, Syzygium munronii* etc. are dominant (Table 2).

Table 2. Dominant tree species in seedling (gbh<10 cm; height <1.0 m) and tree (gbh>10.1 cm) phase in plots established in the relatively undisturbed forests of the Kerala part of NBR.

| Plot name and code | Dominant tree species | |
|---|---|---|
| | Seedlings | Trees |
| Nadukani (UF1) | *Knema attenuata*<br>*Diospyros bourdillonii*<br>*Aglaia lawii*<br>*Vateria indica*<br>*Myristica malabarica* | *Knema attenuata*<br>*Myristica malabarica*<br>*Hopea racophloea*<br>*Vateria indica*<br>*Fahrenheitia zeylanica* |
| Adakkahode (UF2) | *Leptonychia caudata*<br>*Hydnocarpus pentandra*<br>*Nothopegia racemosa*<br>*Mesua ferrea*<br>*Prunus ceylanica* | *Syzygium densiflorum*<br>*Cyathocalyx zeylanica*<br>*Nothopegia racemosa*<br>*Leptonychia caudata*<br>*Hydnocarpus pentandra* |
| Vaniampuzha (UF3) | *Baccaurea courtalensis*<br>*Actinodaphne angustifolia*<br>*Aglaia lawii*<br>*Knema attenuata*<br>*Cinnamomum malabatrum* | *Diospyros bourdillonii*<br>*Polyalthia fragrans*<br>*Otonephlium stipulaceum*<br>*Baccaurea courtallensis*<br>*Knema attenuata* |
| Vaniampuzha-2 (UF4) | *Holigrana arnottiana*<br>*Garcinia gummi-gutta*<br>*Dimocarpus longan*<br>*Alseodaphne semecarpifolia*<br>*Tabernaemontana heyneana* | *Diospyros bourdillonii*<br>*Otonephelium stipulaceum*<br>*Drypetes elata*<br>*Knema attenuata*<br>*Polyalthia fragrans* |
| Chandanathode (UF5) | *Syzygium munronii*<br>*Dimocarpus longan*<br>*Mesua ferrea*<br>*Litsea ghatica*<br>*Vateria indica* | *Cullenia exarillata*<br>*Otonephelium stipulaceum*<br>*Dimocarpus longan*<br>*Vateria indica*<br>*Mesua ferrea* |

In these plots, majority of the species were shade tolerant primary species of evergreen forests with a few representatives of evergreen light demanding late and early succesional species (Appendices 1 to 5). On the other hand, in plots bordering the human habitation, evergreen light demanding late and early successional species and deciduous species such as *Xylia xylocarpa, Terminalia paniculata, Macaranga peltata, Aglaia malabarica, Alseodaphne semecarpifolia, Bischofia javanica, Wrightia tinctoria* etc. were dominant (Table 3).

Table 3. Dominant tree species in seedling ((gbh<10 cm; height <1.0 m) and tree (gbh>10.1 cm) phase in forest plots located adjacent to the human habitation in the Kerala part of NBR.

| Plot name and code | Dominant tree species | |
|---|---|---|
| | Seedlings | Trees |
| Manaliampadam (H1) | *Xylia xylocarpa*<br>*Terminalia paniculata*<br>*Macaranga peltata*<br>*Wrightia tinctoria*<br>*Calycopteris floribunda* | *Xylia xylocarpa*<br>*Macaranga peltata*<br>*Terminalia paniculata*<br>*Acacia intsia*<br>*Calycopteris floribunda* |
| Munnadi (H2) | *Xylia xylocarpa*<br>*Terminalia paniculata*<br>*Acacia intsia*<br>*Calycopteris floribunda*<br>*Mallotus philippensis* | *Xylia xylocarpa*<br>*Terminalia paniculata*<br>*Macaranga peltata*<br>*Anacardium occidentale*<br>*Acacia intsia* |
| Adackakundu (H3) | *Aglaia malabarica*<br>*Alseodaphne semecarpifolia*<br>*Acronychia pedunculata*<br>*Cinnamomum malabatrum*<br>*Ardisia solanacea* | *Aglaia malabarica*<br>*Bischofia javanica*<br>*Myristica malabarica*<br>*Syzygium cuminii*<br>*Antiaris toxicaria* |
| Parackalel (H4) | *Xylia xylocarpa*<br>*Strychnos nux-vomica*<br>*Aporosa lindelyana*<br>*Schleichera oleosa*<br>*Mallotus philippensis* | *Terminalia paniculata*<br>*Xylia xylocarpa*<br>*Wrightia tinctoria*<br>*Grewia tiliaefolia*<br>*Stereospermum colais* |
| Pattakarimba (H5) | *Terminalia paniculata*<br>*Persea macrantha*<br>*Schleichera oleosa*<br>*Ardisia solanacea*<br>*Mallotus philippensis* | *Lagerstroemia speciosa*<br>*Hydnocarpus pentandra*<br>*Schleichera oleosa*<br>*Terminalia paniculata*<br>*Ardisia solanacea* |
| Vellimuttam (H6) | *Aglaia malabarica*<br>*Alseodaphne semecarpifolia*<br>*Acronychia pedunculata*<br>*Cinnamomum malabatrum*<br>*Ardisia solanacea* | *Aglaia malabarica*<br>*Bischofia javanica*<br>*Dimocarpus longan*<br>*Syzygium cuminii*<br>*Myristica malabarica* |
| Punchavayal (H7) | *Xylia xylocarpa*<br>*Terminalia paniculata*<br>*Helecteris isora*<br>*Holarrhena antidysenterica*<br>*Dalbergia latifolia* | *Xylia xylocarpa*<br>*Terminalia paniculata*<br>*Tectona grandis*<br>*Dalbergia latifolia*<br>*Calycopteris floribunda* |
| Appencappu (H8) | *Xylia xylocarpa*<br>*Terminalia paniculata*<br>*Macranga peltata*<br>*Aporosa lindelyana*<br>*Strychnos nux-vomica* | *Xylia xylocarpa*<br>*Terminalia paniculata*<br>*Trewia polycarpa*<br>*Wrightia tinctoria*<br>*Lagerstroemia microcarpa* |
| Kadasseri (H9) | *Aglaia malabarica*<br>*Myristica malabarica*<br>*Alseodaphne semecarpifolia*<br>*Palaquim ellipticum*<br>*Diospyros bourdillonii* | *Myristica malabarica*<br>*Aglaia malabarica*<br>*Dimocarpus longan*<br>*Knema attenuata*<br>*Syzygium laetum* |
| Manikunnumala (H10) | *Wrightia tinctoria*<br>*Dalbergia latifolia*<br>*Tabernaemontana heyneana*<br>*Gmelina arborea*<br>*Aporosa lindeyana* | *Dalbergia latifolia*<br>*Artocarpus hirsutus*<br>*Dalbergia latifolia*<br>*Ficus asperima*<br>*Mallotus tetracoccus* |

In general, contribution by the species characteristic to the relatively undisturbed evergreen forests to the total Importance Value Index of each forest plot was considerably less (Appendices 6 to 15). Inability of primary tree species of evergreen forests to establish in the plots bordering the human habituation indicates severity of biotic pressure in these plots. Similar observation has been made in a logged temperate forest of Sikkim, where due to logging, the light demanding species dominated the shade tolerant evergreen species (Sundriyal and Sharma, 1996).

In the wet evergreen forest of Nelliampathy, the dominance of *Macaranga peltata,* a light demanding evergreen species due to selective logging has been reported (Chandrashekara, 1991). However, not all forest plots near human habitation seem to be experiencing similar levels of disturbance. For instance, in the forest plot at Kadasseri (H9) better regeneration of shade tolerant evergreen species was observed. The reason for low disturbances in Kadasseri (H9) is its occurrence in a comparatively difficult terrain. It is a general notion that the tree-covered village landscapes lessen the anthropogenic pressure on forest plots (Duelli and Obrist, 2003). However, the present study did not support this view. Here, even plots adjacent to the tree-covered village landscape showed poor regeneration of species characteristic to evergreen forests.

Unrestricted and open accessibility may cause enhanced utilization of forest resource and this may eventually lead to a species-poor state (Vetaas,1993). For instance, in plots at Munnadi (H2), Pattakarimba (H5) and Punchavayal (H7), the number of tree species in the seedling phase was lesser than that in the undisturbed plots (Table 4). This could be due to frequent collection of litter from the forest floor of Pattakarimba (H5) and other anthropogenic disturbances.

According to Babu and Chandrashekara (2007), litter removal from forest floor has tri-fold effect on species-richness namely, physical removal of tree propagules while collecting litter, runoff of tree propagules due to the absence of the litter layer and seedling mortality due to soil dryness and desiccation. Even in the tree phase, number of species was generally less in forest patches bordering the village/tribal settlement than that in the undisturbed forest plots (Table 5).

Table 4. Basic information on vegetation with respect to tree seedling community (gbh <10.1cm) in village-adjacent forest plots and in the relatively undisturbed forest plots of the Kerala part of NBR.

| Plot name | No. of species | Density (number of plants $ha^{-1}$) | Basal area ($cm^2$ $ha^{-1}$) | RISQ value | Shannon's Index (H') | Simpson Index (C) |
|---|---|---|---|---|---|---|
| Relatively undisturbed forest plots | | | | | | |
| Nadukani (UF1) | 20 | 2175 | 4543.11 | 1.23 | 2.540 | 0.120 |
| Adakkahode (UF2) | 24 | 4463 | 11470.45 | 1.42 | 2.715 | 0.094 |
| Vaniampuzha (UF3) | 29 | 1080 | 2686.8 | 1.23 | 3.038 | 0.064 |
| Vaniampuzha-2 (UF4) | 25 | 2280 | 1446.99 | 1.34 | 3.026 | 0.059 |
| Chandanathode (UF5) | 26 | 2999 | 12127.7 | 1.19 | 2.887 | 0.075 |
| Village-adjacent forest plots | | | | | | |
| Manaliampadam (H1) | 30 | 2794 | 3108.28 | 3.69 | 3.018 | 0.085 |
| Munnadi (H2) | 16 | 2153 | 2483.81 | 3.78 | 2.473 | 0.111 |
| Adackakundu (H3) | 43 | 4687 | 7038.93 | 3.64 | 3.195 | 0.071 |
| Parackalel (H4) | 26 | 2294 | 4573.27 | 3.72 | 2.858 | 0.096 |
| Pattakarimba (H5) | 19 | 2063 | 3452.4 | 3.35 | 2.420 | 0.133 |
| Vellimuttam (H6) | 36 | 2973 | 5344.6 | 3.01 | 3.081 | 0.078 |
| Punchavayal (H7) | 13 | 2560 | 1855.06 | 3.95 | 2.360 | 0.109 |
| Appencappu (H8) | 21 | 3680 | 7301.2 | 3.15 | 2.598 | 0.102 |
| Kadasseri (H9) | 25 | 3099 | 6474.51 | 1.29 | 2.781 | 0.100 |
| Manikunnumala (H10) | 23 | 1896 | 3763.97 | 2.96 | 2.853 | 0.074 |

Table 5. Basic information on vegetation with respect to tree community (gbh >10.1cm) in village-adjacent forest plots and in the undisturbed forest plots of the Kerala part of NBR.

| Plot name | No. of species | Density (number of plants $ha^{-1}$) | Basal area ($m^2$ $ha^{-1}$) | RISQ value | Shannon's Index (H') | Simpson Index (C) |
|---|---|---|---|---|---|---|
| Relatively undistubed forest plots | | | | | | |
| Nadukani (UF1) | 63 | 1332 | 43.149 | 1.32 | 3.337 | 0.063 |
| Adakkahode (UF2) | 62 | 880 | 46.677 | 1.18 | 3.324 | 0.056 |
| Vaniampuzha (UF3) | 48 | 756 | 43.601 | 1.25 | 3.275 | 0.051 |
| Vaniampuzha-2 (UF4) | 48 | 750 | 38.582 | 1.23 | 3.226 | 0.060 |
| Chandanathode (UF5) | 69 | 1006 | 41.319 | 1.22 | 3.513 | 0.049 |
| Village-adjacent forest plots | | | | | | |
| Manaliampadam (H1) | 31 | 758 | 18.76 | 3.54 | 2.957 | 0.161 |
| Munnadi (H2) | 47 | 1427 | 22.32 | 3.86 | 3.268 | 0.064 |
| Adackakundu (H3) | 36 | 893 | 49.84 | 3.69 | 3.126 | 0.063 |
| Parackalel (H4) | 28 | 467 | 25.62 | 3.72 | 2.788 | 0.098 |
| Pattakarimba (H5) | 35 | 699 | 82.74 | 3.22 | 3.022 | 0.067 |
| Vellimuttam (H6) | 34 | 772 | 49.26 | 3.76 | 3.313 | 0.057 |
| Punchavayal (H7) | 39 | 1109 | 11.92 | 3.95 | 2.686 | 0.127 |
| Appencappu (H8) | 47 | 809.5 | 49.09 | 3.65 | 3.282 | 0.058 |
| Kadasseri (H9) | 84 | 1408 | 70.81 | 1.89 | 3.605 | 0.053 |
| Manikunnumala (H10) | 86 | 1870 | 89.69 | 2.75 | 4.082 | 0.022 |

Dominant plant composition also determines the species richness in a forest plot. For instance, profuse growth of *Bambusa bambos* in the plot at Punchavayal (H7**)** and *Xylia xylocarpa and Calicopteris floribunda* in plots like Manaliampadam (H1), Paracke1 (H4) and Munnadi (H2) is one of the contributors for less number of species in these plots.

There are evidences to indicate that even disturbance can enhance the species number in forest plot (Ohsawa *et al*., 1986). Occurrence of comparatively more number of species in plots at Kadasseri (H9**)** and Manikunnumala (H10**)** than in the plots at undisturbed forests could be due to better regeneration of evergreen and deciduous species. In the plot at Manikunnumala (H10), certain non-forest species such as *Grevillea robusta* and *Coffea arabica* were also noticed. It is reported that exotic species planted in nearby areas have invaded and altered species number and composition of shola forests of the Western Ghats (Kunhikrishnan, 2001). Thus, measurement of species richness of a forest is not enough for forest quality analysis.

In plots at Paracke1 (H4) and Pattakarimba (H5), tree density was considerably lower than in the undisturbed plots (Table 5). Collection of poles and fuel wood by the local people was identified as the major reason for such a decline in tree density. Grazing, browsing and trampling of seedlings were also the reasons for low seedling density and poor recruitment of seedlings to higher girth classes. Such negative impacts of biomass harvest and cattle grazing on regeneration of tree communities have been reported for subtropical pine forest of Northern India (Maikhuri *et al*., 2000), wet evergreen forests of northeast India (Bhuyan *et al.,* 2003) and deciduous forests of Biligiri Rangaswamy Temple Wildlife Sanctuary of Southern India (Aravind *et al*., 2001). However, the present study has enabled to identify another factor responsible for low tree density. In the forest plot at Pattakarimba (H5), litter collection from the forest floor was found to be responsible for poor regeneration of tree seedlings and loss or mortality of un-established seedlings. Contrary to this, in the plot at Munnadi (H2), tree density was more than that in the undisturbed plots. In this plot, *Xylia xylocarpa* and *Terminalia paniculata* are the dominant species. High reproductive ability like regeneration through root suckers, coppices and seeds was found to be responsible for the better recruitment into different girth classes.

Decline in tree density due to disturbance need not affect the total basal area in a forest patch. For instance, compared to the undisturbed plots, the plot at Pattakarimba (H5) had high basal area and low density of tree community (Table 5). This may be attributed to the fact that here a large number of coppiced shoots and also trees belonging to larger girth classes were present. It may also be pointed out here that the forest stands characterized by abundance of only adult trees and absence or very low population of seedlings and saplings are expected to face local extinction of some species in due course. In the plot at Munnadi (H2), despite comparatively high tree density, basal area was less due to selective logging in the past and pole collection in recent days. However, this plot maintained higher tree density due to coppiced shoots of some of the dominant tree species. In the plot at Punchavayal (H7), as compared to all other plots, basal area was significantly low due to absence or poor representation of tree species having coppicing ability. Similar observation was reported from a montane forest of Java (Smiet, 1992).

Measures of species diversity provide information on trophic structure necessary for ecosystem resilience (Nicols and Nicols, 2003). It has been widely believed that disturbances can alter species diversity in an ecosystem (Connell, 1978; Mackey and Currie, 2001). However, magnitude of change in species diversity is determined by disturbances, their intensity and frequency. In the present study, species diversity index values in the seedling phase in plots like Munnadi (H2), Pattakarimba (H5) and Punchavayal (H7) were considerably lower than that in plots established in the undisturbed forests of the Biosphere Reserve (Table 4). Similar observation was made in plots like Manaliampadam (H1), Adackakundu (H3), Parackel (H4), Pattakarimba (H5) and Punchavayal (H7) for the species diversity index values of the tree phase (Table 5). Two reasons have been identified for the low diversity value in these plots. In some of these plots, microclimate was harsh and conducive for the over-dominance of certain species that could withstand such situations and restrict the establishment of evergreen species. According to Pascal (1988), continuous disturbance in the low and midland forests of the Western Ghats could lead to the impoverishment of soil. Such forests are known for poor species diversity and over dominance of *Xylia xylocarpa*, a deciduous species. In some plots, over-harvest of selected species for fuel wood and poles can be attributed for comparatively low species diversity. Among the village-adjacent forest plots, those at Kadasseri (H9**)** and Manikunnumala (H10) showed a relatively high species diversity values both for mature tree and seedling phases. In these plots, occurrence of micro-sites suitable for the establishment of evergreen and deciduous species and absence of over dominance of any single species were responsible for high species diversity. Simpson index of dominance, which is a measure of dominance by a set of species in a forest patch, is usually negatively correlated with index of diversity as recorded in the present study. Thus, it is clear that when the disturbance is intense or more frequent only a few species can thrive well and suppress the diversity. On the other hand at intermediate level of disturbance, as observed in Kadasseri (H9**)** and Manikunnumala (H10), there is a balance between competitive exclusion and loss of competitive dominants; conditions favour the coexistence of competitive species and disturbance tolerant species (Mackey and Currie, 2001). Thus, comparatively high species diversity was recorded in these two plots.

Tree girth class distribution pattern in forest stands has been used as the indicator of forest stand quality. For instance, according to Richards (1952) a healthy forest stand will have a reversed J-shaped girth class distribution curve of trees with clear preponderance to lower girth classes. The tree girth class distribution curves obtained for plots located in the undisturbed forests of NBR followed this trend (Figure 2).

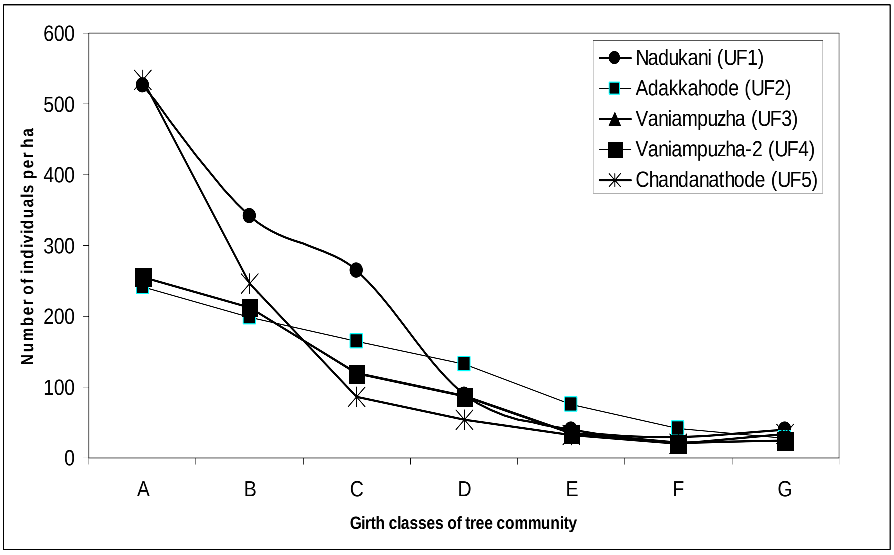


Figure 2. Girth class distribution of tree community of undisturbed plots established in the Kerala part of NBR. Girth classes: A=10.1-30cm, B =30.1-60cm, C=60.1-90 cm, D=90.1-120 cm, E =120.1-150 cm, F=150.1-180 cm and G= >180 cm gbh.

The forest plots located adjacent to the human habitation have distorted exponential girth class distribution curves. Careful analysis of girth class distribution patterns in these plots may provide some indication of disturbance history. For instance, in plots at Parackel (H4) and Pattakarimba (H5), trees belonging to the girth class 150.1 cm to 180.0 cm and >180.1 cm respectively were represented well (Figure 3) as compared trees belonging to lower girth classes. This may be due to the fact that prior to land acquisition by the Governement in 1950s, selection felling was conducted. During selective logging operations larger individuals of *Trewia polycarpa,* species of *Ficus* and also defective trees of *Terminalia paniculata* were not been harvested since their harvesting was not economical. Such trees are now contributing to the highest girth class in the forest patch. The past selective logging operations also led to the creation of more number of canopy open space of large sizes. Such canopy openings may lead to increase in number of individuals in the lower girth classes, as observed mainly in Vellimuttam (H6**)** and Punchavayal (H7), by providing favourable microclimate for light demanding evergreen, deciduous and invasive species.

In general, village-adjacent forest plots showed significantly less number of individuals of lower girth classes (Figures 2 and 3) as compared to undisturbed plots,. This may be either due to lack of seedling establishment or failure of established seedlings to grow under unfavourable microclimatic conditions prevailing in such plots or due to the over-dominance of some other tree species, as the case may be. Thus, it may be mentioned here that some of the plots like Adackakundu (H3), Parackel (H4), Pattakarimba (H5) are experienced intense disturbances where grazing, lopping and litter removal were frequent. Due to such intensive level of forest disturbance both plants and ecosystem were not getting adequate time for recovery. Similar observation was made in the Central Himalayan forests (Singh, 2005).

There are studies to indicate a drastic decline in the number of individuals, particularly in the girth class 20 cm - 60 cm, in different forests due to either legal or illegal harvest of poles by the local people (Nameer, 1993: Silori, 1996; Chandrashekara *et al*., 1998). Since harvesting is easy and the products can be used as poles, beams and agricultural implements, trees of 20 cm to 60 cm in girth are preferred (Dixit and Rajvanshi, 1998; Chandrashekara and Jayaraman, 2002).

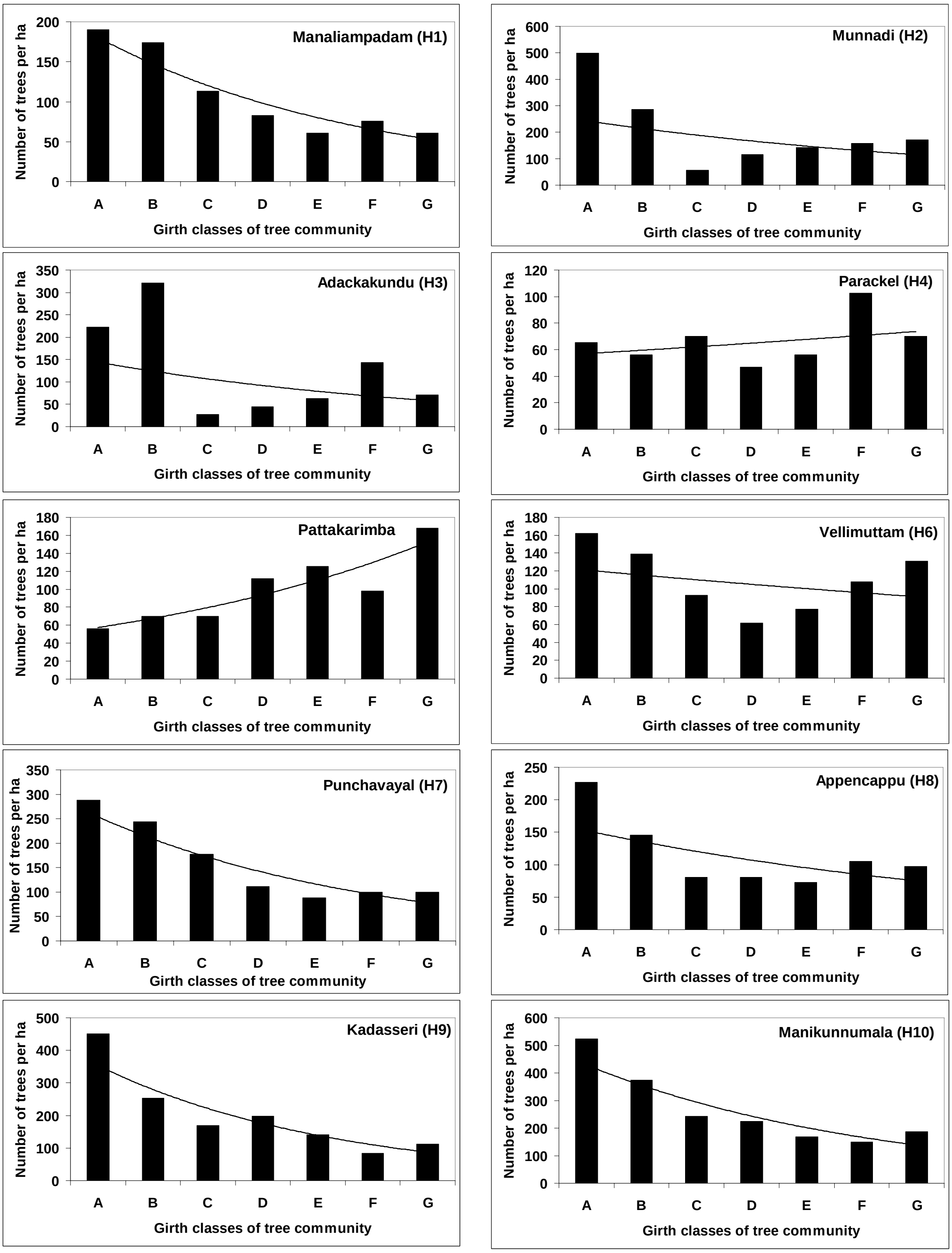


Figure 3. Girth class distribution of tree community in the forest plots adjacent to villages in the Kerala part of NBR. Girth classes: A=10.1-30cm, B =30.1-60cm, C=60.1-90 cm, D=90.1-120 cm, E =120.1-150 cm, F=150.1-180 cm and G= >180 cm gbh.

Assessing the stand quality of a forest ecosystem is a difficult process. However, Chandrashekara (1998) provided an index, Ramakrishnan Index of Stand Quality (RISQ), to quantify the forest stand quality. When this stand quality assessment method was adopted in the present study, different scenarios were recorded. For instance, even the plots adjacent to human habitation could be relatively less disturbed. With the estimated value for RISQ as 1.29 for the seedling community and 1.89 for the tree community, the plot at Kadasseri (H9**)** (Table 4 and 5) was similar to that of undisturbed plots in terms of the level of disturbance. However, the remaining plots adjacent to human habitation were secondary forests under different stages of succession. Thus, it is clear that the forest landscape of NBR is a mosaic of relatively undisturbed forests and also forest patches in various stages of succession. The study also revealed the fact that the plots at Manaliampadam (H1), Munnadi (H2), Adackakundu (H3), Parackel (H4), Pattakarimba (H5), Vellimuttam (H6), Punchavayal (H7) and Appencappu (H8), with high RISQ value (more than 3), may take more time for complete recovery from the disturbance, even if they do not experience further disturbance. Thus, appropriate strategies have to be identified for accelerating secondary succession in the above mentioned plots.

**B. Village ecosystem analysis**

One village adjacent to each forest plot was studied (by sampling the village area of 1 $km^2$ bordering the forest boundary) for landuse patterns, socioeconomic conditions of the villagers and flow of resources from forest to village ecosystem. The area under agriculture ranged from 65 to 81 per cent of the total village area sampled ($1km^2$) while the rest was under non-agriculture use. Categorization of the agricultural landuse types indicated that the mono-cropping of commercial crops such as coconut, arecanut and rubber was prominent in eight villages. However, in villages like Kadasseri (H9) and Manikunnumala (H10) mixed farming was the predominant system (Table 6). Paddy cultivation, once prevalent in all ten villages, is now seen only in six villages. The survey data also indicated that the transformation of paddy fields into other landuse types such as homesteads, single species and mixed species farms was responsible for increase in their area.

In these villages, rain-fed agriculture was the predominant form of landuse and farmers practice low input agriculture. The villagers' economy was basically agrarian in nature and their dependence on agriculture for livelihood was either by way of cultivation in their land or as agricultural wage labourers. The landholdings among the local communities has been analysed separately for each village (Table 7). The number of households showed a wide variation with only 58 households in

Appenkapu (H8) and 320 households in Punchavayal (H7). Majority of them (43 to 79% of the total landholdings) were marginal (< 1ha).

Table 6. Area ($km^2$) under different cropping systems in the villages adjacent to forest plots studied in the NBR. Values in parentheses are percentage of total area under crop lands. Total area sampled in each village was 1 $km^2$.

| Villages | Total area under crop lands ($km^2$) | Area ($km^2$) under different cropping systems | | | | | |
|---|---|---|---|---|---|---|---|
| | | Home-stead farms | Mono-crop farms | Mixed species farms | Paddy fields | Biennial crop fields | Annual crop fields |
| Manaliampadam (H1) | 0.69 | 0.08 (11) | 0.46 (67) | 0.07 (10) | 0.05 (7) | 0.01 (1) | 0.03 (4) |
| Munnadi (H2) | 0.79 | 0.13 (17) | 0.51 (65) | 0.10 (13) | 0.00 (0) | 0.02 (2) | 0.02 (3) |
| Adakkakundu (H3) | 0.78 | 0.11 (14) | 0.48 (62) | 0.07 (9) | 0.07 (9) | 0.02 (2) | 0.03 (4) |
| Parackel (H4) | 0.75 | 0.08 (10) | 0.45 (60) | 0.11 (14) | 0.05 (7) | 0.03 (4) | 0.04 (5) |
| Pattakarimba (H5) | 0.65 | 0.10 (16) | 0.34 (53) | 0.10 (16) | 0.00 (0) | 0.03 (4) | 0.07 (11) |
| Vellimuttam (H6) | 0.71 | 0.13 (19) | 0.41 (58) | 0.07 (10) | 0.01 (2) | 0.04 (5) | 0.04 (6) |
| Punchavayal (H7) | 0.67 | 0.07 (11) | 0.32 (48) | 0.07 (11) | 0.11 (17) | 0.04 (6) | 0.05 (7) |
| Appankapu (H8) | 0.72 | 0.09 (13) | 0.37 (52) | 0.17 (24) | 0.00 (0) | 0.02 (3) | 0.06 (8) |
| Kadasseri (H9) | 0.75 | 0.03 (4) | 0.17 (23) | 0.47 (62) | 0.02 (2) | 0.02 (2) | 0.05 (7) |
| Manikunnumala (H10) | 0.81 | 0.09 (11) | 0.09 (11) | 0.52 (64) | 0.06 (8) | 0.02 (3) | 0.02 (3) |

Table 7. Number of landholding in the villages adjacent to forest plots studied in the NBR. Values in parentheses are percentage of total number of landholdings. Total area sampled in each village was 1 $km^2$.

| Villages | Number of landholdings | Landholding categories * | | |
|---|---|---|---|---|
| | | Marginal (<1 ha) | Small (1 to 2 ha) | Medium (4-10 ha) |
| Manaliampadam (H1) | 109 | 74(68) | 28(26) | 7(6) |
| Munnadi (H2) | 128 | 87(68) | 28(21) | 13(10) |
| Adakkakundu (H3) | 113 | 76(67) | 34(30) | 3(3) |
| Parackel (H4) | 96 | 61(66) | 28(29) | 7(7) |
| Pattakarimba (H5) | 164 | 107(65) | 41(25) | 16(10) |
| Vellimuttam (H6) | 209 | 132 (63) | 65(31) | 12(6) |
| Punchavayal (H7) | 320 | 253(79) | 54(17) | 13(4) |
| Appankapu (H8) | 58 | 45(78) | 10(17) | 3(5) |
| Kadasseri (H9) | 84 | 36(43) | 30(36) | 18(21) |
| Manikunnumala (H10) | 136 | 66(49) | 35(26) | 35(26) |

* Landholding categorization is based on Kerala Agricultural Department, 2004.

The chi-square test done to test the dependency of landholding size on the location indicated that the landholding size varied from village to village (Chi-square value= 59.72, $P<0.05$ with df=18), possibly due to variation in demographic features among villages. Therefore, demographic structures of villages were analysed to understand their influence on landholding size and landuse pattern in each village.The data are summarised in Table 8. The average family size ranged from 4.6 to 6.7 and total population was high in Punchavayal (H7) village and low in Appankapu (H8) tribal settlement. The sex ratio showed the preponderance of the female over the male, which is at par with the State situation. Literacy rate in the villages ranged from 45 to 90 per cent, which was highest in Kadasseri (H9) and Manikunnumala (H10) villages and lowest in the Appankapu (H8) tribal settlement. In majority of the localities a heterogeneous community constituted by Hindus, Muslims and Christians is prevailed. However, in Appankapu (H8), a homogenous group of tribals is seen.

Table 8. Demographic structure of villages adjacent to forest plots studied in the NBR. Values in parentheses are percentage of total population. Total area sampled in each village was 1 $km^2$.

| Villages | Total population | Average family size | Sex | | Education status | |
|---|---|---|---|---|---|---|
| | | | Male | Female | Literate | Illiterate |
| Manaliampadam (H1) | 986 | 9.0 | 473(48) | 513(52) | 779(79) | 207(21) |
| Munnadi (H2) | 755 | 5.9 | 354(47) | 401(53) | 558(74) | 197(26) |
| Adakkakundu (H3) | 1120 | 9.9 | 549(49) | 571(51) | 952(85) | 168(15) |
| Parackel (H4) | 759 | 7.9 | 357(47) | 402(53) | 630(83) | 129(17) |
| Pattakarimba (H5) | 1099 | 6.7 | 484(47) | 615(53) | 846(74) | 253(26) |
| Vellimuttam (H6) | 1236 | 5.9 | 593(48) | 643(52) | 1088(88) | 148(12) |
| Punchavayal (H7) | 1760 | 5.5 | 862(49) | 898(51) | 1443(82) | 316(18) |
| Appankapu (H8) | 360 | 6.2 | 166(46) | 194(54) | 245(68) | 115(32) |
| Kadasseri (H9) | 386 | 4.6 | 185(48) | 201(52) | 359(93) | 27(7) |
| Manikunnumala (H10) | 694 | 5.1 | 319(46) | 375(54) | 666(96) | 28(4) |

Occupational profile of population revealed that farming and agricultural wage labour formed a major chunk of the occupational groups (Table 9). Unemployed group was mainly constituted by elderly members and females involved in household activities. People working abroad and in government services together contributed about 20 per cent of the total population. Therefore, it is clear that agrarian nature of work force and dependence on agriculture for livelihood contributed much to the total population of each village.

Table 9. Occupational pattern of the sample population (Age group: 15 or more than 15 years) in the villages adjacent to forest plots studied in the NBR. Values are percentage of the total sample population.

| Villages | Occupation | | | | | | |
|---|---|---|---|---|---|---|---|
| | Famers | Agricultural labourers | Other labourers | NTFP collectors | Govern-ment employees | Working abroad | Un-employed |
| Manaliam-padam (H1) | 34 | 25 | 22 | 4 | 5 | 3 | 7 |
| Munnadi (H2) | 15 | 19 | 27 | 6 | 14 | 2 | 17 |
| Adakkakundu (H3) | 27 | 20 | 18 | 8 | 12 | 6 | 9 |
| Parackel (H4) | 36 | 25 | 16 | 4 | `15 | 8 | 11 |
| Pattakarimba (H5) | 23 | 12 | 18 | 13 | 11 | 5 | 18 |
| Vellimuttam (H6) | 29 | 14 | 12 | 6 | 18 | 10 | 11 |
| Punchavayal (H7) | 21 | 17 | 11 | 14 | 18 | 13 | 6 |
| Appankapu (H8) | 22 | 34 | 9 | 21 | 2 | 1 | 11 |
| Kadasseri (H9) | 39 | 24 | 12 | 2 | 6 | 3 | 14 |
| Manikunnu-mala (H10) | 27 | 16 | 26 | 4 | 12 | 10 | 5 |

### C. Dependency on forests by the villagers

Landuse changes in the Western Ghats over the last century caused by agricultural expansion, conversion to plantations and infrastructural projects have resulted in loss of forests (Jha *et al*., 2000). While landuse changes remain the major threat to Western Ghats biodiversity, the intensive harvest of forest produces such as fuelwood, small timber, green leaves, litter and fodder has also contributed to loss of biodiversity and forest cover (Davidar *et al*., 2007) as in other Southeast Asian forests (Sodhi and Brook, 2006). In the Indian sub-continent, despite prohibition, extraction of forest resources from most of the protected areas is still continuing (Kothari *et al*., 1989). The extraction of biomass resources, such as fuelwood, timber and fodder by rural communities, perhaps once within the carrying capacity of surrounding forests, has now crossed this limit in many resource rich areas of the world (Reid *et al*., 1990; Silori, 2001). Against this background, the present study was conducted to assess the status of dependency on forests by the villagers and its impacts on forest plots in the Kerala part of Nilgiri Biosphere Reserve and the results of the study are discussed below.

### a. Fuel wood collection

The visual observation technique was adopted to record different kinds of biomass collected from the forest plots by the villagers. In the study area, even today, fuel wood is the major source of energy for cooking (Table 10). The status and distribution of fuel wood extraction from the forests adjacent to ten villages are governed by the availability of crop residues and fuel wood from the farms. For instance, in Kadasseri (H9), the crop residues, chiefly the leaf fronds and shells of coconut were used. Use of LPG, biogas and electricity was significantly low in all villages. Among different villages studied, Pattakarimba (H5) and Appankapu (H8) showed significantly high dependence on adjacent forest plots for fuel wood. In Manikunnumala (H10), villagers collected fuel wood mainly from their tree-based farms (coffee plantations and mixed species farms) than from the nearby forest plot.

Quantity of fuel wood collected from the adjacent forests was significantly more in Punchavayal (H7) (18.9 $\pm$ 0.7 kg day$^{-1}$ from 1-ha forest area) and Pattakarimba (H5) (18.5 $\pm$ 0.6 kg day$^{-1}$ from 1-ha forest area) and less in Kadasseri (H9) (3.9 $\pm$ 0.2 kg day$^{-1}$ from 1-ha forest area) (Figure 4). Fuel wood collection was significantly high during summer months (November to April) (Figure 5). The peak collection of fuel wood was in March and April for enabling the villagers to store fuel wood and use them during rainy days.

Table 10. Sources of fuel for cooking in villages adjacent to forest plots studied in the NBR. Values in parentheses are percentage of total number of landholdings in a given village.

| Villages | Number of landholdings | Source of fuel for cooking | | | | |
|---|---|---|---|---|---|---|
| | | Fuel wood | Crop residue | LPG | Biogas | Electricity |
| Manaliampadam (H1) | 109 | 77(71) | 24(22) | 5(5) | 0(0) | 2(2) |
| Munnadi (H2) | 128 | 82(64) | 33(26) | 10(8) | 3(2) | 0(0) |
| Adackakundu (H3) | 113 | 77(68) | 26(23) | 8(7) | 1(1) | 1(1) |
| Parackal (H4) | 96 | 68(71) | 13(14) | 12(12) | 0(0) | 3(3) |
| Pattakarimba (H5) | 164 | 125(76) | 25(15) | 7(4) | 7(4) | 2(1) |
| Vellimuttam (H6) | 209 | 127(61) | 48(23) | 29(14) | 0(0) | 4(2) |
| Punchavayal (H7) | 320 | 182(57) | 54(17) | 35(11) | 35(11) | 13(4) |
| Appankapu (H8) | 58 | 48(83) | 3(6) | 2(4) | 3(5) | 1(2) |
| Kadasseri (H9) | 84 | 18(22) | 60(72) | 2(2) | 3(4) | 0(0) |
| Manikunnumala (H10) | 136 | 76(56) | 37(27) | 14(10) | 8(6) | 1(1) |

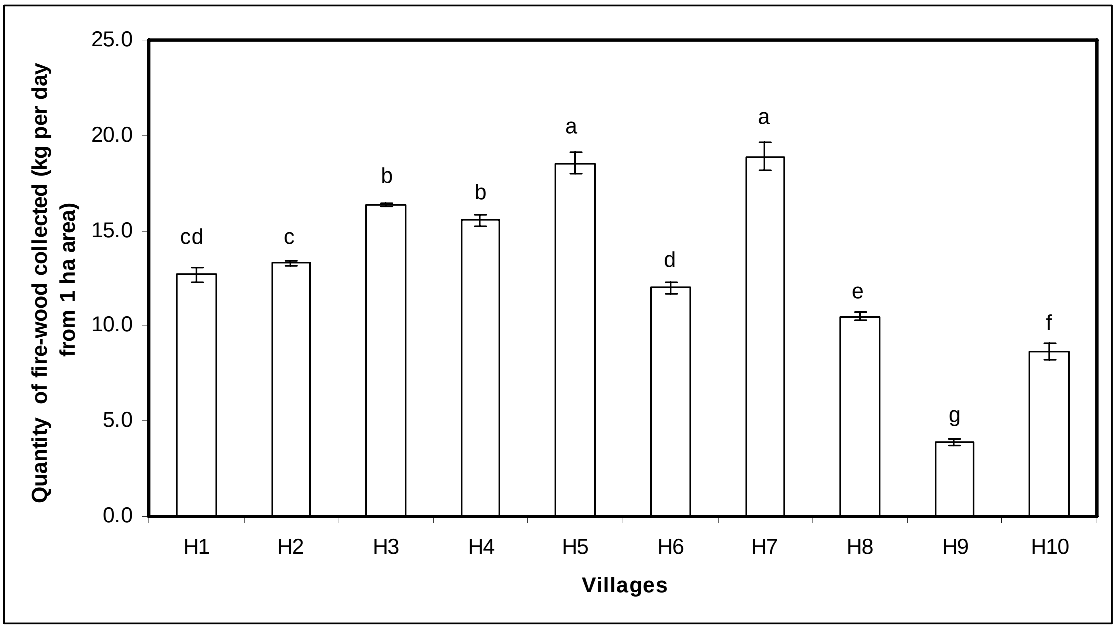


Figure 4. Quantity of fuel wood (kg/day from 1 ha area; Mean ± SE) collected for the villages from the adjacent forest plots studied in the NBR. Values for the villages with same superscript are not statistically different (P>0.05). Code for the villages is as in Table 10.

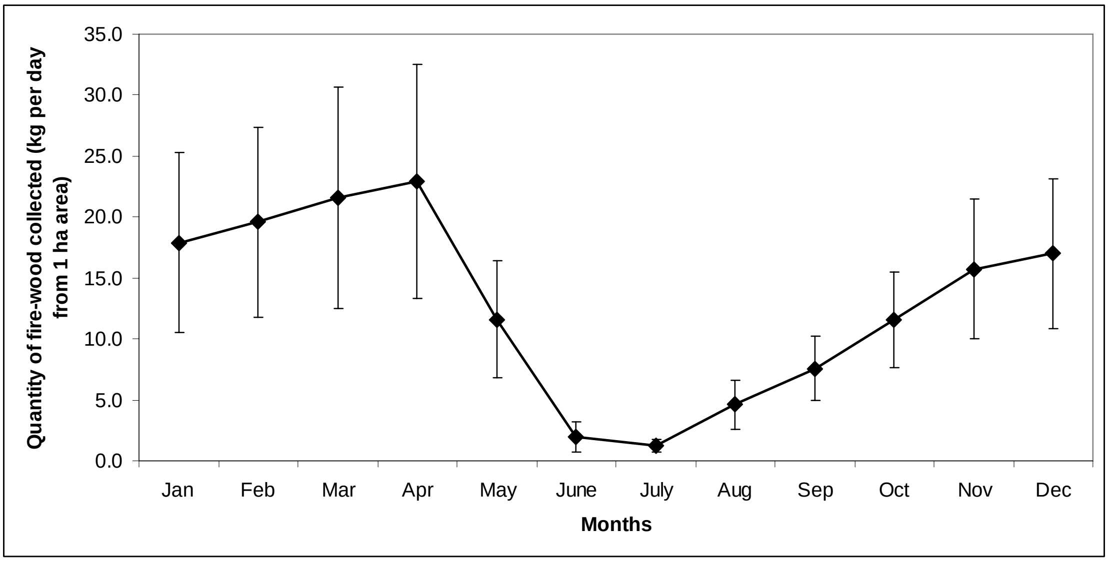


Figure 5. Quantity of fuel wood (kg/day from 1 ha area; Mean ± SE) collected in different months from the village-adjacent forest plots in the NBR.

**b. Litter collection**

In a forest ecosystem, litter biomass is an essential component of energy and biogeochemical cycles (Singh, 1968). However, in many parts of the tropics, the litter is removed from forest floor for using it as the source of nutrients for their crop (Chandrashekara *et al.,* 2009). In the present study, litter collection from the forest floor was recorded in Pattakarimba (H5). In this plot, two areas namely litter colleting area and non-collecting area were demarcated. The area from where litter was not collected was located about 1 km away from the forest boundary and here the standing litter biomass was 9,537 $\pm$ 441 kg $ha^{-1}$, which was significantly more ($P<0.05$) than that in the litter collecting site (5,698 $\pm$ 297 kg $ha^{-1}$). Thus, litter collection in this site reduced the standing litter biomass by about 60 per cent. In both sites, the leaf litter was the major constituent (about 75-80%) of total standing litter, while the reproductive propagules such as seeds and fruits contributed to about 2-4 per cent of the total litter biomass (Table 11).

Table.11. Standing litter (kg $ha^{-1}$; Mean ± SE) in plots with undisturbed forest floor and in litter collected plots in the forest adjacent to Pattakarimba village (H5) in the NBR.

| Plots | Standing litter components | | | Total |
|---|---|---|---|---|
| | Leaf | Seeds/ fruits | Dead twigs and branches | |
| Plots with undisturbed forest floor | 7505 ±353 | 281± 20 | 1750 ± 108 | 9537 ± 441 |
| Litter collection plots | 4591 ± 248 | 164 ±19 | 943± 19 | 5698 ±297 |

In Pattakarimba, the litter collection was done during January to April, coinciding with the summer mulching in farmlands. The estimated litter removed from the forest floor was 4,440 $\pm$ 302 kg $ha^{-1}$ to 12,316 $\pm$ 575 kg $ha^{-1}$ per month, which was significantly more during February and March (Table 12).

It may be pointed here that majority of the dominant tree species (*Lagerstroemia microcarpa*, *Lagerstroemia speciosa*, *Persea macrantha*, *Terminalia paniculata*, *Schleichera oleosa* etc.) shed their seeds and fruits during this period. The study also indicated that on an average 1,019 kg $ha^{-1}$ of seeds/fruits were removed along with leaf litter during these four months. The consequences of litter removal from the forest floor are discussed below.

Table 12. Litter collection (kg $ha^{-1}$; Mean ± SE) in different months from the forest adjacent to Pattakarimba in the NBR.

| Months | Components of litter collected | | | |
|---|---|---|---|---|
| | Leaf | Seeds/fruits | Dead twigs and branches | Total |
| January | 3751 ± 272[a] | 114 ± 10[a] | 575 ± 20[a] | 4440 ± 302[a] |
| February | 8229 ± 251[b] | 252 ± 13[b] | 2719 ± 166[b] | 11,200 ± 430[b] |
| March | 8969 ± 294[c] | 365 ± 41[c] | 2982 ± 240[b] | 12,316 ± 575[c] |
| April | 6343 ± 192[d] | 288 ± 26[b] | 1915 ± 168[c] | 8,546 ± 386[d] |

Observations made for two year period (2004-2006) in the forest plot at Pattakarimba (H5) on the reproductive phenology of dominant trees indicated that the tree seed germination and recruitment to the seedling phase commenced in May and stopped after October (Figure 6). The estimated mortality rate for newly recruited seedlings was 14 per cent in the plots with undisturbed forest floor. However, in plots from where the litter was collected a large number of newly recruited seedlings died during summer months and thus seedling mortality rate was as high as about 70 per cent. As a result, during each month, the tree seedling abundance in the litter collected plots was significantly low ($P<0.05$) ((Figure 6).

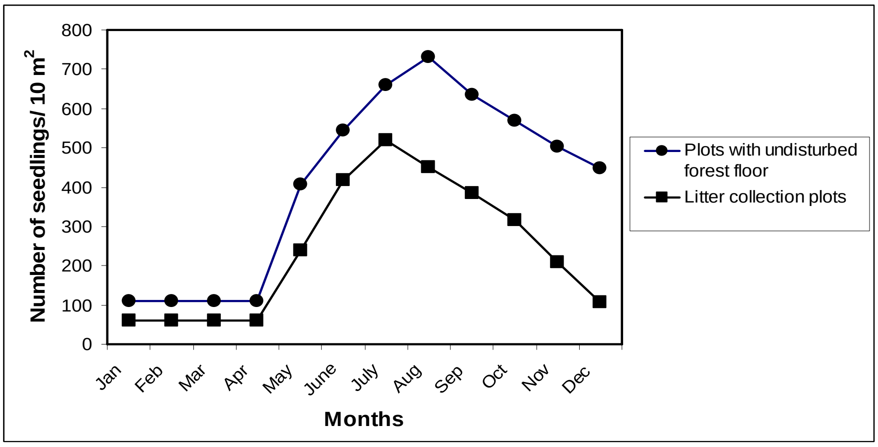


Figure 6. Abundance of tree seedlings (individuals 10 $m^{-2}$) in plots with undisturbed forest floor and litter collected plots in the forest adjacent to Pattakarimba in the NBR.

The study also indicated that seeds of trees like *Persea macrantha* and *Schleichera oleosa* generally escaped the collection due to their small size and globular shape. The estimated density of seedlings of *Persea macrantha* and *Schleichera oleosa* in plots with undisturbed forest floor was 35$\pm$ 7 individuals 10 $m^{-2}$ and 50 $\pm$ 5 individuals 10 $m^{-2}$ respectively. However, significantly low seedling density (*Persea macrantha:* 6 $\pm$ 2 individuals 10 $m^{-2}$ and *Schleichera oleosa:* 8 $\pm$ 2 individuals 10 $m^{-2}$) was noticed in plots from where the litter was collected. Thus, even though the seeds of these species escaped during litter collection, due to lack of litter layer they generally got washed away from the forest floor leading to reduction in tree seedling population in the forest plot. Thus, it can be concluded that litter removal from the forest floor has a three-fold effect, namely a) physical removal of tree propagules while collecting litter for summer mulching, b) run-off of tree propagules from the forest floor due to absence of the litter layer, and c) seedling mortality due to desiccation. However, the type of impacts of litter removal on tree regeneration and species diversity may be different for different forest types in the tropics. Thus, further studies can be conducted to provide insight on linkages between litter removal from the forest floor and forest regeneration patterns in different forest types.

**c. Collection of green mulch materials**

In tropics, depletion of soil organic matter leads to decline in agricultural and biomass productivity, poor environmental quality, soil degradation and nutrient depletion and ultimately to food insecurity (Lal, 2004). The soil organic matter depletion is the major concern both in small-scale agriculture, agroforestry and plantation systems. The farmers of tropical regions have identified mulching as one of the most important practices to maintain soil fertility and crop productivity (Kumar and Nair, 2004). When the pruned materials of trees and shrubs are used as mulch, it can be called as green mulch (Schwendener *et al*., 2005). The green mulch is considered as a good source of nutrients, and is distinct from naturally fallen leaf litter in terms of leaf quality and leaf chemical composition (Palm *et al*., 2001). The green mulch also plays an essential role in increasing soil organic matter reserves, promoting carbon sequestration and nutrient recycling (Lal, 2004). The agricultural communities living in the periphery of forest area depend invariably on forests for green manure (Nayak *et al*., 2000; Jayanarayan, 2001). Landuse change, particularly transformation of mixed species forms into monoculture forms, is also known to reduce the availability of mulch materials internally and enhance the dependency on nearby forests for green mulch materials (Nayak et al., 2000; Lal, 2004). However, the present study showed that extraction of green manure from adjacent forest plot

(H7) prevailed only in the Punchavayal Village. Leaves and leaf bearing twigs of species such as *Calicopteris floribunda, Grewia tiliifolia, Helecteres isora, Macaranga peltata, Miliusa tomentosa, Schleichera oleosa, Terminalia paniculata* and *Xylia xylocarpa* were found as the components of green manure collected from the forest plot. The estimated quantity of green manure collected from the forest plot (H7) was 11,722 $\pm$ 1,087 kg $ha^{-1}$ $yr^{-1}$. The collection started from July, after the commencement of monsoons and completed in October, when the north-east monsoon ends (Figure 7). During these months, the extraction of green manure coincided with its application to farmlands. The harvest of green mulch material was seasonal and lasted for about 3-4 months in a year. However, the number of trees and saplings affected by pruning and lopping was found to be high. In addition, the tolerance of saplings and trees to the intensity and frequency of pruning and lopping may vary from species to species (Chandrashekara, 2007). Therefore, unrestricted and unscientific harvest of green foliage may also be responsible for the high rate of tree mortality and poor quality of the forest stand.

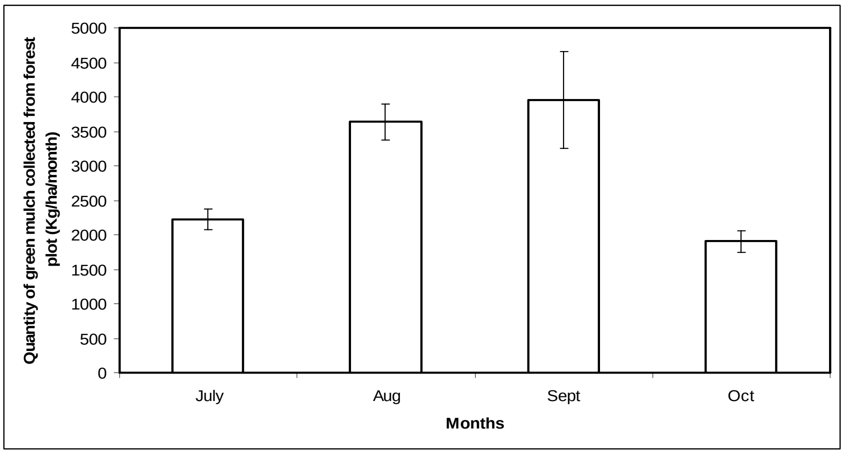


Figure 7. Quantity of green manure (kg $ha^{-1}$ $month^{-1}$) collected from the forest plot (H7) adjacent to Punchavayal Village in the NBR.

### d. Grazing in forest plots

In all ten villages, livestock was an integral part of agriculture and essential for the rural livelihoods. As in other rural areas of the tropics, use of forest land for livestock grazing prevailed in all ten villages. The estimated number of livestock grazing ranged from 78 $\pm$ 8 individuals $km^{-1}$ to 3 $\pm$ 1 individuals $km^{-1}$; with high grazing pressure in forest plot adjacent to Pattakarimba (H5) followed by that to Punchavayal (H7**).** Even the number of Adult Cattle Units (ACUs) of grazing in the forest plots was significantly high in H5, with no significant difference in plots adjacent to Punchavayal (H7**)** and Manikunnumala (H10**)** (Figure 8). In each forest plot, monthly variation in number of livestock and number of ACUs grazing was recorded (Table 13).

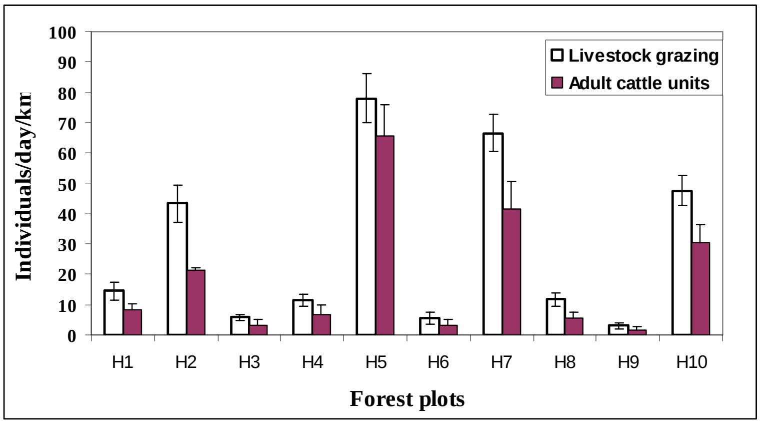


Figure 8. Number of livestock and number of Adult Cattle Units (individuals $day^{-1}$ $km^{-1}$; mean $\pm$ SE) grazing in different forest plots in the NBR. Code for the villages is as in Table 10.

Table 13. Number of livestock (individuals $day^{-1}$ $km^{-1}$) grazing in different months in different forest plots in the NBR. Values in parentheses are Adult Cattle Units (ACUs).

| Villages | Number of livestock (individuals $day^{-1}$ $km^{-1}$; mean $\pm$ SE) grazing | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec |
| Manaliampadam (H1) | 16 (9 | 18 (10) | 21 (11) | 12 (7) | 10 (6) | 5 (4) | 6 (4) | 12 (7) | 18 (10) | 23 (13) | 18 (11) | 16 (9) |
| Munnadi (H2) | 48 (23) | 55 (25) | 46 (22) | 55 (26) | 44 (22) | 31 (14) | 21 (12) | 22 (15) | 38 (21) | 54 (24) | 52 (25) | 54 (25) |
| Adakkakundu (H3) | 5 (3) | 8 (5) | 10 (5) | 8 (5) | 6 (3) | 0 (0) | 0 (0) | 0 (0) | 9 (5) | 9 (5) | 7 (4) | 7 (4) |
| Parackel (H4) | 16 (9) | 12 (7) | 8 (4) | 16 (10) | 9 (5) | 9 (6) | 5 (4) | 12 (7) | 16 (9) | 13 (7) | 12 (7) | 11 (6) |
| Pattakarimba (H5) | 88 (72) | 92 (75) | 94 (76) | 99 (81) | 92 (75) | 33 (36) | 26 (26) | 52 (48) | 83 (73) | 98 (81) | 88 (74) | 91 (72) |
| Vellimuttam (H6) | 3 (2) | 7 (4) | 12 (6) | 14 (8) | 4 (2) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 12 (7) | 10 (6) | 5 (3) |
| Punchavayal (H7) | 76 (48 | 80 (50) | 76 (45) | 76 (47) | 74 (47) | 26 (17) | 36 (25) | 54 (33) | 76 (46) | 81 (51) | 71 (46) | 73 (43) |
| Appankapu (H8) | 14 (6) | 13 (7) | 11 (4) | 8 (4) | 8 (3) | 9 (5) | 11 (5) | 13 (6) | 15 (7) | 12 (6) | 14 (7) | 12 (5) |
| Kadasseri (H9) | 2 (1) | 4 (2) | 4 (2) | 3 (2) | 4 (3) | 0 (0) | 0 (0) | 3 (1) | 4 (2) | 4 (2) | 5 (3) | 3 (2) |
| Manikunnumala (H10) | 51 (34) | 54 (36) | 49 (32) | 56 (36) | 57 (36) | 23 (12) | 14 (8) | 36 (22) | 53 (32) | 56 (35) | 61 (40) | 65 (43) |

Grazing pressure frequently has negative effects on the resilience of the ecosystem and progressive succession in disturbed forests (Perrings and Walker, 1997). In majority of the forest plots grazing has been identified as the major reason for reduction in tree seedling population. In all plots, grazing and browsing of tree seedlings and saplings were noticed. Since the livestock generally grazed native and palatable herbs, shrubs and tree seedlings, density and biomass of unpalatable grasses and weeds increased considerably. These unpalatable biomass, which were prone to fire greatly augmented the probability of catastrophic fire and rapid alteration in structure, composition and diversity of plant community in the forests. It may also be pointed out here that the consequences of grazing pressure elsewhere in the NBR is more obvious, where, due to uncontrolled grazing by resident and migratory livestock, the habitat continuity for elephant conservation is under serious threat (Silori, 1996). In fact, plots like Pattakarimba (H5) and Punchavayal (H7) of the present study, where the grazing pressure by domesticated animals was intense, also happen to form the elephant corridors of the region. The retarded regeneration of tree species in these plots reduced the fodder availability to the wild herbivores like elephants. Lack of forage in the forest corridor is expected to divert them to the surrounding agricultural fields, causing man-wild animal conflicts.

### D. Forest quality analysis

It is clear that the villagers' dependence on forest resources is a major causative for the degradation of forest plots adjacent to villages. Despite prohibition, the resource collection at different forms, magnitude and frequency is continuing in these forest plots. The resultant ecological changes have profound effects on the forest species composition and structure. Some of the major causes for deforestation and species composition changes have been documented. For sustainable conservation of management of forest plots, the current challenge is to quantify the rates and effects of biodiversity decline and habitat change to enable the stakeholders and managers of forest to plan rationally on appropriate measures of conservation and management. Recent trends towards this goal have been on the development of habitat environmental indicators that would measure the natural resource volume and rate of resource depletion. Information from such findings could be used as basis of setting up policy guidelines. Therefore, three forest indicators that will provide important information of ecological and social significance have been used. The parameters used for estimating the indicator value are those that can be measured locally and that may influence change in forest structure and composition. In the present study two vegetation indicators (Ramakrishnan Index of Stand Quality- RISQ and Index of Ecological Quality-IEQ) and one human disturbance indicator (Human Disturbance Index-HDI) were applied for interpretation of results.

Among ten forest plots studied, the one at Kadasseri (H9) showed low value for the RISQ in both tree seedling and tree communities (Figure 9). In this plot, values for the HDI (Table 14) and IEQ (Table 15) were also significantly low. Therefore it is clear that this plot is comparatively less disturbed. The low RISQ value also means high percentage contribution by the primary species to the density and basal cover of tree seedlings and tree communities. Thus, it is possible to conclude that the forest is under progressive succession and moderate level of protection can help it to recover from the disturbance. Contrary to this, forest plots adjacent to Punchavayal (H7) and Munnadi (H2) showed high value for the RISQ, suggesting that the contribution by evergreen species of different successional categories such as primary, late secondary and early secondary to the total importance values of tree seedling and tree communities was significantly low.

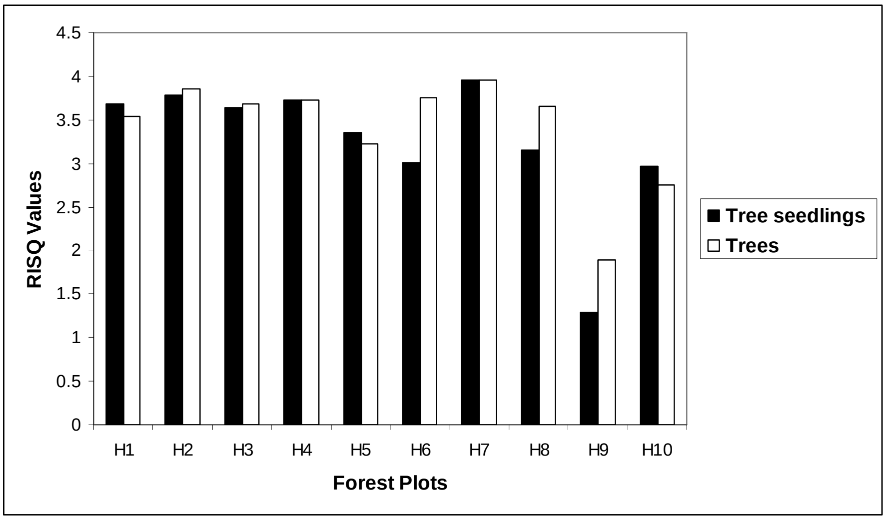


Figure 9. Ramakrishnan Index of Stand Quality (RISQ) value for tree seedling and tree communities of different forest plots in the NBR. Code for the villages is as in Table 10.

Table 14. Index of Human Disturbance (IHD) values for different forest plots in the NBR. Code for the villages is as in Table 10.

| Parameters | C max (mean value ha$^{-1}$) | Forest Plots | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H1 | H2 | H3 | H4 | H5 | H6 | H7 | H8 | H9 | H10 |
| | | C/C Max | | | | | | | | | |
| Number of larger stumps (> 20 cm gbh) of harvested trees | 76.3 | 0.88 | 0.72 | 0.78 | 0.93 | 0.67 | 0.53 | 1.00 | 0.33 | 0.21 | 0.7 |
| Number of pollarded trees (< 20 cm gbh) | 321.3 | 0.82 | 0.96 | 0.76 | 0.82 | 1.00 | 0.22 | 1.00 | 0.19 | 0.11 | 0.99 |
| Number of coppiced stems | 138.75 | 0.61 | 1.00 | 0.57 | 0.56 | 0.33 | 0.14 | 0.52 | 0.16 | 0.11 | 0.88 |
| Number of stems with branch cuttings | 66.3 | 0.81 | 0.98 | 0.62 | 0.78 | 0.87 | 0.51 | 1.00 | 0.57 | 0.53 | 0.94 |
| Number of debarked stems | 122.5 | 0.56 | 0.93 | 0.54 | 0.43 | 0 | 0 | 1.00 | 0.04 | 0 | 0.53 |
| Number of vehicle tracks | 13.8 | 0.87 | 0.72 | 0.77 | 0.71 | 0.82 | 0.75 | 1.00 | 0.45 | 0.27 | 0.09 |
| Number of foot paths | 60 | 0.81 | 0.77 | 0.89 | 0.88 | 1.00 | 0.83 | 0.79 | 0.23 | 0.19 | 0.71 |
| **Y= Sum C/C Max of all parameters** | | 5.36 | 6.08 | 4.93 | 5.11 | 4.69 | 2.98 | 6.31 | 1.97 | 1.42 | 4.84 |
| **Sum/Y** | | 0.77 | 0.87 | 0.70 | 0.73 | 0.67 | 0.43 | 0.90 | 0.28 | 0.20 | 0.69 |
| **Sum/Y (In %)** | | 76.6 | 86.9 | 70.4 | 73.0 | 67.0 | 42.6 | 90.1 | 28.1 | 20.3 | 69.1 |

Table 15. Index of Ecological Quality (IEQ) values for different forest plots in the NBR. Code for the villages is as in Table 10.

| Parameters | **C max (mean value)** | **Forest Plots** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H1 | H2 | H3 | H4 | H5 | H6 | H7 | H8 | H9 | H10 |
| | | **C/C Max** | | | | | | | | | |
| Open canopy area (in % of total canopy area) | 87.5 | 0.78 | 0.98 | 0.68 | 0.81 | 0.65 | 0.92 | 1.00 | 0.56 | 0.38 | 0.97 |
| Ground cover by grasses (in % of total forest floor area ) | 50.8 | 0.68 | 0.77 | 0.62 | 0.76 | 0.33 | 0.89 | 0.49 | 0.25 | 0.06 | 1.00 |
| Ground cover by exotic weeds (in % of total forest floor area ) | 28.1 | 0.63 | 0.73 | 0.58 | 0.69 | 0.26 | 0.94 | 1.00 | 0.52 | 0 | 0.82 |
| Ground cover by exotic weeds (in % of total forest floor area ) | 11.2 | 0.89 | 0.84 | 0.91 | 0.79 | 0.65 | 0.78 | 0.96 | 0.84 | 0.68 | 1.00 |
| Canopy coverage by lianas | 62.8 | 0.92 | 0.82 | 0.83 | 0.89 | 0.11 | 0.12 | 0.69 | 0.75 | 0.49 | 1.00 |
| **Y= Sum C/C Max of all parameters** | | 3.90 | 4.14 | 3.62 | 3.94 | 2.00 | 3.65 | 4.14 | 2.92 | 1.61 | 4.79 |
| **Sum/Y** | | 0.78 | 0.83 | 0.72 | 0.79 | 0.40 | 0.73 | 0.83 | 0.58 | 0.32 | 0.96 |
| **Sum/Y (In %)** | | 78.0 | 82.8 | 72.4 | 78.8 | 40.0 | 73.0 | 82.8 | 58.4 | 32.2 | 95.8 |

High values obtained for IHD and IEQ for these two plots indicate constant and high magnitude disturbance regimes in these plots. It is interesting to note that for the forest plot at Manikunnumala (H10), the RISQ values were lower than those for Punchavayal (H7) and Munnadi (H2); while the opposite trend was recorded for the IEQ values. This is probably because the native understorey species are not affecting the regeneration and establishment of evergreen species of different successional status. High percentage of canopy coverage by lianas recorded for the Manikunnumala (H10) (Table 15) could also reduce the quantam of light falling on the forest floor. The reduced light availability might be reducing the establishment of light demanding species and supporting the recruitment and establishment of primary and late secondary species of evergreen forests.

In the present study, in general, a positive correlation between HDI and IEQ, HDI and RISQ, and IEQ and RISQ was recorded. Therefore, it is clear that these forest indicators do not provide contradictory information for rapid assessment of forest quality. Measuring the values for all the above three indictors can help us to assess accurately ecological and human factors responsible for the present condition of forest plots and identify suitable conservation and management strategies.

**E. Strategies for forest conservation and management**

In all ten villages, post-project meetings were organized to present the results of the study on vegetation structure, composition, quality of the forest plots, landuse systems and their dynamics in village, dependence on the forest plots by the forest-adjacent villages and its impacts on forest plots before the local villagers, staff of forest, revenue and agriculture departments. The meetings were also aimed to identify strategies for conservation and management of village-adjacent forests. During the meeting, participants have agreed that each forest plot is surrounded by a rapidly increasing population, which is highly dependent on it for several needs to support the agricultural systems. The already precarious status of vegetation in forest plots (Manaliampadam, Munnadi, Adakkakundu, Parackel, Pattakarimba, Vellimuttam, Punchavayal and Appankapu) due to unsustainable utilisation of forests warrants for the strategic management plans on a site-by-site basis. The discussions lead to identify five themes representing the major issue or concern with the management of forest plots. The strategies and activities for addressing each theme are presented below.

### a) Conservation of biodiversity in village-adjacent forest plots

Being the part of NBR, each forest plot has great importance as the landscape unit of the Biosphere Reserve. These forest plots, bordering the Reserve and having a rapidly increasing population, that is highly dependent on it for sustainable agricultural systems and for commercial needs, are showing different levels of resource degradation. Changes in forest structure and composition such as those recorded in this study have implications on overall biodiversity of the plots.

During discussion, it was also recorded that the awareness amongst the forest-adjacent communities on many species which have conservation value (eg., rare, endangered, threatened and endemic species) is low. Most of the degradation process stems from an underestimation of the values of biodiversity. Thus, better information and understanding of the forest plots is the key to sustainable biodiversity conservation. Therefore, the participants prioritised the biodiversity documentation, involving local people both as direct beneficiaries (employment) and in order to raise their levels of awareness and expertise, as the major activity to be undertaken in all village-adjacent forest plots of the Biosphere Reserve. However, according to the residents of Appankapu, Kadasseri, Manikunnumala, some of the elder citizens of their villages are the repository of knowledge about forest and associated flora and fauna. Thus, research also needs to be conducted to document and utilise the indigenous knowledge of forest-adjacent communities.

Among forest plots studied, those adjacent to villages like Kadasseri and Manikunnumala still contain populations of trees, shrubs and herbs characteristic to evergreen forests, though the numbers are not enough to persist without promoting population building processes. Therefore, in order to restore these plots, as a strategy, specific intervention such as assisting natural regeneration of evergreen species needs to be undertaken. A list of species that need to be protected and assisted in their natural regeneration is given in Table 16.

However, among the remaining plots, some have undergone commercial exploitation for timber and other products before notifying them as the `Vested Forests' by the Government while other plots have been exploited heavily by the local people for their subsistence. In all these plots, arrested succession is a common feature. Therefore, reduction of human pressure and enrichment planting of a combination of successional species (Table 17) are identified as the strategies for conservation and management of these forest plots.

Table 16. Tree species which require protection for their seedlings, saplings and mature trees and also support for their natural regeneration in the village-adjacent forest plots at Kadasseri and Manikunnumala in NBR.

| Kadasseri (H9) | Manikunnumala (H10) | |
|---|---|---|
| *Arenga wightii* | *Aglaia lawii* | *Garcinia morella* |
| *Elaeocarpus serratus* | *Alseodaphne semecarpifolia* | *Hydnocarpus pentandra* |
| *Garcinia gummi-gutta* | *Bischofia javanica* | *Knema attenuata* |
| *Gmelina arborea* | *Canarium strictum* | *Linociera malabarica* |
| *Hydnocarpus alpina* | *Chukrasia tabularis* | *Mesua ferrea* |
| *Mimusops elengi* | *Cinnamomum malabatrum* | *Persea macrantha* |
| *Myristica dactyloides* | *Dimocarpus longan* | *Prunus ceylanica* |
| *Olea dioica* | *Flacourtia montana* | *Syzygium cumini* |
| *Persea macrantha* | | |
| *Polyalthia fragrans* | | |
| *Sapindus laurifolius* | | |
| *Vateria indica* | | |

Table 17. Tree species suitable for enrichment planting in village-adjacent forest plots at Manaliampadam, Munnadi, Adakkakundu, Parackel, Pattakarimba, Vellimuttam, Punchavayal and Appankapu in NBR.

| Species | Species | Species |
|---|---|---|
| *Acronychia pedunculata* | *Garcinia gummi-gutta* | *Neolamarckia cadamba* |
| *Albizia lebbeck* | *Gmelina arborea* | *Odina wodier* |
| *Albizia odoratissima* | *Grewia tiliifolia* | *Olea dioica* |
| *Alstonia scholaris* | *Holarrhena antidysenterica* | *Pavetta hispidula* |
| *Aporosa lindleyana* | *Hopea parviflora* | *Phyllanthus emblica* |
| *Bischofia javanica* | *Hydnocarpus pentandra* | *Polyalthia coffeoides* |
| *Briedelia retusa* | *Isonandra lanceolata* | *Pongamia pinnata* |
| *Callicarpa tomentosa* | *Knema attenuata* | *Prunus ceylanica* |
| *Calophyllum polyanthum* | *Mallotus philippensis* | *Sapindus trifoliata* |
| *Careya arborea* | *Meiogyne pannosa* | *Schleichera oleosa* |
| *Cassia fistula* | *Melicope lunu-ankenda* | *Strychnos nux vomica* |
| *Chukrasia tabularis* | *Memecylon malabaricum* | *Syzygium cumini* |
| *Dimocarpus longan* | *Memecylon umbellatum* | *Syzygium laetum* |
| *Drypetes oblongifolia* | *Miliusa tomentosa* | *Tabernaemontana heyneana* |
| *Dysoxylum malabaricum* | *Mimusops elengi* | *Toona ciliata* |
| *Fahrenheitia zeylanica* | *Mitragyna parviflora* | *Trichilia connaroides* |
| *Flacourtia indica* | *Murraya exotica* | *Vitex altissima* |
| *Flacourtia montana* | *Myristica dactyloides* | *Wrightia tinctoria* |
| | | *Xanthophyllum flavescens* |

**b. Reduction in forest dependence by the forest-adjacent communities**

The village survey depicted an increasing population in all villages adjacent to the forest plots. Here, fragmentation of joint families is responsible for increase in number of households and reduction in per-capita landholding. One of the effects of reduction in per-capita landholding is reduction in density and diversity of crop plants in different kinds of cropping systems, such as homegardens and mixed-species and single species farm lands in the village (Chandrashekara and Baiju, 2010). The participants further highlighted that decrease in landholding size and increase in number of landholdings cause un-sustainability of their crop lands and increased pressure on adjacent forest patches for bioresources such as green manure, fuel wood and fodder. According to Grimble and Laidlaw (2002), forest dependency leading to unsustainable utilisation is a symptom of poverty, not ignorance, and local people are only too aware of their impacts. It was also recorded that as poverty increases, dependency on forest also increases. This scenario correspondingly changes as livelihoods improve. However, in the present study the participants of the meetings recognised the fact that more than the economic poverty, the `ecological poverty' of the agricultural land-use systems is responsible for increased dependence on the forest resources. In general, in all the ten villages, mixed-species homegardens and farms have been the dominant landuse systems. Household requirements such as fuel wood, small poles, green manure etc. have been met considerably by these farming systems. However, fragmentation and transformation into mono-cropping systems or non-agricultural land-use systems have affected the sustainability and resilience of crop lands and enhanced the pressure on adjacent forest lands. Under this condition, attempts by the Kerala Forest Department to control enhanced use of the forest have not been particularly successful. The Forest Department Staff pointed out that with limited resource and personnel there is very little they can do to control the day-to-day use by the forest-adjacent communities who depend on it. Therefore, enhancement of the sustainability of the crop lands in forest-adjacent villages is the main strategy proposed to minimize the pressure on forest lands. In this context, revival of mixed species homegardens and farms, which are the traditional systems of landuse in the State, is identified as one of major activities to be undertaken.

### c. Forest protection

Since all the forest plots are the part of Reserve Forest or the Protected Forest, any kind of biomass harvest and removal by the people of adjacent villages are regarded as unauthorised and offense. All the stakeholders know this fact and are aware of the impact of unauthorised harvest on forest quality and sustainability. In fact, for the Forest Department, forest protection in the form of joint patrol by the Forest Watchers and Forest Guards is the major function. Despite intensive patrolling, it is clear that it has not been possible to control the level of unregulated use. However, the stakeholders accepted the fact that patrolling has to remain an important strategy for addressing unauthorised utilisation and harvest of bioresources. They also indicated that resources for patrolling are inevitably limited and this reduces both effectiveness and efficiency of patrolling. Discussion with the stakeholders has highlighted that adequate levels of forest protection cannot be achieved through confrontation and conflict between the managers and forest-adjacent communities. In this context, the local people and the government should have a mutual interest in conserving the forest and utilising forest products in a sustainable way. Consequently, the strategy should be for the development of joint protection systems in return for agreed levels of utilisation and benefit-sharing within the capacity of the forest to meet subsistence needs sustainably. Thus, it is suggested that actions can be taken for creating partnerships between local people and the Kerala Forest Department for the local communities to avail the benefits of forest products in an authorized and systematic manner. But, before doing so, levels of sustainable utilisation need to be determined through research and monitoring. For improving the effectiveness of joint patrolling in each forest patch by the local staff of Kerala Forest Department and representatives of the local Vana-Samrakshana Samithi (VSS) following action may be undertaken.

i) The frequency of foot-patrols with vehicle back-up is to be increased.
ii) Patrolling plans need to be improved. Reporting of patrolling findings should be transparent and systematic.
iii) The staff and VSS members have to be trained on skills needed for effective forest protection.
iv) The Forest Department staff engaged in patrolling should not be called for other works such as attending to the VIPs of the Department or the line-departments

or the guests, assisting in organisation of programmes and functions not connected with the forest protection.

**d. Human Resource Development**

The rural societies in the NBR are going through many changes in response to the socio-cultural and economic changes in the region (CES, 1990). In this situation, there is a need for the responsible institutions and individuals to meet the current requirements of all stakeholder groups and at the same time sustainable management of natural resources like forests, water bodies etc., (Easa and Chand Basha, 1995). In the present context, sustainable forest management activities require the institutions concerned to operate in an open, accountable and co-ordinated way. One of the problems faced by the rural institutions related to management of forests, crop lands and other landscape units in the village landscape is the limiting factor to operate effectively due to lack of shared vision and agreed common purpose. This is mainly because different institutions and partners have different strategies and objectives which are at times incompatible. In view of the fact that the forests adjacent to villages are not separate entity and their structure and functions are influenced by the surrounding landscape units, the institutions responsible for sustainable forest management should have representatives from different government departments such as the Forest, Agriculture, Commerce, Water Resources, Geology, Tribal Welfare, and among others. Eventhough, attempts are being made through participatory forest management programmes to involve different government institutions and NGOs as partners in the management of village-adjacent forests, the partner institutions have constraints such as poor motivation and less effective work. High staff turnover, vacant posts, poor levels of pay, uncertainty about continuity of employment, limited promotional opportunities, inadequate infrastructure and poor working and living conditions have been identified as the reasons for poor motivation and less effective work by the staff of partner institutions. Therefore, team building and skill development for staff can be effective only if these underlying issues are addressed. The actions to be taken to build an efficient team for the management of forest plots adjacent to the villages are:

i) Skill development amongst individuals and institutions concerned with the sustainable management of village-adjacent forest plots,

ii) Strengthening the local partnerships for the long-term success of the sustainable management of each forest plot, and
iii) Organising regular review meetings and workshops of partners to assess progress on implementation of management activities and to reward performances.

The present study also revealed that each forest adjacent to village/s in the NBR have to be managed under the partnership arrangements, involving a number of stakeholder groups. The Forest Department will have to continue the legal mandate to manage the forest resources but with increased partnership with other stakeholders. The stakeholders also have the opinion that a village-forest committee, comprising of representative of all stakeholder groups is to be formulated. The village-forest committee should have a specified extent of forest block to manage sustainably. The committee should have the responsibility to review and often oversee the activities formulated for sustainable management of its forest block. However, the long-term partnership at each forest block requires technical and financial support from participating stakeholders and other interested parties in order to realise the goal set out for sustainable forest management. Thus, a village- forest committee fund is proposed as a long-term measure for ensuring continued support for its effort in managing the forest block. The members of the trust, with the help of Kerala Forest Department can raise the fund and ensure that the money raised is used to support protection, conservation and sustainable management of their forest block.

**e. Research and monitoring**

The present work has focussed on a case study of a critical global environmental issue for long developed ecological system. Though the data used in this study cover only a few village-adjacent forest plots in the NBR, the knowledge gained through the case study is crucial for developing regional and global model of sustainable forest management under human and policy influences. Though the analytical methods employed in this study count only a small subset of available research techniques, the approach illustrated in this study serves as a demonstration of the integrated research methodology combining ecological and social methods in coherent manner. The target area of research included here are baseline data collection for forest and adjacent village ecosystems, trend analysis looking at the data on vegetation structure, composition and dynamics and ecological and human disturbance indicator values.

Similar approach can be adopted to obtain improved understanding of other village-adjacent forest areas in the Biosphere Reserve and use the gathered information for better management and monitoring of forests.

# 6. CONCLUSIONS AND RECOMMENDATIONS

A large chunk of forest area in the Nilgiri Biosphere Reserve (NBR) has long porous boundaries, often bordering human settlements. Though the commercial exploitation of forest resources has been brought to an end as early as 1980s, incidences of unauthorised collection of minor forest products are not uncommon. The lack of regulation, coupled with rampant, unauthorised exploitation has contributed to forest degradation and altering the species composition. In fact, the NBR harbors unique endemic flora and fauna which makes it an important area of biodiversity. Based on the present study following strategies and actions are suggested to ensure biodiversity conservation and management in the village-adjacent forests in the NBR.

1. Better information and understanding of the village-adjacent forests is the key to sustainable biodiversity conservation. Therefore, research should be extended to all forest plots, bordering human settlements, to generate sufficient knowledge and awareness of the importance of each forest plot in NBR. However, research should be prioritized and targeted at key issues related to conservation of forests. Many indigenous people and traditional farmers too are the repositories of knowledge about the forests. Their participation and support should be ensured to strengthen the knowledge base.
2. Dependency on forest biomass is the greatest single threat to the unique biodiversity of the NBR, but it is the aspect of the forest which is most valued amongst forest-adjacent villagers. Therefore, minimization of forest dependency on forest biomass is an important strategy. To achieve goals of this strategy, in all forest-adjacent villages, tree farming, agroforestry, energy plantations and use of alternate fuel devices such as biogas, solar cookers and fuel-efficient earthen stoves may be promoted.
3. Most of the utilization and harvesting of forest products of the NBR is for domestic needs. unauthorised collection of forest products is the main cause of forest degradation. In NBR, forest protection is the major function of the Forest Department, often in the form of patrolling by its staff. Patrolling is likely to

remain important strategy for addressing the issue of unauthorised activities. However, adequate levels of forest protection cannot be achieved through confrontation and conflict between the managers and forest-adjacent communities. Consequently, the strategy should be to work together with communities to develop joint protection system in return for agreed levels of utilization and benefit-sharing within the capacity of the forest to meet subsistence needs sustainably.

4. The Forest Department should be the sole authority to manage the resources but has to enter into partnership with other stakeholders to constitute village-forest committees for managing all village-adjacent forests. The village-forest committee should also include local community representatives and representative of the local NGOs concerned with forest conservation and management. Long-term partnership at each village-forest management committee requires technical and financial support in order to equip committee to take appropriate decision on strategies and activities related to forest conservation and management. Thus, a trust fund may be built up with the help of the Forest Department and same may be used for activities related to conservation and management of each village-adjacent forest.
5. Considerable part of the village- adjacent forest plots in the study area have already been degraded. To restore the forest plots, as a strategy, specific interventions such as promotion of natural regeneration of species characteristic of primary forests and enrichment planting to accelerate the rate of progressive succession can be undertaken.

Finally, it can be concluded that the Nilgiri Biosphere Reserve management needs to follow the concept of Biosphere Reserve in its true sense, which strongly advocates the conservation of bioresource in all its landscape units (Batisse, 1982).

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## 8. REFERENCES

Aravind, N.A., Rao, D., Vanaraj, G., Poulsen, J., Shaanker, U. and Ganeshaiah. 2001. Anthropogenic pressures in a tropical forest ecosystem in Western Ghats, India: are they sustainable? In: K.N.Ganeshaiah, U. Shaanker, and K.S. Bawa (Eds.), Tropical Ecosystems: Structure, Diversity and Human Welfare. Proceedings of the International Conference on Tropical Ecosystems. Oxford-IBH, New Delhi. pp.125-128.

Babu, V.B.A. and Chandrashekara, U.M. 2007. Impact of litter removal on tree seedling survival and establishment in New Amarambalam Reserve Forest, Kerala. In: KSCSTE (Ed.), Proceedings of the 19th Kerala Science Congress, Kannur, Kerala. KSCSTE, Kerala. pp. 775-776.

Barbier, E. B., Burgess, J.C. and Floke, C. 1994. Paradise Lost? The Ecological Economics of Biodiversity. Earth Scan, London.

Batisse, S.M., 1982. The Biosphere Reserve: a tool for environmental conservation and management. Environmental Conservation, 9: 101-111.

Bhuyan.P., Khan.M.L. and Tripathi. R.S. 2003. Tree diversity and population structure in undisturbed and human impacted stands of tropical wet evergreen forest in Arunachal Pradesh, eastern Himalaya, India. Biodiversity and Conservation 12:1753-1773.

Black, R. 1990. Regional political ecology in theory and practice: A case study from Northern Portugal. Transactions of Institution of British Geographers 15:35-47.

Browder, J. O. 1989. Development alternatives for tropical rain forests. In: H. J. Leonard (Ed.), Environment and the Poor: Development Strategy for Common Agenda. Transaction Books, New Brunswick, USA. pp. 111-134.

CES (Centre for Ecological Sciences), 1990. Nilgiri Biosphere Reserve: An Overview. Centre for Ecological Sciences, Bangalore.

Chandrashekara, U.M. 1991. Studies on Gap Phase Dynamics of Humid Tropical Forest. Ph.D Thesis, Jawaharlal Nehru University, New Delhi.

Chandrashekara, U.M. 1998. Ramakrishnan Index of Stand Quality (RISQ): an indicator for the level if forest disturbance. In: A.D. Damodaran (Ed.), Proceedings of the Tenth Kerala Science Congress. STEC, Kerala. pp. 398-400.

Chandrashekara, U.M. 2007. Effects of pruning on radial growth and biomass increment of trees growing in homegardens of Kerala, India. Agroforestry Systems 69:231-237.

Chandrashekara, U.M. and Ramakrishnan. P.S. 1994. Vegetation and gap dynamics of a tropical wet evergreen forest in the Western Ghats of Kerala, India. Journal of Tropical Ecology 10: 337-354.

Chandrashekara, U.M. and Jayaraman, K. 2002. Stand Structural Diversity and Dynamics in Natural Forests of Kerala. KFRI Research Report No. 232. Kerala Forest Research Institute, Peechi, Kerala.

Chandrashekara U.M. and Baiju E.C., 2010. Changing pattern of species composition and species utilization in homegardens of Kerala, India. Tropical Ecology 51: 221-233.

Chandrashekara, U.M., Menon, A.R.R., Nair, K.K.N, Sasidharan, N, and Swarupanandan, K. 1998. Evaluating Plant Diversity in Different Forest Types of Kerala by Laying Out Permanent Sample Plots. KFRI Research Report No. 156. Kerala Forest Research Institute, Peechi, Kerala.

Chandrashekara, U.M., Muraleedharan, P.K. and Sibichan, V. 2001. Disturbed shola forests of Kerala and strategies for its conservation and management. In: K. K. N. Nair, S. K. Khanduri and K.Balasubramanyan (Eds.) Shola Forests of Kerala: Environmental and Biodiversity. KFD and KFRI, Kerala. pp. 395-437.

Chandrashekara U.M., Gowda. B., Maikhuri, R.K. Prasanna, K.T., Sujatha, M.P., Sringeswara, A.N., Chinnappa Reddy, B.V., Baiju, E.C., Rane, A., Rajani, B.S., Dangwal, D., Mishra S. and Balakrishna A.N. 2009. Characterization of benchmark sites of the conservation and sustainable management of belowground biodiversity project in India. Journal of Soil Biology and Ecology (Special Volume): 1-22.

Connell, J.H.1978. Diversity in tropical rain forests and coral reefs. Science 199: 1302-1310.

Curtis, J. T. 1959. The Vegetation of Wisconsin: An Ordination of Plant Communities. University of Wisconsin Press, Madison, Wisconsin.

Davidar, P., Arjunan, M., Mammen, P.C., Garrigues, J.P., Puyravaud, J.P. and Roessingh, K. 2007. Forest degradation in the Western Ghats biodiversity hotspot: Resource collection, livelihood concerns and sustainability. Current Science 93:1573-1578.

Davis, F.W. and Mortiz, M.2001. Mechanism of Disturbances. In: S.A. Lewin (Ed.) Encyclopedia of Biodiversity. Academic Press, U.K. pp. 153-160.

Dixit, A.M. and Rajvanshi, A., 1998.Assesment of wood removal from tropical dry deciduous forests of Narmada basin in central India. Tropical Ecology 39:151-154.

Dorren,L.K.A., Berger, F., Imeson, A.C., Marier, B. and Rey, F. 2004. Integrity, stability and management of protection forests in the European Alps. Forest Ecology and Management 195:165-176.

Duelli, P. and Obrist, M.K. 2003. Regional biodiversity in an agricultural landscape: The contribution of seminatural habitat islands. Basic and Applied Ecology 4:129-138.

Easa, P.S. and Chand Basha, S. 1995. A survey on the habitat and distribution of stream fishes in the Kerala part of Nilgiri Biosphere Reserve. KFRI Research Report No. 104. Kerala Forest Research Institute, Peechi, Kerala.

Gadgil, M. 1989. Forest Management, deforestation and people's impoverishment. Social Action (New Delhi) 39: 357-383.

Gills, M. and Repetto, R. 1988. Deforestation and Government Policy. Occasional Paper. International Center for Economic Growth, California, USA.

Grimble, R. and Laidlaw, M. 2002. Biological Resource Management Integrating Biodiversity: Concerns in Rural Development Projects and Programs. Paper No. 85, Environment Department Papers, Natural Resources Institute (NRI), UK.

Heywood, V. and Watson, R. 1995. Global Biodiversity Assessment. Cambridge University Press, Cambridge.

IUCN. 1990. Directory of South-Asian Protected Areas. IUCN, Gland, Switzerland and Cambridge, UK.

Jayanarayan, T. 2001. Forest Degradation in Kerala -Causes and Consequences : A Case Study of Peechi-Vazhani Area. Discussion Paper No. 27. Centre for Development Studies, Thiruvanthapuram.

Jha, C.S., Dutt, C.B.S. and Bawa, K.S. 2000. Deforestation and land use changes in the Western Ghats, India. Current Science 79 : 231-238.

Kerala Agricultural Department, 2004. Agriculture at a Glance- August 2004. Kerala Agriculture Department, Trivandrum.

Kothari, A., Pande, P., Singh, S. and Variava, D.S. 1989. Management of National Parks and Sanctuaries in India: A Status Report. IIPA, New Delhi.

Kumar, B.M. and Nair, P.K.R. 2004. The enigma of tropical homegardens. Agroforestry Systems 61: 135-152.

Kunhikrishnan, E. 2001. The shoals and grass land in the Western Ghats. Science India 4:29-32.

Lal, R. 2004. Soil carbon sequestration impacts on global climate change and food security. Science 304:1623-1629.

Mackey, R.L. and Currie, D.J. 2001. The diversity disturbance relationship: is it generally strong and packed? Ecology 82:3479-3492.

Maikhuri, R.K., Nautiyal, S., Rao, K.S., Chandrasekhar, K., Saxena, K.G. and R. Gavali. 2000. Analysis and resolution of protected area-people conflicts in Nanda Devi Biosphere Reserve, India. Environment Conservation 27: 43-53.

Moench, M. 1989. Forest degradation and structure of biomass utilization in Himalayan foothills village, Environment and Conservation 16: 137-146.

Mutangah, J.G. 1996. An Investigation of Vegetation Status and Processs in Relation to Human Disturbance in Kakamaga Forest, Western Kenya. Ph.D. Thesis, University of Wales, UK. (Mimeo)

Nameer, P.O. 1993. Ecophysiological Studies in Disturbed Forest ecosystem: A Case Study at Pattikad. M.Sc., Dissertation. College of Forestry, Thrissur.

Nayak, S. N. V., Swamy, H. R., Nagaraj, B. C., Usha Rao and Chandrashekara, U. M. 2000. Farmers' attitude towards sustainable management of Soppina Betta forest in Sringeri area of the Western Ghats, South India, Forest Ecology and Management 132: 223-241.

Nicols, O.G. and Nicols, F.M. 2003. Long-term trends in faunal recolonization after bauxite mining in the Jarrah forest of southwestern Austalia. Restoration Ecology 11: 261-272.

Ohsawa, M., Shakya, P.R. and Numata. M., 1986. Distribution and succession of West Himalayan forest types in the eastern parts of Nepal Himalaya. Mountain Research and Development 6:143-157.

Palm, C.A., Gachengo, C.N., Delve, R.J., Cadisch, G. and Giller, K.E. 2001. Organic inputs for soil fertility management in tropical agroecosystems: application of an organic resource database. Agricultural Economics and Environment 83:27-42.

Pascal. J.P. 1988. Wet Evergreen Forests of Western Ghats of India: Ecology, Structure, Floristic Composition and Succession. French Institute Pondicherry, Pondichery, India.

Perring, C. and Walker, B.H., 1997. Biodiversity, resilience and the control of ecological economic system: the cases of fire driven rangelands. Ecological Economics 22:73-83.

Philips. F. A. 1959. Methods of Vegetation Study. Henry Hold and Company, New York.

Reid, N., Marroquin, J. and Beyer-Munzel, P. 1990.Utilisation of shrubs and trees for browse, fuel wood and timber in Tamaulipan thorn scrub, north-eastern Mexico. Forest Ecology and Management 36: 61-79.

Richards.P.W. 1952. The Tropical Rainforest. Cambridge University Press, Cambridge.

Sankar, S. and Muraleedharan, P.K. 1990. Human Ecology in Attappady Reserve. In: K.K.N. Nair, K. V. Bhat, J. K. Sharma and K. Swarupanandan (Eds.) Tropical Forest Ecosystem Conservation and Development in South and South-East Asia. Kerala Forest Research Institute, Peechi, Kerala, India. pp. 127-131.

Schwendener, C.M., Lehmann, J., Luizao, R.C.C. and Fernandes, E.C.M. 2005. Nitrogen transfer between high- and low-quality leaves on a nutrient-poor Oxisol determined by $^{15}N$ enrichment. Soil Biology and Biochemistry 37: 787-794.

Shannon, C. E. and Wiener, W. 1963. The Mathematical Theory of Communication. University of Illinois Press, Urbana, IL.

Silori, C.S. 1996. Study of Pressure and Dependency of Local People on Natural Resource of Mudumalai Wildlife Sanctury. Ph.D. Thesis, Saurashtra University, Rajkot, India (Mimeo).

Silori, C.S. 2001. Status and distribution of anthropogenic pressure in the buffer zone of Nanda Devi Biopshere Reserve in western Himalaya, India. Biodiversity and Conservation 10: 1113-1130.

Simpson, E.H. 1949. Measurement of Diversity. Nature 163: 688.

Singh, J.S. 2005. Sustainable development of the Indian Himalayan region: linking ecological and economic concerns. Current Science 90: 784-788

Singh, K.P. 1968. Studies on decomposition of leaf litter of important trees of tropical deciduous forest at Varanasi. Tropical Ecology 10:292-311.

Smiet.A.C. 1992. Forest Ecology on Java: Human impact and vegetation on montane forest. Journal of Tropical Ecology 8: 129-152.

Sodhi, N.S. and Boork, B. 2006. Southeast Asian Biodiversity in Crisis. Cambridge University Press, U.K.

Sundriyal. R.C. and Sharma. E. 1996. Anthropogenic pressure on tree structure and biomass in the temperate forest of Mamlay watershed in Sikkim. Forest Ecology and Management 81: 113-134.

Veetas, O.R. 1993. Spatial and temporal vegetation changes along a moisture gradient in northeastern Sudan. Biotropica 5:164-175.

Appendix 1. Density, basal area and Importance value index (IVI) of different tree species in seedling and mature stage in a undisturbed forest plot at Nadukani (UF1) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Density (No. of plants $ha^{-1}$) | Basal area ($cm^2$ $ha^{-1}$) | IVI | Density (No. of plants $ha^{-1}$ | Basal area ($m^2$ $ha^{-1}$) | IVI |
| *Actinodaphne angustifolia* | 0 | 0 | 0 | 8 | 0.286 | 2.28 |
| *Actinodaphne bourdillonii* | 100 | 43.48 | 8.98 | 8 | 0.472 | 2.71 |
| *Aglaia lawii* | 233 | 212.7 | 22.03 | 6 | 0.487 | 2.7 |
| *Aglaia malabarica* | 0 | 0 | 0 | 18 | 0.508 | 4.83 |
| *Alstonia scholaris* | 33 | 94.55 | 5.26 | 2 | 0.019 | 0.45 |
| *Aporosa lindleyana* | 100 | 199.3 | 15.87 | 0 | 0 | 0 |
| *Artocarpus gomezianus* | 33 | 75.69 | 4.89 | 2 | 0.043 | 0.51 |
| *Artocarpus heterophyllus* | 0 | 0 | 0 | 10 | 1.532 | 5.52 |
| *Artocarpus hirsutus* | 0 | 0 | 0 | 4 | 0.365 | 1.65 |
| *Baccaurea courtallensis* | 67 | 118.4 | 10.28 | 44 | 0.257 | 8.28 |
| *Bischofia javanica* | 33 | 31.69 | 3.96 | 6 | 1.817 | 5.35 |
| *Calophyllum polyanthum* | 0 | 0 | 0 | 20 | 2.581 | 9.17 |
| *Canthium sp.* | 0 | 0 | 0 | 2 | 0.017 | 0.45 |
| *Cassia fistula* | 0 | 0 | 0 | 2 | 0.098 | 0.63 |
| *Cinnamomum malabatrum* | 33 | 37.71 | 4.7 | 46 | 1.626 | 11.02 |
| *Croton malabaricus* | 0 | 0 | 0 | 6 | 0.307 | 1.92 |
| *Cullenia exarillata* | 67 | 172.1 | 10.16 | 4 | 0.146 | 1.15 |
| *Cyathocalyx zeylanica* | 0 | 0 | 0 | 2 | 0.002 | 0.41 |
| *Debregeasia longifolia* | 0 | 0 | 0 | 20 | 0.76 | 5.55 |
| *Diospyros bourdillonii* | 200 | 329.2 | 39.31 | 10 | 0.02 | 2.09 |
| *Diospyros assimilis* | 0 | | 0 | 2 | 0.011 | 0.43 |
| *Diospyros oocarpa* | 3 | 58.93 | 5.13 | 4 | 0.21 | 1.29 |
| *Diospyros paniculata* | 0 | 0 | 0 | 2 | 0.036 | 0.49 |
| *Diospyros sp.* | 0 | 0 | 0 | 8 | 0.11 | 1.89 |
| *Drypetes oblongifolia* | 33 | 58.93 | 4.52 | 6 | 0.216 | 1.72 |
| *Drypetes elata* | 0 | 0 | 0 | 6 | 0.012 | 1.25 |
| *Fahrenheitia zeylanica* | 0 | 0 | 0 | 44 | 1.781 | 11.22 |
| *Ficus drupacea var pubescens* | 0 | 0 | 0 | 2 | 0.204 | 0.87 |
| *Flacourtia montana* | 0 | 0 | 0 | 2 | 0.003 | 1.42 |
| *Garcinia morella* | 0 | 0 | 0 | 6 | 0.075 | 1.4 |
| *Holigarna arnottiana* | 0 | 0 | 0 | 12 | 1.696 | 6.3 |
| *Holigarna grahamii* | 33 | 31.69 | 4.57 | 2 | 0.252 | 0.98 |
| *Hopea racophloea* | 174 | 4.266 | 15.75 | 174 | 4.266 | 32.32 |
| *Hydnocarpus pentandra* | 0 | 0 | 0 | 16 | 0.539 | 4.23 |
| *Ixora nigricans* | 0 | 0 | 0 | 32 | 0.729 | 5.87 |
| *Kingiodendron pinnatum* | 0 | 0 | 0 | 46 | 0.963 | 9.53 |
| *Knema attenuata* | 700 | 1726 | 82.46 | 316 | 4.984 | 47.21 |
| *Lagerstroemia microcarpa* | 0 | 0 | 0 | 2 | 0.571 | 1.7 |
| *Litsea glabrata* | 0 | 0 | 0 | 2 | 0.03 | 0.48 |
| *Litsea mysorensis* | 0 | 0 | 0 | 4 | 0.357 | 1.63 |
| *Macaranga peltata* | 0 | 0 | 0 | 2 | 0.06 | 0.55 |
| *Mallotus beddomei* | 0 | 0 | 0 | 20 | 0.169 | 4.21 |
| *Mallotus stenanthus* | 0 | 0 | 0 | 2 | 0.002 | 0.41 |
| *Mangifera indica* | 0 | 0 | 0 | 12 | 0.675 | 3.47 |
| *Meiogyne pannosa* | 67 | 529.1 | 17.51 | 2 | 0.039 | 0.5 |
| *Myristica malabarica* | 133 | 237.9 | 17.93 | 212 | 2.952 | 34.57 |
| *Nothopegia racemosa* | 0 | 0 | 0 | 10 | 0.051 | 2.16 |
| *Nothopegia sp.* | 0 | 0 | 0 | 8 | 0.107 | 1.88 |

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Appendix 1. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a undisturbed forest plot at Nadukani (UF1) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Orophea erythrocarpa* | 0 | 0 | 0 | 8 | 0.009 | 1.66 |
| *Otonephelium stipulaceum* | 0 | 0 | 0 | 2 | 0.089 | 0.61 |
| *Palaquium ellipticum* | 0 | 0 | 0 | 8 | 0.083 | 1.82 |
| *Pavetta hispidula* | 0 | 0 | 0 | 4 | 0.007 | 0.58 |
| *Polyalthia coffeoides* | 0 | 0 | 0 | 16 | 0.993 | 5.26 |
| *Polyalthia fragrans* | 0 | 0 | 0 | 12 | 1.033 | 4.54 |
| *Spondias pinnata* | 0 | 0 | 0 | 2 | 0.528 | 1.61 |
| *Syzygim gardneri* | 33 | 37.71 | 4.09 | 20 | 2.879 | 9.84 |
| *Syzygium densiflorum* | 0 | 0 | 0 | 4 | 0.127 | 1.1 |
| *Syzygium mundagam* | 0 | 0 | 0 | 4 | 3 | 7.62 |
| *Toona ciliata* | 33 | 51.33 | 4.37 | 2 | 0.65 | 1.88 |
| *Trewia polycarpa* | 0 | 0 | 0 | 2 | 0.05 | 0.52 |
| *Vateria indica* | 100 | 492.6 | 18.23 | 64 | 0.565 | 13.27 |
| *Vitex altissima* | 0 | 0 | 0 | 4 | 0.125 | 1.1 |
| *Xanthophyllum arnottianum* | 0 | 0 | 0 | 2 | 0.009 | 0.43 |

Appendix 2. Density, basal area and Importance value index (IVI) of different tree species in seedling and mature stage in a undisturbed forest plot at Adakkahode (UF2) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Actinodaphne hookeriana* | 0 | 0 | 0 | 16 | 0.55 | 5.07 |
| *Aglaia lawii* | 33 | 67.1 | 2.84 | 2 | 0.08 | 0.65 |
| *Aglaia malabarica* | 400 | 445 | 20.1 | 0 | 0 | 0 |
| *Antidesma alexiteria* | 0 | 0 | 0 | 30 | 0.33 | 7.16 |
| *Antidesma montanum* | 33 | 51.3 | 2.7 | 2 | 0.01 | 0.49 |
| *Aporosa lindleyana* | 0 | 0 | 0 | 12 | 0.04 | 2.72 |
| *Artocarpus heterophyllus* | 33 | 67.1 | 2.84 | 2 | 0.01 | 0.49 |
| *Artocarpus hirsutus* | 0 | 0 | 0 | 10 | 0.52 | 3.54 |
| *Baccaurea courtallensis* | 33 | 310.7 | 2.83 | 8 | 1.25 | 4.03 |
| *Bischofia javanica* | 133 | 645.1 | 15.24 | 92 | 0.63 | 17.77 |
| *Calophyllum polyanthum* | 0 | 0 | 0 | 4 | 0.09 | 1.17 |
| *Caryota urens* | 33 | 51.3 | 2.7 | 14 | 2.36 | 8.45 |
| *Chionanthus leprocarpa var courtallensis* | 0 | 0 | 0 | 2 | 0.07 | 0.64 |
| *Cinnamomum malabatrum* | 33 | 235.7 | 4.33 | 2 | 0.12 | 0.75 |
| *Croton malabaricus* | 33 | 58.9 | 2.77 | 6 | 0.01 | 1.2 |
| *Cullenia exarillata* | 0 | 0 | 0 | 2 | 0.04 | 0.57 |
| *Cyathocalyx zeylanica* | 200 | 573.8 | 14.05 | 76 | 7.6 | 30.45 |
| *Diospyros bourdillonii* | 0 | 0 | 0 | 2 | 0.01 | 0.49 |
| *Diospyros candolleana* | 67 | 82 | 5.23 | 4 | 0.24 | 1.48 |
| *Diospyros oocarpa* | 33 | 150.9 | 3.56 | 2 | 0.2 | 0.91 |
| *Diospyros paniculata* | 0 | 0 | 0 | 4 | 0.08 | 0.86 |
| *Diospyros sp.* | 0 | 0 | 0 | 4 | 0.03 | 1.05 |
| *Drypetes elata* | 0 | 0 | 0 | 4 | 0.06 | 1.1 |
| *Fahrenheitia zeylanica* | 0 | 0 | 0 | 4 | 0.02 | 1.01 |
| *Flacourtia montana* | 0 | 0 | 0 | 10 | 1.37 | 5.08 |
| *Garcinia gummi-gutta* | 0 | 0 | 0 | 6 | 0.48 | 2.19 |
| *Garcinia morella* | 0 | 0 | 0 | 8 | 0.03 | 2 |
| *Garcinia talbotii* | 100 | 419.8 | 8.95 | 4 | 0.27 | 1.56 |
| *Goniothalamus cardiopetalus* | 0 | 0 | 0 | 2 | 0.01 | 0.51 |
| *Holigarna arnottiana* | 0 | 0 | 0 | 2 | 0.01 | 0.5 |
| *Holigarna grahamii* | 0 | 0 | 0 | 24 | 1.87 | 9.82 |
| *Hopea racophloea* | 0 | 0 | 0 | 6 | 0.72 | 2.99 |
| *Hydnocarpus pentandra* | 633 | 1432.9 | 32.82 | 72 | 2.51 | 18.62 |
| *Kingiodendron pinnatum* | 167 | 501.8 | 11.16 | 4 | 0.91 | 2.9 |
| *Knema attenuata* | 0 | 0 | 0 | 8 | 0.34 | 2.67 |
| *Leptonychia caudata* | 1200 | 2670.6 | 65.44 | 30 | 2.7 | 28.9 |
| *Litsea laevigata* | 0 | 0 | 0 | 2 | 0.01 | 0.49 |
| *Mallotus stenanthus* | 0 | 0 | 0 | 16 | 0.43 | 4.52 |
| *Mangifera indica* | 0 | 0 | 0 | 20 | 0.47 | 5.87 |
| *Meiogyne pannosa* | 0 | 0 | 0 | 8 | 0.14 | 2.24 |
| *Meliosma simplicifolia* | 200 | 463.8 | 16.09 | 12 | 0.8 | 4.63 |
| *Memecylon umbellatum* | 0 | 0 | 0 | 2 | 0.06 | 0.61 |
| *Mesua ferrea* | 333 | 610.8 | 23.39 | 0 | 0 | 0 |
| *Myristica malabarica* | 0 | 0 | 0 | 2 | 0.04 | 0.58 |
| *Nothopegia racemosa* | 300 | 1436.6 | 26.89 | 142 | 2.43 | 29.8 |
| *Nothopegia sp.* | 67 | 42.4 | 3.37 | 6 | 0.01 | 1.47 |
| *Olea dioica* | 0 | 0 | 0 | 8 | 0.04 | 1.75 |

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Appendix 2 (cont'd). Density, basal area and Importance value index (IVI) of different tree species in seedling and mature stage in an undisturbed forest plot at Adakkahode (UF2) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Otonephelium stipulaceum* | 0 | 0 | 0 | 2 | 0.03 | 0.54 |
| *Palaquium ellipticum* | 0 | 0 | 0 | 4 | 0.05 | 1.08 |
| *Polyalthia coffeoides* | 0 | 0 | 0 | 16 | 0.79 | 4.73 |
| *Polyalthia fragrans* | 0 | 0 | 0 | 14 | 0.63 | 4.46 |
| *Prunus ceylanica* | 133 | 930.6 | 17.2 | 4 | 0.01 | 0.98 |
| *Psychotria macrocarpa* | 0 | 0 | 0 | 2 | 0.05 | 0.58 |
| *Pterospermum rubiginosum* | 0 | 0 | 0 | 2 | 0.01 | 0.49 |
| *Syzygim gardneri* | 0 | 0 | 0 | 2 | 0.18 | 0.86 |
| *Syzygium densiflorum* | 133 | 107.6 | 7 | 36 | 10.92 | 31.49 |
| *Syzygium hemisphericum* | 0 | 0 | 0 | 2 | 0.26 | 1.04 |
| *Syzygium mundagam* | 0 | 0 | 0 | 2 | 0.01 | 0.5 |
| *Terminalia bellirica* | 0 | 0 | 0 | 12 | 0.35 | 3.66 |
| *Toona ciliata* | 0 | 0 | 0 | 6 | 2.56 | 6.92 |
| *Vateria indica* | 33 | 58.9 | 2.77 | 6 | 0.5 | 2.52 |
| *Vepris bilocularis* | 100 | 55.8 | 5.74 | 12 | 0.22 | 3.38 |
| *Xanthophyllum arnottianum* | 0 | 0 | 0 | 60 | 0.2 | 13.05 |

Appendix 3. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in an undisturbed zone forest plot at Vaniampuzha (UF3) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Actinodaphne angustifolia* | 112 | 501.8 | 37.9 | 2 | 0.105 | 0.86 |
| *Aglaia lawii* | 86 | 188.8 | 23.9 | 16 | 0.196 | 4.66 |
| *Alseodaphne semecarpifolia* | 14 | 21.6 | 8.8 | 2 | 0.024 | 0.67 |
| *Alstonia scholaris* | 0 | 0 | 0 | 2 | 0.014 | 0.65 |
| *Antiaris toxicaria* | 0 | 0 | 0 | 6 | 7.146 | 18.5 |
| *Aporosa lindleyana* | 16 | 37.7 | 5.1 | 4 | 0.148 | 1.57 |
| *Artocarpus hirsutus* | 0 | 0 | 0 | 8 | 4.034 | 11.86 |
| *Baccaurea courtallensis* | 136 | 493.5 | 39.8 | 72 | 0.853 | 20.92 |
| *Callicarpa tomentosa* | 16 | 23.7 | 4.6 | 4 | 0.08 | 1.41 |
| *Canthium dicoccum var umbellatum* | 24 | 29.6 | 5.5 | 4 | 0.02 | 0.92 |
| *Cinnamomum malabatrum* | 96 | 241.9 | 20.1 | 30 | 2.353 | 12.59 |
| *Croton malabaricus* | 24 | 26.9 | 5.4 | 26 | 0.244 | 7.49 |
| *Dimocarpus longan* | 12 | 18.6 | 6.2 | 4 | 0.028 | 1.29 |
| *Diospyros bourdillonii* | 56 | 150.7 | 17.4 | 70 | 5.402 | 30.56 |
| *Diospyros candolleana* | 0 | 0 | 0 | 2 | 0.2 | 1.8 |
| *Diospyros foliosa* | 0 | 0 | 0 | 12 | 0.477 | 4.79 |
| *Diospyros malabarica* | 0 | 0 | 0 | 2 | 0.011 | 0.64 |
| *Drypetes elata* | 48 | 43.5 | 8.3 | 28 | 1.009 | 9.54 |
| *Elaeocarpus serratus* | 76 | 122.6 | 13.8 | 22 | 2.489 | 10.8 |
| *Ficus nervosa* | 0 | 0 | 0 | 2 | 0.305 | 1.32 |
| *Garcinia gummi-gutta* | 12 | 12.1 | 3.8 | 2 | 0.009 | 0.63 |
| *Garcinia talbotii* | 24 | 31.1 | 5.6 | 2 | 0.095 | 0.83 |
| *Holigarna grahamii* | 36 | 44.5 | 9.4 | 2 | 0.306 | 1.33 |
| *Hydnocarpus pentandra* | 24 | 52.7 | 6.4 | 10 | 0.724 | 4.4 |
| *Ixora nigricans* | 36 | 68.1 | 10.3 | 18 | 0.312 | 5.55 |
| *Ixora sp.* | 0 | 0 | 0 | 6 | 0.092 | 2.05 |
| *Knema attenuata* | 76 | 275.8 | 21.7 | 52 | 3.031 | 20.91 |
| *Lepisanthes tetraphylla* | 0 | 0 | 0 | 14 | 0.181 | 4.36 |
| *Litsea sp.* | 0 | 0 | 0 | 12 | 0.729 | 5.38 |
| *Macaranga peltata* | 12 | 31.3 | 4.5 | 8 | 0.479 | 3.57 |
| *Mangifera indica* | 0 | 0 | 0 | 2 | 0.075 | 0.79 |
| *Myristica malabarica* | 24 | 64.6 | 6.8 | 20 | 0.515 | 6.98 |
| *Olea dioica* | 12 | 24.5 | 4.2 | 4 | 0.018 | 1.27 |
| *Otonephelium stipulaceum* | 12 | 14.8 | 3.9 | 70 | 1.792 | 22.15 |
| *Polyalthia coffeoides* | 0 | 0 | 0 | 2 | 0.513 | 1.81 |
| *Polyalthia fragrans* | 24 | 38.7 | 8.1 | 66 | 3.185 | 23.12 |
| *Pterospermum diversifolium* | 12 | 21.8 | 4.1 | 2 | 0.105 | 0.86 |
| *Pterygota alata* | 0 | 0 | 0 | 74 | 1.331 | 20.56 |
| *Stereospermum personatum* | 0 | 0 | 0 | 2 | 0.035 | 0.7 |
| *Symplacos sp.* | 12 | 23.6 | 3.4 | 6 | 0.135 | 2.15 |
| *Syzygium cumini* | 0 | 0 | 0 | 4 | 0.732 | 2.91 |
| *Syzygim gardneri* | 0 | 0 | 0 | 14 | 1.249 | 6.85 |
| *Syzygium hemisphericum* | 12 | 29.2 | 3.6 | 26 | 1.988 | 12.6 |
| *Tabernaemontana heyneana* | 0 | 0 | 0 | 6 | 0.65 | 1.99 |
| *Tetrameles nudiflora* | 12 | 31.3 | 3 | 6 | 0.027 | 1.55 |
| *Toona ciliata* | 0 | 0 | 0 | 2 | 0.13 | 0.64 |
| *Xanthophyllum arnottianum* | 24 | 21.8 | 4.1 | 6 | 0.025 | 1.9 |

Appendix 4. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in an undisturbed forest plot at Vaniampuzha-2 (UF4) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants ha$^{-1}$) | BA (cm$^2$ ha$^{-1}$) | IVI | Den (No. of plants ha$^{-1}$) | BA (m$^2$ ha$^{-1}$) | IVI |
| *Aglaia lawii* | 40 | 90.83 | 10.04 | 26 | 0.514 | 8.25 |
| *Alseodaphne semecarpifolia* | 120 | 53.43 | 14.99 | 8 | 0.275 | 3.17 |
| *Alstonia scholaris* | 40 | 25.46 | 5.52 | 2 | 0.018 | 0.66 |
| *Antiaris toxicaria* | 80 | 20.43 | 8.94 | 6 | 3.23 | 10.21 |
| *Antidesma montanum* | 40 | 15.4 | 4.83 | 2 | 0.021 | 0.67 |
| *Artocarpus gomezianus* | 0 | 0 | 0 | 2 | 0.485 | 1.87 |
| *Artocarpus hirsurtus* | 120 | 15.71 | 13.89 | 4 | 1.403 | 4.86 |
| *Baccaurea courtallensis* | 0 | 0 | 0 | 42 | 0.521 | 13.89 |
| *Bischofia javanica* | 120 | 41.88 | 12.18 | 0 | 0 | 0 |
| *Calophyllum polyanthum* | 0 | 0 | 0 | 2 | 0.104 | 0.88 |
| *Canarium strictum* | 120 | 59.4 | 11.38 | 0 | 0 | 0 |
| *Canthium dicoccum var umbellatum* | 0 | 0 | 0 | 2 | 0.052 | 0.75 |
| *Cinnamomum malabatrum* | 80 | 19.17 | 8.85 | 2 | 1.835 | 10.19 |
| *Dimocarpus longan* | 160 | 154.6 | 25.75 | 0 | 0 | 0 |
| *Diospyros bourdillonii* | 80 | 42.74 | 10.48 | 128 | 6.223 | 44.11 |
| *Diospyros candolleana* | 40 | 11.91 | 4.55 | 4 | 0.008 | 1.25 |
| *Diospyros paniculata* | 0 | 0 | 0 | 24 | 0.91 | 9.38 |
| *Drypetes elata* | 0 | 0 | 0 | 72 | 2.679 | 25.51 |
| *Elaeocarpus serratus* | 0 | 0 | 0 | 10 | 0.593 | 4.61 |
| *Ficus drupacea* | 0 | 0 | 0 | 2 | 0.486 | 1.87 |
| *Flacourtia montana* | 40 | 15.4 | 4.83 | 4 | 0.255 | 1.89 |
| *Garcinia gummi-gutta* | 240 | 193.6 | 29.94 | 4 | 0.021 | 1.28 |
| *Garcinia morella* | 0 | 0 | 0 | 6 | 0.012 | 1.87 |
| *Holigarna grahamii* | 0 | 0 | 0 | 4 | 0.502 | 2.18 |
| *Holigarna arnottiana* | 240 | 283.5 | 40.18 | 2 | 0.268 | 1.1 |
| *Hopea parviflora* | 0 | 0 | 0 | 6 | 0.303 | 2.63 |
| *Hydnocarpus pentandra* | 0 | 0 | 0 | 10 | 0.605 | 4.28 |
| *Ixora nigricans* | 80 | 78.57 | 12.96 | 8 | 0.144 | 2.83 |
| *Knema attenuata* | 80 | 21.14 | 8.99 | 58 | 2.621 | 21.41 |
| *Lepisanthes tetraphylla* | 0 | 0 | 0 | 6 | 0.17 | 2.28 |
| *Litsea laevigata* | 0 | 0 | 0 | 6 | 0.13 | 2.18 |
| *Mallotus philippensis* | 80 | 105.9 | 12.84 | 10 | 0.314 | 3.53 |
| *Mangifera indica* | 40 | 17.68 | 4.99 | 0 | 0 | 0 |
| *Myristica malabarica* | 80 | 40.23 | 10.31 | 34 | 1.247 | 12.61 |
| *Neolamarckia cadamba* | 0 | 0 | 0 | 2 | 0.034 | 0.7 |
| *Otonephelium stipulaceum* | 0 | 0 | 0 | 108 | 1.941 | 29.34 |
| *Pajanelia longifolia* | 0 | 0 | 0 | 2 | 1.186 | 3.69 |
| *Polyalthia fragrans* | 0 | 0 | 0 | 28 | 3.064 | 15.47 |
| *Pterygota alata* | 0 | 0 | 0 | 34 | 1.443 | 13.11 |
| *Sapindus trifoliata* | 0 | 0 | 0 | 4 | 0.109 | 1.51 |
| *Spondias pinnata* | 0 | 0 | 0 | 2 | 0.059 | 0.77 |
| *Sterculia guttata* | 40 | 6.36 | 4.2 | 2 | 0.102 | 0.88 |
| *Syzygium cumini* | 0 | 0 | 0 | 2 | 0.124 | 0.93 |
| *Syzygium gardneri* | 80 | 28.68 | 9.51 | 10 | 2.79 | 9.95 |
| *Syzygium hemisphericum* | 40 | 20.11 | 5.16 | 24 | 0.262 | 7.69 |
| *Tabernaemontana heyneana* | 120 | 38.03 | 13.92 | 2 | 0.06 | 0.77 |
| *Xanthophyllum arnottianum* | 80 | 46.83 | 10.77 | 34 | 1.461 | 12.81 |

Appendix 5. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in an undisturbed forest plot at Chandanathode (UF5) in the Kerala part of Nilgiri Biosphere Reserve.

| species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants ha$^{-1}$) | BA (cm$^2$ ha$^{-1}$) | IVI | Den (No. of plants ha$^{-1}$) | BA (m$^2$ ha$^{-1}$) | IVI |
| *Actinodaphne angustifolia* | 100 | 109.5 | 15 | 24 | 0.174 | 5.7 |
| *Actinodaphne lawsonii* | 0 | 0 | 0 | 2 | 0.003 | 0.5 |
| *Aglaia sp.1* | 0 | 0 | 0 | 12 | 0.437 | 3.98 |
| *Alseodaphne semecarpifolia* | 0 | 0 | 0 | 40 | 0.072 | 6.72 |
| *Antidesma alexiteria* | 33 | 75.7 | 4.49 | 2 | 0.003 | 0.5 |
| *Antidesma menasu* | 33 | 21.2 | 3.26 | 0 | 0 | 0 |
| *Antidesma montanum* | 0 | 0 | 0 | 6 | 0.221 | 2 |
| *Aporosa lindleyana* | 0 | 0 | 0 | 2 | 0.003 | 0.5 |
| *Artocarpus heterophyllus* | 0 | 0 | 0 | 2 | 0.065 | 2.04 |
| *Baccaurea courtallensis* | 0 | 0 | 0 | 2 | 0.012 | 0.52 |
| *Bischofia javanica* | 33 | 21.2 | 3.26 | 4 | 0.036 | 1.07 |
| *Canarium strictum* | 0 | 0 | 0 | 2 | 0.003 | 0.5 |
| *Chionanthus malabaricus* | 0 | 0 | 0 | 12 | 0.074 | 3.11 |
| *Cinnamomum malabatrum* | 0 | 0 | 0 | 8 | 0.421 | 2.67 |
| *Cullenia exarillata* | 33 | 26.2 | 3.37 | 38 | 9.467 | 31.6 |
| *Dimocarpus longan* | 167 | 268.7 | 28.28 | 120 | 3.327 | 27.89 |
| *Diospyros paniculata* | 0 | 0 | 0 | 12 | 0.122 | 2.93 |
| *Dysoxylum malabaricum* | 0 | 0 | 0 | 2 | 0.017 | 0.53 |
| *Elaeocarpus serratus* | 0 | 0 | 0 | 14 | 0.461 | 3.94 |
| *Elaeocarpus tuberculataus* | 0 | 0 | 0 | 14 | 3.528 | 11.85 |
| *Ficus exasperata* | 0 | 0 | 0 | 6 | 0.353 | 2.02 |
| *Ficus nervosa* | 0 | 0 | 0 | 2 | 0.151 | 0.85 |
| *Flacourtia montana* | 33 | 37.7 | 3.63 | 0 | 0 | 0 |
| *Garcinia gummi-gutta* | 33 | 37.7 | 3.63 | 2 | 0.144 | 0.83 |
| *Garcinia sp.* | 0 | 0 | 0 | 8 | 0.083 | 2.15 |
| *Heritiera papilio* | 0 | 0 | 0 | 6 | 0.074 | 1.64 |
| *Holigarna arnottiana* | 0 | 0 | 0 | 14 | 3.322 | 11.35 |
| *Holigarna grahamii* | 0 | 0 | 0 | 2 | 0.019 | 0.54 |
| *Holigarna nigra* | 0 | 0 | 0 | 2 | 0.034 | 0.57 |
| *Holoptelia integrifolia* | 33 | 44.3 | 3.78 | 0 | 0 | 0 |
| *Hopea ponga* | 0 | 0 | 0 | 4 | 0.004 | 0.99 |
| *Isonandra lanceolata* | 0 | 0 | 0 | 2 | 0.005 | 0.5 |
| *Knema attenuata* | 0 | 0 | 0 | 12 | 0.042 | 2.74 |
| *Lagerstroemia microcarpa* | 0 | 0 | 0 | 2 | 0.552 | 1.81 |
| *Ligustrum perrottetii var obovatum* | 0 | 0 | 0 | 2 | 0.05 | 0.61 |
| *Litsea bourdillonii* | 33 | 16.8 | 3.16 | 2 | 0.063 | 0.64 |
| *Litsea coriacea* | 167 | 386.3 | 19.23 | 6 | 0.519 | 2.41 |
| *Litsea floribunda* | 0 | 0 | 0 | 2 | 0.173 | 0.9 |
| *Litsea ghatica* | 167 | 454.1 | 20.24 | 2 | 0.002 | 0.49 |
| *Litsea insignis* | 0 | 0 | 0 | 28 | 0.905 | 8.13 |
| *Litsea laevigata* | 33 | 26.2 | 3.37 | 0 | 0 | 0 |
| *Macaranga peltata* | 0 | 0 | 0 | 4 | 0.266 | 1.61 |
| *Mallotus philippensis* | 33 | 51.3 | 3.94 | 12 | 0.406 | 3.91 |
| *Mallotus stenanthus* | 0 | 0 | 0 | 10 | 0.059 | 2.59 |
| *Mallotus tetracoccus* | 0 | 0 | 0 | 2 | 0.12 | 0.78 |
| *Mangifera indica* | 0 | 0 | 0 | 6 | 0.174 | 1.88 |

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Appendix 5 (cont'd). Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in an undisturbed forest plot at Chandanathode (UF5) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Meiogyne pannosa* | 0 | 0 | 0 | 6 | 0.249 | 2.06 |
| *Meliosma pinnata* | 0 | 0 | 0 | 2 | 0.097 | 0.72 |
| *Memecylon malabaricum* | 67 | 111.1 | 8.07 | 2 | 0.006 | 0.5 |
| *Mesua ferrea* | 400 | 214.8 | 26.36 | 32 | 2.742 | 12.9 |
| *Myristica dactyloides* | 0 | 0 | 0 | 2 | 0.006 | 0.5 |
| *Neolitsea cassia* | 0 | 0 | 0 | 12 | 0.041 | 3.03 |
| *Nothopegia sp.* | 0 | 0 | 0 | 16 | 0.228 | 3.87 |
| *Olea dioica* | 0 | 0 | 0 | 18 | 0.42 | 4.52 |
| *Otonephelium stipulaceum* | 267 | 208.2 | 16.78 | 140 | 2.062 | 28.3 |
| *Palaquium ellipticum* | 0 | 0 | 0 | 18 | 1.383 | 7.7 |
| *Persea macrantha* | 100 | 155.6 | 10.16 | 16 | 0.691 | 5.27 |
| *Polyalthia fragrans* | 0 | 0 | 0 | 6 | 0.033 | 1.55 |
| *Sterculia guttata* | 33 | 37.7 | 3.63 | 0 | 0 | 0 |
| *Symplocos macrocrpa sp. kanara* | 0 | 0 | 0 | 2 | 0.16 | 0.87 |
| *Symplocos racemosa var racemosa* | 167 | 101.4 | 12.81 | 2 | 0.002 | 0.49 |
| *Syzygim gardneri* | 67 | 111.3 | 6.38 | 4 | 0.098 | 1.21 |
| *Syzygium hemisphericum* | 33 | 251.7 | 8.46 | 2 | 0.189 | 5.05 |
| *Syzygium munronii* | 600 | 849.4 | 53.98 | 26 | 0.637 | 7 |
| *Syzygium sp.* | 0 | 0 | 0 | 54 | 0.781 | 9.78 |
| *Syzygium sp.4* | 0 | 0 | 0 | 16 | 0.229 | 2.7 |
| *Tabernaemontana heyneana* | 0 | 0 | 0 | 6 | 0.054 | 1.6 |
| *Taraktogenos macrocarpa* | 0 | 0 | 0 | 6 | 0.009 | 1.2 |
| *Trichilia connaroides* | 100 | 1170.9 | 9.31 | 18 | 0.156 | 4.48 |
| Unidentified 1 | 0 | 0 | 0 | 6 | 0.309 | 1.91 |
| Unidentified 2 | 0 | 0 | 0 | 16 | 0.083 | 3.53 |
| Unidentified 3 | 0 | 0 | 0 | 12 | 0.047 | 2.75 |
| *Vateria indica* | 167 | 484.8 | 19.7 | 106 | 4.626 | 26.98 |

Appendix 6. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Manaliampadam (H1) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Acacia intsia* | 100 | 89.2 | 9.67 | 87 | 0.26 | 19.3 |
| *Albizia odoratissima* | 32 | 46.2 | 3.95 | 24 | 1.43 | 16.18 |
| *Alstonia scholaris* | 0 | 0 | 0 | 6 | 0.52 | 5.35 |
| *Aporosa lindleyana* | 40 | 126.8 | 8.27 | 9 | 0.36 | 4.66 |
| *Bauhinia malabarica* | 0 | 0 | 0 | 9 | 0.92 | 9.14 |
| *Briedelia retusa* | 80 | 78.6 | 8.09 | 6 | 0.3 | 3.59 |
| *Callicarpa tomentosa* | 80 | 123.8 | 10.27 | 4 | 0.2 | 2.39 |
| *Calycopteris floribunda* | 120 | 87.9 | 10.68 | 75 | 0.31 | 17.32 |
| *Caryota urens* | 40 | 36.8 | 3.92 | 4 | 0.36 | 3.67 |
| *Cassia fistula* | 80 | 26.8 | 5.59 | 5 | 0.06 | 1.47 |
| *Dalbergia lanceolaria* | 48 | 46.9 | 4.84 | 4 | 0.4 | 3.99 |
| *Dalbergia latifolia* | 136 | 46.9 | 9.57 | 2 | 0.25 | 2.39 |
| *Dillenia pentagyna* | 24 | 36.8 | 3.06 | 6 | 0.18 | 2.63 |
| *Melicope lunu-ankenda* | 32 | 120.5 | 7.53 | 18 | 0.6 | 8.36 |
| *Ficus asperrima* | 28 | 56.8 | 4.24 | 12 | 0.11 | 3.25 |
| *Grewia monosperma* | 56 | 38.9 | 4.88 | 18 | 0.2 | 5.16 |
| *Grewia tiliifolia* | 76 | 26.9 | 5.38 | 8 | 0.42 | 4.94 |
| *Holarrhena antidysenterica* | 58 | 126.8 | 9.23 | 18 | 0.16 | 4.84 |
| *Linociera malabarica* | 68 | 78.98 | 7.46 | 8 | 0.56 | 6.06 |
| *Macaranga peltata* | 126 | 154.8 | 14.24 | 46 | 3.13 | 34.13 |
| *Mallotus philippensis* | 86 | 89.4 | 8.93 | 12 | 0.48 | 6.21 |
| *Miliusa tomentosa* | 78 | 43.8 | 6.3 | 8 | 0.46 | 5.26 |
| *Schleichera oleosa* | 80 | 56.8 | 7.04 | 36 | 0.18 | 8.56 |
| *Sterculia villosa* | 46 | 38.9 | 4.35 | 6 | 0.54 | 5.51 |
| *Strychnos nux vomica* | 80 | 36.9 | 6.07 | 25 | 0.78 | 11.18 |
| *Tabernaemontana heyneana* | 68 | 76.8 | 7.36 | 8 | 0.36 | 4.46 |
| *Terminalia bellirica* | 48 | 86.9 | 6.77 | 16 | 0.18 | 4.61 |
| *Terminalia paniculata* | 40 | 458.9 | 24.29 | 76 | 1.36 | 25.91 |
| *Wrightia tinctoria* | 56 | 178.9 | 11.64 | 18 | 0.38 | 6.6 |
| *Xylia xylocarpa* | 856 | 569 | 73.42 | 179 | 3.19 | 60.93 |
| *Ziziphus oenoplia* | 48 | 64.8 | 5.7 | 5 | 0.12 | 1.95 |
| *Ziziphus rugosa* | 84 | 56.8 | 7.25 | 0 | 0 | 0 |

Appendix 7. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Munnadi (H2) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Acacia auriculiformis* | 0 | 0 | 0 | 19 | 0.39 | 3.84 |
| *Acacia intsia* | 160 | 188.89 | 26.37 | 113 | 0.16 | 13.93 |
| *Albizia odoratissima* | 0 | 0 | 0 | 16 | 1.31 | 7.09 |
| *Alstonia scholaris* | 0 | 0 | 0 | 3 | 0.25 | 6.23 |
| *Anacardium occidentale* | 0 | 0 | 0 | 22 | 1.41 | 19.23 |
| *Aporosa lindleyana* | 0 | 0 | 0 | 6 | 0.24 | 1.78 |
| *Artocarpus heterophyllus* | 80 | 141.11 | 14.51 | 0 | 0 | 0 |
| *Artocarpus hirsutus* | 0 | 0 | 0 | 3 | 0.22 | 1.53 |
| *Bauhinia malabarica* | 0 | 0 | 0 | 3 | 0.34 | 2.05 |
| *Bombax ceiba* | 40 | 181.03 | 12.27 | 34 | 0.77 | 11.08 |
| *Breynia sp.* | 0 | 0 | 0 | 13 | 0.29 | 3.98 |
| *Briedelia retusa* | 40 | 31.43 | 8.99 | 3 | 0.1 | 1.25 |
| *Butea monopserma* | 0 | 0 | 0 | 22 | 0.02 | 2.62 |
| *Caesalpinia cucullata* | 0 | 0 | 0 | 3 | 0.03 | 1.19 |
| *Callicarpa tomentosa* | 0 | 0 | 0 | 6 | 0.03 | 2.38 |
| *Calycopteris floribunda* | 200 | 177.57 | 24.51 | 75 | 0.31 | 10.58 |
| *Caryota urens* | 0 | 0 | 0 | 6 | 0.22 | 2.54 |
| *Cassia fistula* | 0 | 0 | 0 | 3 | 0.01 | 1.19 |
| *Dalbergia lanceolaria* | 0 | 0 | 0 | 3 | 0.03 | 1.22 |
| *Dalbergia latifolia* | 120 | 38.03 | 15.04 | 6 | 0.43 | 1.71 |
| *Dillenia pentagyna* | 0 | 0 | 0 | 3 | 0.16 | 1.29 |
| *Melicope lunu-ankenda* | 0 | 0 | 0 | 13 | 0.4 | 6.65 |
| *Ficus asperrima* | 0 | 0 | 0 | 31 | 0.22 | 9.64 |
| *Grewia monosperma* | 0 | 0 | 0 | 13 | 0.1 | 3.03 |
| *Grewia tiliifolia* | 80 | 19.17 | 8.79 | 13 | 0.77 | 3.04 |
| *Haldina cordifolia* | 0 | 0 | 0 | 6 | 0.06 | 1.48 |
| *Holarrhena antidysenterica* | 40 | 229.11 | 13.39 | 28 | 0.14 | 4.15 |
| *Linociera malabarica* | 40 | 38.03 | 6.5 | 6 | 0.67 | 5.66 |
| *Macaranga peltata* | 40 | 45.26 | 6.28 | 38 | 2.17 | 24.04 |
| *Mallotus philippensis* | 120 | 105.91 | 21.71 | 9 | 0.22 | 3.85 |
| *Melia dubia* | 0 | 0 | 0 | 3 | 0.48 | 10.24 |
| *Miliusa tomentosa* | 0 | 0 | 0 | 6 | 0.33 | 1.47 |
| *Odina wodier* | 0 | 0 | 0 | 3 | 0.04 | 1.36 |
| *Phyllanthus emblica* | 0 | 0 | 0 | 6 | 0.03 | 2.39 |
| *Pongamia pinnata* | 0 | 0 | 0 | 9 | 0.16 | 1.7 |
| *Sapindus laurifolius* | 0 | 0 | 0 | 9 | 0.34 | 2.65 |
| *Schleichera oleosa* | 200 | 58.14 | 19.89 | 22 | 0.15 | 4.86 |
| *Sterculia villosa* | 0 | 0 | 0 | 3 | 0.31 | 1.42 |
| *Stereospermum personatum* | 40 | 15.4 | 5.12 | 19 | 0.14 | 4.43 |
| *Strychnos nux vomica* | 40 | 15.4 | 4.86 | 19 | 0.73 | 4.58 |
| *Swietenia macrophylla* | 0 | 0 | 0 | 13 | 0.39 | 3.42 |
| *Tabernamontana heyneana* | 0 | 0 | 0 | 3 | 0.24 | 1.18 |
| *Terminalia bellirica* | 0 | 0 | 0 | 22 | 0.26 | 6.31 |
| *Terminalia paniculata* | 40 | 528.31 | 38.71 | 150 | 2.54 | 26.22 |
| *Wrightia tinctoria* | 0 | 0 | 0 | 62 | 1.03 | 9.43 |
| *Xylia xylocarpa* | 873 | 671.02 | 72.71 | 534 | 3.53 | 54.37 |
| *Ziziphus oenoplia* | 0 | 0 | 0 | 6 | 0.13 | 2.35 |
| *Ziziphus rugosa* | 0 | 0 | 0 | 19 | 0.02 | 3.4 |

Appendix 8. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Adackakundu (H3) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Acronychia pedunculata* | 680 | 569 | 33.89 | 18 | 0.12 | 3.38 |
| *Aglaia malabarica* | 1050 | 986.4 | 54.62 | 220 | 3.42 | 47.25 |
| *Alseodaphne semecarpifolia* | 460 | 998.4 | 36 | 36 | 0.26 | 6.83 |
| *Alstonia scholaris* | 46 | 33.8 | 2.19 | 10 | 3.89 | 13.39 |
| *Ancistrocladus heyneanus* | 12 | 312.8 | 7.05 | 0 | 0 | 0 |
| *Antiaris toxicaria* | 56 | 56.98 | 3.01 | 56 | 2.46 | 16.81 |
| *Aporosa lindleyana* | 88 | 78.9 | 4.5 | 16 | 0.48 | 4.13 |
| *Ardisia solanacea* | 128 | 221.56 | 8.82 | 0 | 0 | 0 |
| *Arenga wightii* | 43 | 78.9 | 3.06 | 7 | 0.22 | 1.84 |
| *Artocarpus hirsutus* | 12 | 46.8 | 1.38 | 0 | 0 | 0 |
| *Baccaurea courtallensis* | 48 | 120.2 | 4.1 | 16 | 0.28 | 3.53 |
| *Bischofia javanica* | 36 | 68.8 | 2.62 | 12 | 10.16 | 32.59 |
| *Breynia patens* | 24 | 65.8 | 2.17 | 0 | 0 | 0 |
| *Callicarpa tomentosa* | 86 | 126.8 | 5.45 | 36 | 1.86 | 11.64 |
| *Calycopteris floribunda* | 112 | 76.8 | 5.22 | 8 | 0.08 | 1.58 |
| *Cinnamomum malabatrum* | 67 | 391.03 | 10.48 | 12 | 1.38 | 6.17 |
| *Croton malabaricus* | 56 | 112.8 | 4.2 | 0 | 0 | 0 |
| *Cycas circinalis* | 32 | 87.8 | 2.9 | 12 | 0.88 | 4.66 |
| *Dimocarpus longan* | 98 | 56.8 | 4.35 | 56 | 1.83 | 14.91 |
| *Diospyros bourdillonii* | 156 | 178.3 | 8.79 | 10 | 0.45 | 3.03 |
| *Diospyros malabarica* | 86 | 120.6 | 5.32 | 8 | 1.93 | 7.15 |
| *Ficus beddomei* | 108 | 56.8 | 4.67 | 0 | 0 | 0 |
| *Flacourtia indica* | 68 | 112.8 | 4.58 | 10 | 0.44 | 3 |
| *Garcinia gummi-gutta* | 68 | 126.8 | 4.88 | 6 | 0.15 | 1.46 |
| *Garcinia morella* | 102 | 18.9 | 3.67 | 16 | 0.56 | 4.37 |
| *Grewia tiliifolia* | 68 | 36.8 | 2.96 | 3 | 0.2 | 1.11 |
| *Holigarna arnottiana* | 24 | 28.9 | 1.38 | 20 | 1.88 | 9.02 |
| *Hydnocarpus pentandra* | 33 | 108.9 | 3.38 | 18 | 3.18 | 12.59 |
| *Macaranga peltata* | 89 | 189.6 | 6.89 | 22 | 0.08 | 3.94 |
| *Mallotus philippensis* | 112 | 136 | 6.48 | 12 | 2.18 | 8.58 |
| *Myristica dactyloides* | 68 | 188 | 6.18 | 6 | 3.48 | 11.48 |
| *Myristica malabarica* | 40 | 152.8 | 4.54 | 112 | 0.08 | 19.05 |
| *Olea dioica* | 40 | 246.8 | 6.54 | 6 | 1.61 | 5.85 |
| *Palaquium ellipticum* | 120 | 187.9 | 7.84 | 12 | 0.02 | 2.08 |
| *Persea macrantha* | 48 | 122.8 | 4.15 | 10 | 0.07 | 1.89 |
| *Polyalthia fragrans* | 67 | 68.96 | 3.61 | 0 | 0 | 0 |
| *Strychnos nux vomica* | 0 | 0 | 0 | 12 | 0.48 | 3.46 |
| *Syzygium cumini* | 40 | 38.9 | 2.11 | 16 | 4.87 | 17.34 |
| *Syzygium laetum* | 40 | 69.8 | 2.77 | 52 | 0.02 | 8.79 |
| *Tabernamontana heyneana* | 43 | 112.8 | 3.78 | 12 | 0.03 | 2.11 |
| *Vateria indica* | 0 | 0 | 0 | 8 | 0.64 | 3.27 |
| *Vepris bilocularis* | 33 | 205.33 | 5.43 | 4 | 0.16 | 1.15 |
| *Xanthophyllum flavescens* | 100 | 40.07 | 4.05 | 3 | 0.01 | 0.53 |

Appendix 9. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Parackalel (H4) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Acacia intsia* | 38 | 128.8 | 6.71 | 26 | 0.22 | 9.64 |
| *Albizia lebbeck* | 26 | 218.9 | 8.88 | 12 | 0.98 | 9.59 |
| *Allophylus cobbe* | 40 | 112.9 | 6.32 | 0 | 0 | 0 |
| *Aporosa lindelyana* | 220 | 218.9 | 21.57 | 12 | 0.78 | 8.42 |
| *Briedelia retusa* | 112 | 87.8 | 10.2 | 8 | 0.24 | 3.97 |
| *Callicarpa tomentosa* | 86 | 112.8 | 9.32 | 3 | 0.02 | 1.08 |
| *Careya arborea* | 46 | 22.89 | 3.76 | 6 | 0.46 | 4.62 |
| *Cassia fistula* | 112 | 89.9 | 10.27 | 5 | 0.04 | 1.84 |
| *Dalbergia latifolia* | 12 | 128 | 4.98 | 8 | 0.28 | 4.21 |
| *Dillenia pentagyna* | 25 | 166 | 7.08 | 24 | 0.97 | 13.39 |
| *Flacourtia montana* | 24 | 112 | 5.24 | 3 | 0.34 | 2.95 |
| *Grewia tiliifolia* | 36 | 28.96 | 3.3 | 15 | 1.5 | 13.6 |
| *Helicteres isora* | 56 | 28.6 | 4.6 | 35 | 0.04 | 11.48 |
| *Litsea coriacea* | 78 | 38.8 | 6.37 | 3 | 0.08 | 1.43 |
| *Macaranga peltata* | 112 | 99.89 | 10.6 | 5 | 0.11 | 2.25 |
| *Mallotus philippensis* | 165 | 87.12 | 13.65 | 28 | 0.52 | 12.04 |
| *Miliusa tomentosa* | 24 | 126.8 | 5.73 | 3 | 0.01 | 1.02 |
| *Mitragyna parviflora* | 0 | 0 | 0 | 5 | 0.35 | 3.66 |
| *Persea macrantha* | 80 | 19.65 | 5.88 | 8 | 0.72 | 6.79 |
| *Phyllanthus emblica* | 0 | 0 | 0 | 13 | 0.31 | 5.99 |
| *Polyalthia fragrans* | 40 | 229.96 | 10.16 | 12 | 0.45 | 6.49 |
| *Sapindus laurifolius* | 0 | 0 | 0 | 16 | 0.29 | 6.84 |
| *Schleichera oleosa* | 120 | 226.8 | 15.29 | 12 | 0.69 | 7.89 |
| *Stereospermum colais* | 80 | 158.9 | 10.44 | 24 | 0.98 | 13.45 |
| *Streblus asper* | 48 | 112.6 | 6.83 | 12 | 0.28 | 5.49 |
| *Strychnos nux-vomica* | 180 | 345.6 | 23.11 | 12 | 0.08 | 4.32 |
| *Tabernaemontana heyneana* | 56 | 112.9 | 7.36 | 0 | 0 | 0 |
| *Terminalia paniculata* | 0 | 0 | 0 | 38 | 8.98 | 64.78 |
| *Wrightia tinctoria* | 40 | 56.9 | 4.48 | 43 | 1.12 | 20.37 |
| *Xylia xylocarpa* | 438 | 1500.9 | 77.87 | 76 | 4.78 | 52.4 |

Appendix 10. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Pattakaimba (H5) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Alstonia scholaris* | 0 | 0 | 0 | 6 | 0.43 | 3.22 |
| *Aporosa lindleyana* | 20 | 618.1 | 18.3 | 40 | 0.3 | 10.52 |
| *Ardisia solanacea* | 200 | 295.2 | 28.9 | 108 | 0.39 | 19.55 |
| *Bauhinia malabarica* | 0 | 0 | 0 | 2 | 0.08 | 1.3 |
| *Callicarpa tomentosa* | 0 | 0 | 0 | 2 | 0 | 1.2 |
| *Carallia integerrima* | 0 | 0 | 0 | 2 | 0 | 1.2 |
| *Dalbergia latifolia* | 0 | 0 | 0 | 4 | 0.63 | 3.16 |
| *Dillenia pentagyna* | 0 | 0 | 0 | 15 | 3.18 | 11.34 |
| *Ficus sp.* | 67 | 82 | 8 | 2 | 3.88 | 5.91 |
| *Flacourtia montana* | 0 | 0 | 0 | 8 | 0.02 | 2.11 |
| *Grewia tiliifolia* | 33 | 9.4 | 3.4 | 0 | 0 | 0 |
| *Hydnocarpus pentandra* | 67 | 83.8 | 8 | 100 | 9.66 | 35.91 |
| *Lagerstroemia speciosa* | 0 | 0 | 0 | 115 | 13.56 | 39.12 |
| *Lagerstroemia microcarpa* | 0 | 0 | 0 | 29 | 6.17 | 16.16 |
| *Lannea coromandelica* | 0 | 0 | 0 | 2 | 1.96 | 3.57 |
| *Linociera malabarica* | 0 | 0 | 0 | 2 | 0.04 | 1.25 |
| *Mallotus philippensis* | 200 | 333.7 | 26.2 | 10 | 1.25 | 6.61 |
| *Miliusa tomentosa* | 0 | 0 | 0 | 2 | 0.2 | 1.44 |
| *Mitragyna parviflora* | 33 | 21.2 | 3.6 | 13 | 1.8 | 7.58 |
| *Olea dioica* | 33 | 94.5 | 5.3 | 2 | 0.2 | 1.2 |
| *Persea macrantha* | 233 | 329 | 32.3 | 23 | 2.2 | 10.45 |
| *Phyllanthus emblica* | 100 | 119 | 10.2 | 2 | 0.01 | 1.21 |
| *Sapindus laurifolius* | 33 | 44.3 | 4 | 2 | 0 | 1.2 |
| *Schleichera oleosa* | 33 | 150.9 | 31.9 | 79 | 6.52 | 29.12 |
| *Sterculia guttata* | 33 | 75.7 | 4.6 | 6 | 1 | 3.91 |
| *Stereospermum colais* | 33 | 85.3 | 6.8 | 13 | 0.67 | 6.2 |
| *Strychnos nux-vomica* | 33 | 37.7 | 3.9 | 6 | 1.69 | 5.64 |
| *Tamarindus indica* | 0 | 0 | 0 | 4 | 0.1 | 1.5 |
| *Tectona grandis* | 0 | 0 | 0 | 23 | 4.57 | 15.12 |
| *Terminalia bellirica* | 33 | 67.1 | 4 | 4 | 0.2 | 2.64 |
| *Terminalia crenulata* | 0 | 0 | 0 | 17 | 6.54 | 13.02 |
| *Terminalia paniculata* | 813 | 588 | 87 | 33 | 12.45 | 24.37 |
| *Trewia polycarpa* | 33 | 358.6 | 9.4 | 4 | 2.7 | 5.67 |
| *Wrightia tinctoria* | 0 | 0 | 0 | 13 | 0.32 | 4.88 |
| *Xylia xylocarpa* | 33 | 58.9 | 4.3 | 0 | 0 | 0 |
| *Ziziphus oenoplia* | 0 | 0 | 0 | 2 | 0.01 | 1.21 |
| *Ziziphus rugosa* | 0 | 0 | 0 | 4 | 0.01 | 1.5 |

Appendix 11. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Vellimuttam (H6) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Acronychia pedunculata* | 578 | 569.3 | 33.89 | 24 | 0.18 | 5.21 |
| *Aglaia malabarica* | 186 | 789.2 | 54.62 | 126 | 2.82 | 33.07 |
| *Alseodaphne semecarpifolia* | 360 | 768.2 | 36 | 44 | 0.36 | 9.65 |
| *Alstonia scholaris* | 24 | 32.8 | 2.19 | 8 | 2.89 | 10.35 |
| *Ancistrocladus heyneanus* | 12 | 112.8 | 7.05 | 4 | 0.36 | 1.87 |
| *Antiaris toxicaria* | 48 | 43.2 | 3.01 | 34 | 1.48 | 11.11 |
| *Aporosa lindleyana* | 76 | 68.8 | 4.5 | 12 | 0.44 | 3.67 |
| *Ardisia solanacea* | 108 | 128.9 | 8.82 | 0 | 0 | 0 |
| *Arenga wightii* | 24 | 58.8 | 3.06 | 8 | 0.24 | 2.29 |
| *Baccaurea courtallensis* | 36 | 87.9 | 4.1 | 18 | 0.98 | 6.48 |
| *Bischofia javanica* | 24 | 56.8 | 2.62 | 12 | 8.98 | 29.68 |
| *Callicarpa tomentosa* | 56 | 108.9 | 5.45 | 12 | 0.86 | 4.95 |
| *Calycopteris floribunda* | 87 | 56.8 | 5.22 | 8 | 0.09 | 1.83 |
| *Cinnamomum malabatrum* | 56 | 289 | 10.48 | 24 | 1.78 | 10.08 |
| *Croton malabaricus* | 46 | 108 | 4.2 | 0 | 0 | 0 |
| *Cycas circinalis* | 24 | 56 | 2.9 | 0 | 0 | 0 |
| *Dimocarpus longan* | 56 | 46.8 | 4.35 | 78 | 2.48 | 22.71 |
| *Diospyros bourdillonii* | 108 | 160.2 | 8.79 | 12 | 0.45 | 3.7 |
| *Diospyros malabarica* | 46 | 65.8 | 5.32 | 12 | 1.93 | 8.21 |
| *Ficus beddomei* | 66 | 43.6 | 4.67 | 0 | 0 | 0 |
| *Flacourtia indica* | 68 | 112.8 | 4.58 | 24 | 1.22 | 8.38 |
| *Garcinia gummi-gutta* | 56 | 109.3 | 4.88 | 12 | 0.36 | 3.43 |
| *Garcinia morella* | 78 | 28.8 | 3.67 | 24 | 0.56 | 6.37 |
| *Grewia tiliifolia* | 46 | 24.8 | 2.96 | 12 | 0.6 | 4.16 |
| *Holigarna arnottiana* | 24 | 18.6 | 1.38 | 36 | 2.86 | 15.7 |
| *Hydnocarpus pentandra* | 36 | 108.9 | 3.38 | 8 | 2.16 | 8.13 |
| *Macaranga peltata* | 102 | 189.6 | 6.89 | 12 | 0.08 | 2.58 |
| *Mallotus philippensis* | 86 | 136 | 6.48 | 6 | 2.18 | 7.8 |
| *Myristica dactyloides* | 76 | 188 | 6.18 | 6 | 3.48 | 11.76 |
| *Myristica malabarica* | 56 | 102 | 4.54 | 76 | 1.2 | 18.42 |
| *Olea dioica* | 40 | 146.8 | 6.54 | 6 | 1.61 | 6.07 |
| *Palaquium ellipticum* | 86 | 108.2 | 7.84 | 8 | 0.02 | 1.62 |
| *Persea macrantha* | 56 | 102.6 | 4.15 | 24 | 1.2 | 8.32 |
| *Polyalthia fragrans* | 60 | 76.8 | 3.61 | 0 | 0 | 0 |
| *Strychnos nux vomica* | 12 | 120 | 0 | 14 | 0.48 | 4.18 |
| *Syzygium cumini* | 0 | 0 | 0 | 24 | 4.87 | 19.49 |
| *Syzygium laetum* | 0 | 0 | 0 | 30 | 0.02 | 5.89 |
| *Tabernaemontana heyneana* | 24 | 86.8 | 3.78 | 8 | 0.03 | 1.65 |
| *Xanthophyllum flavescens* | 46 | 32.8 | 4.05 | 6 | 0.01 | 1.2 |

Appendix 12. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Punchavayal (H7) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants ha$^{-1}$) | BA (cm$^2$ ha$^{-1}$) | IVI | Den (No. of plants ha$^{-1}$) | BA (m$^2$ ha$^{-1}$) | IVI |
| *Acacia intsia* | 0 | 0 | 0 | 3 | 0.01 | 1.63 |
| *Bauhinia malabarica* | 40 | 25.9 | 6.6 | 1 | 0.03 | 0.87 |
| *Breynia sp.* | 0 | 0 | 0 | 3 | 0.16 | 3.44 |
| *Butea monopserma* | 0 | 0 | 0 | 24 | 0.15 | 6.01 |
| *Calycopteris floribunda* | 0 | 0 | 0 | 33 | 0.04 | 10.89 |
| *Careya arborea* | 0 | 0 | 0 | 4 | 0.18 | 2.87 |
| *Cassia fistula* | 0 | 0 | 0 | 8 | 0.06 | 3.73 |
| *Ceiba pentandra* | 0 | 0 | 0 | 1 | 0.05 | 1.23 |
| *Cordia myxa* | 0 | 0 | 0 | 7 | 0.21 | 2.34 |
| *Dalbergia lanceolaria* | 0 | 0 | 0 | 1 | 0.3 | 0.83 |
| *Dalbergia latifolia* | 160 | 263 | 28.6 | 21 | 2.01 | 22.93 |
| *Dillenia pentagyna* | 0 | 0 | 0 | 3 | 0.09 | 1.83 |
| *Erythrina indica* | 0 | 0 | 0 | 1 | 0.15 | 1.38 |
| *Ficus asperrima* | 0 | 0 | 0 | 7 | 0.18 | 3.82 |
| *Ficus hispida* | 0 | 0 | 0 | 6 | 0.08 | 3.6 |
| *Grewia tiliifolia* | 40 | 25 | 6 | 3 | 0.13 | 1.09 |
| *Haldina cordifolia* | 0 | 0 | 0 | 8 | 0.13 | 3.84 |
| *Helicteres isora* | 320 | 115.5 | 30.9 | 15 | 0.02 | 4.23 |
| *Holarrhena antidysenterica* | 320 | 94.76 | 29.8 | 18 | 0.05 | 3.9 |
| *Lagerstroemia microcarpa* | 0 | 0 | 0 | 3 | 0.02 | 1.66 |
| *Lagerstromia reginae* | 0 | 0 | 0 | 6 | 0.05 | 1.25 |
| *Macaranga peltata* | 120 | 350.5 | 27.6 | 7 | 0.3 | 3.02 |
| *Miliusa tomentosa* | 0 | 0 | 0 | 35 | 0.11 | 10.19 |
| *Odina wodier* | 0 | 0 | 0 | 1 | 0.2 | 2.27 |
| *Phyllanthus emblica* | 0 | 0 | 0 | 3 | 0.04 | 1.66 |
| *Pterocarpus marsupium* | 120 | 86.4 | 15.4 | 0 | 0 | 0 |
| *Sapindus laurifolius* | 0 | 0 | 0 | 3 | 0.18 | 2.05 |
| *Schleichera oleosa* | 80 | 10.1 | 7.7 | 8 | 0.03 | 2.94 |
| *Sterculia guttata* | 0 | 0 | 0 | 4 | 0.25 | 2.45 |
| *Stereospermum colais* | 120 | 116 | 17 | 13 | 0.1 | 6.92 |
| *Strychnos nux-vomica* | 0 | 0 | 0 | 4 | 0.02 | 1.78 |
| *Swietenia macrophylla* | 0 | 0 | 0 | 11 | 0.23 | 3.01 |
| *Tectona grandis* | 80 | 19.2 | 8.2 | 106 | 1.07 | 27.13 |
| *Terminalia bellirica* | 0 | 0 | 0 | 10 | 0.13 | 4.95 |
| *Terminalia crenulata* | 0 | 0 | 0 | 28 | 0.33 | 6.4 |
| *Terminalia paniculata* | 440 | 160.8 | 38 | 258 | 2.08 | 67.99 |
| *Wrightia tinctoria* | 200 | 134.9 | 23.2 | 10 | 0.15 | 0.99 |
| *Xylia xylocarpa* | 520 | 453 | 60.94 | 407 | 2.54 | 70.93 |
| *Ziziphus oenoplia* | 0 | 0 | 0 | 14 | 0.02 | 1.12 |
| *Ziziphus rugosa* | 0 | 0 | 0 | 11 | 0.04 | 0.83 |

Appendix 13. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Appencappu (H8) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Acacia intsia* | 40 | 219.2 | 6.21 | 43 | 0.34 | 10.21 |
| *Albizia lebbeck* | 40 | 318.2 | 8.32 | 3 | 0.17 | 1.27 |
| *Allophylus cobbe* | 0 | 0 | 0 | 3 | 0.15 | 1.15 |
| *Aporosa lindleyana* | 320 | 197. 7 | 21.65 | 5 | 0.21 | 1.67 |
| *Briedelia retusa* | 0 | 0 | 0 | 5 | 0.12 | 2.28 |
| *Butea monopserma* | 0 | 0 | 0 | 10 | 0.03 | 2.16 |
| *Callicarpa tomentosa* | 0 | 0 | 0 | 3 | 0.02 | 1.17 |
| *Calycopteris floribunda* | 0 | 0 | 0 | 45 | 0.24 | 10.33 |
| *Careya arborea* | 80 | 32.8 | 5.61 | 3 | 0.41 | 1.93 |
| *Cassia fistula* | 0 | 0 | 0 | 5 | 0.04 | 1.54 |
| *Cordia sp* | 0 | 0 | 0 | 5 | 0.1 | 2.44 |
| *Cycas circinalis* | 0 | 0 | 0 | 5 | 0.17 | 2.57 |
| *Dalbergia horrida* | 0 | 0 | 0 | 5 | 0.02 | 1.5 |
| *Dalbergia latifolia* | 0 | 0 | 0 | 8 | 0.28 | 2.34 |
| *Dillenia pentagyna* | 0 | 0 | 0 | 30 | 0.97 | 10.62 |
| *Ervatamia heyneana* | 0 | 0 | 0 | 2.5 | 0.21 | 1.24 |
| *Flacourtia montana* | 0 | 0 | 0 | 3 | 0.34 | 1.13 |
| *Grewia tiliifolia* | 40 | 30.6 | 3.41 | 15 | 1.5 | 7.33 |
| *Helicteres isora* | 40 | 28.6 | 8.8 | 35 | 0.04 | 4.94 |
| *Ixora sp.* | 0 | 0 | 0 | 8 | 0.01 | 1.8 |
| *Lagerstroemia speciosa* | 0 | 0 | 0 | 28 | 1.76 | 8.19 |
| *Lagerstroemia microcarpa* | 40 | 53.6 | 3.79 | 18 | 4.8 | 18.73 |
| *Linociera malabarica* | 0 | 0 | 0 | 5 | 0.14 | 2.52 |
| *Litsea coriacea* | 0 | 0 | 0 | 3 | 0.08 | 1.27 |
| *Lnociera malabarica* | 0 | 0 | 0 | 5 | 0.11 | 2.47 |
| *Macaranga peltata* | 600 | 1854.7 | 43.84 | 0 | 0 | 0 |
| *Mallotus philippensis* | 120 | 95.8 | 9.21 | 28 | 0.52 | 6.83 |
| *Memycylon sp.* | 40 | 61.6 | 3.57 | 3 | 0.01 | 1.14 |
| *Miliusa tomentosa* | 40 | 318.2 | 2.53 | 3 | 0.01 | 1.13 |
| *Mitragyna parviflora* | 0 | 0 | 0 | 5 | 0.35 | 2.93 |
| *Persea macrantha* | 80 | 19.7 | 5.4 | 8 | 0.72 | 4.01 |
| *Phyllanthus emblica* | 0 | 0 | 0 | 13 | 0.31 | 3.83 |
| *Polyalthia fragrans* | 40 | 230 | 6.39 | 25 | 0.45 | 6.55 |
| *Sapindus laurifolius* | 0 | 0 | 0 | 15 | 0.29 | 5.06 |
| *Schleichera oleosa* | 280 | 314.7 | 18.67 | 10 | 0.69 | 5.06 |
| *Spondias pinnata* | 0 | 0 | 0 | 3 | 0.68 | 2.48 |
| *Sterculia guttata* | 160 | 226.5 | 13.93 | 5 | 0.39 | 3.28 |
| *Stereospermum colais* | 80 | 258.6 | 9.4 | 35 | 1.85 | 13.02 |
| *Streblus asper* | 0 | 0 | 0 | 10 | 0.28 | 4.26 |
| *Strychnos nux-vomica* | 200 | 551.3 | 19.02 | 8 | 0.05 | 2.67 |
| *Syzygium sp.* | 0 | 0 | 0 | 3 | 0.06 | 1.24 |
| *Tabernaemontana heyneana* | 0 | 0 | 0 | 3 | 0.02 | 2.28 |
| *Terminalia bellirica* | 0 | 0 | 0 | 8 | 1.25 | 5.56 |
| *Terminalia paniculata* | 760 | 849 | 46.46 | 58 | 11.11 | 31.59 |
| *Trewia polycarpa* | 40 | 50.9 | 3.39 | 13 | 9.97 | 24.7 |
| *Wrightia tinctoria* | 40 | 79.6 | 3.87 | 65 | 2.19 | 19.22 |
| *Xylia xylocarpa* | 600 | 1707.6 | 56.53 | 163 | 5.57 | 43.48 |
| *Ziziphus rugosa* | 0 | 0 | 0 | 25 | 0.06 | 6.88 |

Appendix 14. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Kadasseri (H9) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Acacia concinna* | 0 | 0 | 0 | 17 | 0.12 | 2.31 |
| *Acronychia pedunculata* | 0 | 0 | 0 | 11 | 0.09 | 1.86 |
| *Aglaia malabarica* | 1300 | 1507.79 | 76.21 | 195 | 2.31 | 34.29 |
| *Ailanthus malabarica* | 0 | 0 | 0 | 1 | 0.69 | 0.89 |
| *Alseodaphne semecarpifolia* | 200 | 781.26 | 26.49 | 14 | 0.1 | 2.57 |
| *Alstonia scholaris* | 0 | 0 | 0 | 1 | 1.29 | 0.37 |
| *Ancistrocladus heyneanus* | 0 | 0 | 0 | 4 | 0.02 | 0.68 |
| *Antiaris toxicaria* | 33 | 21.21 | 4.05 | 34 | 1.53 | 5.61 |
| *Aphanamixis polystachya* | 0 | 0 | 0 | 32 | 2.11 | 4.61 |
| *Aporosa lindleyana* | 0 | 0 | 0 | 3 | 0.37 | 0.76 |
| *Ardisia solanacea* | 100 | 316.9 | 13.42 | 4 | 0.02 | 1.44 |
| *Arenga wightii* | 0 | 0 | 0 | 9 | 0.16 | 2.45 |
| *Artocarpus heterophyllus* | 0 | 0 | 0 | 4 | 0.81 | 1.07 |
| *Artocarpus hirsutus* | 0 | 0 | 0 | 3 | 0.71 | 0.75 |
| *Baccaurea courtallensis* | 0 | 0 | 0 | 16 | 0.16 | 3.87 |
| *Bischofia javanica* | 0 | 0 | 0 | 8 | 9.49 | 1.51 |
| *Breynia patens* | 0 | 0 | 0 | 1 | 0.1 | 0.37 |
| *Callicarpa tomentosa* | 0 | 0 | 0 | 16 | 0.35 | 3.86 |
| *Calycopteris floribunda* | 0 | 0 | 0 | 1 | 0.01 | 0.45 |
| *Canarium strictum* | 33 | 628.83 | 13.43 | 7 | 0.02 | 1.46 |
| *Caryota urens* | 0 | 0 | 0 | 5 | 0.32 | 1.59 |
| *Cinnamomum malabatrum* | 67 | 391.03 | 10.85 | 7 | 1.1 | 1.45 |
| *Cinnamomum sp.* | 0 | 0 | 0 | 20 | 0.44 | 3.94 |
| *Cissus pedata* | 0 | 0 | 0 | 1 | 0.04 | 0.49 |
| *Clerodendrum infortunatum* | 0 | 0 | 0 | 25 | 0.06 | 4.62 |
| *Croton malabaricus* | 0 | 0 | 0 | 13 | 0.2 | 4.19 |
| *Cullenia exarillata* | 0 | 0 | 0 | 11 | 1.77 | 2.94 |
| *Cycas circinalis* | 0 | 0 | 0 | 1 | 0.02 | 0.37 |
| *Dimocarpus longan* | 67 | 48.45 | 5.55 | 67 | 1.83 | 16.32 |
| *Diospyros bourdillonii* | 167 | 185.17 | 13.56 | 12 | 0.45 | 3.22 |
| *Diospyros malabarica* | 0 | 0 | 0 | 13 | 1.93 | 2.88 |
| *Elaeocarpus serratus* | 0 | 0 | 0 | 4 | 0.48 | 1.04 |
| *Ficus altissima* | 0 | 0 | 0 | 3 | 0.04 | 0.73 |
| *Ficus asperrima* | 0 | 0 | 0 | 16 | 0.2 | 3.65 |
| *Ficus beddomei* | 0 | 0 | 0 | 7 | 2.92 | 1.57 |
| *Ficus hispida* | 0 | 0 | 0 | 3 | 0.26 | 0.47 |
| *Ficus nervosa* | 0 | 0 | 0 | 16 | 0.44 | 3.56 |
| *Garcinia gummi-gutta* | 0 | 0 | 0 | 1 | 0.06 | 0.45 |
| *Garcinia morella* | 33 | 16.76 | 3.98 | 24 | 0.56 | 5.58 |
| *Gmelina arborea* | 0 | 0 | 0 | 1 | 0.01 | 0.37 |
| *Gnetum ula* | 0 | 0 | 0 | 1 | 0.03 | 0.62 |
| *Grewia tiliifolia* | 0 | 0 | 0 | 4 | 0.21 | 1.21 |
| *Hopea parviflora* | 33 | 104.76 | 5.34 | 11 | 5.31 | 2.16 |
| *Hydnocarpus alpina* | 0 | 0 | 0 | 3 | 0.9 | 0.52 |
| *Hydnocarpus pentandra* | 33 | 115.5 | 5.5 | 30 | 2.14 | 10.2 |
| *Knema attenuata* | 33 | 37.71 | 4.3 | 92 | 0.01 | 13.45 |

Appendix 14 (cont'd). Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Kadasseri (H9) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Lagerstroemia microcarpa* | 0 | 0 | 0 | 1 | 0.16 | 0.37 |
| *Laportea crenulata* | 0 | 0 | 0 | 20 | 0.01 | 3.24 |
| *Leea sambucina* | 0 | 0 | 0 | 1 | 0.01 | 0.47 |
| *Litsea coriacea* | 0 | 0 | 0 | 3 | 0.57 | 0.75 |
| *Macaranga peltata* | 0 | 0 | 0 | 16 | 0.04 | 2.94 |
| *Mallotus philippensis* | 0 | 0 | 0 | 4 | 1.99 | 0.88 |
| *Mangifera indica* | 0 | 0 | 0 | 16 | 0.01 | 4.15 |
| *Memecylon malabaricum* | 0 | 0 | 0 | 3 | 0.35 | 0.68 |
| *Mesua ferrea* | 0 | 0 | 0 | 9 | 0.46 | 2.13 |
| *Mimusops elengi* | 0 | 0 | 0 | 3 | 0.41 | 0.78 |
| *Murraya exotica* | 33 | 94.55 | 5.18 | 18 | 0.07 | 2.69 |
| *Myristica dactyloides* | 0 | 0 | 0 | 3 | 6.42 | 0.47 |
| *Myristica malabarica* | 167 | 916.4 | 30.12 | 230 | 0.12 | 46.38 |
| *Olea dioica* | 0 | 0 | 0 | 4 | 1.61 | 1.14 |
| *Palaquium ellipticum* | 267 | 383.69 | 17.25 | 16 | 0.01 | 3.01 |
| *Persea macrantha* | 0 | 0 | 0 | 1 | 0.09 | 0.37 |
| *Pinanga dicksonii* | 33 | 37.71 | 4.3 | 13 | 1.31 | 1.33 |
| *Poeciloneuron indicum* | 67 | 59.88 | 4.64 | 49 | 0.22 | 9.28 |
| *Polyalthia fragrans* | 67 | 68.96 | 8.49 | 5 | 1.93 | 1.22 |
| *Prunus ceylanica* | 0 | 0 | 0 | 1 | 0.03 | 0.39 |
| *Pterospermum reticulatum* | 0 | 0 | 0 | 3 | 0.48 | 0.54 |
| *Sapindus laurifolius* | 0 | 0 | 0 | 1 | 0.04 | 0.37 |
| *Spondias pinnata* | 0 | 0 | 0 | 7 | 0.22 | 1.77 |
| *Strychnos nux vomica* | 0 | 0 | 0 | 3 | 0.48 | 0.46 |
| *Syzygium cumini* | 33 | 58.93 | 4.63 | 11 | 4.87 | 2.32 |
| *Syzygium laetum* | 33 | 285.21 | 8.12 | 46 | 0.01 | 13.41 |
| *Tabernaemontana heyniana* | 0 | 0 | 0 | 3 | 0.01 | 0.77 |
| *Terminalia bellirica* | 0 | 0 | 0 | 4 | 1.61 | 0.83 |
| *Toddalia asiatica* | 67 | 37.98 | 5.39 | 26 | 0.2 | 5.38 |
| *Trewia polycarpa* | 0 | 0 | 0 | 3 | 0.42 | 3.66 |
| *Turpinia malabarica* | 0 | 0 | 0 | 7 | 0.29 | 1.82 |
| *Vateria indica* | 0 | 0 | 0 | 8 | 0.64 | 1.4 |
| *Ventilago sp.* | 0 | 0 | 0 | 18 | 0.12 | 4.87 |
| *Vepris bilocularis* | 33 | 205.33 | 6.89 | 4 | 0.12 | 1.19 |
| *Villebrunea integrifolia* | 33 | 94.55 | 5.18 | 45 | 0.33 | 13.32 |
| *Xanthophyllum flavescens* | 100 | 40.07 | 9.14 | 3 | 0.02 | 0.47 |

Appendix 15. Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Manikunnumala (H10) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants $ha^{-1}$) | BA ($cm^2$ $ha^{-1}$) | IVI | Den (No. of plants $ha^{-1}$) | BA ($m^2$ $ha^{-1}$) | IVI |
| *Acacia concinna* | 0 | 0 | 0 | 30 | 0.18 | 2.97 |
| *Acacia intsia* | 133 | 101.88 | 14.57 | 154 | 0.63 | 12.15 |
| *Acronychia pedunculata* | 0 | 0 | 0 | 25 | 0.09 | 3.23 |
| *Aglaia lawii* | 0 | 0 | 0 | 2 | 0.22 | 0.49 |
| *Albizia lebbeck* | 0 | 0 | 0 | 11 | 0.71 | 2.05 |
| *Alseodaphne semecarpifolia* | 0 | 0 | 0 | 20 | 0.05 | 9.34 |
| *Alstonia scholaris* | 0 | 0 | 0 | 13 | 4.91 | 1.28 |
| *Anamirta cocculus* | 0 | 0 | 0 | 4 | 0.02 | 0.5 |
| *Antiaris toxicaria* | 33 | 235.71 | 7.59 | 5 | 2.73 | 3.7 |
| *Antidesma menasu* | 0 | 0 | 0 | 2 | 0.01 | 0.39 |
| *Aphanamixis polystachya* | 0 | 0 | 0 | 11 | 1.65 | 2.98 |
| *Aporosa lindleyana* | 167 | 172.6 | 19.53 | 27 | 0.08 | 3 |
| *Ardisia solanacea* | 0 | 0 | 0 | 4 | 0.01 | 0.79 |
| *Artocarpus heterophyllus* | 0 | 0 | 0 | 5 | 0.03 | 0.6 |
| *Artocarpus hirsutus* | 33 | 26.19 | 4.25 | 30 | 5.05 | 13.03 |
| *Bischofia javanica* | 0 | 0 | 0 | 9 | 4.13 | 3.24 |
| *Bombax ceiba* | 0 | 0 | 0 | 5 | 0.44 | 1.23 |
| *Breynia patens* | 0 | 0 | 0 | 14 | 0.05 | 1.99 |
| *Callicarpa tomentosa* | 0 | 0 | 0 | 4 | 0.03 | 0.8 |
| *Canarium strictum* | 0 | 0 | 0 | 5 | 1.38 | 2.15 |
| *Canthium angustifolium* | 0 | 0 | 0 | 13 | 0.08 | 1.65 |
| *Canthium dicoccum var umbellatum* | 0 | 0 | 0 | 20 | 2.4 | 5.36 |
| *Chukrasia tabularis* | 0 | 0 | 0 | 9 | 0.06 | 1.45 |
| *Cinnamomum malabatrum* | 0 | 0 | 0 | 13 | 0.14 | 2.64 |
| *Clerodendrum infortunatum* | 0 | 0 | 0 | 21 | 0.12 | 2.14 |
| *Coffea arabica* | 0 | 0 | 0 | 20 | 0.08 | 1.4 |
| *Cryptocarya neilgherrensis* | 0 | 0 | 0 | 25 | 0.13 | 2.57 |
| *Dalbergia lanceolaria* | 33 | 26.19 | 6.62 | 39 | 0.43 | 4.06 |
| *Dalbergia latifolia* | 133 | 931.6 | 38.22 | 120 | 4.27 | 16.03 |
| *Debregeasia velutina* | 0 | 0 | 0 | 2 | 0.02 | 0.4 |
| *Dimocarpus longan* | 0 | 0 | 0 | 25 | 0.05 | 2.89 |
| *Erythrina indica* | 0 | 0 | 0 | 30 | 2.25 | 6.82 |
| *Melicope lunu-ankenda* | 167 | 172.6 | 19.53 | 48 | 1.1 | 6.47 |
| *Ficus altissima* | 0 | 0 | 0 | 4 | 1.18 | 0.81 |
| *Ficus asperrima* | 0 | 0 | 0 | 4 | 0.02 | 11.56 |
| *Ficus benghalensis* | 0 | 0 | 0 | 25 | 18.82 | 4.23 |
| *Flacourtia montana* | 100 | 55.79 | 7.62 | 25 | 0.36 | 3.95 |
| *Garcinia morella* | 0 | 0 | 0 | 5 | 1.12 | 1.1 |
| *Glycosmis pentaphylla* | 0 | 0 | 0 | 11 | 0.04 | 1.2 |
| *Gmelina arborea* | 167 | 98.21 | 20.72 | 5 | 1.56 | 3.67 |
| *Grevillea robusta* | 0 | 0 | 0 | 14 | 0.63 | 2.34 |
| *Grewia tiliifolia* | 33 | 26.19 | 6.62 | 34 | 0.87 | 6.02 |
| *Helicteres isora* | 0 | 0 | 0 | 91 | 0.21 | 7.56 |
| *Hibiscus tiliaceus* | 0 | 0 | 0 | 2 | 0.01 | 0.39 |
| *Holigarna arnottiana* | 0 | 0 | 0 | 11 | 0.03 | 1.19 |

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Appendix 15 (cont'd). Density (Den), basal area (BA) and Importance value index (IVI) of different tree species in seedling and mature stage in a village-adjacent forest plot at Manikunnumala (H10) in the Kerala part of Nilgiri Biosphere Reserve.

| Species | Tree seedlings | | | Mature trees | | |
|---|---|---|---|---|---|---|
| | Den (No. of plants ha$^{-1}$) | BA (cm$^2$ ha$^{-1}$) | IVI | Den (No. of plants ha$^{-1}$) | BA (m$^2$ ha$^{-1}$) | IVI |
| *Hydnocarpus pentandra* | 100 | 75.69 | 12.7 | 14 | 3.95 | 7.76 |
| *Jasminum arborescens* | 0 | 0 | 0 | 2 | 0.01 | 0.4 |
| *Knema attenuata* | 0 | 0 | 0 | 9 | 0.18 | 1.15 |
| *Lagerstroemia microcarpa* | 0 | 0 | 0 | 13 | 0.61 | 3.47 |
| *Lannea coromandelica* | 0 | 0 | 0 | 9 | 0.09 | 1.49 |
| *Leea sambucina* | 0 | 0 | 0 | 2 | 0.03 | 0.5 |
| *Linociera malabarica* | 0 | 0 | 0 | 2 | 0.6 | 0.67 |
| *Litsea floribunda* | 33 | 12.83 | 4.04 | 14 | 0.06 | 1.39 |
| *Macaranga peltata* | 33 | 37.71 | 6.87 | 30 | 1.68 | 4.38 |
| *Mallotus philippensis* | 33 | 26.19 | 6.62 | 20 | 1.15 | 5.78 |
| *Mallotus tetracoccus* | 0 | 0 | 0 | 93 | 0.03 | 11.36 |
| *Mangifera indica* | 0 | 0 | 0 | 20 | 2.89 | 6.24 |
| *Melia dubia* | 0 | 0 | 0 | 7 | 1.41 | 2.58 |
| *Mesua ferrea* | 33 | 156.17 | 6.1 | 2 | 3.06 | 1.81 |
| *Murraya exotica* | 0 | 0 | 0 | 7 | 0.06 | 1.63 |
| *Naringi crenulata* | 0 | 0 | 0 | 11 | 0.02 | 1.78 |
| *Olea dioica* | 0 | 0 | 0 | 100 | 0.98 | 10.32 |
| *Persea macrantha* | 0 | 0 | 0 | 9 | 0.07 | 1.45 |
| *Phyllanthus emblica* | 0 | 0 | 0 | 11 | 0.31 | 2.01 |
| *Prunus ceylanica* | 0 | 0 | 0 | 2 | 1.03 | 0.87 |
| *Pterocarpus marsupium* | 67 | 169.78 | 12.81 | 50 | 1.58 | 7.16 |
| *Pterospermum reticulatum* | 33 | 44.26 | 4.54 | 20 | 1.35 | 3.06 |
| *Schefflera micrantha* | 0 | 0 | 0 | 5 | 0.22 | 1.07 |
| *Spondias pinnata* | 0 | 0 | 0 | 4 | 0.91 | 1.6 |
| *Sterculia guttata* | 0 | 0 | 0 | 4 | 0.04 | 0.5 |
| *Stereospermum colais* | 33 | 44.26 | 4.54 | 32 | 0.69 | 5.1 |
| *Symplacos cochinchinensis* | 33 | 21.21 | 6.52 | 39 | 0.33 | 4.19 |
| *Syzygium cumini* | 0 | 0 | 0 | 18 | 2.12 | 5.08 |
| *Tabernaemontana heyneana* | 233 | 222.1 | 23.21 | 48 | 0.49 | 6.19 |
| *Terminalia bellirica* | 33 | 462 | 15.9 | 14 | 0.87 | 3.45 |
| *Terminalia crenulata* | 0 | 0 | 0 | 21 | 0.72 | 1.85 |
| *Toddalia asiatica* | 0 | 0 | 0 | 27 | 0.11 | 3.04 |
| *Turpinia malabarica* | 0 | 0 | 0 | 2 | 0.01 | 0.4 |
| *Vateria macrocarpa* | 0 | 0 | 0 | 11 | 0.29 | 2.04 |
| *Vepris bilocularis* | 0 | 0 | 0 | 4 | 0.05 | 0.62 |
| *Villebrunea integrifolia* | 0 | 0 | 0 | 14 | 0.29 | 1.7 |
| *Vitex altissima* | 0 | 0 | 0 | 21 | 1.69 | 6.63 |
| *Wrightia tinctoria* | 200 | 628.05 | 46.83 | 100 | 1.02 | 8.61 |
| *Xanthophyllum arnottianum* | 0 | 0 | 0 | 2 | 0.01 | 0.39 |
| *Ziziphus oenoplia* | 0 | 0 | 0 | 18 | 0.15 | 2.22 |
| *Ziziphus rugosa* | 33 | 16.76 | 4.1 | 43 | 0.15 | 4.28 |