FLORISTIC AND EDAPHIC ATTRIBUTES OF THREE LAND USE SYSTEMS IN WAYANAD, KERALA

By

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THESIS

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KERALA, INDIA

2011

DECLARATION

I hereby declare that this thesis entitled "**Floristic and edaphic attributes of three land use systems in Wayanad, Kerala**" is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society

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Dedicated to My Parents

Introduction

INTRODUCTION

The tropical regions are endowed with remarkably high level of biological diversity and habitat heterogeneity. The forests harbors a complex interaction of ecosystem and their conservation is highly necessary for the sustainable management of the environment. However, these pristine ecosystem faces destruction due to various anthropogenic pressure like conversion to agriculture land, unsustainable harvesting of timbers, unsound land management etc. Unfortunately, tropical forests are disappearing at an estimated rate of 15- 17 m ha yr^{-1} (Swamy et al., 2010). Similarly, the forests in India are being exploited at an alarming rate which has resulted in various ecological and economic problems.

The Western Ghats which runs parallel to the southwestern coast of the Indian Peninsula is one of the world biodiversity hotspots (Myers et al., 2000). Due to the peculiar geographic, edaphic and climatic conditions, Western Ghats hosts some of the best representatives of non-equatorial tropical evergreen forests in the world. In addition to the diversity of species, it also harbors several endemic species and unique vegetation. The floral diversity of Western Ghats estimated as 5,000 species, belongs to 2,200 genera including 1,700 endemics. As a part of the Western Ghats, Kerala holds 3,800 species of flowering plants and 1,272 southern Western Ghats endemics (Ramesh, 2001). But, these vast stretches of vegetation and its biodiversity are facing the prospect of increasing degradation due to a variety of human pressures.

Wayanad lies as a transition area between the moist forests of southern parts of the Western Ghats and the dry-deciduous forests of south Deccan Plateau. The faunal and floral elements species from both these regions has contributed to the high species richness (Rodgers and Panwar, 1988; Nair, 1991; Pascal, 1991). In Wayanad, some time back, large areas under evergreen forests were opened up for cultivation of plantation crops. Forest areas lying contiguous to pristine forest tracks were manipulated to facilitate farming, especially cardamom. In those areas, where cultivation is still being continued were notified as "section 5 land" as per section 5 of Kerala Preservation of Trees Act (1986). On such lands farmers were allowed to cultivate the land without any claim on the land or on the standing trees. In some of these lands, farmers abandoned cultivation due to various reasons. In such areas the natural vegetation recouped and became a "forest-look-alike" ecosystem. The government then promulgated the Kerala Forest (Vesting and Management of Ecologically Fragile Land) Act, 2003 and took over these lands in the name of conservation. As per the Act, the definition of ecologically fragile lands (EFL) is "any forestland or any portion thereof held by any person and lying contiguous to or encircled by a reserved forest or a vested forest or any other forestland owned by the Government and predominantly supporting natural vegetation". In the Thollayiram area of Meppady forest division, there are number of such EFL areas. These areas were vested by the government under the EFL Act. While the government cites a biodiversity value to take over and manage such "ecologically fragile areas", the owners claimed that these lands are not "ecologically fragile", but, farm land with wild vegetation. The owners have severely contested the biodiversity value of these lands which were taken up.

Without any scientific studies, it is very difficult to verify the claims by both the government and the farmers, *vis-à-vis* the biodiversity value of these lands. As the land is lying contiguous to vested forest, a comparative study on species diversity with that of vested forest will help to develop a better picture of the floristic diversity of ecologically fragile lands. Biodiversity of an ecosystem is also depending on various soil characters. Soil characters affect both the productivity of an ecosystem and the richness of its biodiversity. Thus, a detailed analysis of the plant diversity and structure as well as the soil attributes of these lands will give a better understanding of the diversity in these lands, which can be made use answering questions regarding the biodiversity value of these "Ecologically Fragile Lands". It was in this background that this study was taken up. The objective study was to compare the various floristic and edaphic attributes of three land use system, *viz.* a vested forest, an ecologically fragile land(EFL) and a section 5 land (as per section 5 of Kerala Preservation of Trees Act (1986) found in the South Wayanad forest division of Kerala.

Review of Literature

REVIEW OF LITERATURE

Forest is a complex community with predominance of phanerophytes and complete understanding of such a community can be revealed through various qualitative and quantitative investigations of its structure and function. Innumerable studies are undertaken in this direction.

2.1 Floristic studies in India

Pascal and Pelissier (1996), established a permanent plot of 28 ha in the foothills of the Western Ghats of India (Kadamakal Forest Reserve, Karnataka) to study the functioning of the ecosystem. Despite the high diversity (Simpson's D= 0.92 and Shannon's H' =4.56), 4 species were distinctly dominant in terms of an importance value index. Each of these 4 species occupied a different layer in the ecosystem: *Humboldtia brunonis* dominates the undergrowth, *Myristica dactyloides* the intermediate strata, *Vateria indica* the higher canopy level, and *Dipterocarpus indicus*, the emergents. This pronounced species hierarchy is one of the most important characteristics of the evergreen forests of the Western Ghats. Reddy et al. (2006) studied the vegetation and floristic diversity of Bhitarkanika National Park in Orissa. They explored rich floristic diversity and great variability at species and ecosystem levels in consisting of different types of vegetation in different habitats representing *Diospyros* swamp forest, *Tamarix-Salvadora* scrub, palm swamp, salt marshes, grasslands, sand dune and aquatic vegetation.

A permanent 2 ha (200 m x 100 m) plot was established for long-term monitoring of plant diversity and dynamics in a tropical dry deciduous forest of Bhadra Wildlife Sanctuary by Krishnamurthy et al. (2010). Enumeration of all woody plants $\geq$1 cm DBH (diameter at breast height) yielded a total of 1766 individuals that belonged to 46 species, 37 genera and 24 families. Combretaceae was the most abundant family in the forest with a family importance value of 68.3. Plant density varied from 20-90 individuals with an average 35 individuals/quadrat (20 m x 20 m). *Randia dumetorum*, with 466 individuals (representing 26.7% of the total density 2 ha^{-1}) with species importance value of 36.25, was the dominant species in the plot. The total basal area of the plot was 18.09 m^2 ha^{-1} with a mean of 0.72 m^2 $quadrat^{-1}$. The highest basal area of the plot was contributed by Combretaceae (12.93 m^2 ha^{-1}) at family level and *Terminalia tomentosa* (5.58 m^2 ha^{-1}) at species level. The lowest diameter class (1-10 cm) had the highest density (1054 individuals ha^{-1}), but basal area was highest in the 80-90 cm diameter class (5.03 m^2 ha^{-1}). Most of the species exhibited random or aggregated distribution over the plot. These studies provide a baseline information on the dry forests of Bhadra Wildlife Sanctuary.

Mohandas and Priya (2009) conducted a study on the Floristic structure and diversity of tropical montane evergreen forest of the Nilgiri Mountains. All plants having $\geq$1 cm diameter at breast height were inventoried in sholas of area $\leq$ 1.26 ha, whereas in sholas having area of $\geq$1.26 ha, randomly laid 30x30 m (0.09 ha) plots were used. A total of 30495 individuals from 87 species, 65 genera and 42 families were recorded. Of these 57 species of trees, 13 lianas, 12 shrubs and 5 large herbs were recorded. Species diversity as measured by Fisher's alpha was 11; stem density was 2652 stems ha^{-1} and basal area 59.4 m^2 ha^{-1}.

Reddy et al. (2008a) inventoried three tropical dry deciduous forest tree communities in Eastern Ghats of Southern Andhra Pradesh. Three 1 ha plots area were established one each in Nallamalais, Seshachalam and Nigidi hills. A total of 137 tree species, 2205 stems (735 ha^{-1}) of $\geq$10 cm girth were enumerated. Tree communities at the three sites differed in dominance, composition, diversity and structure. Tree stand density varied from 674 to 796 ha^{-1} with average basal area of 11.46 m^2 ha^{-1}. Shannon-Wiener index (H) ranges from 4.11 to 4.89. Site 1 was dominated by *Pterocarpus marsupium* (28.1) and *Anogeissus latifolia* (26.2), site 2 by *Pterocarpus santalinus* (44.5) and *Terminalia pallida* (42.4) and site 3 by *Chloroxylon swietenia* (46.2) and *Albizia amara* (25.9). Site 1 (Nallamalais) forests were more diverse at spatial scale and all taxonomic levels than their counterparts, due to high rainfall and favourable edaphic conditions. Their study served as the baseline information for monitoring and sustaining the phytodiversity of tropical dry deciduous forests in the State of Andhra Pradesh.

Ilorkar and Totey (2001) carried out a Floristic diversity and edaphic studies in the natural mixed deciduous forest of Navegaon National Park in Maharashtra. Vegetation was classified into three plant communities, viz., *Tectona-Pterocarpus-Buchanania, Cleistanthus-Ougeinia-Tectona, and Cleistanthus-Lagerstroemia-Terminalia*, corresponding to three elevation ranges (300-400, 400-500 and 500-600 m), respectively. A total of 39 trees, 16 shrubs and 44 herb species were recorded. Highest floristic diversity and density were observed at the 500-600 m elevation range. The productivity classes and indices for each soil profiles in the study area were presented. Soils at the 300-400 m elevation range presented maximum productivity index. The results indicated that the soils under *Tectona grandis* and its associates were productive and can be classified as a good productivity class.

The Phytosociological characteristics, diversity and distribution of tree species at three proposed reserve forests of the hill ranges between elevations from 400-1306 m were studied by Dash et al. (2009). A total of 152 tree species were recorded from the study sites belonging to 114 genera and 41 families. Species diversity was found to be maximum at Khambesi Reserve Forest and minimum at Niyamgiri Reserve Forest. Significant correlation of species diversity with species evenness and species richness were observed. Bhat and Kaveriappa (2009) conducted an Ecological study on Myristica swamp forests in Uttara Kannada district of Karnataka state in India with reference to floristic composition, structure, diversity and edaphic factors. Transect method was employed by laying out sample plots and enumeration of all trees $\geq$10 cm DBH was made. Sixty three species belonging to twenty six families with DBH >10 cm were recorded. The forest is of evergreen type dominated by *Myristica fatua var. magnifica*, *Gymnacranthera farquhariana*, *Hopea* *ponga* and *Dipterocarpus indicus.* Myristicaceae dominated the swamps with maximum Importance Value Index of 102.63 represented mainly by *G. farquhariana* (57.83) and *M. fatua var. magnifica* (38.49).

Comparison of regeneration, tree diversity and floristic diversity of natural and planted tropical deciduous forests in western Uttar Pradesh was carried out by Chauhan et al. (2008). Species diversity as well as species evenness was found to be higher in natural forests than in planted forests. Natural forest sites also had higher mature tree, pole, sapling and seedling densities compared with planted forests. In spite of differences in diversity, natural and planted forests did not differ strongly in species composition, fifty six species occurred in both sites. Dominant families in both forest types are Fabaceae, Euphorbiaceae, Verbenaceae, Rubiaceae and Caesalpiniaceae (5 species each), followed by Moraceae, Mimosaceae and Combretaceae. Of the 126 species found in both sites, 32.5% showed good regeneration, 19.8% fair, 24.6% poor and 11.1% lacked regeneration. The remaining 11.9% of species were present as seedlings but not as adult individuals.

Reddy et al. (2008b) made an assessment of quantitative structure and floristic composition of tropical forests of Mudumalai Wildlife Sanctuary, Western Ghats, India. Forest structure was analyzed across girth classes and height intervals. Altogether 156 tree species were analyzed. Importance Value Index, Shannon-Weiner index, Simpson index, Margalef's index and Pielou Index were calculated. The tree stand density varies from 112-406.8 ha^{-1} with the average basal area of 26.25 m^2 ha^{-1}. Shannon-Weiner Index (H') ranges from 3.94-4.90. The Simpson Index of dominance varied from 0.86-0.94. The Margalef Species Richness Index varies from 4.61-8.31. The population density of tree species across girth class intervals shows that 65.4% and 36.4% of individuals belong to 30-60 cm gbh. Tree distribution by height class intervals showed that around 28.7% of individuals were in the height class of 20-25 m, followed by 24.4% in the height of 15-20 m, whereas 3.37% of individuals were in the height class of >30 m.

A quantitative floristic inventory of three tropical forest types in Similipal Biosphere Reserve in Eastern Ghats of Orissa was carried out by Reddy et al. (2007). The study dealt with the quantitative floristic inventory of three tropical forest types in Similipal Biosphere Reserve. Three forest types were distinct in field and differed in dominance, composition, diversity and structure. The study resulted in documentation of a total 549 species of flowering plants. Altogether, 4819 stems of ≥30 cm gbh belonging to 185 tree species were enumerated and analyzed. Tree stand density varied from 527 to 665 ha^{-1} with average basal area of 43.51 m^2ha^{-1}. Shannon-Wiener index (H') ranges from 4.3 to 5.46. Similarity index revealed that only 25% of floristic composition of semi-evergreen forest was similar with moist deciduous forest. Analysis of population density of tree species across girth class interval showed that around 48.9% of individuals belong to 30-60 cm gbh. Their study served as a baseline information for phytodiversity characterization of tropical forests in the Similipal Biosphere Reserve in particular and Eastern Ghats of Orissa in general.

Chauhan et al. (2006) compared regeneration, tree diversity and floristic diversity of natural and planted deciduous forests (dominated by *Shorea robusta, Tectona grandis, Acacia catechu, Syzygium cumini* and *Terminalia* sp. respectively) in Tarai-Bhabhar belt of the Dudwa National Park, in Uttar Pradesh, India. Species diversity (105 species in natural and 41 species in planted forests) as well as species evenness was higher in natural forest than in planted forest and diversity indices (3.3235) values were low in all the planted forest sites as compared to those in natural forests. Only thirty one species were common in both sites. Natural forest sites also had higher mature trees, pole, sapling and seedling densities as compared to planted forest sites. This may be due to different soil types and levels of available soil nutrients in natural and planted forests. The dominant family in both forest types was

Fabaceae (13 species) followed by Mimosaceae, Euphorbiaceae and Moraceae. Tree species dominated the flora with 67.8% share. Of the 146 species found in both sites, 17.1% showed good regeneration, 24.0% fair, 24.7% poor and 20.5% no regeneration. The remaining 13.7% species were present as seedlings but not as adult individuals. Good quality timber species were not regenerating with the exception of *Shorea robusta*, although its mortality at seedling stage was high. The results suggested that species richness and diversity differed from natural to planted forest and regeneration of some important tree species also varied from natural to planted forests because of variations in microclimate, soil nutrients and edaphic characteristics. It is hoped that this study will help in the formulation of effective forest management and conservation strategies.

Preliminary studies of four representative forest sites having dense, medium, regenerated and degraded forest plots of one ha area were conducted in the Achanakmar-Amarkantak Biosphere Reserve (Yadav and Lalji, 2010). A total of 33 species were recorded. Density and basal area of trees in forest plots ranged from 240 (degraded forest) to 1270 (regeneration forest) stems ha^{-1} and 23.65 (regeneration forest) to 37.57 (dense forest plot) m^2 ha^{-1} respectively. Diversities in these forest plots were 1.46 to 2.24 (Shannon index), 0.61 to 0.83 (equitability), 2.95 to 6.06 (species richness), 0.41 to 0.53 (concentration of dominance) and 4.05 to 12.8 (Beta diversity). The beta diversity was highest at distributed forest plot. Forest represents the gradient in diversity and composition as high, medium, poor. Knowledge gained from these studies will help in framing the policy on R and D for conserving the forest for biomass and diversity and its use on sustainable basis.

Barua and Singh, (2009) conducted intensive field studies on two forest stand Nambor Daigrong Wild Life Sanctuary and adjacent Borneoria forests of Assam to assess floristic composition, distribution pattern, species diversity and dominance. During their investigation it was observed that the Nambor Daigrong forest and Borneoria forest tend to be floristically distinct. *Vatica lanceaefolia* was the common tree species in Nambor Daigrong forest. Otherwise, *Hydnocarpus kurzii* expressed its dominancy with highest IVI values (62.98) in Borneoria forest. Suryanarayana et al. (2008) carried out an enumeration of floristic composition in JFM managed and adjoining natural forests in Guddada Budihal area of Gadag Division, Karnataka. The study has inferred the higher species diversity in the JFM managed forests compared to the natural forests. There were 19 species in JFM managed forests, among them *Hardwickia binata* possessed higher IVI value of 120.41. It was followed by *Steropermum personatum* and *Anogeissus latifolia*. The data on regeneration indicated that, *Hardwickia binata* was most ecologically success species constituting IVI value of 74.7 of the total regenerating individuals. The data has clearly indicated a high diversity and more species composition among regenerated individuals in JFM managed forests compared to adjoining natural forests. The results indicated that an urgent need for taking enrichment works in many of the patches with indigenous local species and protecting the forests from grazing by involving local people.

A Qualitative information on the structure, composition and diversity of a dry deciduous forest of Bidar District in northeastern Karnataka was done by Seetharam et al. (2000). Results showed that the Bidar dry forest has a total of 438 species out of which 203 species are recorded from outside the forest itself. Transect studies revealed the occurrence of 80 woody species including 43 tree species and 37 shrubs and lianas. A total of 1261 trees had a girth size of more than 15 cm diameter at breast height. The tree density of the area was 530 to 1760 individuals/ha while stem density and basal area of the forest was 900/ha and 7.7 m^2/ha, respectively. Shannon's tree diversity indices were H' = 2.98 and E=0.81 and Simpson's were D = 0.07 and 1-D = 0.93. The dominant plant communities were *Chloroxylon swietenia/Anogeissus latifolia/Acacia chundra, Albizia amara/Bauhinia racemosa/Lannea coromandelica and Dalbergia paniculata/Butea monosperma/Soymida febrifuga.*

Parandiyal (2000) conducted a study in a forest in Kota, Rajasthan represented by three sites viz., protected forest (PRF), partially disturbed forest

(PDRF) and unprotected (disturbed) forest (UPRF), to assess the impact of varying levels of disturbances on quantitative and qualitative characters of the forest vegetation. Species richness and overall plant density increased with decreasing biotic pressure. In the UPRF, no tree above 3 m and no shrub in the woody layer was observed and recorded. The evenness of distribution of species increased with increasing protection in the woody layer.

The vegetation structure and regeneration studies on two adjacent protected and unprotected tropical forest sites in central India was carried out by (Jagjeevan, 1990). Random quadrat sampling was done in both areas and the resulting data analyzed for various floristic attributes. The result revealed that the species diversity (Shannon-Wiener) index was significantly higher at the Bandhavgarh National Park site. The most important species at both sites was *Dendrocalamus strictus* (IVI) of 99.8 and 81.6 at Bandhavgarh and Tala, respectively followed by *Diospyros melanoxylon* (which had an IVI of 49.1 at Tala but only 19.7 at Bandhavgarh). *Shorea robusta* was the third most important species, with similar IVIs at both sites.

2.2 Floristic studies in Kerala

The floristic composition of a particular community is characteristic to it and has evolved due to the particular set of edaphic and climatic conditions. There are few floristic studies had been carried out in the fragile ecosystems of Kerala. A study was carried out to investigate the floristic and phytosociological aspects of the shola forests at Mannavan shola and Eravikulam National Park in Idukki District by Swarupanandan et al. (2001). A total of 543 taxa of pteridophytes and angiosperms were recorded from the two areas of which 109 taxa are endemic, 123 are rare and 26 are endangered. The result revealed that the number of species decreased with an increase in altitude, i.e. 94 species at 1850 m and 84 species at 2100 m.

Floristic and edaphic attributes of 3 fresh water swamp forests in southern Kerala were analyzed (Varghese and Kumar, 1997). Sample plots of 0.5 ha were established at Kulathupuzha, Anchal and Shendurney in the Western Ghats and all trees $\geq$10 cm in girth at breast height were enumerated. Soil profile developments, physicochemical and electrochemical properties of the swamp soils were also examined. The swamp vegetation exhibited lower floristic diversity than other tropical evergreen forest formations in the Western Ghats, and variations in the floristic spectrum of the swamp sites were small. The family Myristicaceae dominated the fresh water swamps with *Gymnacranthera farquhariana* and *Myristica magnifica* accounting for most of the stand basal area, relative density and importance value index. Diameter and height distributions followed a negative exponential relationship.

Varghese and Menon (1999) made a floristic study in order to explore the diversity of Myristica swamp forest of Southern Western Ghats. Random sampling was done using census quadrat techniques. In the 0.1 ha area sampled (ten 10x10 m quadrats) 18 species were recorded belonging to >12 families. The Myristica swamp forest had a comparatively low stand density (520 trees ha^{-1}), maturity index value (18.33) and species density (18 species ha^{-1}). It showed medium diversity (2.50), an absence of higher frequency classes and a high concentration of dominance (0.09). On the basis of dominance, the forest is identified as of the *Gymnacranthera farquhariana/Myristica fatua var. magnifica/Knema attenuata* type.

A field study was conducted in the wet evergreen forests of Sholayar in the Western Ghats to characterize vegetation development as a function of time after selection felling (Rajesh et al. 1996). Four quadrats (40x40 m) were established in selected patches of forests selection felled 7, 16, 21 and 28 yr before 1992. All trees and shrubs ($\geq$10 cm girth at breast height) were enumerated. Species wise counts of seedlings <10 cm gbh were also made in four 5x5 m quadrats within each of the main quadrats. The current suite of species in the selection felled forest gaps exhibited both early and late seral characteristics. About 62-83% of the tree species encountered at these sites (logging coupes) were, however, common. Further, the relative proportion of early and late successional species was dependent on gap age. As the gap age increased, abundance of late successional species such as *Palaquium ellipticum*, *Mesua nagassarium* and *Vateria indica* (the dominant species of the natural forest) increased. Floristic diversity declined as time after gap formation increased. Moreover, floristic diversity indices were generally lower than those of many other formations in the Western Ghats.

Nair and Jayakumar (2005) explored the floristic diversity of Shola-grassland vegetation in New Amarambalam reserved forests. The reserve covers an area of 265.72 km^2 and is the abode of all the seven tropical hill forest types represented in peninsular India, namely moist deciduous, semi evergreen, evergreen and subtropical hill forests, subtropical savannahs, montane wet temperate forests and montane wet temperate grasslands. Fifty six sample plots of 30 m x 30 m size were laid randomly in relation to altitude variations of the area harbouring the vegetation types. The different components of the Shola vegetation were also classified according to the life forms, viz., trees, lianas, shrubs and herbs, and analysis of the data gathered showed that diversity of tree species (>30.1 cm gbh) is 2.75 and that of lianas, shrubs and herbs are 1.45, 1.23 and 3.70, respectively. Floristically, the Shola vegetation harboured 65 species of angiosperms, composed of 41 trees, nine shrubs, three liana and two herbaceous species, as represented in 25 sample plots of 30 m x 30 m size. From the adjoining grasslands, 50 species of angiosperms, composed of four trees, five shrub and 42 herbaceous elements were recorded from the 32 sample plots of 30 m x 30 m size, laid for data collection. Plant diversity analysis indicated that Shannon index of Shola forests is higher than that of the grasslands, and due to forest fire and other anthropogenic influences, both the formations are in a degraded condition.

The traditional system of cardamom production represents a unique agroforestry system which involves growing a sciophytic commercial crop under the shade of trees in the natural forest, with little or no reliance on external inputs. A field study was conducted in the Western Ghats part of Kerala by Kumar et al. (1995) to test two hypotheses on the floristic attributes of the cardamom hill reserves (CHR). The two hypotheses are (1) that there is a lower floristic diversity in the cardamom hill reserves than in undisturbed evergreen forests, and (2) that the vegetation structure of cardamom areas will be dominated by a few of the larger size classes of trees (i.e. truncated), in comparison with the typical inverse 'J'-shaped distribution pattern of natural forest. The experimental sites involved three CHRs and an evergreen forest site. The CHRs, regardless of their locations, were characterized by lower floristic diversity and density than the evergreen forest site. The undisturbed forest site at Ayyappancoil registered the highest floristic richness and diversity (Simpson's floristic diversity index, D=0.93), followed by the well managed CHR site, suggesting that managerial interventions may have a strong bearing on the floristic diversity of CHRs. The current suite of species in the CHRs included both heliophilic and shade-tolerant components. However, dominant tree species, their density and relative abundance exhibited marked variations among the CHR sites, although about one third of the species were common at all sites. Stand physiognomy was characterized by the dominance of a single layer of trees in the CHRs, while the wet evergreen forest exhibited a multilayered canopy structure. Some of the lower height classes were poorly represented in the cardamom areas, where the evergreen forests depicted an inverse 'J' shaped height distribution pattern. Implicit in the truncated stand structure of the CHR is the poor regeneration status, due to systematic removal of the lower size classes.

Shibu et al. (1994) carried out a study on Structural, floristic and edaphic attributes of the grassland-shola forests of Eravikulam. Structural and floristic elements of the shola forest revealed a very high floristic richness and diversity, probably the highest in the Western Ghats region. A total of 942 stems of a least 10 cm girth at breast height (GBH) and belonging to 53 species were encountered in the 5000 m^2 sampling area. Species with the greatest percentage of stem density were: *Pithecellobium subcoriaceum* (11.25%), *Ternstroemia gymnanthera* (9.02%), *Ixora* *notoniana* (6.48%), *Syzygium arnottianum* (5.94%) and *Maesa indica var. perrottetiana* (5.63%).

Vidyasagaran et al. (2000) conducted an ecological study in the highland riverain island of Kuruva, Wayanad. Four vegetation types namely riverain forest, moist deciduous forest, Careya dominant and Bamboo dominant forests were reported. *Hopea ponga, Calophyllum apetalum* and *Diospyros malabarica* forms the major vegetation association in riverain forests; *Terminalia crenulata, Terminalia paniculata* and *Pterocarpus marsupium* are the major groups in moist deciduous forest. In the case of degraded careya dominant and bamboo dominant forests, *Careya arborea* and *Bambusa arundianaceae* were the dominant species. The floristic diversities of different forest types of the Island were comparable to similar forests of Western Ghats except the Careya dominant forests.

2.3 Profile diagram

Profile diagrams are used in the management of mixed stands in urban woodlands of Denmark (Nielsen and Nielsen, 2005). The profile diagram was considered a useful instrument for the study and comparison of forests physiognomic structures. Lemos et al. (2001) had drawn a profile diagram in order to compare the vegetation of two contiguous areas: an area on quaternary sandy terrain and on the top of a small hill (Table-land). Profile diagrams of representative 10 x 40 m strip were drawn in the four vegetation types of Kuruva Island by Vidyasagaran et al. (2000). Four distinct strata were identified in the riverain forest as well as moist deciduous forest in the Island.

Srivastava and Lal (1996) prepared a profile diagram for a tropical lowland wet evergreen rain forest in Sumatra. He also listed the floristic composition for each vegetation type. George et al. (1993) made a vegetation profiles of 80x10 m strip transects at 2 locations to describe stand physiognomy in the 15 yr old secondary forest in an abandoned *Eucalyptus tereticornis* plantation in the Western Ghats of India.

2.4 Edaphic attributes

Although climate is the most critical factor in shaping the range of plant communities, the edaphic factors are often responsible for limiting its occurrence. The physical, chemical and biological relations of the soils to forest growth are extremely complex. Several earlier workers have made attempts to examine the interrelations between soil and vegetation (Das et al.1980; Dhar and Jha, 1980; Daniel et al., 1983).

Alexander et al. (1980) found that soils under dry deciduous and to some extent moist deciduous forests were more resilient and can be developed for forestry or agricultural purposes through scientific soil management practices, while soils under evergreen and semi-evergreen forests were fragile. However, the soil differences related to vegetation were more pronounced in the surface layer (0-15 cm) and the effect decreased with depth (Elsy, 1989)

2.4.1 Soil colour

Soil colour depends on pedogenic process and the parent material from which the soil was derived. Red colours due to ferric compounds are associated with well aerated soils, while yellow colours signify intermediate aeration. Ferrous compounds of blue and green colours are often associated with poorly aerated soils. Mottling often indicates a one of alternately good and poor aeration. Manganese and organic matter produce dark colours in soils. Brown colour predominates in slightly decomposed plant material, but the more decomposed materials are nearly black.

Elsy (1989) evaluated the morphological, physical and chemical properties of soils of tropical evergreen, semi- evergreen, moist deciduous, grassland, hill top evergreen and dry deciduous forests of Kerala. The surface horizon from all the profiles were rich in organic matter and had darker colours, ranging from greyish brown to brown, increasing redness in the sub-surface horizon was noticed in all soils.

Vidyasagaran et al. (2000) observed a light colour soils in all the vegetation of Kuruva Island except in Careya dominant forest, where it is darker (ie, Brown, Dark greyish brown and dark brown).

2.4.2 Soil texture

Texture of a forest soil influences its productivity, but this influence may be more of indirect than of a direct nature. Texture per se has little effect on tree growth as long as moisture, nutrients and aeration are adequate (Pritchett, 1987).Wide variations in texture were observed between the soils from evergreen, semi evergreen and moist deciduous forests (Elsy, 1989). Coarse fragments, mostly in the form of secondary laterite gravel constituted a major portion of such soils.

Elsy (1989) observed an increase in clay content with depth from different forest ecosystem of Kerala. This may be due to increased translocation of clay down the profile due to heavy rainfall (Rajmannar and Krishnamoorthy, 1987).The Myristica swamps in the evergreen forests of Travancore are characterized by alluvial soil brought down from surroundings and contain a large proportion of (up to 80%) humified sand (Varghese and Kumar, 1997)

Balagopalan (1987) reported that there was no noticeable effect of fire on the texture of different ecosystems including moist deciduous forests, semi-evergreen forest, grasslands, eucalyptus plantations and teak plantations of Kulamav. The presence of sandy loam soils in the eucalyptus and teak plantations of Trivandrum Forest divisions was also reported by Balagopalan (1989a).

A study made by Balagopalan (1989b) on the properties of soils in the natural forests of Trivandrum Forest Division revealed that the soils of evergreen and semi evergreen forests are sandy loam whereas in moist deciduous forest it was loamy sand. Similarly the soils in evergreen forest and moist deciduous forest of Malyattoor division are sandy loam and loamy sand (Balagopalan, 1994).

2.4.3 Soil Bulk density

Bulk density is the mass of dry soil per unit bulk volume and it is generally increases with depth in forest soils. The variation in forest soil bulk densities was mainly explained by five input variables: organic carbon content, tree species, the coarse fragment content, parent material and sampling depth (Jalabert et al. 2010)

Root and shoot growth of various tree species have been reported to decrease with increasing bulk density (Davis, 1984; Wasterlund, 1985) though degree of tolerance or adaptability varies from species to species. Bulk density and associated soil moisture was found to influence the root growth of teak, eucalypt and Albizia (Thomas, 1989)

2.4.4 Soil acidity

The acidity of the forest soils varies widely and it is of great importance in determining the type and quality of forest that occurs on any particular site. Organic acids produced from the decomposition of forest litter are important weathering agents and producers of soil acidity. Alexander and Balagopalan (1980) in a case study of the Reserved and vested forests in Attapaddy areas of Kerala observed that most of the surface horizons were slightly acidic to neutral in reaction and pH increased with depth. Evergreen soil was the most acidic followed by the slightly acidic semi evergreen and near neutral moist deciduous and dry deciduous soils.

pH value of the soil in tropical and subtropical forests of Kerala decreases with altitude (Balagopalan and Jose, 1995). Balagopalan (1980) identified the presence of strongly acidic soils in evergreen and semi evergreen forests of Trivandrum whereas in Malayattoor forests the same vegetation exhibit moderately acidic nature (Balagopalan, 1994). A comparison made between natural and plantation ecosystems of Wayanad revealed the presence of less acidic soils in moist deciduous forests whereas in evergreen forests it was more acidic in nature. Riverain forests of Kuruva Island were reported to have slightly acidic soil (Vidyasagaran et al. 2000)

Few studies on soil acidity were also reported from the plantations of Kerala. Soil pH was increased with depth in Teak and Eucalyptus plantations of Trichur (Balagopalan, 1986). In Trivandrum, the soils under the same plantations are varying from strongly to very strongly acidic (Balagopalan, 1989a). Low value of soil pH was reported from the Bombax plantations of Thrissur (Balagopalan et al. 1992). The soil characteristics studies of Cashew plantations had shown the presence of moderately acidic soils (Balagopalan, 1994).

2.4.4 Organic carbon

Alexander and Balagopalan (1980) reported a decrease in the organic carbon content with depth in the profiles of Reserved and vested forests in Attapaddy areas of Kerala. Most of the surface samples of evergreen, semi-evergreen and moist deciduous soils were rich in organic carbon and it decreased from evergreen to moist deciduous; further there was considerable reduction (about 50%) in dry deciduous. A close correlation between the organic carbon content and that of bases was reported in the soils of natural forests of Kerala by Sankar et al. (1987).Soil organic carbon often improves the moisture retention capacities of soil. Allen (1985) showed that organic carbon content is positively related to rainfall and negatively to temperature.

Organic matter content was found to be decreased with altitude (Balagopalan and Jose, 1995). C: N ratio of the soil was found to be a constant of 12: 1 in all altitudes. Organic carbon content also showed a reducing trend down the soil (Vidyasagaran et al. 2000; Balagopalan, 1995). Balagopalan and Jose (1995) made a comparative study on the soils which reveals high value of organic carbon in forests as compared to adjacent plantations. Similarly the comparison of soils in the natural and plantation ecosystems of Wayanad shows more or less same level of organic carbon (Thomas, 1991).

2.4.5 Available phosphorous

Balagopalan (1989b) made a study on the properties of soils in the natural forests revealed a decrease of available phosphorous with depth in both evergreen and semi evergreen forests. Available phosphorous in the swamp soil of Kerala were lower than in other forest ecosystems of the region (Varghese and Kumar, 1997). Soil studies in the Myristica swamp forests of Uttara Kannada also revealed the range of phosphorous and potassium was 0.64-1.26%, also slightly lower than other forest ecosystems of the region (Bhat and Kaveriappa, 2009).

There was a considerable difference between the level of available phosphorous and available potassium between natural and planted deciduous forests (Chauhan et al. 2006).

2.4.6 Available potassium

The ecological study on the riverain island of Kuruva by Vidyasagaran et al. (2000) reported a reducing trend of available K down the soil. Potassium content in the swamp soils is lower than other forest ecosystems of the region (Bhat and Kaveriappa, 2009; Varghese and Kumar, 1997). Available potassium showed high significant positive correlation at different altitudes and seasons and significant negative correlation with soil depth (Dimri et al. 2006).

Materials and methods

MATERIALS AND METHODS

3.1 Location

The present study was carried out at Thollayiram area, which is situated in Vellarimala village of Vythiri Taluk of Wayanad District (Fig. 1). As the name indicates, the extent of this area is 900 (Thollayiram) Acres, exactly 937.57 Acres. Half of the land in Thollayiram was owned by private people and is under cardamom and coffee cultivation (Section 5 lands). Second half is possessed by Forest Department as Vested Forest and Ecologically Fragile Lands.

3.2 History of the area

Thollayiram area was private forest owned by Nilambur Kovilakam. The entire Thollayiram forest area was lying in Survey Nos. 1186, 1187 and 1188 of Muppayinad Amsom Desom in South Wayanad Taluk of Vythiri Sub-District in Kozhikode District. In 1923, M/s Malayalam Plantations Ltd. purchased this 937.57 Acres from Nilambur Kovilakam vide Indenture made on the 25.09.1923 and registered as Document No. 2804 of 1923 of the Office of the Registrar of Madras. M/s Malayalam Plantations Ltd. was a company incorporated in England having its registered office at ¼ Great Tower Street, London E.C.3, England. The land was covered under Madras Preservation of Private Forest Act, 1949.

On 10.01.1968 M/s Malayalam Plantations Ltd entered into an agreement with Kottayam based agriculturist D. Dominic, Karippaparambil House, Kanjirappilly for the sale of 937.57 Acres. As per Madras Preservation of Private Forest Act, 1949, permission from the District Collector is to be obtained for alienating and subdividing a private forest having extent more than 100 Acres. They obtained the permission from the District Collector, Kozhikode vide Order No. D-Dis. 37660/69 dated 20.11.1970. The entire 937.57 Acres was subdivided into 36 plots and 36 people possessed the concerned plot. Majority of the plots were planted with cardamom. Rocky patches and other forests were retained as such. It is important to note that if the District Collector wouldn't have issued the permission for sale and subdivision, the entire 937.57 Acres would have vested in Government as Vested Forest on 10.05.1971.

As per Kerala Private Forest (Vesting and Assignment) Act, 1971 some portion of this Thollayiram area got vested in Government. The ex-owners filed applications before the Hon'ble Forest Tribunal and some bits were allowed to the applicants. Approximately 125 Acres got vested in Government as Vested Forest. While some of the applications were pending before the Forest Tribunal and High Court and some pending with the Forest Department for restoration, the cardamom cultivation came down due to low care and diseases. The cardamom plantations started supporting natural vegetation and later the majority of the plantation ended as failed plantations and achieved the physical status of forest.

Kerala Forest (Vesting and Management) of Ecologically Fragile Lands Act came into force on 02.06.2000. By virtue of Section 3(1) of the above Act about 100 hectares of land was notified as EFL. Survey finalized the extent of EFL as 145 hectares (375 Acres). Now about 500 acres is owned and possessed by Forest Department as Vested Forest and EFL. The balance area is owned by private people.

Bifurcation of Kozhikode District was effected as Kozhikode and Wayanad Districts. Muppayinad Village was bifurcated into Muppayinad and Vellarimala Villages. Thollayiram area came under the jurisdiction of Vellarimala Village. The forest was under Kalpetta Range of Kozhikode Special Division. In 1990 Meppady Range was formed and Thollayiram area is now under the jurisdiction of Sentinel Rock Beat of Mundakkai Section in Meppady Range of South Wayanad Division.

3.3 Climate

The mean temperature varied between 15^0C and 29^0C. January and March were the coldest and hottest months respectively. Mean annual rainfall for the year was 2655 mm. The number of rainy days was 131. Relative humidity was above 72% throughout the year.

3.4 Soil

The soils of Wayanad belong to the red ferrous series with a sprinkling of reguar soils in the north of the district. The red ferrous soils are of various shades of red and brown due to the presence of iron in the original rock. There are different degrees of fertility mostly good, varying with the quantity of humus derived from the de-composition of organic substances. Tea and coffee can thrive in this soil provided there are enough rainfall and drainage possibilities.

3.5 Floristic analysis

3.5.1 Sample plots

For carrying out floristic analysis, three sample plots (1 ha in extent) were established in the three land use systems *viz*. ecologically fragile land, section 5 land and in vested forest. Twenty five quadrats of 20 m x 20m size were established in each of these study areas by expanding quadrat method (Varghese and Kumar, 1997).The quadrats were established on the ground using pegs outlined by coloured nylon ropes. Initially two pegs were driven in to the ground at a distance of 20 m (baseline). Perpendicular lines were taken at both ends of the base line and a distance of 20 m was measured and marked using pegs. Subsequent quadrats were established by extending the areas of first quadrat in both directions. All trees or shrub equal to and above 10 cm GBH were enumerated by measuring their height and GBH using Ravi altimeter and a tape respectively. All individuals having a GBH below 10 cm were also recorded separately. For lichens and bryophytes the samples were collected from different trees in each quadrat up to a height of about 2 m and from dried twigs and stems from the forest floor (Nair et al., 2005; Rout et al., 2010)

3.5.2 Phytosociology

The analysis of vegetation in the study area was carried out using phytosociological methods (Goldsmith et al., 1986). The vegetation was quantitatively analyzed for their abundance, frequency, density and their relative values and Importance value index (Curtis and McIntosh, 1950). In order to determine the quantitative relationship between the tree species, the following parameters were determined.

1. Density (D) = No: of individuals/hectare
2. Relative Density (R.D) $= \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$
3. Abundance (A) $= \frac{\text{Total No. of individuals of the species}}{\text{No. of quadrats of occurrence}}$
4. Percentage Frequency (PF) $= \frac{\text{No. of quadrats of occurrence}}{\text{Total No. of quadrats studied}} \times 100$
5. Relative Frequency (RF) $= \frac{\text{Percentage frequency of individual species}}{\text{Sum percentage frequency of all species}} \times 100$
6. Basal Area (BA) $= \frac{GBH^2}{4\pi}$
7. Relative Basal Area (RBA) $= \frac{\text{Basal area of the species}}{\text{Basal area of all species}} \times 100$
8. Importance Value Index (IVI) = RD + RF+ RBA

9. Relative Importance Value Index

(RIVI) $= \frac{IVI}{3}$

3.5.3 Floristic diversity

Species diversity is applied to represent the species richness, relative abundance or the variability in a community. Shannon- Weiner index and Simpson index are used as species diversity measurements (Magurann, 1988). The above indices were worked out using following formulae:

1. a. Simpson Index , $D = 1 - \sum (n_i/N)^2$ (Simpson, 1949)

   Where,

   n_i - Number of individuals of the species

   N- Total number of individuals in the plot

   D- Diversity

   b. Concentration of dominance, $Cd = \sum (n_i/N)^2$

2. a. Shannon-Weiner's index, $H' = 3.3219(\text{Log } N - 1/N \sum n_i \log n_i)$ (Shannon and Weiner, 1962)

   Where,

   n_i –Number of individuals of the species

   N- Total number of individuals

   S- Total number of species

   b. $H_{max} = 3.3219 \log_{10} S$

   Where, H_{max} is the maximum dispersion taking in to account the number of species present in the plot.

   c. Equitability (E) = H' / H_{max}

Equitability gives an idea of the real distribution as compared to the maximum dispersion taking into account the number of species present in the plot.

3.6 Profile diagram

Profile diagram is a physical, size to scale, pictorial transactional representation of a representative segment of the forest land (Richards, 1952). A strip of 20 x 80 m stand was selected from each land use type and a linear representation of this strip was made in a size to scale graph ignoring the width of the strip. Positions of each tree were marked on the line. Total height and height to the first branch forming crown were recorded using an altimeter. Crown diameter was measured by tracing it on the ground with the help of two long rods. The vertical projection of the crown shape of each tree was drawn by hand in the field. From these pictorial and quantitative data obtained, the profile diagram was made, keeping the measurements to scale.

3.7 Soil studies

3.7.1 Sample collection

From each land use systems, three soil profiles were taken to a depth of 60 cm and samples from 0-10, 10-30 and 30-60 cm layers were collected. After sample collection, morphological examination (using Munsell colour chart) and profile descriptions were made for each horizon.

3.7.2 Soil analysis

The samples collected were packed in air tight containers and brought to laboratory. The air dried soil passed through a 2 mm sieve and stored in a polythene bag for carrying out physico-chemical analysis.

3.7.3 Physical properties

3.7.3.1. Soil texture

Texture of soils was determined by international pipette method (Piper, 1942). 20 g air dried soil samples were taken in 500 ml beaker. 60 ml, 6% H_2O_2 was added to destroy the organic matter which acts as a binding material. 8 ml, 1N NaOH was added and stirred well for better dispersion of soil particles. Contents were transferred into a spoutless cylinder of 1000 ml and from which 20 ml of suspension pipetted out to find out clay and silt particles based on their sedimentation time. By repeated washing of the sediments and after oven drying, the weight of sand particles was also obtained.

3.7.3.2. Bulk density

The bulk density of the soil was determined using core sampler method. The soil collected was transferred in to an air tight container and the weight of the soil (both moist as well as dry) was estimated.

Bulk density= Mass of soil/ Core volume

3.7.4 Chemical properties

3.7.4.1. Soil pH

The pH of the soils was determined in a 1:2.5 soil water suspension potentiometrically using a pH meter (Jackson, 1958).

3.7.4.2. Organic carbon

Organic carbon of the soil was estimated by wet digestion method (Walkley and Black, 1934).

3.7.4.3. Available phosphorus

Available phosphorus in the soil samples were extracted using Bray No.1 reagent (Bray and Kurtz, 1945) and estimated calorimetrically by reduced molybdate Ascorbic acid blue color method (Watanabe and Olsen, 1965) using a spectrophotometer

3.7.4.4. Available potassium

Available potassium in the soil samples were extracted using neutral one normal ammonium acetate and its content in the extract was estimated by flame photometry (Jackson, 1958).

3.7 Statistical analysis

Diversity t-test (Magurann, 1988) was used to compare the diversities of two areas whereas as cluster analysis gave an idea about the similarity between floristic composition of two sites. Statistical packages like PAST and BD Pro are used for carrying out diversity t- test and Bray-Curtis cluster analysis. Simple correlation analysis was carried out to find the significance of each soil properties across depth wise in each land use types whereas two way analysis of variance was used to test the significance of soil properties among three land use types. Both correlation and one-way analysis of variance are analyzed using SPSS ver. 16

Fig 1. Geographic location of the study area

Ecologically fragile land

Section 5 land

Vested forest

Plate 1. An overview of three land use systems in Thollayiram

Results

RESULTS

4. 1. Species composition and vegetation structure (> 10 cm GBH)

4. 1. 1. Abundance, density and relative density

Abundance, density and relative density of species (> 10 cm GBH) in the ecologically fragile land, section 5 land and vested forest are given in Tables 1- 3

4.1.1.1. Ecologically Fragile Land

Melicope lunu-ankenda recorded the highest abundance of 3.88 individuals per quadrat and seen in all the quadrats studied. A total of 40 species having a density of 411 individuals per hectare was recorded from the sampled area (Table 1). *Melicope lunu-ankenda* recorded the highest density of 97 individuals per hectare, followed by *Litsea oleoides* with 41 individuals. Relative densities of *Melicope lunu-ankenda* and *Litsea oleoides* were 23.60 % and 9.98 % respectively; no other species had value more than 9%.

4. 1. 1. 2. Section 5 land

The abundance and density of all species from the section 5 land were 34.27 and 270 individuals ha^{-1} respectively. Among the 26 species present, *Litsea wightiana, Diospyros nilagirica* and *Dillenia bracteata* recorded the highest densities with 49, 27 and 25 individuals per hectare respectively. These three species accounted for 18.15, 10.00 and 9.26 per cent of relative densities while all other species had values below 9 (Table 2)

4. 1.1. 3. Vested forest

From the Table 3, it can be seen that out of 32 species present in the area *Palaquium ellipticum, Myristica beddomei* and *Dimocarpus longan* had an abundance value 3.68, 3.45 and 2.68 respectively. The density of the vested forest

Table 1. Abundance (A), Density (D) and Relative Density (RD) of species (>10 cm GBH) in Ecologically Fragile Land

Sl no:	Species	Abundance	Density (individuals per ha)	Relative density (%)
1.	*Melicope lunu-ankenda*	3.88	97.00	23.60
2.	*Litsea oleoides*	3.42	41.00	9.98
3.	*Litsea wightiana*	2.77	36.00	8.76
4.	*Diospyros nilagirica*	1.57	22.00	5.35
5.	*Persea macrantha*	1.91	21.00	5.11
6.	*Clerodendrum infortunatum*	1.43	20.00	4.87
7.	*Dillenia bracteata*	1.90	19.00	4.62
8.	*Myristica beddomei*	1.89	17.00	4.14
9.	*Drypetes wightii*	1.56	14.00	3.41
10.	*Syzygium densiflorum*	1.38	11.00	2.68
11.	*Eurya nitida*	2.75	11.00	2.68
12.	*Syzygium cumini*	1.25	10.00	2.43
13.	*Macaranga peltata*	1.67	10.00	2.43
14.	*Chukrasia tabularis*	1.17	7.00	1.70
15.	*Artocarpus heterophyllus*	1.40	7.00	1.70
16.	*Knema attenuata*	1.40	7.00	1.70
17.	*Calophyllum polyanthum*	1.20	6.00	1.46
18.	*Dimocarpus longan*	2.50	5.00	1.22
19.	*Alseodaphne semecarpifolia*	1.00	4.00	0.97
20.	*Chionanthus ramiflorus*	1.00	4.00	0.97
21.	*Ficus microcarpa*	2.00	4.00	0.97
22.	*Gomphandra tetrandra*	2.00	4.00	0.97
23.	*Coffea liberica*	1.00	3.00	0.73
24.	*Psydrax umbellata*	1.00	3.00	0.73

Contd....

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Sl no:	Species	Abundance	Density (individuals per ha)	Relative density (%)
25	*Bischofia javanica*	1.50	3.00	0.73
26	*Palaquium ellipticum*	1.50	3.00	0.73
27	*Syzygium laetum*	1.50	3.00	0.73
28	*Gordonia obtusa*	3.00	3.00	0.73
29	*Cinnamomum wightii*	1.00	2.00	0.49
30	*Neolitsea cassia*	2.00	2.00	0.49
31	*Paracroton pendulus*	2.00	2.00	0.49
32	*Syzygium lanceolatum*	2.00	2.00	0.49
33	*Canarium strictum*	1.00	1.00	0.24
34	*Cullenia exarillata*	1.00	1.00	0.24
35	*Ficus racemosa*	1.00	1.00	0.24
36	*Glochidion ellipticum*	1.00	1.00	0.24
37	*Mesua ferrea*	1.00	1.00	0.24
38	*Nothapodytes nimmoniana*	1.00	1.00	0.24
39	*Syzygium grande*	1.00	1.00	0.24
40	*Vernonia arborea*	1.00	1.00	0.24
	Total	65.53	411.00	100.00

Table 2. Abundance (A), Density (D) and Relative Density (RD) of species (>10 cm GBH) in Section 5 land

Sl no:	Species	Abundance	Density (individuals per ha)	Relative density (%)
1.	*Litsea wightiana*	2.58	49.00	18.15
2.	*Dillenia bracteata*	1.79	27.00	10.00
3.	*Diospyros nilagirica*	1.93	25.00	9.26
4.	*Myristica beddomei*	1.83	22.00	8.15
5.	*Chionanthus ramiflorus*	1.09	19.00	7.04
6.	*Melicope lunu-ankenda*	1.73	16.00	5.93
7.	*Persea macrantha*	1.45	14.00	5.19
8.	*Artocarpus heterophyllus*	1.40	14.00	5.19
9.	*Dimocarpus longan*	1.56	14.00	5.19
10.	*Syzygium cumini*	1.00	12.00	4.44
11.	*Chukrasia tabularis*	1.75	9.00	3.33
12.	*Drypetes wightii*	1.00	6.00	2.22
13.	*Syzygium laetum*	1.00	6.00	2.22
14.	*Trema orientalis*	1.00	6.00	2.22
15.	*Bischofia javanica*	1.50	5.00	1.85
16.	*Calophyllum polyanthum*	1.00	4.00	1.48
17.	*Coffea liberica*	1.00	4.00	1.48
18.	*Cinnamomum wightii*	1.00	4.00	1.48
19.	*Erythrina subumbrans*	1.33	4.00	1.48
20.	*Litsea oleoides*	1.33	3.00	1.11
21.	*Glochidion ellipticum*	1.00	2.00	0.74
22.	*Actinodaphne malabarica*	1.00	1.00	0.37
23.	*Cullenia exarillata*	1.00	1.00	0.37
24.	*Ficus microcarpa*	1.00	1.00	0.37
25.	*Garcinia gummigutta*	1.00	1.00	0.37
26.	*Vernonia arborea*	1.00	1.00	0.37
	Total	34.27	270.00	100.00

Table 3. Abundance (A), Density (D) and Relative Density (RD) of species (>10 cm GBH) in Vested forest

Sl no:	Species	Abundance	Density (individuals per ha)	Relative density (%)
1.	*Palaquium ellipticum*	3.68	81.00	14.86
2.	*Myristica beddomei*	3.45	76.00	13.94
3.	*Dimocarpus longan*	2.68	59.00	10.83
4.	*Leea indica*	2.64	29.00	5.32
5.	*Litsea oleoides*	1.42	27.00	4.95
6.	*Mesua ferrea*	2.17	26.00	4.77
7.	*Dillenia bracteata*	2.36	26.00	4.77
8.	*Cullenia exarillata*	1.71	24.00	4.40
9.	*Cinnamomum wightii*	1.64	18.00	3.30
10.	*Drypetes wightii*	2.25	18.00	3.30
11.	*Polyalthia coffeoides*	1.40	14.00	2.57
12.	*Artocarpus heterophyllus*	1.56	14.00	2.57
13.	*Paracroton pendulus*	1.56	14.00	2.57
14.	*Antidesma montanum*	1.86	13.00	2.39
15.	*Syzygium cumini*	1.86	13.00	2.39
16.	*Syzygium laetum*	1.00	12.00	2.20
17.	*Mastixia arborea*	1.50	12.00	2.20
18.	*Chionanthus ramiflorus*	2.20	11.00	2.02
19.	*Clerodendrum infortunatum*	1.13	9.00	1.65
20.	*Hydnocarpus alpina*	1.40	7.00	1.28
21.	*Neolitsea cassia*	1.40	7.00	1.28
22.	*Elaeocarpus munronii*	1.00	6.00	1.10
23.	*Macaranga peltata*	1.00	6.00	1.10
24.	*Actinodaphne malabarica*	1.50	6.00	1.10
25.	*Bischofia javanica*	1.00	4.00	0.73
26.	*Calophyllum polyanthum*	1.33	4.00	0.73
27.	*Elaeocarpus serratus*	1.00	2.00	0.37
28.	*Glochidion ellipticum*	1.00	2.00	0.37
29.	*Sterculia guttata*	1.00	2.00	0.37
30.	*Canarium strictum*	1.00	1.00	0.18
31.	*Eurya nitida*	1.00	1.00	0.18
32.	*Malottus philippensis*	1.00	1.00	0.18
	Total	52.89	545.00	100.00

was 545 individuals per hectare. *Palaquium ellipticum* recorded the highest density with 81 individuals per hectare. Density and relative density values of *Myristica beddomei* were 76 individuals ha^{-1} and 13.94 % respectively whereas *Dimocarpus longan* had a density of 59 individuals ha^{-1} and relative density 10.83%.

4. 1. 2. Frequency, percentage frequency and relative frequency

Tables 4-6 depicts frequency, percentage frequency and relative frequency of all species (>10 cm GBH) present in the three land use systems.

4. 1. 2. 1. Ecologically Fragile Land

Melicope lunu-ankenda recorded the highest frequency (25) followed by *Diospyros nilagirica* (14) and *Clerodendrum infortunatum* (14). Percentage frequencies of 11 species among the total 40 species enumerated were found to be more than 25 %. In terms of relative frequencies *Melicope lunu-ankenda, Diospyros nilagirica* and *Clerodendrum infortunatum* topped the figures with values 12.25 %, 6.86 % and 6.86 % respectively (Table 4).

4. 1. 2. 2. Section 5 land

Litsea wightiana had the highest frequency in section 5 land (19) and was seen in 76 % of the quadrats studied. *Diospyros nilagirica* and *Dillenia bracteata* were present in 56% of the quadrats at a frequency of 14.00 and 14.00 respectively. Among relative frequencies, *Litsea wightiana, Diospyros nilagirica* and *Dillenia bracteata* had the maximum values of 10.98 %, 8.09 % and 8.09 % respectively. Out of the 26 species seen, only 11 species had percentage frequencies more than 25 (Table 5)

4. 1. 2. 3. Vested forest

Palaquium ellipticum, Myristica beddomei and *Dimocarpus longan* recorded the highest frequency of vested forest with a value of 22.00 for each (Table 6).

Table 4. Frequency (F), Percentage Frequency (PF) and Relative Frequency (RF) of species (>10 cm GBH) in Ecologically Fragile Land.

Sl no:	Species	Frequency	Percentage frequency	Relative frequency (%)
1.	*Melicope lunu-ankenda*	25.00	100.00	12.25
2.	*Diospyros nilagirica*	14.00	56.00	6.86
3.	*Clerodendrum infortunatum*	14.00	56.00	6.86
4.	*Litsea wightiana*	13.00	52.00	6.37
5.	*Litsea oleoides*	12.00	48.00	5.88
6.	*Persea macrantha*	11.00	44.00	5.39
7.	*Dillenia bracteata*	10.00	40.00	4.90
8.	*Myristica beddomei*	9.00	36.00	4.41
9.	*Drypetes wightii*	9.00	36.00	4.41
10.	*Syzygium densiflorum*	8.00	32.00	3.92
11.	*Syzygium cumini*	8.00	32.00	3.92
12.	*Macaranga peltata*	6.00	24.00	2.94
13.	*Chukrasia tabularis*	6.00	24.00	2.94
14.	*Artocarpus heterophyllus*	5.00	20.00	2.45
15.	*Knema attenuata*	5.00	20.00	2.45
16.	*Calophyllum polyanthum*	5.00	20.00	2.45
17.	*Eurya nitida*	4.00	16.00	1.96
18.	*Alseodaphne semecarpifolia*	4.00	16.00	1.96
19.	*Chionanthus ramiflorus*	4.00	16.00	1.96
20.	*Coffea liberica*	3.00	12.00	1.47
21.	*Psydrax umbellata*	3.00	12.00	1.47
22.	*Dimocarpus longan*	2.00	8.00	0.98
23.	*Ficus microcarpa*	2.00	8.00	0.98
24.	*Gomphandra tetrandra*	2.00	8.00	0.98

Contd.....

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Sl no:	Species	Frequency	Percentage frequency	Relative frequency (%)
25	*Bischofia javanica*	2.00	8.00	0.98
26	*Palaquium ellipticum*	2.00	8.00	0.98
27	*Syzygium laetum*	2.00	8.00	0.98
28	*Cinnamomum wightii*	2.00	8.00	0.98
29	*Gordonia obtusa*	1.00	4.00	0.49
30	*Neolitsea cassia*	1.00	4.00	0.49
31	*Paracroton pendulus*	1.00	4.00	0.49
32	*Syzygium lanceolatum*	1.00	4.00	0.49
33	*Canarium strictum*	1.00	4.00	0.49
34	*Cullenia exarillata*	1.00	4.00	0.49
35	*Ficus racemosa*	1.00	4.00	0.49
36	*Glochidion ellipticum*	1.00	4.00	0.49
37	*Mesua ferrea*	1.00	4.00	0.49
38	*Nothapodytes nimmoniana*	1.00	4.00	0.49
39	*Syzygium grande*	1.00	4.00	0.49
40	*Vernonia arborea*	1.00	4.00	0.49
	Total	204.00	816.00	100.00

Table 5. Frequency (F), Percentage Frequency (PF) and Relative Frequency (RF) of species (>10 cm GBH) in Section 5 land.

SI no:	Species	Frequency	Percentage frequency	Relative frequency (%)
1.	*Litsea wightiana*	19.00	76.00	10.98
2.	*Diospyros nilagirica*	14.00	56.00	8.09
3.	*Dillenia bracteata*	14.00	56.00	8.09
4.	*Myristica beddomei*	12.00	48.00	6.94
5.	*Melicope lunu-ankenda*	11.00	44.00	6.36
6.	*Persea macrantha*	11.00	44.00	6.36
7.	*Chionanthus ramiflorus*	11.00	44.00	6.36
8.	*Artocarpus heterophyllus*	10.00	40.00	5.78
9.	*Dimocarpus longan*	9.00	36.00	5.20
10.	*Syzygium cumini*	9.00	36.00	5.20
11.	*Chukrasia tabularis*	8.00	32.00	4.62
12.	*Drypetes wightii*	6.00	24.00	3.47
13.	*Syzygium laetum*	6.00	24.00	3.47
14.	*Trema orientalis*	5.00	20.00	2.89
15.	*Bischofia javanica*	4.00	16.00	2.31
16.	*Calophyllum polyanthum*	4.00	16.00	2.31
17.	*Coffea liberica*	4.00	16.00	2.31
18.	*Erythrina subumbrans*	3.00	12.00	1.73
19.	*Litsea oleoides*	3.00	12.00	1.73
20.	*Cinnamomum wightii*	3.00	12.00	1.73
21.	*Glochidion ellipticum*	2.00	8.00	1.16
22.	*Actinodaphne malabarica*	1.00	4.00	0.58
23.	*Cullenia exarillata*	1.00	4.00	0.58
24.	*Ficus microcarpa*	1.00	4.00	0.58
25.	*Garcinia gummigutta*	1.00	4.00	0.58
26.	*Vernonia arborea*	1.00	4.00	0.58
	Total	173.00	692.00	100.00

Table 6. Frequency (F), Percentage Frequency (PF) and Relative Frequency (RF) of species (>10 cm GBH) in Vested forest.

Sl no:	Species	Frequency	Percentage frequency	Relative frequency
1.	*Palaquium ellipticum*	22.00	88.00	8.24
2.	*Myristica beddomei*	22.00	88.00	8.24
3.	*Dimocarpus longan*	22.00	88.00	8.24
4.	*Litsea oleoides*	19.00	76.00	7.12
5.	*Cullenia exarillata*	14.00	56.00	5.24
6.	*Mesua ferrea*	12.00	48.00	4.49
7.	*Leea indica*	11.00	44.00	4.12
8.	*Dillenia bracteata*	11.00	44.00	4.12
9.	*Cinnamomum wightii*	11.00	44.00	4.12
10.	*Polyalthia coffeoides*	10.00	40.00	3.75
11.	*Syzygium laetum*	10.00	40.00	3.75
12.	*Artocarpus heterophyllus*	9.00	36.00	3.37
13.	*Paracroton pendulus*	9.00	36.00	3.37
14.	*Drypetes wightii*	8.00	32.00	3.00
15.	*Mastixia arborea*	8.00	32.00	3.00
16.	*Clerodendrum infortunatum*	8.00	32.00	3.00
17.	*Antidesma montanum*	7.00	28.00	2.62
18.	*Syzygium cumini*	7.00	28.00	2.62
19.	*Elaeocarpus munronii*	6.00	24.00	2.25
20.	*Macaranga peltata*	6.00	24.00	2.25
21.	*Chionanthus ramiflorus*	5.00	20.00	1.87
22.	*Hydnocarpus alpina*	5.00	20.00	1.87
23.	*Neolitsea cassia*	5.00	20.00	1.87
24.	*Actinodaphne malabarica*	4.00	16.00	1.50
25.	*Bischofia javanica*	4.00	16.00	1.50
26.	*Calophyllum polyanthum*	3.00	12.00	1.12
27.	*Elaeocarpus serratus*	2.00	8.00	0.75
28.	*Glochidion ellipticum*	2.00	8.00	0.75
29.	*Sterculia guttata*	2.00	8.00	0.75
30.	*Canarium strictum*	1.00	4.00	0.37
31.	*Eurya nitida*	1.00	4.00	0.37
32.	*Malottus philippensis*	1.00	4.00	0.37
	Total	267.00	1068.00	100.00

Percentage frequencies and relative frequencies of these species were 88% and 8.24 % respectively. Out of 32 species, 18 had percentage frequencies of more than 25 per cent.

4. 1. 3. Basal area and relative basal area

The basal area and relative basal area for all species (> 10 cm GBH) are given in Tables 7- 9.

4. 1. 3. 1. Ecologically Fragile Land

The total basal area of the ecologically fragile land comes to 37.47 m^2 of which 22.61% and 9.15% were accounted by two species *viz*., *Melicope lunu-ankenda* and *Diospyros nilagirica* (Table7). Among these, except *Myristica beddomei*, *Syzygium densiflorum*, *Syzygium cumini* and *Persea macrantha* all others had relative basal area less than 5 per cent.

4. 1. 3. 2. Section 5 land

Compared to Ecologically fragile land, there was a decrease in total basal area of section 5 land. Table 8 shows that *Litsea wightiana* accounted for 21.61 per cent of the total basal area of 33.60 m^2. Out of the 26 species, 7 species had relative basal area of more than 5 per cent.

4. 1. 3. 3. Vested forest

Among three land use systems, vested forest had the maximum stocking and the total basal area was found to be 44.56 m^2. The major share in this figure is contributed by *Palaquium ellipticum* and *Myristica beddomei* had a basal area of 11.00 m^2 and 9.00 m^2. Relative basal area of these two species was found to be 24.91% and 20.20 % respectively. Among 32 species enumerated from the area, only four species had relative basal area of more than 5 per cent (Table 9).

Table 7. Basal Area (BA) and Relative Basal Area (RBA) of species (>10 cm GBH) in Ecologically Fragile Land

Sl no:	Species	Basal area (m^2)	Relative basal area (%)
1.	*Melicope lunu-ankenda*	8.47	22.61
2.	*Diospyros nilagirica*	3.43	9.15
3.	*Myristica beddomei*	3.17	8.46
4.	*Syzygium cumini*	2.43	6.48
5.	*Syzygium densiflorum*	2.43	6.47
6.	*Persea macrantha*	2.00	5.35
7.	*Ficus microcarpa*	1.64	4.39
8.	*Dillenia bracteata*	1.37	3.66
9.	*Drypetes wightii*	1.37	3.65
10.	*Knema attenuata*	1.20	3.19
11.	*Litsea wightiana*	1.12	2.98
12.	*Artocarpus heterophyllus*	1.06	2.83
13.	*Ficus racemosa*	0.82	2.18
14.	*Litsea oleoides*	0.81	2.17
15.	*Eurya nitida*	0.73	1.96
16.	*Calophyllum polyanthum*	0.73	1.95
17.	*Palaquium ellipticum*	0.63	1.68
18.	*Chukrasia tabularis*	0.62	1.65
19.	*Macaranga peltata*	0.50	1.33
20.	*Glochidion ellipticum*	0.46	1.22
21.	*Coffea liberica*	0.39	1.03
22.	*Dimocarpus longan*	0.30	0.79
23.	*Psydrax umbellata*	0.26	0.69
24.	*Alseodaphne semecarpifolia*	0.26	0.68
25.	*Mesua ferrea*	0.23	0.61

Contd....

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Sl no:	Species	Basal area (m^2)	Relative basal area (%)
26	*Gordonia obtusa*	0.20	0.54
27	*Syzygium lanceolatum*	0.20	0.52
28	*Gomphandra tetrandra*	0.12	0.33
29	*Chionanthus ramiflorus*	0.12	0.32
30	*Syzygium laetum*	0.10	0.27
31	*Bischofia javanica*	0.10	0.27
32	*Clerodendrum infortunatum*	0.07	0.20
33	*Cinnamomum wightii*	0.07	0.18
34	*Nothapodytes nimmoniana*	0.03	0.07
35	*Vernonia arborea*	0.02	0.05
36	*Paracroton pendulus*	0.01	0.03
37	*Canarium strictum*	0.01	0.02
38	*Neolitsea cassia*	0.01	0.02
39	*Cullenia exarillata*	0.00	0.01
40	*Syzygium grande*	0.00	0.01
	Total	37.47	100.00

Table 8. Basal Area (BA) and Relative Basal Area (RBA) of species (>10 cm GBH) in Section 5 land

Sl no:	Species	Basal area(m^2)	Relative basal area (%)
1.	*Litsea wightiana*	7.26	21.61
2.	*Diospyros nilagirica*	3.33	9.91
3.	*Dillenia bracteata*	3.04	9.05
4.	*Dimocarpus longan*	2.81	8.36
5.	*Myristica beddomei*	2.52	7.50
6.	*Persea macrantha*	2.37	7.05
7.	*Chukrasia tabularis*	1.76	5.24
8.	*Artocarpus heterophyllus*	1.50	4.46
9.	*Melicope lunu-ankenda*	1.48	4.40
10.	*Chionanthus ramiflorus*	1.34	3.99
11.	*Trema orientalis*	0.77	2.31
12.	*Calophyllum polyanthum*	0.77	2.30
13.	*Syzygium cumini*	0.77	2.29
14.	*Syzygium laetum*	0.54	1.59
15.	*Bischofia javanica*	0.44	1.31
16.	*Drypetes wightii*	0.43	1.29
17.	*Ficus microcarpa*	0.39	1.15
18.	*Erythrina subumbrans*	0.38	1.13
19.	*Cullenia exarillata*	0.35	1.04
20.	*Cinnamomum wightii*	0.32	0.97
21.	*Litsea oleoides*	0.31	0.92
22.	*Vernonia arborea*	0.29	0.86
23.	*Glochidion ellipticum*	0.24	0.73
24.	*Actinodaphne malabarica*	0.11	0.32
25.	*Garcinia gummigutta*	0.07	0.20
26.	*Coffea liberica*	0.00	0.01
	Total	33.60	100.00

Table 9. Basal Area (BA) and Relative Basal Area (RBA) of species (>10 cm GBH) in Vested forest

Sl no:	Species	Basal area (m^2)	Relative basal area
1.	*Palaquium ellipticum*	11.10	24.91
2.	*Myristica beddomei*	9.00	20.20
3.	*Dimocarpus longan*	3.79	8.50
4.	*Mesua ferrea*	3.78	8.49
5.	*Cullenia exarillata*	1.87	4.21
6.	*Cinnamomum wightii*	1.49	3.33
7.	*Litsea oleoides*	1.27	2.84
8.	*Syzygium laetum*	1.25	2.81
9.	*Artocarpus heterophyllus*	1.22	2.73
10.	*Mastixia arborea*	1.09	2.45
11.	*Elaeocarpus munronii*	1.05	2.37
12.	*Syzygium cumini*	0.96	2.16
13.	*Paracroton pendulus*	0.94	2.11
14.	*Dillenia bracteata*	0.89	2.00
15.	*Polyalthia coffeoides*	0.76	1.70
16.	*Drypetes wightii*	0.57	1.27
17.	*Hydnocarpus alpina*	0.54	1.21
18.	*Neolitsea cassia*	0.51	1.15
19.	*Chionanthus ramiflorus*	0.50	1.11
20.	*Macaranga peltata*	0.31	0.69
21.	*Bischofia javanica*	0.27	0.62
22.	*Actinodaphne malabarica*	0.27	0.61
23.	*Antidesma montanum*	0.24	0.54
24.	*Calophyllum polyanthum*	0.22	0.50
25.	*Elaeocarpus serratus*	0.20	0.45
26.	*Leea indica*	0.14	0.31
27.	*Sterculia guttata*	0.12	0.27
28.	*Glochidion ellipticum*	0.10	0.23
29.	*Clerodendrum infortunatum*	0.08	0.19
30.	*Canarium strictum*	0.02	0.04
31.	*Eurya nitida*	0.00	0.01
32.	*Malottus philippensis*	0.00	0.00
	Total	44.56	100.00

4. 1. 4. Important value Index (IVI) and Relative Importance Value Index (RIVI)

Tables 10-12 shows the IVI and RIVI of species (>10 cm GBH) in three land use systems. IVI class-wise species distributions are given in Tables 13- 15 and Figs.2-4. Accumulations of species in the lower IVI classes had been observed in each area.

4. 1. 4.1. Ecologically Fragile Land

In ecologically fragile land, *Melicope lunu-ankenda* was the dominant species with IVI of 58.47, followed by *Diospyros nilagirica* (21.37). All other species had IVI below 20. Table 13 shows that 72.50 per cent of the species in the enumerated area had IVI value less than 10.

4. 1. 4.2. Section 5 land

Litsea wightiana dominates the vegetation with an IVI of 50.74 followed by *Diospyros nilagirica* (28.00) and *Dillenia bracteata* (26.40) (Table 11). 57.69 per cent species had IVI less than 10 (Table 14).

4. 1. 4.3. Vested forest

Table 12 shows that *Palaquium ellipticum* dominates the vegetation with an IVI of 48.01 followed by *Myristica beddomei* (42.38) and *Dimocarpus longan* (27.55). About 75 per cent of species in the studied area had IVI less than 10 (Table 15).

Table 10. IVI and RIVI of species (>10 cm GBH) in Ecologically Fragile Land.

Sl no:	Species	IVI	RIVI
1.	*Melicope lunu-ankenda*	58.47	19.49
2.	*Diospyros nilagirica*	21.37	7.12
3.	*Litsea wightiana*	18.11	6.04
4.	*Litsea oleoides*	18.03	6.01
5.	*Myristica beddomei*	17.01	5.67
6.	*Persea macrantha*	15.85	5.28
7.	*Dillenia bracteata*	13.18	4.39
8.	*Syzygium densiflorum*	13.07	4.36
9.	*Syzygium cumini*	12.84	4.28
10.	*Clerodendrum infortunatum*	11.92	3.97
11.	*Drypetes wightii*	11.47	3.82
12.	*Knema attenuata*	7.34	2.45
13.	*Artocarpus heterophyllus*	6.99	2.33
14.	*Macaranga peltata*	6.71	2.24
15.	*Eurya nitida*	6.60	2.20
16.	*Ficus microcarpa*	6.34	2.11
17.	*Chukrasia tabularis*	6.29	2.10
18.	*Calophyllum polyanthum*	5.86	1.95
19.	*Alseodaphne semecarpifolia*	3.62	1.21
20.	*Palaquium ellipticum*	3.40	1.13
21.	*Chionanthus ramiflorus*	3.25	1.08
22.	*Coffea liberica*	3.23	1.08
23.	*Dimocarpus longan*	2.99	1.00
24.	*Ficus racemosa*	2.91	0.97
25.	*Psydrax umbellata*	2.89	0.96
26.	*Gomphandra tetrandra*	2.28	0.76
27.	*Syzygium laetum*	1.98	0.66
28.	*Bischofia javanica*	1.98	0.66
29.	*Glochidion ellipticum*	1.96	0.65
30.	*Gordonia obtusa*	1.76	0.59
31.	*Cinnamomum wightii*	1.65	0.55

Contd .....

Contd....

Sl no:	Species	IVI	RIVI
32	*Syzygium lanceolatum*	1.50	0.50
33	*Mesua ferrea*	1.35	0.45
34	*Paracroton pendulus*	1.01	0.34
35	*Neolitsea cassia*	1.00	0.33
36	*Nothapodytes nimmoniana*	0.81	0.27
37	*Vernonia arborea*	0.79	0.26
38	*Canarium strictum*	0.75	0.25
39	*Cullenia exarillata*	0.74	0.25
40	*Syzygium grande*	0.74	0.25
	Total	300.00	100.00

Table 11. IVI and RIVI of species (>10 cm GBH) in Section 5 land

Sl no:	Species	IVI	RIVI
1.	*Litsea wightiana*	50.74	16.91
2.	*Diospyros nilagirica*	28.00	9.33
3.	*Dillenia bracteata*	26.40	8.80
4.	*Myristica beddomei*	22.58	7.53
5.	*Persea macrantha*	19.33	6.44
6.	*Dimocarpus longan*	18.75	6.25
7.	*Melicope lunu-ankenda*	17.80	5.93
8.	*Chionanthus ramiflorus*	15.43	5.14
9.	*Artocarpus heterophyllus*	15.05	5.02
10.	*Chukrasia tabularis*	14.79	4.93
11.	*Syzygium cumini*	10.83	3.61
12.	*Trema orientalis*	7.28	2.43
13.	*Syzygium laetum*	7.05	2.35
14.	*Drypetes wightii*	6.98	2.33
15.	*Calophyllum polyanthum*	6.09	2.03
16.	*Bischofia javanica*	5.84	1.95
17.	*Erythrina subumbrans*	4.35	1.45
18.	*Cinnamomum wightii*	4.14	1.38
19.	*Litsea oleoides*	3.82	1.27
20.	*Coffea liberica*	3.80	1.27
21.	*Glochidion ellipticum*	2.63	0.88
22.	*Ficus microcarpa*	2.10	0.70
23.	*Cullenia exarillata*	1.99	0.66
24.	*Vernonia arborea*	1.81	0.60
25.	*Actinodaphne malabarica*	1.27	0.42
26.	*Garcinia gummigutta*	1.15	0.38
	Total	299.99	100.00

Table 12. IVI and RIVI of species (>10 cm GBH) in Vested forest

Sl no:	Species	IVI	RIVI
1.	*Palaquium ellipticum*	48.01	16.00
2.	*Myristica beddomei*	42.38	14.13
3.	*Dimocarpus longan*	27.55	9.18
4.	*Mesua ferrea*	17.76	5.92
5.	*Litsea oleoides*	14.91	4.97
6.	*Cullenia exarillata*	13.85	4.62
7.	*Cinnamomum wightii*	10.76	3.59
8.	*Dillenia bracteata*	10.59	3.53
9.	*Leea indica*	9.75	3.25
10.	*Syzygium laetum*	8.74	2.91
11.	*Artocarpus heterophyllus*	8.41	2.80
12.	*Mastixia arborea*	8.31	2.77
13.	*Polyalthia coffeoides*	8.10	2.70
14.	*Paracroton pendulus*	7.74	2.58
15.	*Drypetes wightii*	7.65	2.55
16.	*Syzygium cumini*	7.43	2.48
17.	*Elaeocarpus munronii*	5.51	1.84
18.	*Antidesma montanum*	5.34	1.78
19.	*Clerodendrum infortunatum*	5.10	1.70
20.	*Chionanthus ramiflorus*	4.69	1.56
21.	*Hydnocarpus alpina*	4.43	1.48
22.	*Neolitsea cassia*	4.31	1.44
23.	*Macaranga peltata*	3.96	1.32
24.	*Actinodaphne malabarica*	3.14	1.05
25.	*Bischofia javanica*	2.85	0.95
26.	*Calophyllum polyanthum*	2.55	0.85
27.	*Elaeocarpus serratus*	1.56	0.52
28.	*Sterculia guttata*	1.39	0.46
29.	*Glochidion ellipticum*	1.35	0.45
30.	*Canarium strictum*	0.74	0.25
31.	*Eurya nitida*	0.57	0.19
32.	*Malottus philippensis*	0.56	0.19
	Total	300.00	100.00

Table 13. Number of species in each IVI class in Ecologically Fragile Land.

IVI class	No: of species	Percentage
0-10	29	72.50
10-20	9	22.50
20-30	1	2.50
30-40	0	0.00
40-50	0	0.00
50-60	1	2.50
>60	0	0.00

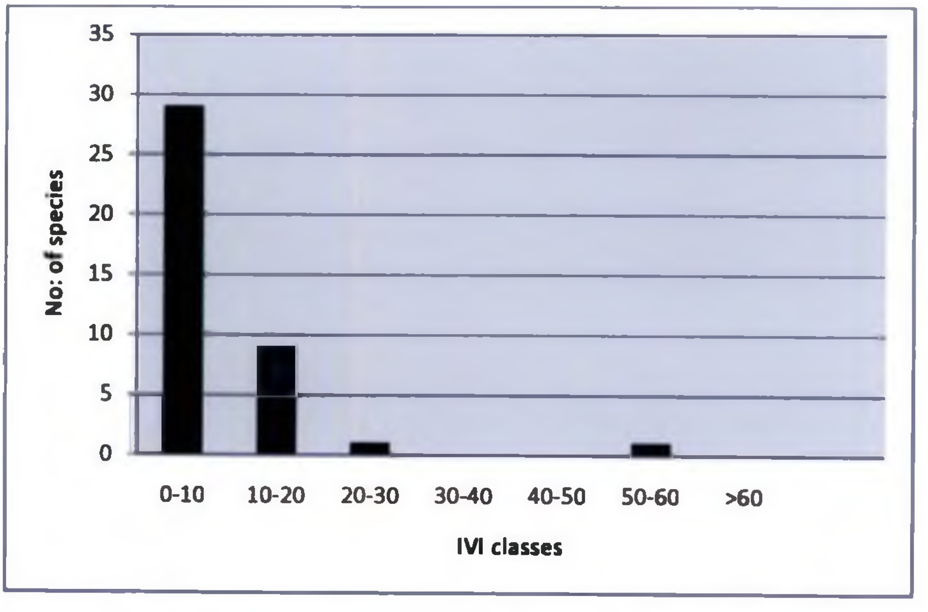

Fig.2. Number of species in each IVI class in Ecologically Fragile Land

Table 14. Number of species in each IVI class in Section 5 land.

IVI class	No: of species	Percentage
0-10	15	57.69
10-20	7	23.08
20-30	3	11.54
30-40	0	0.00
40-50	0	0.00
50-60	1	3.85
>60	0	0.00

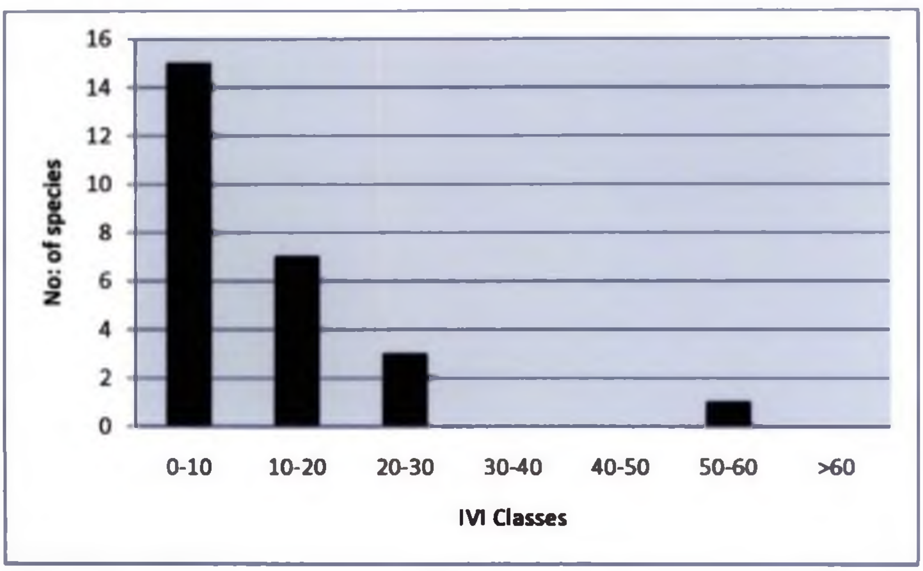

Fig.3. Number of species in each IVI class in Section 5 land

Table 15. Number of species in each IVI class in Vested forest.

IVI class	No: of species	Percentage
0-10	24	75.00
10-20	5	15.63
20-30	1	3.13
30-40	0	0.00
40-50	2	6.25
50-60	0	0.00
>60	0	0.00

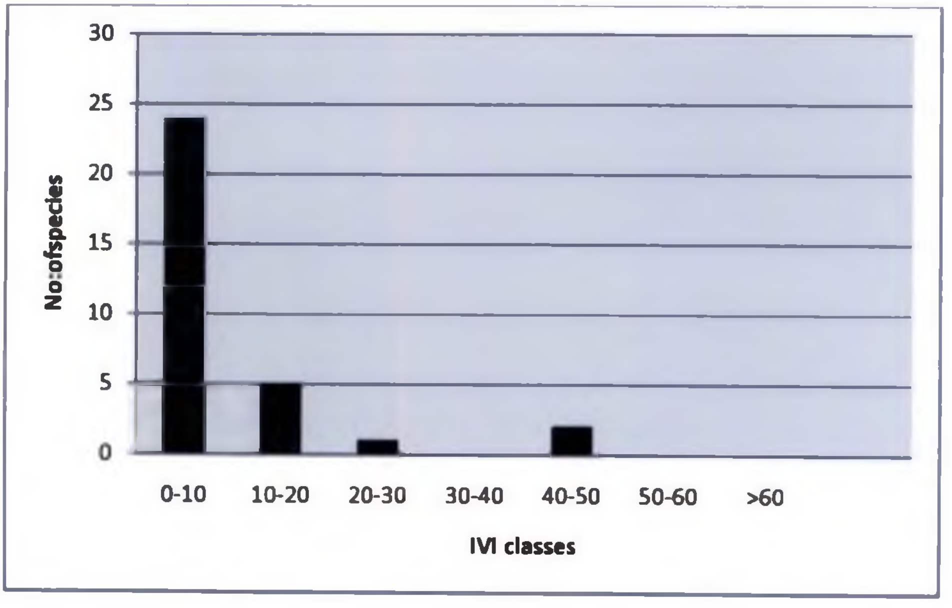

Fig.4. Number of species in each IVI class in Vested forest

4.2. Dominant natural orders

4.2.1. Family-wise frequency, density, relative density, abundance, percentage frequency and relative frequency

Tables 16-18 depict the family-wise frequency, density, relative density, abundance, percentage frequency and relative frequency in three land use systems.

4. 2. 1.1. Ecologically Fragile Land

Meliaceae recorded the highest frequency (25) followed by Lauraceae (21) and Myrtaceae (16). Similarly highest relative frequency of families was also observed in Meliaceae (15.53%) followed by Lauraceae (13.04%) and Myrtaceae (9.94%). Among the density Lauraceae stands first with 106 individuals followed by Meliaceae having 104 individuals. Relative densities of these two families are 25.79 and 25.30 per cent respectively (Table 16).

4. 2. 1.2. Section 5 land

From the Table 17, it was observed that of the total 16 families, Lauraceae recorded the highest frequency (22), density (73), relative density (27.04) and relative frequency (14.47) followed by Meliaceae with frequency (16), density (33), relative density(12.22) and relative frequency(10.53)

4. 2. 1.3. Vested forest

Lauraceae had the highest frequency (23) followed by Myristicaceae, Sapindaceae and Sapotaceae each with frequency of 22. Sapotaceae had highest density with 81 individuals followed by Myristicaceae (76) and Sapindaceae (59). Highest relative frequency of families was observed in Lauraceae (9.83%) and relative density for Sapotaceae (14.86%). The more details of these parameters are provided in Table 18.

Table 16. Family-wise Frequency (F), Density (D) and Relative Density (RD), Abundance (A), Percentage Frequency (PF) and Relative Frequency of Ecologically Fragile Land.

Sl no:	Family	Frequency	Density	Relative Density (%)	Abundance	Percentage frequency (%)	Relative frequency (%)
1.	Meliaceae	25.00	104.00	25.30	4.16	100.00	15.53
2.	Lauraceae	21.00	106.00	25.79	5.05	84.00	13.04
3.	Myrtaceae	16.00	27.00	6.57	1.69	64.00	9.94
4.	Ebenaceae	14.00	22.00	5.35	1.57	56.00	8.70
5.	Myristicaceae	10.00	24.00	5.84	2.40	40.00	6.21
6.	Euphorbiaceae	14.00	30.00	7.30	2.14	56.00	8.70
7.	Dilleniaceae	10.00	19.00	4.62	1.90	40.00	6.21
8.	Verbenaceae	14.00	20.00	4.87	1.43	56.00	8.70
9.	Moraceae	7.00	12.00	2.92	1.71	28.00	4.35
10.	Clusiaceae	6.00	7.00	1.70	1.17	24.00	3.73
11.	Theaceae	5.00	14.00	3.41	2.80	20.00	3.11
12.	Rubiaceae	5.00	6.00	1.46	1.20	20.00	3.11
13.	Oleaceae	4.00	4.00	0.97	1.00	16.00	2.48
14.	Icacinaceae	3.00	5.00	1.22	1.67	12.00	1.86
15.	Sapindaceae	2.00	5.00	1.22	2.50	8.00	1.24
16.	Sapotaceae	2.00	3.00	0.73	1.50	8.00	1.24
17.	Asteraceae	1.00	1.00	0.24	1.00	4.00	0.62
18.	Burseraceae	1.00	1.00	0.24	1.00	4.00	0.62
19.	Bombacaceae	1.00	1.00	0.24	1.00	4.00	0.62
	Total	161.00	411.00	100.00	36.89	644.00	100.00

Table 17. Family-wise Frequency (F), Density (D) and Relative Density (RD), Abundance (A), Percentage Frequency (PF) and Relative Frequency of Section 5 land.

Sl no:	Family	Frequency	Density	Relative density (%)	Abundance	Percentage frequency (%)	Relative frequency (%)
1.	Lauraceae	22.00	73.00	27.04	3.32	88.00	14.47
2.	Moraceae	11.00	15.00	5.56	1.36	44.00	7.24
3.	Myrtaceae	14.00	15.00	5.56	1.07	56.00	9.21
4.	Dilleniaceae	14.00	25.00	9.26	1.79	56.00	9.21
5.	Meliaceae	16.00	33.00	12.22	2.06	64.00	10.53
6.	Ebenaceae	14.00	27.00	10.00	1.93	56.00	9.21
7.	Myristicaceae	12.00	22.00	8.15	1.83	48.00	7.89
8.	Oleaceae	11.00	12.00	4.44	1.09	44.00	7.24
9.	Fabaceae	3.00	4.00	1.48	1.33	12.00	1.97
10.	Sapindaceae	9.00	14.00	5.19	1.56	36.00	5.92
11.	Euphorbiaceae	10.00	14.00	5.19	1.40	40.00	6.58
12.	Clusiaceae	5.00	5.00	1.85	1.00	20.00	3.29
13.	Rubiaceae	4.00	4.00	1.48	1.00	16.00	2.63
14.	Bombacaceae	1.00	1.00	0.37	1.00	4.00	0.66
15.	Ulmaceae	5.00	5.00	1.85	1.00	20.00	3.29
16.	Asteraceae	1.00	1.00	0.37	1.00	4.00	0.66
	Total	152.00	270.00	100.00	23.74	608.00	100.00

Table 18. Family-wise Frequency (F), Density (D) and Relative Density (RD), Abundance (A), Percentage frequency (PF) and Relative Frequency of Vested forest.

Sl no:	Family	Frequency	Density	Relative Density (%)	Abundance	Percentage frequency (%)	Relative frequency (%)
1.	Sapotaceae	22.00	81.00	14.86	3.68	88.00	9.40
2.	Myristicaceae	22.00	76.00	13.94	3.45	88.00	9.40
3.	Lauraceae	23.00	58.00	10.64	2.52	92.00	9.83
4.	Sapindaceae	22.00	59.00	10.83	2.68	88.00	9.40
5.	Clusiaceae	15.00	30.00	5.50	2.00	60.00	6.41
6.	Bombacaeae	14.00	24.00	4.40	1.71	56.00	5.98
7.	Myrtaceae	16.00	25.00	4.59	1.56	64.00	6.84
8.	Euphorbiaceae	21.00	58.00	10.64	2.76	84.00	8.97
9.	Moraceae	9.00	14.00	2.57	1.56	36.00	3.85
10.	Cornaceae	8.00	12.00	2.20	1.50	32.00	3.42
11.	Elaeocarpaceae	8.00	8.00	1.47	1.00	32.00	3.42
12.	Dilleniaceae	11.00	26.00	4.77	2.36	44.00	4.70
13.	Annonaceae	10.00	14.00	2.57	1.40	40.00	4.27
14.	Flacourtiaceae	5.00	7.00	1.28	1.40	20.00	2.14
15.	Oleaceae	5.00	11.00	2.02	2.20	20.00	2.14
16.	Leeaceae	11.00	29.00	5.32	2.64	44.00	4.70
17.	Sterculiaceae	2.00	2.00	0.37	1.00	8.00	0.85
18.	Verbenaceae	8.00	9.00	1.65	1.13	32.00	3.42
19.	Burseraceae	1.00	1.00	0.18	1.00	4.00	0.43
20.	Theaceae	1.00	1.00	0.18	1.00	4.00	0.43
	Total	234.00	545.00	100.00	38.56	936.00	100.00

4. 2.2 Family-wise basal area, relative basal area, Important Value Index (IVI) and relative Importance value Index (RIVI)

Details of these parameters are furnished in Tables 19-21.

4. 2. 2. 1. Ecologically Fragile Land

Meliaceae had higher values for all these parameters. Of the total basal area of 37.47 m^2, Meliaceae accounts for 9.09 m^2 followed by Myrtaceae (5.15 m^2) and Myristicaceae (4.37 m^2). Among the IVI values, Meliaceae recorded an IVI of 65.09 followed by Lauraceae (50.20) and Myrtaceae (30.25). The details are given in Table 19.

4. 2. 2. 2. Section 5 land

Lauraceae and Ebenaceae accounted for 30.91 and 9.91 per cent of the total basal areas of the section 5 land. The IVI for these families were 72.42 and 29.12 respectively (Table 20)

4. 2. 2. 3. Vested forest

Sapotaceae and Myristicaceae are the dominant families of the vegetation in this area and having a basal area of 11.10 m^2 and 9.02 m^2 respectively. Their corresponding values for IVI were 49.17 and 43.59 respectively (Table 21)

4.3 Diameter – frequency distribution

The diameter-frequency distribution of the vegetation of three land use systems is depicted in Tables 22- 24 and Fig. 5-7.

Table 19. Family-wise Basal Area (BA), Relative Basal Area (RBA), Importance Value Index (IVI) and Relative Importance Value Index (RIVI) of Ecologically Fragile Land.

Sl no:	Family	BA(m^2)	RBA (%)	IVI	RIVI
1.	Meliaceae	9.09	24.26	65.09	21.70
2.	Lauraceae	4.26	11.37	50.20	16.73
3.	Myrtaceae	5.15	13.74	30.25	10.08
4.	Ebenaceae	3.43	9.15	23.20	7.73
5.	Myristicaceae	4.37	11.66	23.71	7.90
6.	Euphorbiaceae	2.44	6.51	22.51	7.50
7.	Dilleniaceae	1.37	3.66	14.49	4.83
8.	Verbenaceae	0.07	0.19	13.75	4.58
9.	Moraceae	3.52	9.39	16.66	5.55
10.	Clusiaceae	0.96	2.56	7.99	2.66
11.	Theaceae	0.93	2.48	8.99	3.00
12.	Rubiaceae	0.65	1.73	6.30	2.10
13.	Oleaceae	0.12	0.32	3.78	1.26
14.	Icacinaceae	0.15	0.40	3.48	1.16
15.	Sapindaceae	0.30	0.80	3.26	1.09
16.	Sapotaceae	0.63	1.68	3.65	1.22
17.	Asteraceae	0.02	0.05	0.92	0.31
18.	Burseraceae	0.01	0.03	0.89	0.30
19.	Bombacaceae	0.00	0.00	0.86	0.29
	Total	37.47	100.00	300.00	100.00

Table 20. Family-wise Basal Area (BA), Relative Basal Area (RBA), Importance Value Index (IVI) and Relative Importance Value Index (RIVI) of section 5 land.

Sl no:	Family	BA(m^2)	RBA	IVI	RIVI
1.	Lauraceae	10.39	30.91	72.42	24.14
2.	Moraceae	1.89	5.62	18.42	6.14
3.	Myrtaceae	1.31	3.90	18.66	6.22
4.	Dilleniaceae	3.04	9.04	27.51	9.17
5.	Meliaceae	3.24	9.64	32.39	10.80
6.	Ebenaceae	3.33	9.91	29.12	9.71
7.	Myristicaceae	2.52	7.50	23.54	7.85
8.	Oleaceae	1.34	3.99	15.67	5.22
9.	Fabaceae	0.38	1.13	4.59	1.53
10.	Sapindaceae	2.81	8.36	19.47	6.49
11.	Euphorbiaceae	1.11	3.30	15.07	5.02
12.	Clusiaceae	0.84	2.50	7.64	2.55
13.	Rubiaceae	0.00	0.00	4.11	1.37
14.	Bombacaceae	0.35	1.04	2.07	0.69
15.	Ulmaceae	0.77	2.29	7.43	2.48
16.	Asteraceae	0.29	0.86	1.89	0.63
	Total	33.60	100.00	300.00	100.00

Table 21. Family-wise Basal Area (BA), Relative Basal Area (RBA), Importance Value Index (IVI) and Relative Importance Value Index (RIVI) of Vested forest.

Sl no:	Family	BA(m^2)	RBA (%)	IVI	RIVI
1.	Sapotaceae	11.10	24.91	49.17	16.39
2.	Myristicaceae	9.02	20.24	43.59	14.53
3.	Lauraceae	3.57	8.01	28.48	9.49
4.	Sapindaceae	3.78	8.48	28.71	9.57
5.	Clusiaceae	4.10	9.20	21.12	7.04
6.	Bombacaeae	1.87	4.20	14.58	4.86
7.	Myrtaceae	2.27	5.09	16.52	5.51
8.	Euphorbiaceae	2.74	6.15	25.77	8.59
9.	Moraceae	1.25	2.81	9.22	3.07
10.	Cornaceae	1.09	2.45	8.07	2.69
11.	Elaeocarpaceae	1.09	2.45	7.33	2.44
12.	Dilleniaceae	0.76	1.71	11.18	3.73
13.	Annonaceae	0.50	1.12	7.96	2.65
14.	Flacourtiaceae	0.51	1.14	4.57	1.52
15.	Oleaceae	0.54	1.21	5.37	1.79
16.	Leeaceae	0.14	0.31	10.34	3.45
17.	Sterculiaceae	0.12	0.27	1.49	0.50
18.	Verbenaceae	0.02	0.04	5.12	1.71
19.	Burseraceae	0.08	0.18	0.79	0.26
20.	Theaceae	0.01	0.02	0.63	0.21
	Total	44.56	100.00	300.00	100.00

4. 3. 1. Ecologically Fragile Land

The diameter-frequency distribution (Table 22) showed that maximum individuals were seen in the lower diameter classes (ie. 0-10, 10-20, 20-30 and 30-40 cm). The diameter classes of EFL area showed a reverse J shaped pattern (Fig.5).

4. 3. 2. Section 5 land

Diameter- frequency distribution of individuals (Table 23 and Fig. 6) showed that the three diameter classes (20-30, 30-40, 40-50cm) had maximum contribution in the composition of vegetation. The reverse J shaped curve was visible from 30-40 cm diameter classes onwards.

4. 3. 3. Vested forest

Accumulation of individuals was maximum in the lower diameter classes (Table 24). Except for the 0-10 and 10-20 cm class, the remaining diameter classes showed a reverse J shaped pattern (Fig. 7).

4.4. Height- frequency distribution

Tables 25-27 and Figs.8-10 depict the height-frequency distribution in the vegetation of three land use systems.

4. 4. 1. Ecologically Fragile Land

The height- frequency had a peak at 5-10 m height class (Fig. 8). However other classes were also well represented (Table 25)

4. 4. 2. Section 5 land

Fig. 9 and Table 26 showed that majority of the individuals of this stand were in the middle height classes (that is at 5-10 and 10-15 m classes)

Table 22.Diameter-frequency distribution of species (>10 cm GBH) in Ecologically Fragile Land

Sl no	Species	Diameter class (cm)											Total
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	
1	*Alseodaphne semecarpifolia*	3					1						4
2	*Artocarpus heterophyllus*				4	1	2						7
3	*Bischofia javanica*	1	1		1								3
4	*Calophyllum polyanthum*		1	1	1	2	1						6
5	*Canarium strictum*	1											1
6	*Chionanthus ramiflorus*	1	1	2									4
7	*Chukrasia tabularis*	1		3	1	1	1						7
8	*Cinnamomum wightii*	1		1									2
9	*Clerodendrum infortunatum*	19	1										20
10	*Coffea liberica*	1	1					1					3
11	*Cullenia exarillata*	1											1
12	*Dillenia bracteata*	6	5	1	2	4		1					19
13	*Dimocarpus longan*		4			1							5
14	*Diospyros nilagirica*			4	7	5	3	2	1				22
15	*Drypetes wightii*		4	4	3	2		1					14
16	*Eurya nitida*	3	1	5	2								11
17	*Ficus microcarpa*					1	1	1				1	4
18	*Ficus racemosa*											1	1
19	*Glochidion ellipticum*								1				1
20	*Gomphandra tetrandra*	2		2									4

Contd.....

Table 23. Diameter-frequency distribution of species (>10 cm GBH) in Section 5 land.

Sl no	Species	Diameter class (cm)											Total
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	
1	*Actinodaphne malabarica*			1									1
2	*Artocarpus heterophyllus*	1	2	4	3	1	2	1					14
3	*Bischofia javanica*		1	2	2	1							6
4	*Calophyllum polyanthum*			1	1	1				1			4
5	*Chionanthus ramiflorus*			3	6	2		1					12
6	*Chukrasia tabularis*		1	2	5	3	2	1					14
7	*Cinnamomum wightii*				1	2							3
8	*Coffea liberica*	4											4
9	*Cullenia exarillata*							1					1
10	*Dillenia bracteata*			7	5	3	8	2					25
11	*Dimocarpus longan*			2	4	3	2		3				14
12	*Diospyros nilagirica*		1	12	5	4	2	3					27
13	*Drypetes wightii*			4	2								6
14	*Erythrina subumbrans*		1		2	1							4
15	*Ficus microcarpa*							1					1
16	*Garcinia gummigutta*			1									1
17	*Glochidion ellipticum*				1	1							2
18	*Litsea oleoides*	1			1	2							4
19	*Litsea wightiana*			15	14	7	8	4			1		49

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	Species	Diameter class (cm)											Total
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	
21	*Gordonia obtusa*	1			2								3
22	*Knema attenuata*		2		1	1	2	1					7
23	*Litsea oleoides*	27	6	4	3	1							41
24	*Litsea wightiana*	19	8	4	3	1	1						36
25	*Macaranga peltata*	1	1	6	2								10
26	*Melicope lunu-ankenda*	22	28	16	7	11	6	3	3		1		97
27	*Mesua ferrea*						1						1
28	*Myristica beddomei*			3	4	4	3	1	1	1			17
29	*Neolitsea cassia*	2											2
30	*Nothapodytes nimmoniana*		1										1
31	*Palaquium ellipticum*				1		1	1					3
32	*Paracroton pendulus*	2											2
33	*Persea macrantha*	7	1	1	5	3	3	1					21
34	*Psydrax umbellata*	1			1	1							3
35	*Syzygium cumini*				4	2	1	1		2			10
36	*Syzygium densiflorum*				4	2	2	2	1				11
37	*Syzygium grande*	1											1
38	*Syzygium laetum*	1		2									3
39	*Syzygium lanceolatum*	1				1							2
40	*Vernonia arborea*		1										1
	Total	125	67	59	58	44	29	16	7	3	1	2	411

Table 23. Diameter-frequency distribution of species (>10 cm GBH) in Section 5 land.

Sl no	Species	Diameter class (cm)											Total
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	
1	*Actinodaphne malabarica*			1									1
2	*Artocarpus heterophyllus*	1	2	4	3	1	2	1					14
3	*Bischofia javanica*		1	2	2	1							6
4	*Calophyllum polyanthum*			1	1	1				1			4
5	*Chionanthus ramiflorus*			3	6	2		1					12
6	*Chukrasia tabularis*		1	2	5	3	2	1					14
7	*Cinnamomum wightii*				1	2							3
8	*Coffea liberica*	4											4
9	*Cullenia exarillata*							1					1
10	*Dillenia bracteata*			7	5	3	8	2					25
11	*Dimocarpus longan*			2	4	3	2		3				14
12	*Diospyros nilagirica*		1	12	5	4	2	3					27
13	*Drypetes wightii*			4	2								6
14	*Erythrina subumbrans*		1		2	1							4
15	*Ficus microcarpa*							1					1
16	*Garcinia gummigutta*			1									1
17	*Glochidion ellipticum*				1	1							2
18	*Litsea oleoides*	1			1	2							4
19	*Litsea wightiana*			15	14	7	8	4			1		49

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Sl no	Species	Diameter class (cm)											Total
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	
20	*Melicope lunu-ankenda*		2	7	8	2							19
21	*Myristica beddomei*		1	6	8	4	3						22
22	*Persea macrantha*		1	3	3	6	2	1					16
23	*Syzygium cumini*			4	2	3							9
24	*Syzygium laetum*			2	3	1							6
25	*Trema orientalis*				2	1	1	1					5
26	*Vernonia arborea*					1							1
	Total	6	10	76	78	49	30	16	3	1	1	0	270

Table 24. Diameter-frequency distribution of species (>10 cm GBH) in Vested forest.

Sl no	Species	Diameter class (cm)											Total
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	
1	*Actinodaphne malabarica*	3		2	1								6
2	*Antidesma montanum*	5	5	2									12
3	*Artocarpus heterophyllus*	1	1	5	4	1	2						14
4	*Bischofia javanica*		1	2		1							4
5	*Calophyllum polyanthum*		2		1	1							4
6	*Canarium strictum*				1								1
7	*Chionanthus ramiflorus*	1	3	5	1	1							11
8	*Cinnamomum wightii*	1	1	6	7	3							18
9	*Clerodendrum infortunatum*	9											9
10	*Cullenia exarillata*	1	5	6	5	6	1						24
11	*Dillenia bracteata*	2	10	13	2	2							29
12	*Dimocarpus longan*	7	22	13	11	2	2		2				59
13	*Drypetes wightii*	4	8	3		1		2					18
14	*Elaeocarpus munronii*				1	4	1						6
15	*Elaeocarpus serratus*			1		1							2
16	*Eurya nitida*	1											1
17	*Glochidion ellipticum*			2									2
18	*Hydnocarpus alpina*		1	2	2	1		1					7
19	*Leea indica*	23	6										29
20	*Litsea oleoides*	6	8	6	6	1	1						28
21	*Macaranga peltata*	1		1	1	1							4
22	*Malottus philippensis*	1											1

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Sl no	Species	Diameter class (cm)											Total
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	
23	*Mastixia arborea*			6	3	2	1						12
24	*Mesua ferrea*		2	8	7	5	3					1	26
25	*Myristica beddomei*		4	30	21	8	7	2	1	1	1		75
26	*Neolitsea cassia*		1	2	2	2							7
27	*Palaquium ellipticum*	1	9	25	14	10	7	12	3				81
28	*Paracroton pendulus*	2	4	4	1	2		1					14
29	*Polyalthia coffeoides*		6	6	2								14
30	*Sterculia guttata*		1		1								2
31	*Syzygium cumini*		2	5	3	3							13
32	*Syzygium laetum*	1	2	4	3	1	1						12
	Total	70	104	159	100	59	26	18	6	1	1	1	545

Table 25. Height- Frequency distribution in Ecologically Fragile Land

Sl no:	Species	Height class (m)					Total
		0-5	5-10	10-15	15-20	20-25	
1	*Alseodaphne semecarpifolia*	1	2		1		4
2	*Artocarpus heterophyllus*		1	5	1		7
3	*Bischofia javanica*	1	1	1			3
4	*Calophyllum polyanthum*		3	3			6
5	*Canarium strictum*		1				1
6	*Chionanthus ramiflorus*		4				4
7	*Chukrasia tabularis*		5	1	1		7
8	*Cinnamomum wightii*		1	1			2
9	*Clerodendrum infortunatum*	12	8				20
10	*Coffea liberica*	3					3
11	*Cullenia exarillata*	1					1
12	*Dillenia bracteata*	5	9	5			19
13	*Dimocarpus longan*		4	1			5
14	*Diospyros nilagirica*		8	9	4	1	22
15	*Drypetes wightii*	1	7	5	1		14
16	*Eurya nitida*	4		7			11
17	*Ficus microcarpa*			3	1		4
18	*Ficus racemosa*			1			1
19	*Glochidion ellipticum*				1		1
20	*Gomphandra tetrandra*	2	2				4
21	*Gordonia obtusa*		1	2			3
22	*Knema attenuata*		2	3	2		7
23	*Litsea oleoides*	23	16	2			41
24	*Litsea wightiana*	16	16	3	1		36
25	*Macaranga peltata*	2	6	2			10
26	*Melicope lunu-ankenda*	28	42	18	5	4	97
27	*Mesua ferrea*				1		1
28	*Myristica beddomei*		3	9	5		17
29	*Neolitsea cassia*	2					2
30	*Nothapodytes nimmoniana*		1				1
31	*Palaquium ellipticum*		1		1	1	3
32	*Paracroton pendulus*	2					2
33	*Persea macrantha*	3	7	10	1		21
34	*Psydrax umbellata*		2	1			3
35	*Syzygium cumini*		1	5	3	1	10
36	*Syzygium densiflorum*		2	4	4	1	11
37	*Syzygium grande*	1					1
38	*Syzygium laetum*		3				3
39	*Syzygium lanceolatum*	1		1			2
40	*Vernonia arborea*		1				1
	Total	108	160	102	33	8	411

Table 26. Height- Frequency distribution in Section 5 land.

Sl no:	Species	Height class(m)					
		0-5	5-10	10-15	15-20	20-25	Total
1	*Actinodaphne malabarica*		1				1
2	*Artocarpus heterophyllus*		7	7			14
3	*Bischofia javanica*		4	2			6
4	*Calophyllum polyanthum*			2	2		4
5	*Chionanthus ramiflorus*		3	8	1		12
6	*Chukrasia tabularis*	1	6	5	2		14
7	*Cinnamomum wightii*		1	2			3
8	*Coffea liberica*	4					4
9	*Cullenia exarillata*				1		1
10	*Dillenia bracteata*		15	10			25
11	*Dimocarpus longan*	2	10	2			14
12	*Diospyros nilagirica*		8	16	3		27
13	*Drypetes wightii*		4	2			6
14	*Erythrina subumbrans*		4				4
15	*Ficus microcarpa*				1		1
16	*Garcinia gummigutta*		1				1
17	*Glochidion ellipticum*		1	1			2
18	*Litsea oleoides*	1	1	2			4
19	*Litsea wightiana*		19	23	7		49
20	*Melicope lunu-ankenda*		8	11			19
21	*Myristica beddomei*		4	16	2		22
22	*Persea macrantha*		3	13			16
23	*Syzygium cumini*		2	7			9
24	*Syzygium laetum*		3	3			6
25	*Trema orientalis*		3	2			5
26	*Vernonia arborea*			1			1
	Total	8	108	135	19	0	270

Table 27. Height- Frequency distribution in Vested forest.

Sl no	Species	Height class (m)						Total
		0-5	5-10	10-15	15-20	20-25	25-30	
1	*Actinodaphne malabarica*	3	1	2				6
2	*Antidesma montanum*	1	11	1				13
3	*Artocarpus heterophyllus*	1	6	5	2			14
4	*Bischofia javanica*		4					4
5	*Calophyllum polyanthum*		1	3				4
6	*Canarium strictum*		1					1
7	*Chionanthus ramiflorus*		10	1				11
8	*Cinnamomum wightii*		6	10	2			18
9	*Clerodendrum infortunatum*	9						9
10	*Cullenia exarillata*	1	10	11	2			24
11	*Dillenia bracteata*	2	22	2				26
12	*Dimocarpus longan*	2	43	11	3			59
13	*Drypetes wightii*	3	12	3				18
14	*Elaeocarpus munronii*			5	1			6
15	*Elaeocarpus serratus*		1		1			2
16	*Eurya nitida*	1						1
17	*Glochidion ellipticum*		2					2
18	*Hydnocarpus alpina*		4	2	1			7
19	*Leea indica*	29						29
20	*Litsea oleoides*	4	16	6	1			27
21	*Macaranga peltata*	1	4	1				6
22	*Malottus philippensis*	1						1
23	*Mastixia arborea*		3	7	2			12
24	*Mesua ferrea*		4	16	5	1		26
25	*Myristica beddomei*		37	32	6	1		76
26	*Neolitsea cassia*		3	4				7
27	*Palaquium ellipticum*	1	20	37	21	2		81
28	*Paracroton pendulus*	1	9	4				14
29	*Polyalthia coffeoides*		12	2				14
30	*Sterculia guttata*		2					2
31	*Syzygium cumini*		5	7		1		13
32	*Syzygium laetum*	1	3	8				12
	Total	61	252	180	47	5	0	545

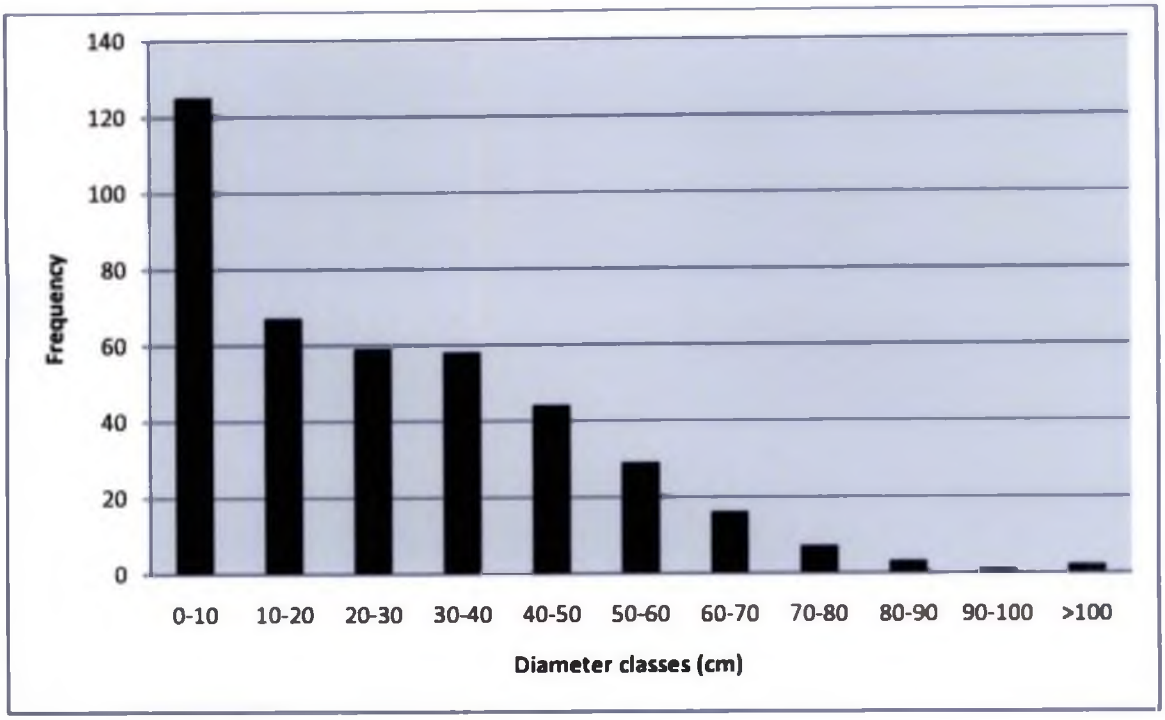


Fig. 5 Diameter-Frequency distribution in Ecologically Fragile Land

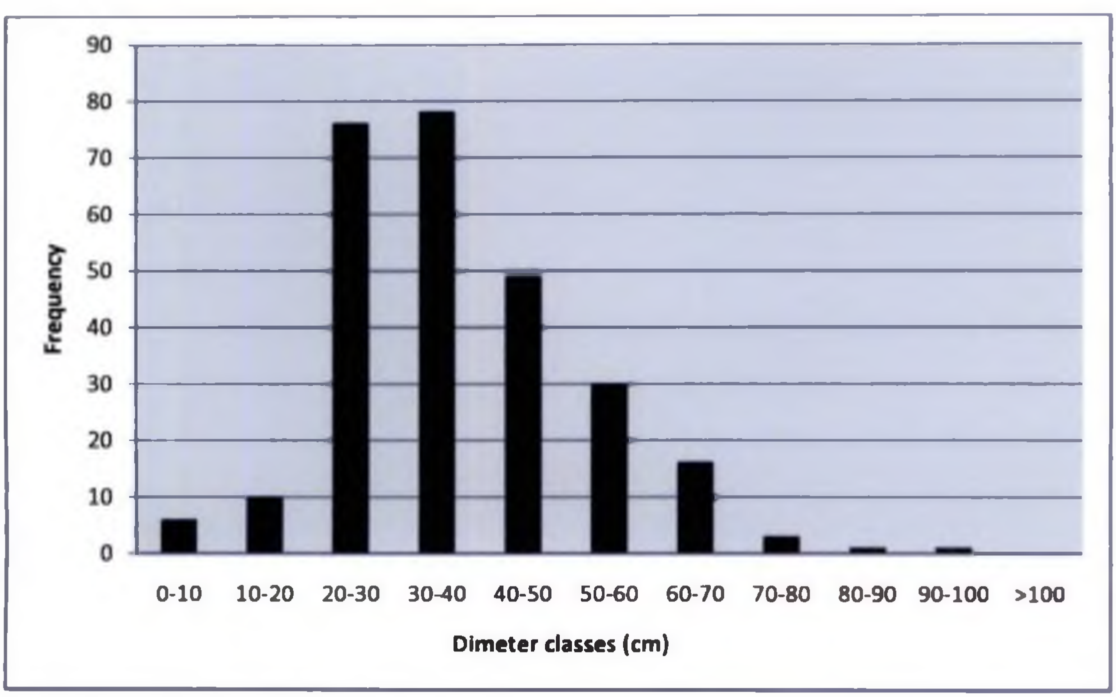


Fig.6 Diameter-Frequency distribution in Section 5 land

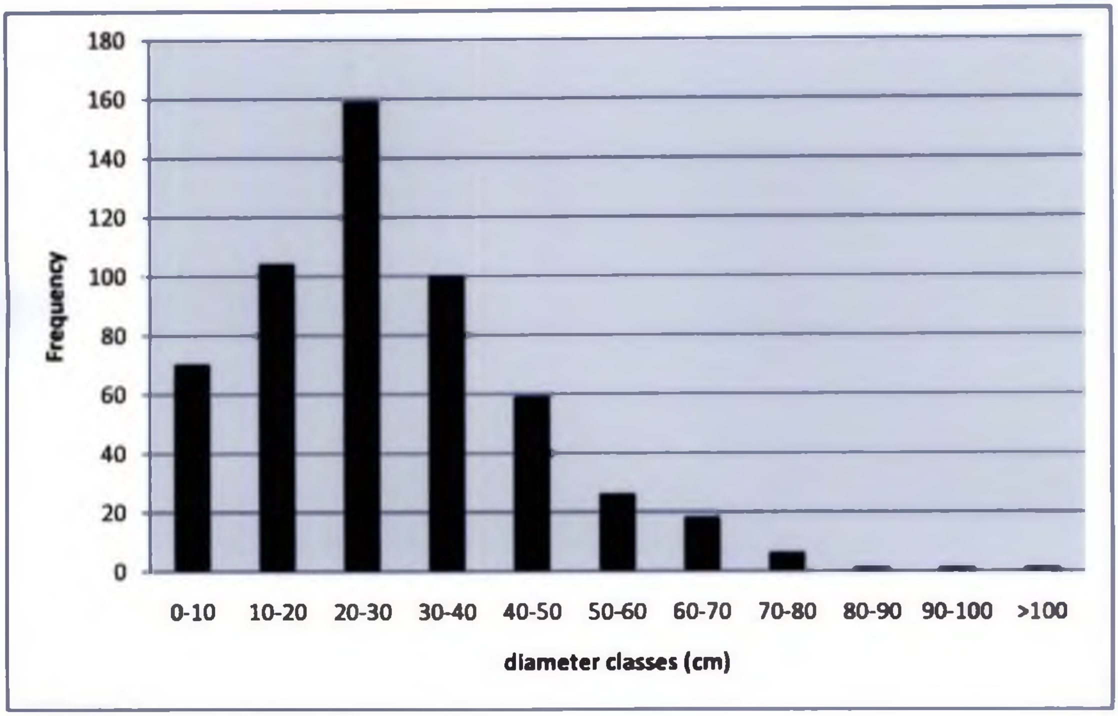


Fig.7 Diameter-Frequency distribution in Vested forest

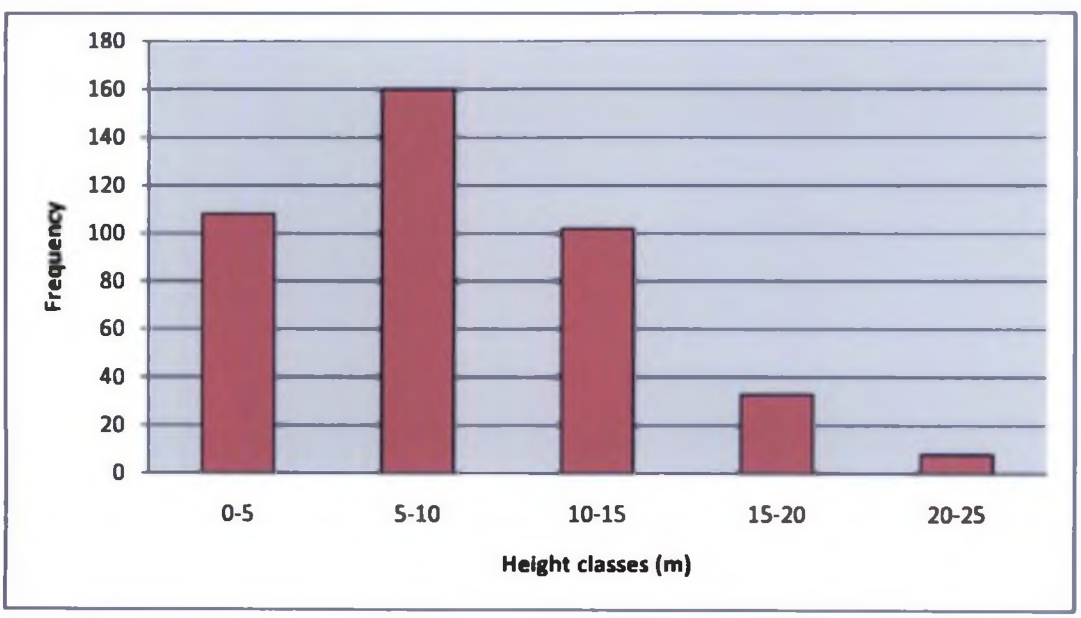


Fig. 8 Height-Frequency distribution in Ecologically Fragile Land.

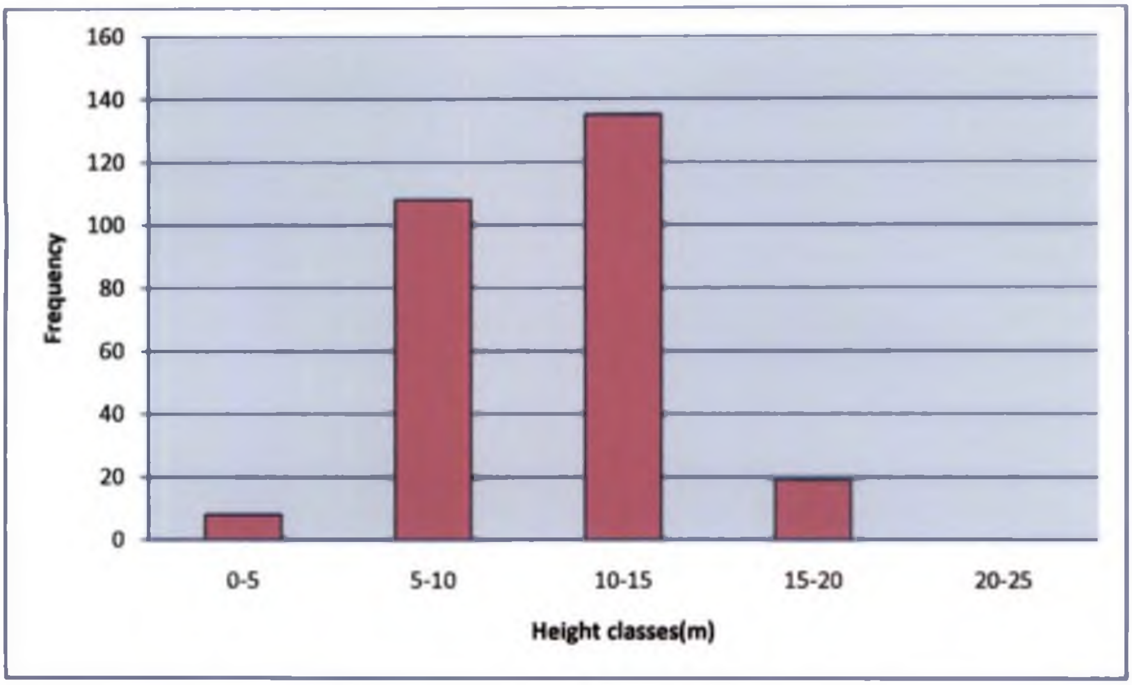


Fig.9 Height-Frequency distribution in Section 5 land

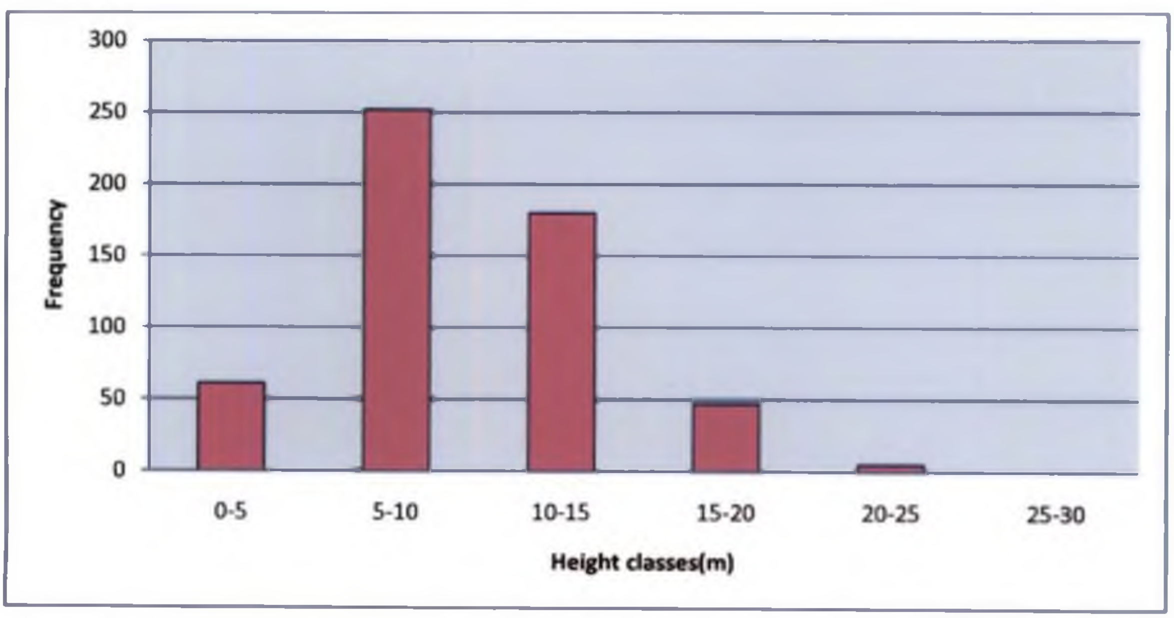


Fig.10 Height-Frequency distribution in Vested forest

4. 4. 3. Vested forest

Majority of individuals were in the 5-10 and 10-15 m height classes (Fig. 10). 252 individuals were seen in the 5-10 m height class and 10-15 m height class had 180 individuals (Table 27)

4. 5. Floristic diversity (>10 cm GBH)

Floristic diversity indices for the three land use systems are given in Table 28.

4. 5. 1. Ecologically Fragile Land

A total of 411 individuals (>10 cm GBH) spread over 40 species were found in this area. Simpson's indices for diversity and concentration of dominance (cd) were 0.91 and 0.09 respectively i.e, if 100 pairs of trees were taken at random, 91 will comprise of different species. The Shannon Weiner indices, Hmax and equitability (E) were 2.93, 5.32 and 0.55 respectively

4. 5. 2. Section 5 land

Simpson's diversity index (D) and concentration of dominance (cd) of the section 5 land was found to be 0.92 and 0.08 respectively. Shannon Weiner index, Hmax and E values were 2.80, 4.68 and 0.61 respectively.

4. 5. 3. Vested forest

A total of 545 individuals (>10 cm GBH) spread over 32 species were found in this area. Simpson's diversity index (D) and concentration of dominance (cd) was found 0.93 and 0.07 respectively. Among the three land use types, the maximum value of Shannon-Weiner's index (2.96) was found to be here. Hmax and E values were 5.02 and 0.59 respectively.

Table 28. Floristic diversity indices for the vegetations of three land use systems.

Land use type	Area(Ha)	No: of Species (S)	No: of individuals (N)	Simpson index		Shannon-Wieners index		
				D	Cd	H'	Hmax	E
Ecologically Fragile Land	1	40	411	0.91	0.09	2.93	5.32	0.55
Section 5 land	1	26	270	0.92	0.08	2.80	4.68	0.61
Vested forest	1	32	545	0.93	0.07	2.96	5.02	0.59

4. 6. Vegetation structure

4.6.1. Stratification

The percentage distribution of individuals occupying in different storeys (<10, 10-20, >20 m) in the three land use types are given in Table 29.

4.6.1.1. Ecologically Fragile Land

65.21 per cent of the individuals of the EFL were present in the First storey (<10m). Second (10-20 m) and third storey (>20m) had 32.85 and 1.95 per cent of individuals

4.6.1.2. Section 5 land

From the Table 29, it was observed that second and first storey were well represented in the vegetation of this area. 57.04 per cent of the individuals are confined to second storey and 42.96 per cent confined to first storey. No individuals were represented in third storey (>20 m)

4.6.1.3. Vested forest

The percentage distribution of trees was maximum in the first storey (57.43%) and second storey (41.65%). Third storey had poor stocking having a value of 0.92 per cent.

4.6.2. Profile diagram

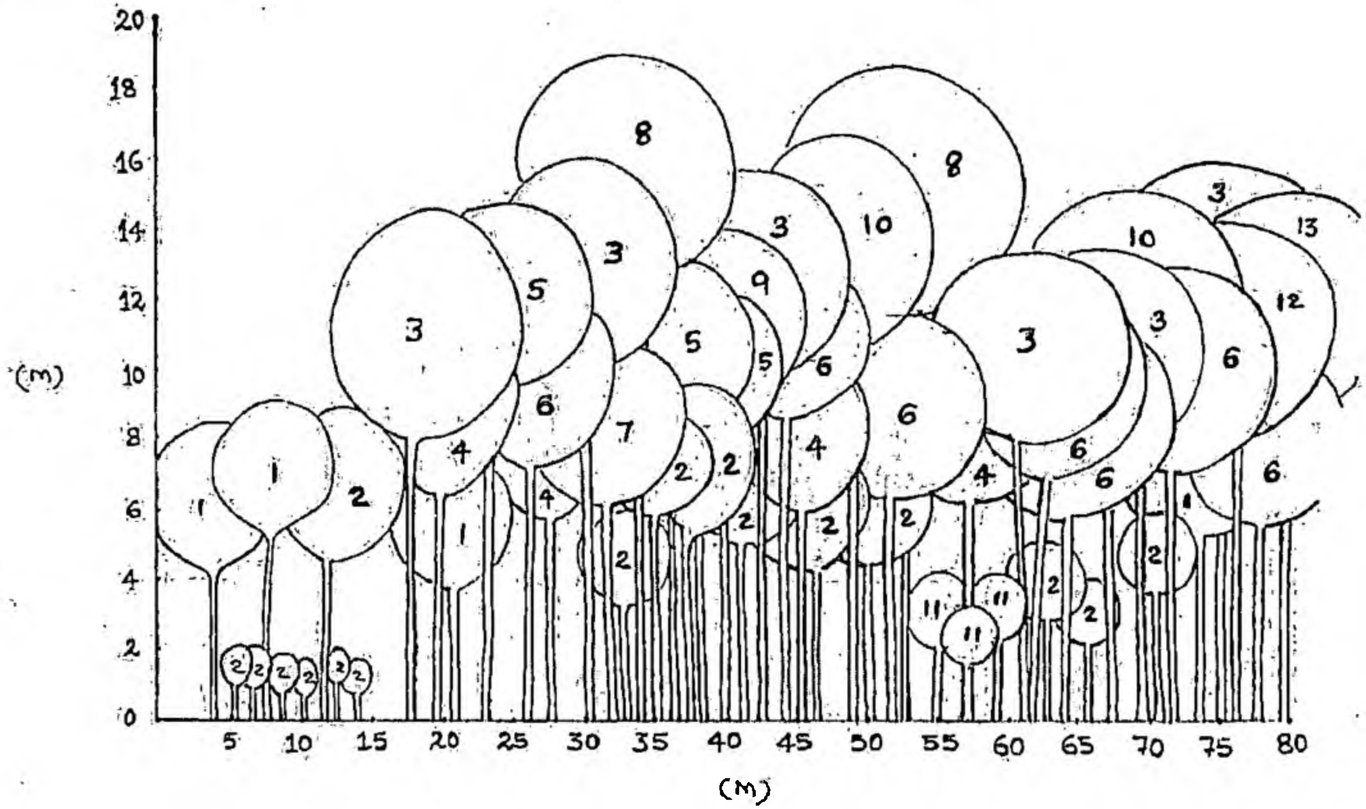
Profile diagrams of representative 20 m x 80 m strips of the three land use systems are shown in Figs. 11-13.

4.6.2.1. Ecologically Fragile Land

The profile diagram of ecologically fragile land was shown in Fig. 11. Three distinct strata were identified.

Table 29. Percentage distribution of individuals occupying different storey in the three land use systems

Land use type	No: of individuals (N)	Percentage distribution		
		First storey (<10 m)	Second storey (10-20 m)	Third storey (>20 m)
Ecologically Fragile Land	411	65.21	32.85	1.95
Section 5 land	270	42.96	57.04	0.00
Vested forest	545	57.43	41.65	0.92



1.Dillenia bracteata | *2 Litsea oleoides* | *3.Syzygium cumini*

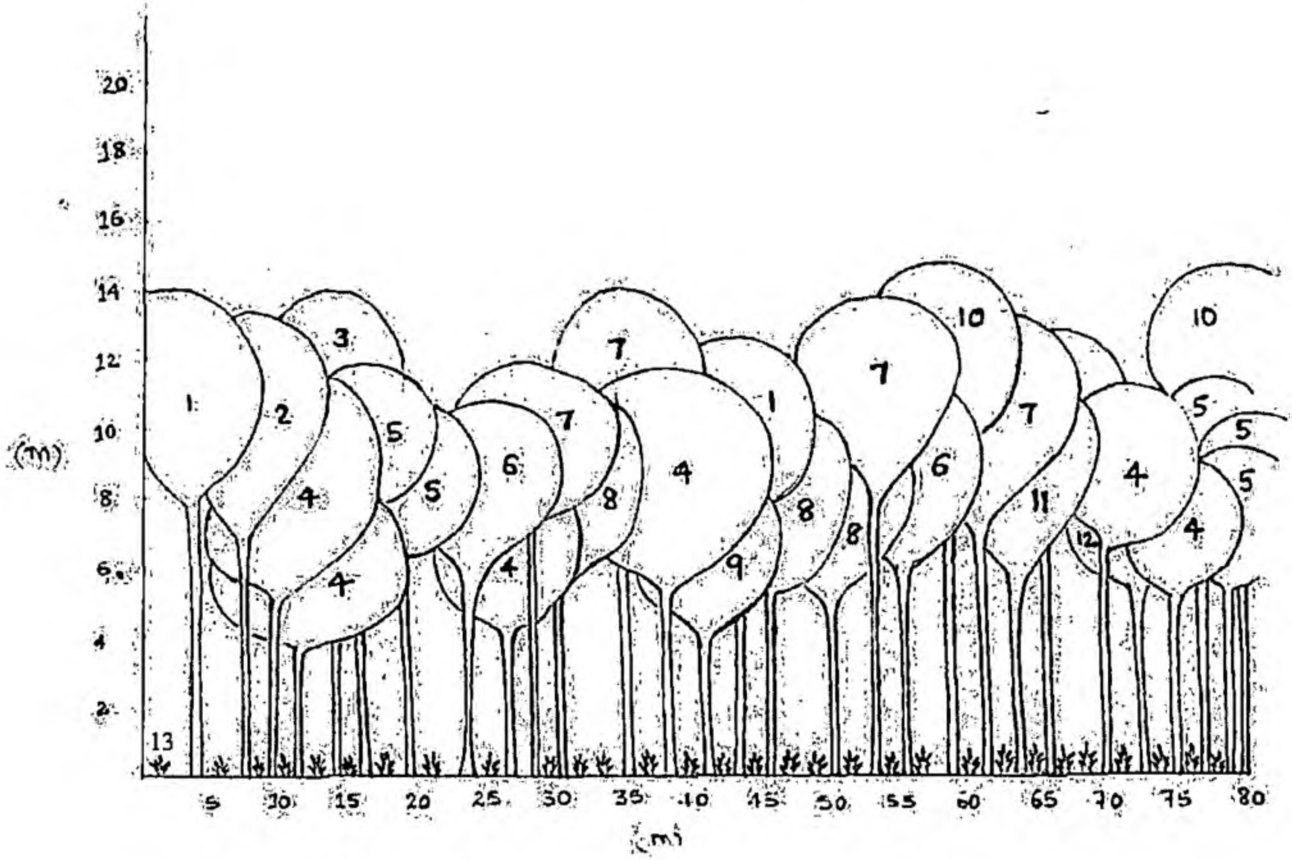
4. Persea macrantha | *5. Myristica beddomei* | *6. Melicope lunu-ankenda*

7. Psydrax umbellata | *8. Palaquium ellipticum* | *9. Drypetes wightii*

10. Diospyros nilagirica | *11. Clerodendrum infortunatum* | *12. Artocarpus heterophyllus*

13. Syzygium densiflorum

Fig. 11 Profile diagram of Ecologically Fragile Land



1.Chukrasia tabularis *2.Artocarpus heterophyllus* *3.Cinnamomum wightii*

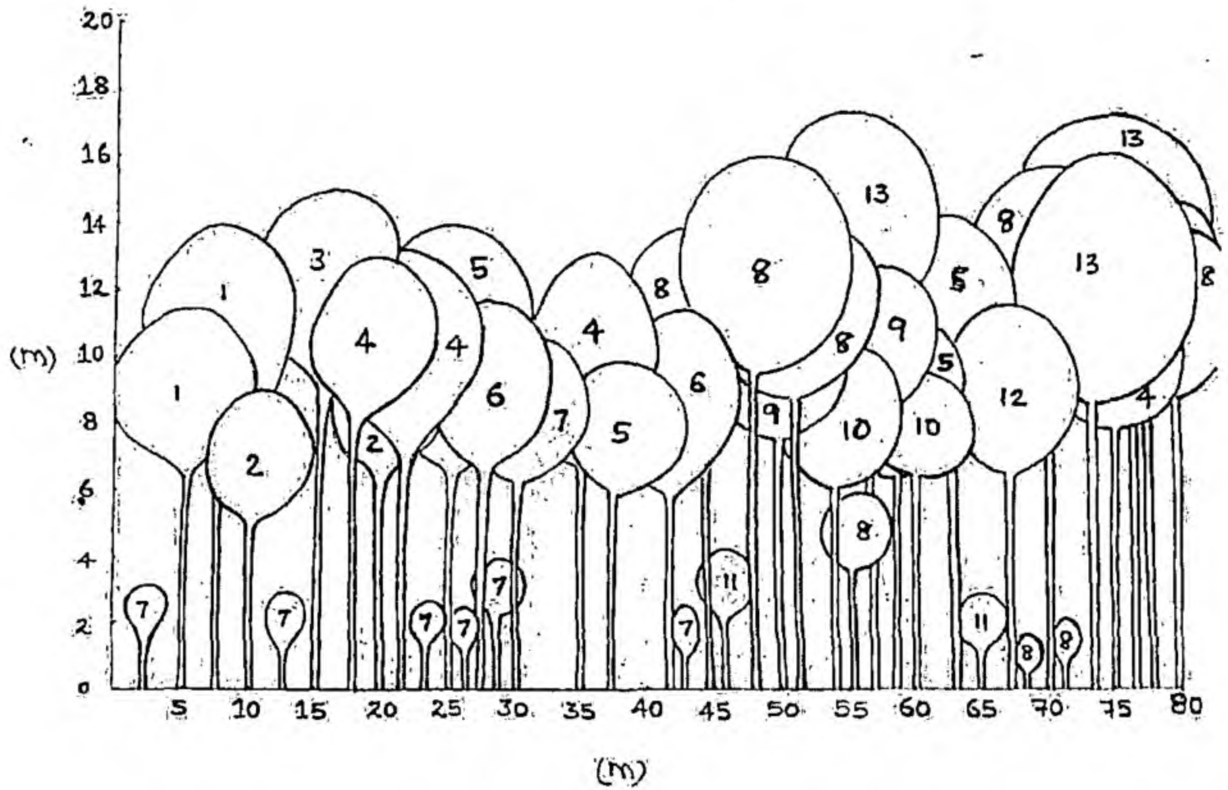
4.Myristica beddomei *5.Litsea wightiana* *6.Drypetes wightii*

7.Syzygium cumini *8.Melicope lunu-ankenda* *9.Syzygium laetum*

10.Calophyllum polyanthum *11.Dillenia bracteata* *12.Bischofia javanica*

13. Cardamom

Fig. 12 Profile diagram of Section 5 Land



1.Dillenia bracteata	*2.Polyalthia coffeoides*	*3.Hydnocarpus alpine*
4.Myristica beddomei	*5.Dimocarpus longan*	*6.Paracroton pendulus*
7.Actinodaphne malabarica	*8.Palaquium ellipticum*	*9.Cullenia exarillata*
10.Mastixia arborea	*11.Litsea oleoides*	*12.Neolitsea cassia*
13.Mesua ferrea		

Fig. 13 Profile diagram of Vested Forest

First stratum consists of species like *Litsea oleoides*, *Clerodendrum infortunatum* and *Dillenia bracteata*. Majority of the species occupied in the second stratum with dominant ones were *Melicope lunu-ankenda*, *Persea macrantha* and *Myristica beddomei*. *Diospyros nilagirica*, *Palaquium ellipticum* and *Syzygium cumini* were the prominent species seen in the upper stratum.

4.6.2.2. Section 5 land

Typical structure of this land use system was shown in the Fig. 12. Only two strata were distinguished in this area. First stratum was more stocked as compared to the second, which had dominant species like *Cinnamomum wightii*, *Calophyllum polyanthum* and *Syzygium cumini*. Cardamomum cultivation in this area is also represented in the diagram.

4.6.2.3. Vested forest

Fig. 13 represents the profile diagram of vested forest. The crowns were dense and form a closed canopy. Three strata were identified in which species like *Actinodaphne malabarica*, *Litsea oleoides and Polyalthia coffeoides* occupied in the lower storey. *Dimocarpus longan*, *Myristica beddomei* and *Dillenia bracteata* were the prominent species in the second strata. Upper stratum consists of *Cullenia exarillata*, *Palaquium ellipticum* and *Mesua ferrea*.

4. 7. Species composition (<10 cm GBH)

All individuals having a GBH below 10 cm were recorded species wise for each land use system.

4.7.1. Ecologically Fragile Land

A total of 97 species including 14 trees, 7 shrubs, 46 herbs, 12 pteridophytes, 8 bryophytes and 10 lichens were identified from the sampled one hectare area. The detailed classifications of these groups are presented in Table 30.

Table 30. Species composition (< 10 cm GBH) in Ecologically Fragile Land

Sl no:	Scientific name	Family	Habit
1.	*Cinnamomum wightii**	Lauraceae	Tree
2.	*Litsea wightiana**	Lauraceae	,,
3.	*Litsea oleoides**	Lauraceae	,,
4.	*Persea macrantha*	Lauraceae	,,
5.	*Macaranga peltata*	Euphorbiaceae	,,
6.	*Alseodaphne semecarpifolia*	Lauraceae	,,
7.	*Actinodaphne malabarica***	Lauraceae	,,
8.	*Psychotria flavida**	Rubiaceae	,,
9.	*Dimocarpus longan*	Sapindaceae	,,
10.	*Palaquium ellipticum**	Sapotaceae	,,
11.	*Cullenia exarillata**	Bombacaceae	,,
12.	*Dillenia bracteata*	Dilleniaceae	,,
13.	*Neolitsea cassia*	Lauraceae	,,
14.	*Clerodendrum infortunatum*	Euphorbiaceae	,,
15.	*Aeschynanthus perrottetii**	Gesneriaceae	Shrub
16.	*Ageratina adenophora*	Asteraceae	,,
17.	*Allophylus serratus*	Sapindaceae	,,
18.	*Coffea liberica*	Rubiaceae	,,
19.	*Dendrophthoe falcata*	Loranthaceae	,,
20.	*Isonandra lanceolata*	Sapotaceae	,,
21.	*Ligustrum perrottetii*	Oleaceae	,,
22.	*Amorphophallus commutatus**	Araceae	Herb
23.	*Begonia cordifolia***	Begoniaceae	,,
24.	*Belosynapsis vivipara***	Commelinaceae	,,
25.	*Commelina diffusa*	Commelinaceae	,,
26.	*Digitaria ciliaris*	Poaceae	,,
27.	*Elettaria cardamomum*	Zingiberaceae	,,
28.	*Hydrocotyle javanica*	Apiaceae	,,
29.	*Justicia japonica*	Acanthaceae	,,
30.	*Knoxia wightiana*	Rubiaceae	,,
31.	*Lecanthus peduncularis*	Urticaceae	,,
32.	*Oplismenus composites*	Poaceae	,,
33.	*Oxalis corniculata*	Oxalidaceae	,,
34.	*Oxalis corymbosa*	Oxalidaceae	,,
35.	*Oxalis latifolia*	Oxalidaceae	,,
36.	*Peperomia portulacoides*	Piperaceae	,,

37.	*Phyllanthus kozhikodianus*	Euphorbiaceae	,,
38.	*Plantago erosa*	Plantaginaceae	,,
39.	*Remusatia vivipara*	Araceae	,,
40.	*Scleria lithosperma*	Cyperaceae	,,
41.	*Smythea bombaiensis**	Rhamnaceae	,,
42.	*Solanum virginianum*	Solanaceae	,,
43.	*Sonerila rheedei**	Melastomataceae	,,
44.	*Sonerila versicolor***	Melastomataceae	,,
45.	*Spermacoce sp.*	Rubiaceae	,,
46.	*Utricularia striatula*	Lentibulariaceae	,,
47.	*Utricularia uliginosa*	Lentibulariaceae	,,
48.	*Zingiber neesanum**	Zingiberaceae	,,
49.	*Oberonia josephii**	Orchidaceae	,,
50.	*Oberonia brunoniana**	Orchidaceae	,,
51.	*Sirhookera latifolia*	Orchidaceae	,,
52.	*Dendrobium aqueum**	Orchidaceae	,,
53.	*Coelogyne nervosa**	Orchidaceae	,,
54.	*Bulbophyllum sp.*	Orchidaceae	,,
55.	*Calanthe sylvatica*	Orchidaceae	,,
56.	*Papilionanthe cylindrica*	Orchidaceae	,,
57.	*Robiquetia josephiana*	Orchidaceae	,,
58.	*Impatiens gardneriana**	Balsaminaceae	,,
59.	*Impatiens parasitica**	Balsaminaceae	,,
60.	*Impatiens minor*	Balsaminaceae	,,
61.	*Impatiens scapiflora**	Balsaminaceae	,,
62.	*Asparagus racemosus*	Lilliaceae	,,
63.	*Ceropegia metziana***	Asclepiadaceae	,,
64.	*Hoya wightii*	Asclepiadaceae	,,
65.	*Piper nigrum*	Piperaceae	,,
66.	*Rubus glomeratus*	Rosaceae	,,
67.	*Ochlandra travancorica**	Poaceae	,,
68.	*Asplenium decrescens*	Aspleniaceae	Pteridophyte
69.	*Crepidomanes bilabiatum*	Hymnophllaceae	,,
70.	*Huperzia squarrosa*	Lycopodiaceae	,,
71.	*Nephrolepis cordifolia*	Oleandraceae	,,
72.	*Lycopodiella cernua***	Lycopodiaceae	,,
73.	*Pteridium aquilina*	Pteridaceae	,,
74.	*Selaginella crassicaulis*	Selaginellaceae	,,
75.	*Davallia bullata*	Davalliaceae	,,

76.	*Huperzia phlegmaria*	Lycopodiaceae	,,
77.	*Cyathea gigantean*	Cyatheaceae	,,
78.	*Polystichum subinerme*	Dryopteridaceae	,,
79.	*Osmunda regalis***	Osmundaceae	,,
80.	*Leucophanes octoblepharoides*	Lecuobryaceae	Bryophyte
81.	*Bryum pseudotriquetrum*	Bryaceae	,,
82.	*Floribundaria floribunda*	Meteoriaceae	,,
83.	*Lejeunea sp.*	Lejeuneaceae	,,
84.	*Leucoloma amoenevirens*	Dicranaceae	,,
85.	*Macromitrium sulcatum*	Othotrichaceae	,,
86.	*Meteoriopsis reclinata*	Meteoriaceae	,,
87.	*Philonotis mollis*	Bartramiaceae	,,
88.	*Cladonia sp.*	Cladoniaceae	Lichen
89.	*Heterodermia dissecta*	Physciaceae	,,
90.	*Heterodermia japonica*	Physciaceae	,,
91.	*Hypotrachyna crenata*	Parmeliaceae	,,
92.	*Usnea undulata*	Parmeliaceae	,,
93.	*Leptogium adpressum*	Collemataceae	,,
94.	*Leptogium austo-americanum*	Collemataceae	,,
95.	*Leptogium brebisonii*	Collemataceae	,,
96.	*Ramalina conduplicans*	Ramalinaceae	,,
97.	*Usnea sp.*	Parmeliaceae	,,
(* - Endemic to Western Ghats, **- endemic to Western Ghats and under IUCN Red List			

Aeschynanthus perrottetii

Hoya wightii

Smythea bombaiensis

Sonerila rheedei

Strobilanthes ciliates

Zingiber neesanum

Plate 4. Some of the endemic plants of Western Ghats recorded from Ecologically Fragile Land.

Impatiens gardneriana

Impatiens parasitica

Impatiens scapiflora

Coelogyne nervosa

Dendrobium aqueum

Oberonia josephii

Plate 5. Endemic species of Impatiens and Orchids recorded from the Ecologically Fragile Land

Actinodaphne malabarica

Begonia cordifolia

Belosynapsis vivipara

Ceropegia metziana

Dicranopteris linearis

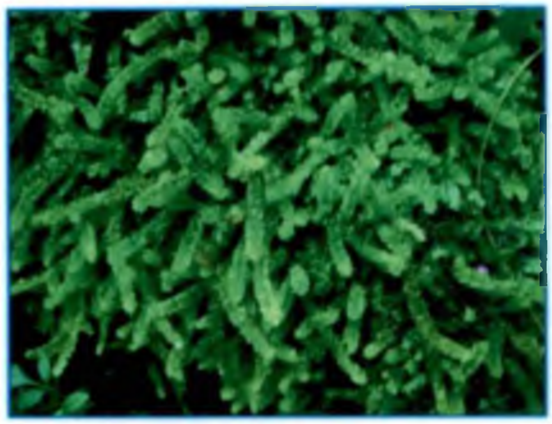
Lycopodium cernua

Osmunda regalis

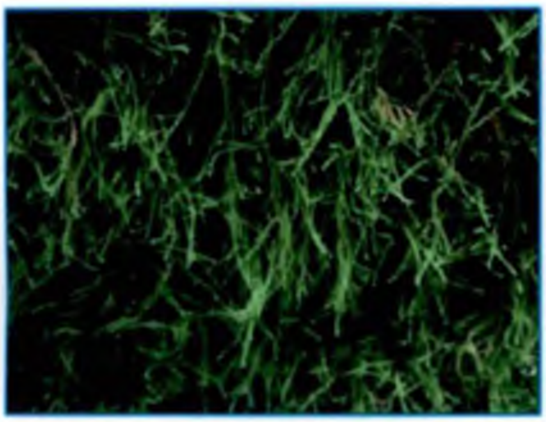
Sonerila versicolor

Plate 6. RET species recorded from the Ecologically Fragile Land

Macromitrium sulcatum



Meteoriopsis reclinata



Floribundaria floribunda

Heterodermia japonica

Leptogium adpressum

Leptogium austo-americanum

Plate 7. Bryophytes and lichens recorded from the Ecologically Fragile Land

Table 31. Species composition (< 10 cm GBH) in Section 5 Land (1 hectare)

	Scientific name	Family	Habit
1.	*Actinodaphne malabarica***	Lauraceae	Tree
2.	*Persea macrantha*	Lauraceae	,,
3.	*Aeschynanthus perrottetii**	Gesneriaceae	Shrub
4.	*Ageratina adenophora*	Asteraceae	,,
5.	*Brugmansia suaveolens*	Solanaceae	,,
6.	*Dendrophthoe falcata*	Loranthaceae	,,
7.	*Justicia beddomei*	Acanthaceae	,,
8.	*Isonandra lanceolata*	Sapotaceae	,,
9.	*Ludwigia peruviana*	Onagraceae	,,
10.	*Persicaria chinensis*	Polygonaceae	,,
11.	*Solanum torvum*	Solanaceae	,,
12.	*Solanum virginianum*	Solanaceae	,,
13.	*Strobilanthes ciliatus**	Acanthaceae	,,
14.	*Strobilanthes sp.*	Acanthaceae	,,
15.	*Urena lobata*	Malvaceae	,,
16.	*Ageratum conyzoides*	Asteraceae	Herb
17.	*Amorphophallus commutatus*	Araceae	,,
18.	*Belosynapsis vivipara**	Commelinaceae	,,
19.	*Bidens pilosa*	Asteraceae	,,
20.	*Blainvillea acmella*	Asteraceae	,,
21.	*Commelina diffusa*	Commelinaceae	,,
22.	*Crassocephalum crepidioides*	Asteraceae	,,
23.	*Cyanotis cristata*	Commelinaceae	,,
24.	*Desmodium repandum*	Fabaceae	,,
25.	*Digitaria ciliaris*	Poaceae	,,
26.	*Drymaria cordata*	Caryophyllaceae	,,
27.	*Elatostema acuminatum*	Urticaceae	,,
28.	*Elettaria cardamomum*	Zingiberaceae	,,
29.	*Gynura nitida*	Asteraceae	,,
30.	*Hydrocotyle javanica*	Apiaceae	,,
31.	*Justicia japonica*	Acanthaceae	,,
32.	*Knoxia wightiana*	Rubiaceae	,,
33.	*Kyllinga brevifolia*	Cyperaceae	,,
34.	*Laportea bulbifera*	Urticaceae	,,

Plate 8. Profuse regeneration of *Clerodendrum infortunatum* in Ecologically Fragile Land.

Plate 9. Cardamom cultivation in Section 5 land

35.	*Lecanthus peduncularis*	Urticaceae	,,
36.	*Lindernia ruellioides*	Scrophulariaceae	,,
37.	*Murdannia japonica*	Commelinaceae	,,
38.	*Murdannia spirata*	Commelinaceae	,,
39.	*Oplismenus composites*	Poaceae	,,
40.	*Oxalis corniculata*	Oxalidaceae	,,
41.	*Oxalis corymbosa*	Oxalidaceae	,,
42.	*Oxalis latifolia*	Oxalidaceae	,,
43.	*Paspalum conjugatum*	Poaceae	,,
44.	*Peperomia portulacoides*	Piperaceae	,,
45.	*Plectranthus malabaricus*	Lamiaceae	,,
46.	*Pouzolzia wightii*	Melatostomaceae	,,
47.	*Pratia begonifolia*	Begoniaceae	,,
48.	*Scleria lithosperma*	Cyperaceae	,,
49.	*Smythea bombaiensis**	Rhamnaceae	,,
50.	*Solanum virginianum*	Solanaceae	,,
51.	*Spermacoce sp.*	Rubiaceae	,,
52.	*Synedrella nodiflora*	Asteraceae	,,
53.	*Utricularia striatula*	Lentibulariaceae	,,
54.	*Impatiens cordata**	Balsaminaceae	,,
55.	*Impatiens scabriuscula**	Balsaminaceae	,,
56.	*Impatiens gardneriana**	Balsaminaceae	,,
57.	*Impatiens parasitica**	Balsaminaceae	,,
58.	*Impatiens minor*	Balsaminaceae	,,
59.	*Impatiens scapiflora**	Balsaminaceae	,,
60.	*Oberonia josephii**	Orchidaceae	,,
61.	*Oberonia brunoniana**	Orchidaceae	,,
62.	*Coelogyne nervosa**	Orchidaceae	,,
63.	*Robiquetia josephiana*	Orchidaceae	,,
64.	*Papilionanthe cylindrica*	Orchidaceae	,,
65.	*Sirhookera latifolia*	Orchidaceae	,,
66.	*Bulbophyllum sp.*	Orchidaceae	
67.	*Cayratia pedata*	Vitaceae	,,
68.	*Cissus heyneana*	Vitaceae	,,
69.	*Gymnopetalum tubiflorum*	Cucurbitaceae	,,
70.	*Piper nigrum*	Piperaceae	,,
71.	*Rubus glomeratus*	Rosaceae	,,
72.	*Stephania wightii*	Menispermaceae	,,
73.	*Thunbergia mysorensis**	Acanthaceae	,,

74.	*Trichosanthes tricuspidata*	Cucurbitaceae	,,
75.	*Ochlandra travancorica**	Poaceae	,,
76.	*Arachniodes aristata*	Dryopteridaceae	Pteridophyte
77.	*Asplenium decrescens*	Aspleniaceae	,,
78.	*Asplenium aethiopicum*	Aspleniaceae	,,
79.	*Adiantum raddianum*	Adiantaceae	,,
80.	*Blechnum orientale*	Blechnaceae	,,
81.	*Dicranopteris linearis*	Gleicheniaceae	,,
82.	*Pteris argyraea*	Pteridaceae	,,
83.	*Asplenium yoshinagae*	Aspleniaceae	,,
84.	*Christella meeboldii*	Thelypteridaceae	,,
85.	*Hemionitis arifolia*	Adiantaceae	,,
86.	*Lycopodiella cernua*	Lycopodiaceae	,,
87.	*Pellaea boivini*	Pteridaceae	,,
88.	*Phymatosorus montana*	Polypodiaceae	,,
89.	*Pteridium aquilina*	Pteridaceae	,,
90.	*Pteris confusa*	Pteridaceae	,,
91.	*Tectaria paradoxa*	Dryopteridaceae	,,
92.	*Selaginella crassicaulis*	Selaginellaceae	,,
93.	*Davallia bullata*	Davalliaceae	,,
94.	*Pyrossia mollis*	Polypodiaceae	,,
95.	*Cyathodium cavernarum*	Targioniaceae	Bryophyte
96.	*Ctenidium lychnitis*	Hypnaceae	,,
97.	*Bryum wightii*	Bryaceae	,,
98.	*Leucophanes octoblepharoides*	Leucobryaceae	,,
99.	*Funaria hygrometrica*	Funariaceae	,,
100.	*Lejeunea sp.*	Lejeuneaceae	,,
101.	*Leucoloma amoenevirens*	Dicranaceae	,,
102.	*Macromitrium sulcatum*	Othotrichaceae	,,
103.	*Pogonatum neesii*	Polytrichaceae	,,
104.	*Meteoriopsis reclinata*	Meteoriaceae	,,
105.	*Philonotis mollis*	Bartramiaceae	,,
106.	*Cladonia sp.*	Cladoniaceae	Lichen
107.	*Heterodermia dissecta*	*Physciaceae*	,,
108.	*Heterodermia japonica*	*Physciaceae*	,,
109.	*Leptogium adpressum*	*Collemataceae*	,,
110.	*Leptogium austo-americanum*	*Collemataceae*	,,
111.	*Leptogium brebisonii*	*Collemataceae*	,,
(* - Endemic to Western Ghats, **- endemic to Western Ghats and under IUCN Red List)			

Plate 8. Profuse regeneration of *Clerodendrum infortunatum* in Ecologically Fragile Land.

Plate 9. Cardamom cultivation in Section 5 land

Table 32. Species composition (< 10 cm GBH) in Vested forest

	Scientific name	Family	Habit
1.	*Cinnamomum wightii**	Lauraceae	Tree
2.	*Mesua ferrea*	Guttiferae	,,
3.	*Litsea oleoides**	Lauraceae	,,
4.	*Leea indica*	Leeaceae	,,
5.	*Macaranga peltata*	Euphorbiaceae	,,
6.	*Chionanthus ramiflorus*	Oleaceae	,,
7.	*Actinodaphne malabarica***	Lauraceae	,,
8.	*Syzygium cumini*	Myrtaceae	,,
9.	*Dimocarpus longan*	Sapindaceae	,,
10.	*Palaquium ellipticum**	Sapotaceae	,,
11.	*Cullenia exarillata**	Bombacaceae	,,
12.	*Dillenia bracteata*	Dilleniaceae	,,
13.	*Neolitsea cassia*	Lauraceae	,,
14.	*Clerodendrum infortunatum*	Euphorbiaceae	,,
15.	*Sterculia guttata*	Sterculiaceae	,,
16.	*Agrostistachys indica*	Euphorbiaceae	,,
17.	*Syzygium laetum**	Myrtaceae	,,
18.	*Grewia serrulata*	Tiliaceae	Shrub
19.	*Justicia beddomei*	Acanthaceae	,,
20.	*Lasianthus acuminatus**	Rubiaceae	,,
21.	*Thottea siliquosa*	Aristolochiaceae	,,
22.	*Lepianthes umbellata*	Piperaceae	,,
23.	*Octotropis travancorica***	Rubiaceae	,,
24.	*Cyrtococcum longipes**	Poaceae	Herb
25.	*Cyrtococcum trigonum*	Poaceae	,,
26.	*Justicia japonica*	Acanthaceae	,,
27.	*Lycianthes laevis*	Solanaceae	,,
28.	*Micrococca beddomei**	Euphorbiaceae	,,
29.	*Oplismenus composites*	Poaceae	,,
30.	*Peperomia portulacoides*	Piperaceae	,,
31.	*Remusatia vivipara*	Araceae	,,
32.	*Sonerila rheedei***	Melatostoamataceae	,,
33.	*Sonerila versicolor***	Melatostoamataceae	,,
34.	*Utricularia striatula*	Lentibulariaceae	,,
35.	*Utricularia uliginosa*	Lentibulariaceae	,,
36.	*Zingiber neesanum**	Zingiberaceae	,,
37.	*Impatiens gardneriana**	Balsaminaceae	,,
38.	*Impatiens parasitica**	Balsaminaceae	,,

39.	*Impatiens scapiflora**	Balsaminaceae	,,
40.	*Cleisostoma tenuifolium*	Orchidaceae	,,
41.	*Robiquetia josephiana*	Orchidaceae	,,
42.	*Papilionanthe cylindrica*	Orchidaceae	,,
43.	*Sirhookera latifolia*	Orchidaceae	,,
44.	*Bulbophyllum sp.*	Orchidaceae	,,
45.	*Oberonia josephii**	Orchidaceae	,,
46.	*Calanthe sylvatica*	Orchidaceae	,,
47.	*Asparagus racemosus*	Lilliaceae	,,
48.	*Erythropalum scandens*	Erythropalaceae	,,
49.	*Ficus laevis**	Moraceae	,,
50.	*Hoya wightii*	Asclepiadaceae	,,
51.	*Paramignya beddome**	Rutaceae	,,
52.	*Piper mullesua*	Piperaceae	,,
53.	*Smilax zeylanica*	Smilacaceae	,,
54.	*Toddalia asiatica*	Rutaceae	,,
55.	*Tylophora indica*	Asclepiadaceae	,,
56.	*Calamus hookerianus**	Poaceae	,,
57.	*Calamus thwaitesii*	Poaceae	,,
58.	*Asplenium hindusthanensis*	Aspleniaceae	Pteridophyte
59.	*Huperzia squarrosa***	Lycopodiaceae	,,
60.	*Nephrolepis cordifolia*	Oleandraceae	,,
61.	*Bolbitis appendiculata*	Lomariopsidaceae	,,
62.	*Lepisorus nidus*	Polypodiaceae	,,
63.	*Botrychium lanuginosum*	Botrychiaceae	,,
64.	*Leptochilus axillaris***	Polypodiaceae	,,
65.	*Huperzia phlegmaria***	Lycopodiaceae	,,
66.	*Ctenidium lychnitis*	Hypnaceae	Bryophyte
67.	*Leucophanes octoblepharoides*	Leucobryaceae	,,
68.	*Isopterygium sp.*	Hypnaceae	,,
69.	*Lejeunea sp.*	Lejeuneaceae	,,
70.	*Leucoloma amoenevirens*	Dicranaceae	,,
71.	*Meteoriopsis reclinata*	Meteoriaceae	,,
72.	*Macromitrium sulcatum*	Orthotricahceae	,,
73.	*Heterodermia japonica*	*Physciaceae*	Lichen
74.	*Leptogium adpressum*	*Collemataceae*	,,
75.	*Leptogium austo-americanum*	*Collemataceae*	,,
76.	*Leptogium brebisonii*	*Collemataceae*	,,

(* - Endemic to Western Ghats, **- endemic to Western Ghats and under IUCN Red List)

4.7.2. Section 5 land

In section 5 land, 112 species belonging to trees (2), shrubs (14), herbs (60), pteridophytes (19), bryophytes (11) and lichens (6) were identified (Table 31)

4.7.3. Vested forest

. A total of 76 species including 17 trees, 6 shrubs, 34 herbs, 8 pteridophytes, 7 bryophytes and 4 lichens were identified. The details are provided in Table 32.

4.8. Soil studies

4.8.1. Soil Colour

The colour of soil profiles in each land use systems is presented in the Table 33.

4.8.1.1. Ecologically Fragile Land

In ecologically fragile land, the 0-10, 10-30 and 30-60 cm layers got hue values of 2.5YR 3/4 (dark reddish brown), 5R 2.5/4 (very dusky red) and 7.5 R 5/8 (red) respectively.

4.8.1.2. Section 5 land

In section 5 land, the surface 0-10 cm layer was very dusky red with a hue value of 7.5 R 2.5/2. The 10-30 and 30-60 cm layers had hue values 2.5YR 3/4 (dark reddish brown) and 5 YR 5/8 (yellowish red) respectively.

4.8.1.3. Vested Forest

The 0-10 and 10-30 cm layers had very dusky red (2.5YR 2.5/2) and dark reddish brown (5YR 3/3) colours. While in the 30-60 cm layer, reddish brown (10 YR 7/2) soil was observed.

Table 33. Morphological description of soil under different land use types

Land use system	Depth(cm)	Description
Ecologically Fragile Land	0-10	2.5YR 3/4 - dark reddish brown
	10-30	5R 2.5/4 - very dusky red
	30-60	7.5 R 5/8- red
Section 5 land	0-10	7.5 R 2.5/2 – very dusky red
	10-30	2.5YR 3/4 - dark reddish brown
	30-60	5 YR 5/8- yellowish red
Vested forest	0-10	2.5YR 2.5/2 – very dusky red
	10-30	5YR 3/3 - dark reddish brown
	30-60	5 YR 4/4- reddish brown

4.8.2. Physical properties of soil

4.8.2.1. Soil texture

Textural analysis revealed that soil texture is sandy loam for all the three land use system and are shown in Figs. 14-16.

4.8.2.1.1. Sand

The result of analysis of variance (Appendix I) revealed that the interaction between depth and land use system was significant. Comparison of sand fraction between land use system in each depth level (Table 34) showed that there was no significant difference in the sand content at 0-10 cm depth level for vested forest and ecologically fragile land, whereas in section 5 land the value was significantly lower (79%) than the other two land use system. At 10-30 cm depth, sand content showed significant difference across three land use systems with vested forest has higher sand fraction (82%) followed by ecologically fragile land (77%) and least for Section 5 land (75%). At 30-60 cm depth, ecologically fragile land and section 5 land showed no significant differences in sand fraction and vested forest shown significantly higher sand fraction (78%) than the other two land use system.

Comparison between different depth levels (Table 34) showed that there was no significant difference of sand content in vested forest at 0-10 and 10-30 cm depth whereas in 30-60 cm had significantly low sand fraction (78%). In ecologically fragile land, comparison between different depth levels showed that there was significant decrease in sand fraction from surface to deeper level. Though the section 5 land also showed a decrease in sand content while going deeper into the depth no significant difference was noted between 10-30 cm and 30-60 cm depth level. The sand fraction was correlated with all other soil properties except soil pH and silt fraction in ecologically fragile land. In section 5 land and vested forest, sand fraction was found to be correlated with all the studied chemical properties (Table 47-49).

Table. 34 Sand fractions across three land use systems

	Sand (%) (Mean$\pm$ SE)		
Depth (cm)	Ecologically Fragile Land	Section 5 Land	Vested Forest
0-10	82 ± 0.67^{aA}	79 ± 0.67^{aB}	83 ± 0.88^{aA}
10-30	77 ± 0.33^{bB}	75 ± 0.33^{bC}	82 ± 0.33^{aA}
30-60	73 ± 0.33^{cB}	74 ± 0.88^{bB}	78 ± 0.33^{bA}

SE-Standard error; F-value for interaction = 5.981**
CD for comparison = 1.715

Means with same small letter as superscript are homogeneous within a column
Means with same capital letter as superscript are homogeneous within a row

4.8.2.1.2. Silt

The result of analysis of variance for comparing silt fraction showed that the interaction between depth and land use system was significant (Appendix II). The comparison of silt fraction between land use systems in each depth level was given in the Table 35. It showed that there was a significant difference in the silt content at 0-10 cm depth level for vested forest and section 5 land, whereas in ecologically fragile land silt content was homogenous with that of section 5 land and vested forest. At 10-30 cm depth, significantly higher fraction was obtained for ecologically fragile land whereas section 5 land and vested forest had no significant difference in silt fraction in the soil. For 30-60 cm depth, there was no significant difference exist between ecologically fragile land and vested forest whereas section 5 land had the significantly higher silt content at this depth compared to other two land use system.

Comparison between different depth levels showed that there was no significant difference of silt content in all depth of vested forest whereas in section 5 land it was significantly different for all depth levels with an increasing trend from surface to deeper level. In ecologically fragile land, silt fraction had no significant difference between 0-10 and 30-60 cm depth. There was no significant correlation between silt fraction and other soil parameters observed in ecologically fragile land. In section 5 land, silt fraction was correlated with all soil properties except available phosphorous, bulk density (dry weight) and clay fraction (Table 47-49).

Table 35. Silt fractions across three land use systems

	Silt (%)(Mean± SE)		
Depth (cm)	Ecologically Fragile land	Section 5 Land	Vested Forest
0-10	12±0.88^{bAB}	10±0.67^{cB}	12±0.58^{aA}
10-30	18±0.33^{aA}	12±0.58^{bB}	12±0.88^{aB}
30-60	12±0.88^{bB}	20±0.33^{aA}	13±0.88^{aB}
SE-Standard error; F-value for interaction 26.200** CD for comparison = 2.087 *Means with same small letter as superscript are homogeneous within a column* *Means with same capital letter as superscript are homogeneous within a row*			

4.8.2.1.3. Clay

The result of analysis of variance (Appendix III) for comparing clay fraction showed that the interaction between depth and land use system was significant. The comparison of clay fraction between land use system in each depth level (Table 36) showed that there was no significant difference at 0-10 cm depth between vested forest and ecologically fragile land. In section 5 land, clay fraction was significantly higher at 0-10 cm from that of vested forest and ecologically fragile land but found to be homogenous in 10-30 cm depth. At 30-60 cm depth, the values of section 5 land and vested forest were homogenous whereas clay fraction at ecologically fragile land was significantly higher than other two vegetation.

Comparison between different depth levels revealed that there was no significant difference in the clay fraction at 0-10 cm and 10-30 cm depth level for all the three land use system. In the case of ecologically fragile land, 30-60 cm depth levels showed significantly higher clay fraction compared to other two levels and Section 5 land showed significantly lower clay fraction at 30-60 cm depth level. In vested forest there was no significant difference of clay content was observed between different depth levels.

Table 36. Clay fractions across three land use systems

	Clay (%) (Mean$\pm$ SE)		
Depth (cm)	Ecologically Fragile Land	Section 5 Land	Vested Forest
0-10	6 ± 1.53^{bB}	11 ± 1.16^{aA}	4 ± 0.88^{aB}
10-30	5 ± 0.58^{bA}	9 ± 1.52^{abA}	5 ± 1.16^{aA}
30-60	14 ± 1.16^{aA}	6 ± 1.16^{bB}	8 ± 1.16^{aB}

SE-Standard error; F-value for interaction 7.365**
CD for comparison = 4.014
Means with same small letter as superscript are homogeneous within a column
Means with same capital letter as superscript are homogeneous within a row

In ecologically fragile land, clay fraction was correlated with all other physical properties except silt fraction whereas in section 5 land it was correlated only with bulk density (wet weight). There was a significant negative correlation exist between organic carbon and sand fraction in vested forest (Table 47-49).

4.8.2.2. Bulk density

4.8.2.2.1. Bulk density (dry weight)

The analysis of variance result of bulk density (dry weight) confirmed that the interaction between depth and land use system was not significant (Appendix IV). The depth wise variations of bulk density (dry weight) in three land use systems are shown in Table 37 and Fig 17. The comparison of bulk density (dry weight) between

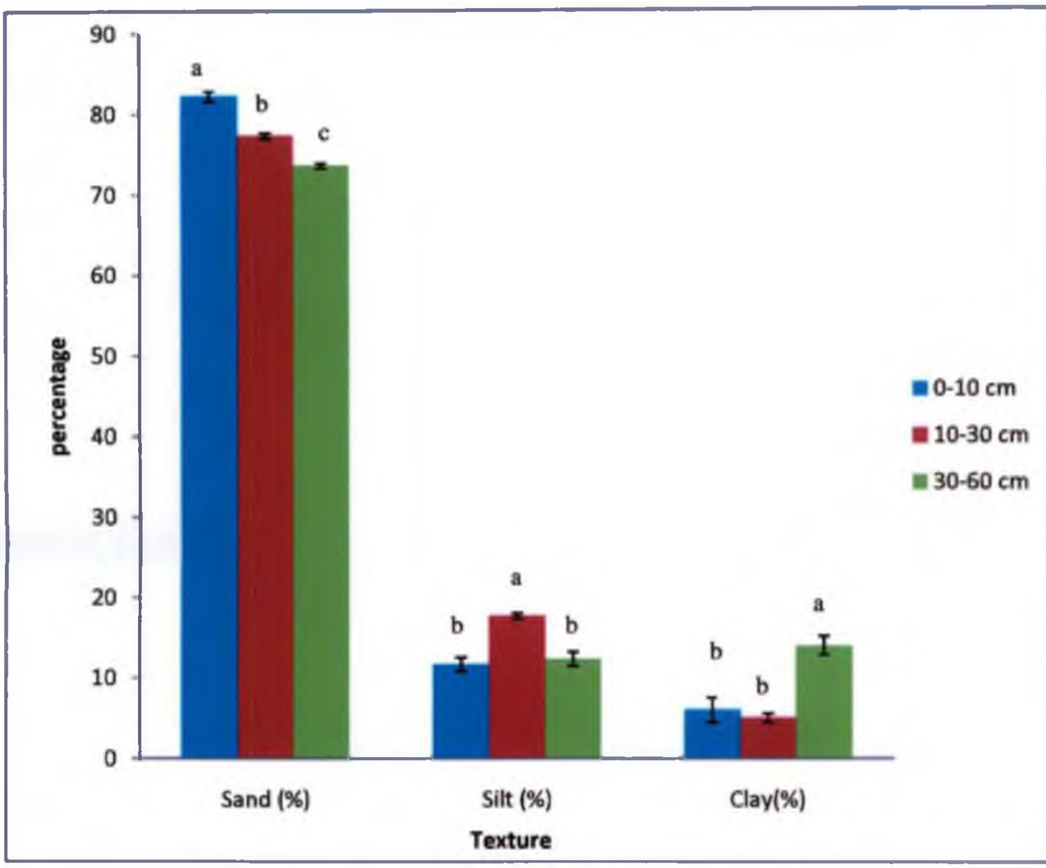


Fig.14. Textural classification of soil in Ecologically Fragile Land (error bar indicates standard error, same small letter as superscript indicates homogeneous within land use system)

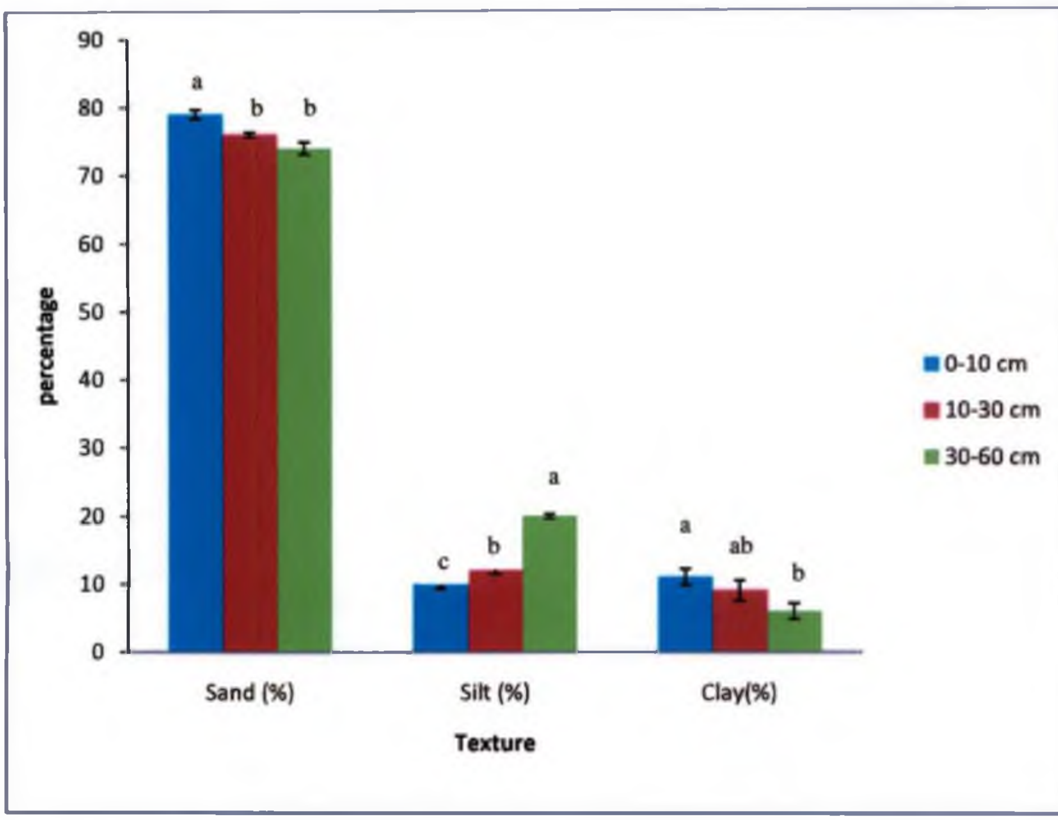


Fig.15. Textural classification of soil in Section 5 land (error bar indicates standard error, same small letter as superscript indicates homogeneous within land use system)

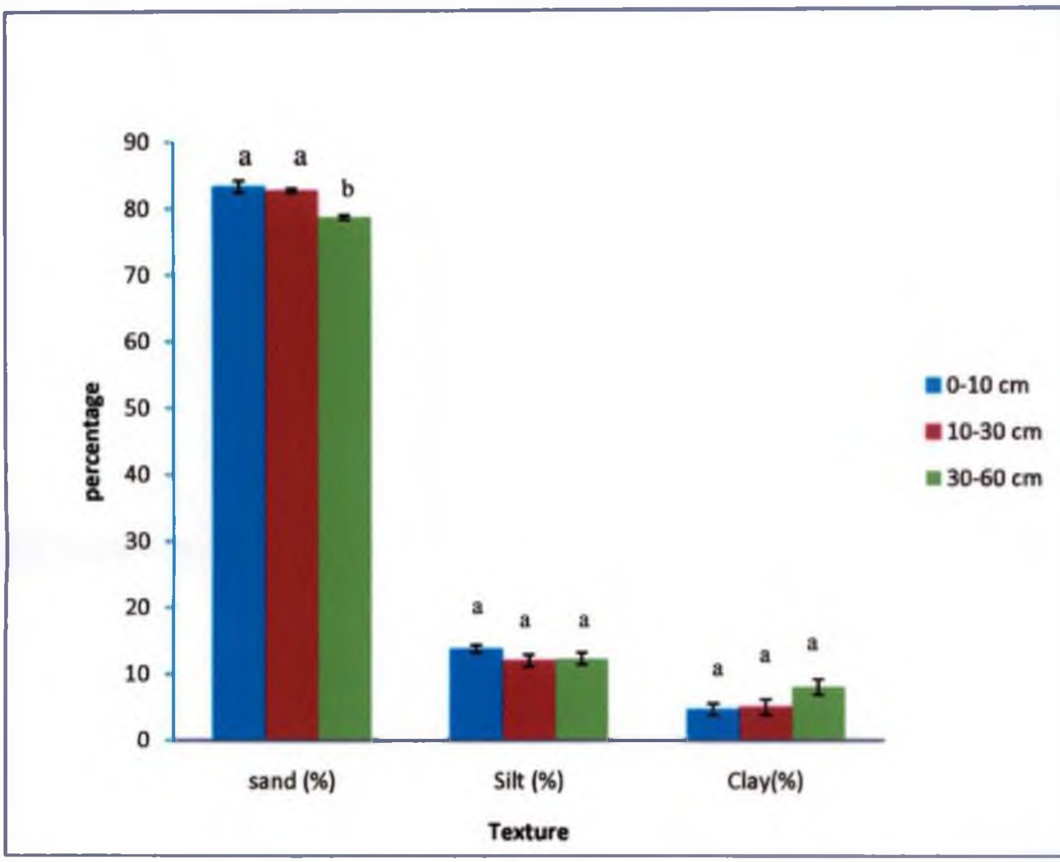


Fig.16. Textural classification of soil in Vested forest (error bar indicates standard error, same small letter as superscript indicates homogeneous within land use system)

land use system showed that bulk density (dry weight) differ significantly with higher value in section 5 land (Table 38). There was no significant correlation between bulk density (dry weight) and other soil properties in ecologically fragile land. In section 5 land, bulk density (dry weight) was correlated with all other soil properties except available potassium whereas in vested forest it was correlated with bulk density (wet weight) and sand fraction (Table 47-49).

Table 37. Bulk density (dry weight) at different depth level for each land use system

	Bulk density (dry weight) ($g\ cm^{-3}$) (Mean$\pm$ SE)		
Depth (cm)	Ecologically Fragile Land	Section 5 Land	Vested Forest
0-10	1.30$\pm$0.05	1.42$\pm$0.02	0.85$\pm$0.05
10-30	1.32$\pm$0.04	1.47$\pm$0.01	0.87$\pm$0.06
30-60	1.40$\pm$0.02	1.50$\pm$0.02	0.93$\pm$0.03
SE-Standard error; F-value for interaction = 0.176^{ns} CD for comparison = 0.108			

Table 38. Bulk density (dry weight) across three land use system averaged over all depth level

Land use system	Mean bulk density (dry weight) ($g\ cm^{-3}$)
Ecologically Fragile Land	1.34^{b}
Section 5 Land	1.46^{a}
Vested forest	0.88^{c}
F-value = 4.563* CD-value = 0.063 *Means with same letter as superscript are homogeneous*	

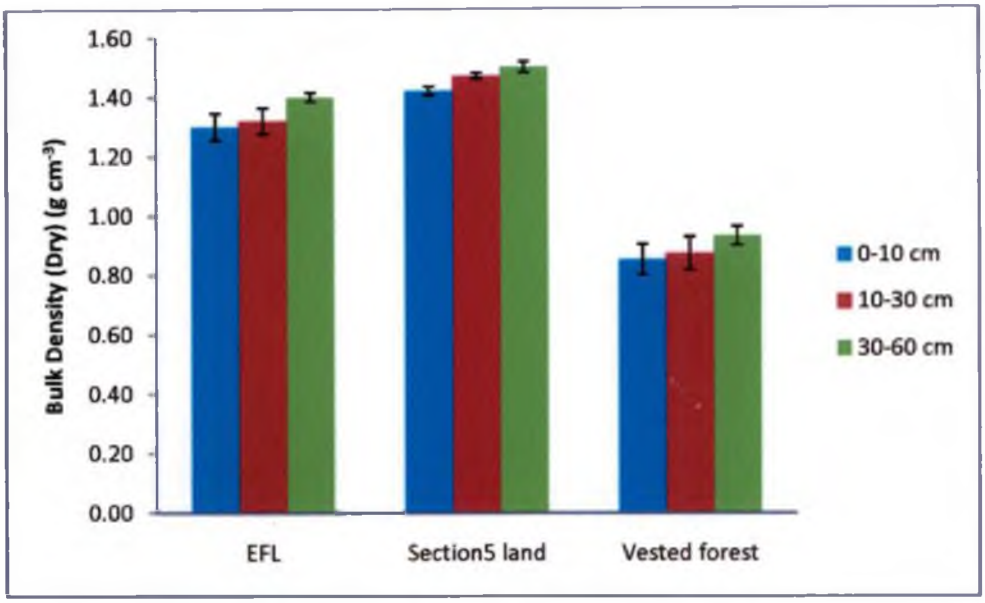


Fig.17. Bulk density (dry weight) across three land use systems
(Error bar indicates standard error)

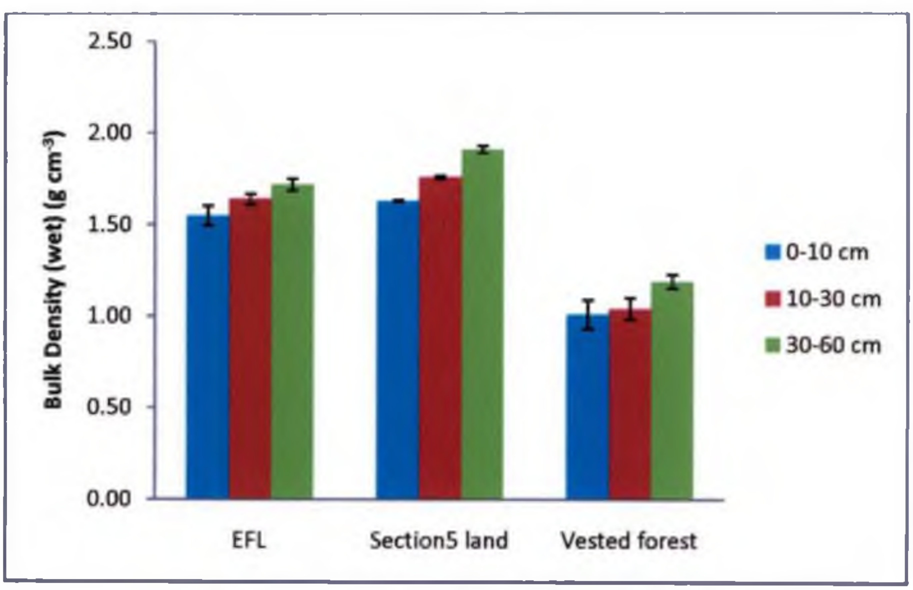


Fig.18. Bulk density (wet weight) across three land use systems
(Error bar indicates standard error)

4.8.2.2.2. Bulk density (wet weight)

The analysis of variance result of bulk density (wet weight) showed that the interaction between depth and land use system was not significant (Appendix V). The depth wise variations of bulk density (wet weight) in three land use systems were shown in Table 39 and Fig 18. The comparison of bulk density (wet weight) in all land use system showed that bulk density (wet weight) differ significantly with higher value in section 5 land (Table 40). There was no significant correlation between bulk density (wet weight) and other soil properties in ecologically fragile land. In section 5 land, bulk density (wet weight) was correlated with all other soil properties except available potassium whereas in vested forest it was correlated with bulk density (wet weight) and sand fraction (Table 47-49).

Table 39. Bulk density (wet weight) at different depth level for each land use system

	Bulk density (wet weight) (g cm^{-3}) (Mean± SE)		
Depth (cm)	Ecologically Fragile Land	Section 5 Land	Vested Forest
0-10	1.55± 0.05	1.76± 0.003	1.01± 0.08
10-30	1.64± 0.03	1.83± 0.01	1.04± 0.06
30-60	1.72± 0.03	1.91± 0.02	1.19± 0.04
SE-Standard error			

Table 40. Bulk density (wet weight) across three land use system averaged over all depth level

Land use system	Mean bulk density (wet weight) ($g\ cm^{-3}$)
Ecologically Fragile Land	1.63^{b}
Section 5 Land	1.84^{a}
Vested forest	1.08^{c}
F-value = 11.766** CD value = 0.070	
Means with same letter as superscript are homogeneous	

4.8.3. Chemical properties of soil

4.8.3.1. Soil pH

The analysis of variance showed that the interaction between depth and land use system was not significant (Appendix VI). The soil pH values in the three land use systems are shown in the Table 41 and Fig. 19. The pH values of these land use systems indicated that soil was acidic in nature.

Table 41. Soil pH across three land use system

	Soil pH (Mean± SE)		
Depth (cm)	Ecologically Fragile Land	Section 5 Land	Vested Forest
0-10	4.44 ±0.13	4.03±0.13	3.84±0.05
10-30	4.56±0.18	4.36±0.03	4.44±0.06
30-60	4.79±0.12	4.64±0.02	4.62±0.03
SE-Standard error			

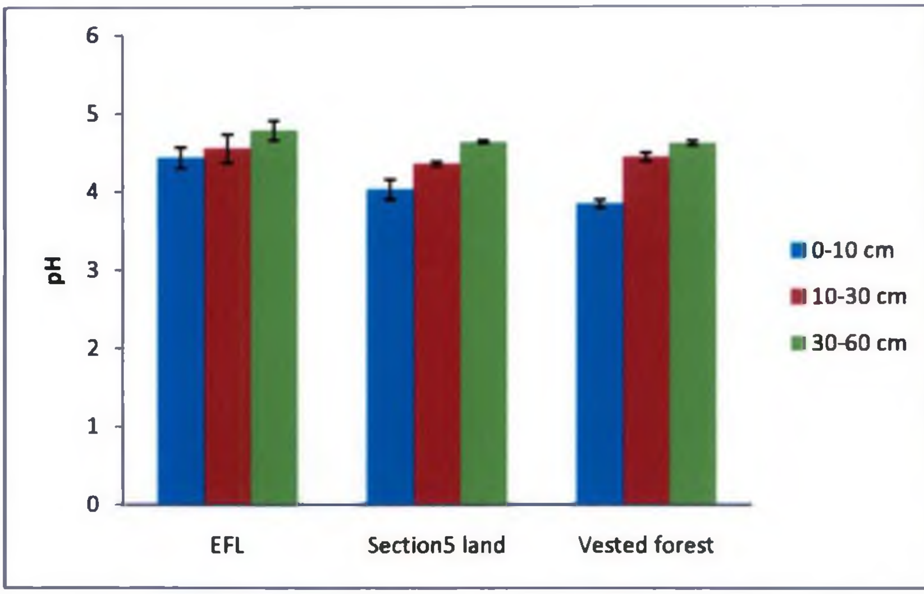


Fig.19. Soil pH across three land use systems (Error bar indicates standard error)

The comparison of soil pH in all land use system showed that pH was significantly higher (4.60) for ecologically fragile land whereas no significant differences exists between section 5 land and vested forest (Table 42). The correlation studies revealed that soil pH values were negatively correlated with other soil chemical properties of these land use systems (Table 47-49).

Table 42. Soil pH across three land use system averaged over all depth level

Land use system	Mean soil pH
Ecologically Fragile Land	4.60[a]
Section 5 Land	4.34[b]
Vested forest	4.30[b]
F-value = 23.348** CD-value = 0.177	
Means with same letter as superscript are homogeneous	

4.8.3.2. Organic carbon

The analysis of variance for comparing organic carbon showed that the interaction between depth and land use system was significant (Appendix VII). Comparison of organic carbon between land use systems in each depth level was given in the Table 43 and Fig 20. It showed that there was no difference in the organic carbon content at 0-10 cm depth level of all the three land use system. Comparison of organic carbon at 10-30 cm depth level for the three land use system showed that vested forest had significantly higher organic carbon (2.51%) at this depth level. However, there was no significant difference in the organic carbon at 10 – 30 cm depth level of ecologically fragile land and section 5 land. Comparison of organic carbon at 30 -60 cm depth level of the three land use system showed that vested forest had significantly higher organic carbon (1.25%) than Section 5 land.

Comparison between different depth level (Table 43) showed that there was significant decrease in organic carbon content from 0-10cm to 10 -30 cm and that to 30-60 cm depth level for ecologically fragile land and section 5 land. Though the vested forest also shown a decrease in organic carbon content while going deeper into the depth, no significant difference was noted in the organic carbon content between 0-10 and 10-30 cm

In ecologically fragile land, the values of organic carbon was correlated with available potassium and available phosphorous whereas in section 5 land organic carbon was correlated with all physico-chemical properties except clay fraction. In vested forest organic carbon was correlated with all soil properties except bulk density (dry) and silt fraction (Table 47-49).

Table 43. Organic carbon at different depth level for each land use system

	Organic carbon (%) (Mean± SE)		
Depth(cm)	Ecologically Fragile Land	Section 5 Land	Vested Forest
0-10	2.71±0.02^{aA}	2.61±0.01^{aA}	2.76±0.01^{aA}
10-30	1.38±0.23^{bB}	1.61±0.10^{bB}	2.51±0.03^{aA}
30-60	0.97±0.10^{cAB}	0.93±0.02^{cB}	1.25±0.14^{bA}
SE-Standard error; F-value for interaction = 8.06** , CD for comparison = 0.31			
Means with same small letter as superscript are homogeneous within a column *Means with same capital letter as superscript are homogeneous within a row*			

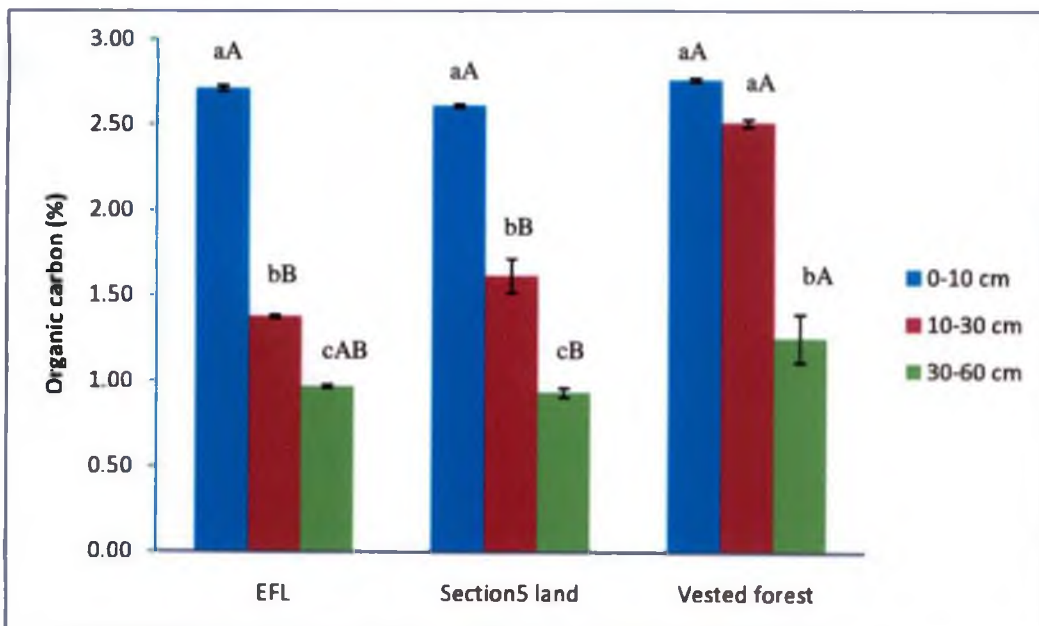


Fig.20. Organic carbon across three land use system (error bar indicates standard error, same small letter as superscript indicates homogeneous within land use system; same capital letter as superscript indicates homogeneous between land use system)

4.8.3.3. Available potassium

The analysis of variance carried out for comparing available potassium showed that the interaction between depth and land use system was not significant (Appendix VIII). The available potassium in three land use systems was shown in the Table 44 and Fig. 21. Results of comparison between vegetation showed that available potassium was higher in section 5 land (Table 45) and it had no significant difference with that of vested forest and it was significantly higher than that of ecologically fragile land. There was no significant difference observed in available potassium between ecologically fragile land and vested forest.

Table 44. Available potassium at different depth level for each land use system

	Available potassium (Kg ha^{-1}) (Mean$\pm$ SE)		
Depth (cm)	Ecologically Fragile Land	Section 5 Land	Vested Forest
0-10	318.83$\pm$37.19	357.65$\pm$34.88	414.73$\pm$24.41
10-30	129.92$\pm$44.29	233.33$\pm$33.62	120.59$\pm$22.42
30-60	93.33$\pm$17.48	160.91$\pm$44.52	64.59$\pm$7.82

Table 45. Available Potassium across three land use system for overall depth level

Land use system	Mean Available potassium (Kg ha^{-1})
Ecologically Fragile Land	180.69^{b}
Section 5 Land	250.63^{a}
Vested forest	199.97^{ab}
F-value = 54.31** CD-value = 54.64 *Means with same letter as superscript are homogeneous*	

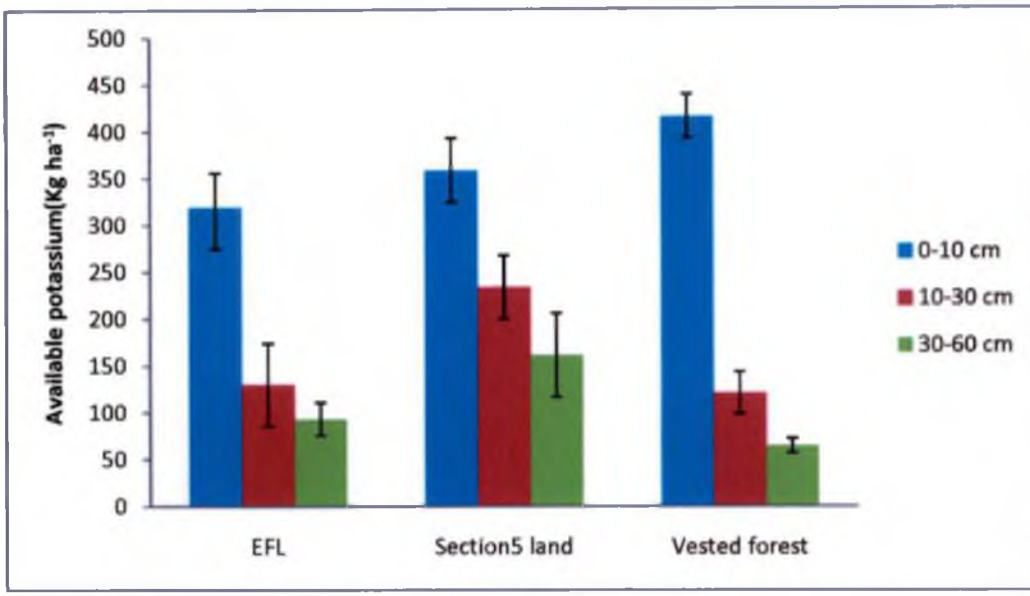


Fig. 21. Available potassium across three land use system (Error bar indicates standard error)

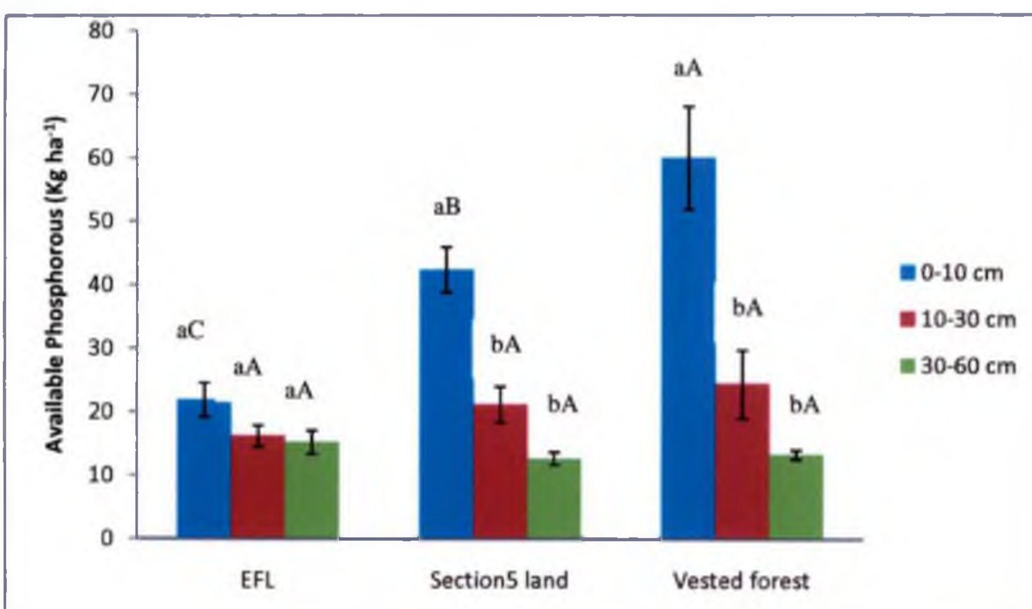


Fig. 22. Available phosphorous across three land use system (error bar indicates standard error, same small letter as superscript indicates homogeneous within land use system; same capital letter as superscript indicates homogeneous between land use system)

The values of available potassium in ecologically fragile land was significantly correlated to organic carbon whereas in section 5 land and vested forest it was correlated with organic carbon, soil pH and available phosphorous (Table 47-49).

4.8.3.4. Available phosphorous

Results of two way analysis of variance showed that the interaction between depth and vegetation was significant for available phosphorus (Appendix IX). The available phosphorous between land use systems in each depth level was given in the Table 46 and Fig. 22. Comparison of available phosphorous between land use system in each depth level showed that there was a significant difference in the available phosphorous content at 0-10 cm depth level of three land use systems. Available phosphorous was higher for vested forest (59.90 Kg ha^{-1}) followed by section 5 land (42.37 Kg ha^{-1}) and the least for ecologically fragile land (21.91 Kg ha^{-1}). Available phosphorous content at 10-30 cm and 30-60 cm depth level showed that there was no significant difference exists in three land use system.

Comparison between different depth level showed that there was no significant difference between available phosphorous in ecologically fragile land whereas in section 5 land and vested forest available phosphorous was higher in 0-10cm depth level compared to 10-30 cm and 30-60 cm depth level and no significant difference was noted in the available phosphorous in the 10-30 cm and 30-60 cm depth level.

In ecologically fragile land, available phosphorous was significantly correlated with organic carbon, bulk density (wet weight) and sand fraction whereas in section 5 land and vested forest it was significantly correlated with organic carbon, available potassium, soil pH and sand fraction (Table 47-49)

Table 46. Available phosphorous at different depth level for each land use system

	Available phosphorous (Kg ha^{-1}) (Mean$\pm$ SE)		
Depth (cm)	Ecologically Fragile Land	Section 5 Land	Vested Forest
0-10	21.91$\pm$2.68 ^{aC}	42.37$\pm$3.51 ^{aB}	59.90$\pm$8.10 ^{aA}
10-30	16.23$\pm$1.69 ^{aA}	21.10$\pm$2.82 ^{bA}	24.35$\pm$5.37 ^{bA}
30-60	15.26$\pm$1.83 ^{aA}	12.66$\pm$1.01 ^{bA}	13.31$\pm$0.71 ^{bA}

SE-Standard error; F-value for interaction = 8.72**

CD for comparison = 11.27

Means with same small letter as superscript are homogeneous within a column
Means with same capital letter as superscript are homogeneous within a row

Table 47. Correlation coefficient for the interrelationship between soil properties in Ecologically Fragile Land

	Organic carbon	Avail. K	Avail. P	pH	BD (dry weight)	BD (wet weight)	Sand (%)	Silt (%)	Clay (%)
Organic carbon	1.00								
Avail. K	0.87**								
Avail. P	0.72*	0.36							
pH	-0.32	-0.58	-0.04						
BD (dry weight)	-0.64	-0.34	-0.62	-0.15					
BD (wet weight)	-0.82**	-0.53	-0.86**	-0.05	0.87**				
Sand (%)	0.94**	0.83**	0.69*	-0.47	-0.69*	-0.84**			
Silt (%)	-0.29	-0.40	-0.19	-0.11	-0.33	-0.07	-0.12		
Clay (%)	-0.58	-0.42	-0.45	-0.31	-0.80**	0.74*	-0.75*	-0.56	1.00

** Significant at 0.01 levels; * Significant at 0.05 levels; others are non-significant

(Avail. K- Available potassium, Avail. P- Available phosphorous, BD- Bulk density)

Table 48. Correlation coefficient for the interrelationship between soil properties in Section 5 land

(Avail.	Organic carbon	Avail. K	Avail. P	pH	BD (dry weight)	BD (wet weight)	Sand (%)	Silt (%)	Clay (%)
Organic carbon	1.00								
Avail. K	0.82**								
Avail. P	0.73*	0.69*							
pH	0.90**	0.68*	0.69*						
BD (dry weight)	0.85**	-0.65	-0.77**	0.89**					
BD (wet weight)	0.95**	-0.73	0.58	0.88**	0.76*				
Sand (%)	0.91**	0.91**	0.84**	0.80*	-0.87*	-0.77**			
Silt (%)	0.89**	0.72*	-0.38	0.81*	0.66	0.90**	-0.72*		
Clay (%)	0.68	0.45	0.26	0.49	-0.53	-0.76*	0.47	-0.61	1.00

** Significant at 0.01 levels; * Significant at 0.05 levels; others are non-significant

(Avail. K- Available potassium, Avail. P- Available phosphorous, BD- Bulk density)

Table 49. Correlation coefficient for the interrelationship between soil properties in vested forest

	Organic carbon	Avail. K	Avail. P	pH	BD (dry weight)	BD (wet weight)	Sand (%)	Silt (%)	Clay (%)
Organic carbon	1.00								
Avail. K	0.72*								
Avail. P	0.73*	0.97**							
pH	-0.76*	-0.91**	-0.97**						
BD (dry weight)	-0.42	-0.43	-0.56	0.52					
BD (wet weight)	0.70*	-0.59	-0.69	0.68*	0.89**				
Sand (%)	0.93**	0.69*	0.74*	-.69*	-0.36	-0.64			
Silt (%)	0.45	-0.46	-0.54	0.53	0.89**	0.88**	-0.35		
Clay (%)	-0.69**	-0.44	-0.45	0.40	-0.15	-0.15	-0.83**	-0.22	1.00

** Significant at 0.01 levels; * Significant at 0.05 levels; others are non-significant

(Avail. K- Available potassium, Avail. P- Available phosphorous, BD- Bulk density)

Discussion

DISCUSSION

The present study was carried out for assessing the diversity of three land use systems, *viz.* a forest land, an ecologically fragile land (EFL) and a section 5 land (as per section 5 of Kerala Preservation of Trees Act, 1986) found in the South Wayanad forest division of Kerala by comparing the various floristic and edaphic attributes. The salient features of these lands with respect to the above features are discussed here under:

5.1. Vegetation

5.1.1. Floristic composition

The phytosociological analyses revealed that the species composition varied markedly between the three land use systems. The crop composition in all the three land use systems was found to be evergreen. The major associations of trees in the upper storey of ecologically fragile land were *Diospyros nilagirica- Litsea wightiana and Syzygium cumini* whereas *Melicope lunu-ankenda- Litsea oleoides* and *Persea macrantha* were the dominant trees in second storey. The lower storey of ecologically fragile land was occupied with saplings of *Litsea oleoides, Macaranga peltata and Clerodendrum infortunatum. Macaranga peltata* and *Clerodendrum infortunatum* are considered as a light demanding pioneer species (Muthuramkumar et al., 2006). Presence of these pioneer species observed in the canopy gaps of ecologically fragile land indicated the recouping of vegetation from an abandoned cardamom cultivated area to the status of a vested forest. The Bray-Curtis cluster analysis data (Fig. 23) based on the abundance of tree species illustrated that ecologically fragile land has more similarity towards section 5 land in species composition. In section 5 land, the major associations of trees in upper storey were *Litsea wightiana* and *Diospyros nilagirica* whereas *Dillenia bracteata, Myristica beddomei* and *Persea macrantha* occupied the second storey. The vested forest was dominated with *Palaquium ellipticum, Mesua ferrea and Cullenia exarillata* in the upper storey whereas

Table 50. Diversity t-test for comparing the diversity values across three land use systems

	Ecologically fragile land	Section 5 land	Vested forest
Ecologically fragile Land			
Section 5 land	0.0675[ns] (p- value)		
Vested forest	0.603[ns] (p- value)	0.006** (p- value)	
**- Significant at 1% level; ns- Non-significant			

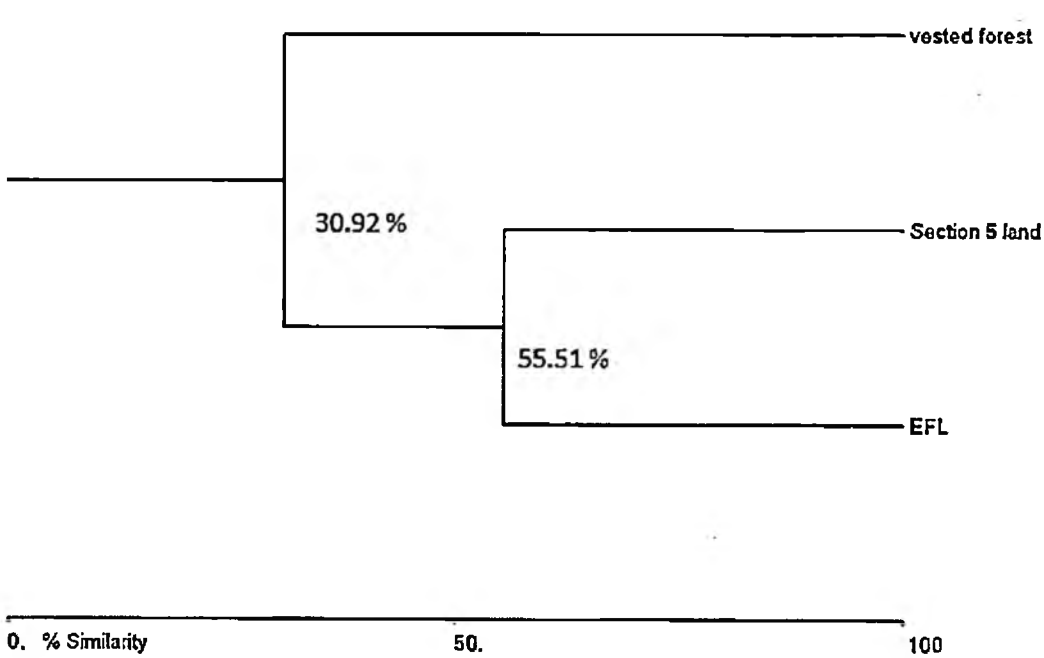


Fig. 23. Bray-Curtis cluster analysis based on abundance of tree species in three land use system

Myristica beddomei and *Dimocarpus longan* were dominated in second storey. The dominant tree species in these three land use systems revealed the same floristic composition as that of a tropical evergreen forest of Western Ghats (Swamy et al., 2010)

It is generally recognized that species abundance was positively associated with species richness (Condit et al. 1998) and provide firsthand information about the diversity of an area. In the present study, species abundance values for ecologically fragile land, section 5 land and vested forest were 65.53, 34.27 and 52.89 respectively and are positively related with species richness (40, 26 and 32 species). The species richness of these land use systems were within the range of 26-79 species ha^{-1} reported from Western Ghats (Chittibabu and Parthasarathy, 2000). Stand densities of the ecologically fragile land, section 5 land and vested forests were 411 individuals ha^{-1}, 270 individuals ha^{-1}, and 545 individuals ha^{-1} respectively. The stand density values were within the range of 257 individuals ha^{-1} to 644 individuals ha^{-1} for the evergreen forest of Western Ghats (Ayyappan and Parthasarathy, 2001; Swamy et al., 2010). The low value of stand density (270 ha^{-1}) observed in section 5 land could be due to the poor representation of trees with lower diameter classes. The frequent farming interventions in this land in all probability might have negated the chances of natural regeneration of trees.

The total basal area of ecologically fragile land, section 5 land and vested forests were 37.47 m^2, 33.60 m^2 and 44.56 m^2 respectively. Vested forest recorded the highest basal area which could be due to the presence of species with higher girth like *Palaquium ellipticum, Myristica beddomei* and *Mesua ferrea.* The low basal area of section 5 land compared to ecologically fragile land could be due to the absence of trees with lower diameter class only. However the basal area values of these land use systems are well within the range (25-47 m^2 ha^{-1}) of the evergreen forest of Western Ghats (Srinivas and Parthasarathy, 2000; Ayappan and Parthasarathy, 2001).

In an unevenaged forest the number of individuals in the lower size classes is usually large and the number in the higher classes would decrease progressively. Hence the size class frequency distribution would show a reverse 'J' shaped pattern in an uneven aged forest (Khamyong et al., 2004). A reverse 'J' shaped distribution pattern was clearly visible in the ecologically fragile land (Fig. 5) which indicated a continuous regeneration there. In vested forest, this reverse J shaped pattern is more prominent in the 0-10 and 10-20 cm diameter classes (Fig. 7). This could be due to the presence of more number of saplings than seedlings. In evergreen forests, due to high "species packing", the young recruits wait for a canopy opening to occur and then shoot up to harness the available sunlight. Hence younger diameter classes will be lower in evergreen forests. Poor stocking of younger floristic elements in the section 5 land (Fig. 6) was due to the frequent and intense cultivation interventions.

The height-frequency distribution of ecologically fragile land and vested forest (Figs. 8 and 10) showed a reverse 'J' shaped distribution pattern (excluding 0-5 m classes). No such pattern was visible in section 5 land (Fig.9). As in the case of diameter- frequency distribution, section 5 land also had poor stocking in lower height classes (0-5 m) which could be due to the poor regeneration arising out of farming interventions. Similar trend was noticed by (Kumar et al., 1995) in a study on the floristic attributes of Cardamom Hill Reserve area. A deviation in the reverse 'J' shaped pattern in the Cardamom Hill Reserve area was attributed to the systematic removal of the lower size classes. As section 5 land is a cultivated land, various farm operations, including weeding had restricted the development of young recruits.

The percentage distribution of individuals occupying different storeys in the canopy (<10 m, 10-20 m and >20 m) showed marked difference between the land use systems (Table 29). Majority of the individuals in the ecologically fragile land and vested forests were in the first storey (< 10-20 m) whereas in section 5 land, majority of the individuals were in the second storey (10-20 m). Poor stocking was observed in the third storey of all land use systems. Profile diagram is a pictorial transactional representation of a representative segment of the forest land. The typical three layered structure of evergreen forests described by Swamy et al. (2010) was noticed in ecologically fragile land and vested forest. The ecologically fragile land was a land which was long let fallow allowing the vegetation to mimic a "forest-look-alike". So a typical three layered structure of an evergreen forest can be expected in an EFL too. However in section 5 land, due to the frequent removal of trees having lower diameter classes, a third stratum was absent.

5.1.2. Indices of diversity

The Simpson's index of diversity for the three land use systems *viz* ecologically fragile land, Section 5 land and vested forest were 0.91, 0.92 and 0.93 respectively (Table 28). It indicates that for every hundred individuals taken at random in these land use systems, 91, 92 and 93 individuals belong to different species. The observed values are within the range recorded for evergreen forests of Western Ghats by several workers (Pascal and Pellissier, 1996; Reddy et al., 2008; Bhat and Kaveriappa, 2009).

The Shannon-Wiener index is an indication of the species richness as well as species evenness of an area. This index value generally ranges between 0.0 and 5.0. In this study, the Shannon-Wiener indices for the ecologically fragile land, section 5 land and vested forest were 2.93, 2.80 and 2.96 respectively. These values are within the range of 1.5 - 3.7 reported for the tropical wet evergreen forests of Western Ghats by Swamy et al. (2010). The Shannon-Wiener index value of ecologically fragile land had no significant difference with that of the vested forest in terms of floristic diversity (Table 50). Floristic diversity wise, the ecologically fragile land in the study site and the adjacent vested forest were similar.

5.2 Edaphic properties

5.2.1. Soil colour

The surface layers (0-10 cm and 10-30 cm) from all the profiles in all the land use systems were mostly dark in colour indicating the presence of organic matter accumulation (Table 33). Elsy (1989) had similar observation in the evergreen forests of Western Ghats. It was reported that the surface soils from all the profiles had darker colours ranging from greyish brown to brown indicated the presence of organic matter accumulation. According to Webster (1985), red colour in the soil profile could be associated with free iron oxide content. In this study also, a reddish colour was observed in the lower layers (30-60 cm) in all the three land use system. This could be due to the influence of iron oxide. However, more specific studies have to be done to confirm this probability.

5.2.2. Soil texture

Proportion of sand, silt and clay determines the texture of soil and in the present study soil texture observations is in line with the trend seen in forest soils. Textural analysis revealed that soils of these land use systems are sandy loam. Table 34 clearly shows that all these land use systems had more sand in the surface layers and it decreased with depth. Balagopalan (1987) working on forests in Trivandrum and Trichur divisions has reported the predominance of sand fraction in tropical evergreen and semi evergreen forests of these areas. A comparative study on the soils of Wayanad forest division carried out by Thomas (1991) also noticed the same trend of sand fraction in the evergreen forest. In this study silt did not differ much between the surface layers of all land use systems and it increased with depth in section 5 land whereas in vested forest it remains same and in ecologically fragile land it increased up to 10-30 cm and then decreased. Increase in clay content on 30-60 cm soil depth was observed in all land use system. It was reported by Alexander et al. (1986) that increase in the clay with depth was due to its translocation by the process of eluviation. The high rainfall conditions in the study area could be one probable reason for migration of clay to the lower layers.

5.2.3. Bulk density (dry and wet weight)

Bulk density is the mass of dry soil per unit bulk volume and it generally increases with depth in forest soils. The values of bulk density also provide an idea about the structure of soil (Armson, 1977). The bulk density (both dry and wet weight basis) of all the land use system increased with depth (Figs. 17 and 18). The same trend in bulk density was reported in many soil studies of Western Ghats (Thomas, 1991; Balagopalan and Jose, 1993).The lower value of bulk density in vested forest indicated that the soil was loose and porous with good aeration and drainage. This low value could be due to high organic matter deposition. Forest clearance, subsequent logging and plantation establishment also affect the soil and increased the value of bulk density (Balagopalan and Jose, 1993). Cardamom cultivation and soil conservation measures carried out in the section 5 land could be the reason for the higher values of bulk density in this land. In ecologically fragile land, the values of bulk density was reported within the range (1.23 -1.43) of evergreen forest (Balagopalan and Jose, 1995). Though this area was also subjected to disturbances, it was left fallow for considerably longer periods allowing the recouping of vegetation. Organic matter production and recycling processes will be more dynamic in this "forest-look-alike" ecosystem. This could be a reason for the low value of bulk density in the ecologically fragile land.

5.2.4. Soil pH

Tropical forest soils were developed under intense humid conditions, where leaching has depleted the bases from surface and sub surface layer. Hence the pH of these soils are generally acidic in nature (Elsy, 1989). In the present study pH values were found between a range 3.84 to 4.62 for vested forests, 4.03 to 4.64 for section 5 land and 4.44 to 4.79 for ecologically fragile land (Table 41). Lower pH values of these three land use systems can again be attributed to higher rainfall patterns in the study site and also because of the resultant low base saturation. Soil pH values were found to be increasing with depth within each profile (Fig 19). The same trend in soil pH *ie*, increasing downwards the profile was observed by Balagopalan and Jose (1995). Excessive leaching losses of exchangeable bases and continuous decomposition of organic residues under the condition of high rainfall and high temperature were the reasons for acidic nature of forest soil. The higher soil pH values in the ecologically fragile land compared to other land use system could be due to the slow decomposition of organic residues. However, more detailed investigations are required to confirm this observation.

5.2.5. Organic carbon

Generally organic carbon content in the forest soil is more in the surface horizon and decreasing downwards (Maro et al., 1993). The organic carbon content from all the land use types showed the similar trend *ie*, more in the surface horizon and decreasing downwards (Fig. 20). Nandakumar et al. (2001) observed the same pattern of organic carbon in surface horizon of natural forest in Wayanad. Contribution of litter and the diversity of vegetation cover in natural forest was the reason pointed out by Balagopalan and Jose (1993) for the high values of organic carbon in the surface layers. In all the three land use systems, the high organic carbon content could be attributed to the leaf litter as well as cycling of nutrients from deep layers. In all land use system, the presence of vegetation with high diversity and structure explains the higher organic carbon

5.2.6. Available potassium

Available potassium decreased downwards in the profile for all the three land use systems (Fig. 21). The similar trend was also reported by many workers in the soils of evergreen forest (Elsy, 1989; Balagopalan and Jose, 1995; Nandakumar et al., 2001). The higher amount of available potassium in the upper layers (0-10 cm) of all the land use system could be due to higher organic matter content, which will retain higher fraction of available potassium in the exchange complex in spite of higher plant uptake. Among the three land use system, vested forest recorded the highest value of available potassium in the top layer (0-10 cm) followed by section 5 land and ecologically fragile land. A better structure of vegetation as well as high species diversity partially explains the high amount of available potassium in the vested forest. At the same time, the higher value of available potassium in section 5 land could possibly be due to frequent fertilizer application as a part of farming activities.

5.2.7. Available phosphorous

Vested forest recorded the highest value of available phosphorous in the top layer (0-10 cm) followed by section 5 land and ecologically fragile land (Table 46; Fig. 22). The decreasing nature of phosphorus downwards the soil profile was noticed by Balagopalan and Jose (1993) in the evergreen forests of Thrissur. Similar trend of available phosphorous was observed all the three land use systems. The higher fraction of phosphorous in the upper layer of soils in all three land use systems could be due to the contribution from higher organic matter content. Litter production and consequently high organic matter production and recycling exist in these tree based ecosystems, explains the higher values of available phosphorous.

In terms of the numerous floristic and edaphic features investigated, the three land use systems did not radically differ in most of the parameters. The vegetation characters closely resembled a tropical evergreen ecosystem. The soils, too also mostly exhibited the characters of a typical evergreen forest. The basic objective was to answer questions regarding the diversity value of the "Ecologically Fragile Lands" at Thollayiram in south Wayanad Forest Division. The studied ecologically fragile land exhibited features very similar to that of the adjacent vested evergreen forest. Species composition and soil characters matched that of the vested forest. The current results confirmed the biodiversity value of this ecologically fragile land. However, more detailed biodiversity studies encompassing other biotic components like insects, microorganisms, lower plant forms etc has to be taken up to assess the true biodiversity value of this and other EFLs elsewhere. More detailed soil studies also have to be attempted to paint a complete picture. But whether the government can cite the biodiversity worthiness to take over and manage a farmer owned or privately owned land in the name of biodiversity conservation alone is open to debate.

Summary

Summary

SUMMARY

The present study was carried out to compare the various floristic and edaphic attributes of three land use systems, *viz.* a forest land, an ecologically fragile land (EFL) and a section 5 land (as per section 5 of Kerala Preservation of Trees Act (1986) found in South Wayanad Forest Division of Wayanad district of Kerala State. The results obtained are summarized below:

1. Vested forest had the maximum density of 545 individuals per hectare followed by ecologically fragile land (411) and section 5 land (270).

2. The stand basal area was the highest at vested forest (44.56 m^2) followed by ecologically fragile land (33.60 m^2) and section 5 land (37.47 m^2).

3. *Melicope lunu-ankenda* was the dominant species in ecologically fragile land whereas *Litsea wightiana* and *Palaquium ellipticum* are the dominant ones in section 5 land and vested forest.

4. Among family wise, Meliaceae was the dominant in ecologically fragile land whereas Lauraceae and Sapotaceae are the dominant families in section 5 land and vested forest.

5. The diameter frequency as well as height frequency distribution of ecologically fragile land and vested forest showed a reverse J- shaped pattern whereas section 5 land show variation in this trend which reflect the poor status of regeneration.

6. The floristic diversity was found to be maximum in vested forest with Simpson index of diversity (0.93) and Shannon-wiener index (2.86) followed by ecologically fragile land and section 5 land.

7. The Bray-Curtis cluster analysis based on the abundance of tree species illustrated that ecologically fragile land has more similarity towards section 5 land in species composition.

8. The percentage distribution of individuals occupying in different storeys showed that second and first storey are well represented in the vegetation of this area.

9. Textural analysis showed that sandy loam was the soil texture in three land use systems

10. The values of bulk density (dry weight) was ranged between 1.30 to 1.40 for ecologically fragile land whereas section 5 land it was ranged between 1.42 to 1.50 and vested forest 0.85 to 0.93.

11. Soil pH was found to be highly acidic in all the land use systems having a value ranged from 3.84 to 4.79.

12. Organic carbon was found to be maximum in the surface layer (0-10 cm) of all land use system and decreased downwards the profile. There is no significant difference in organic carbon across three land use system.

13. The comparison of available potassium across three land use systems revealed that section 5 land had high potassium content (250.63 kg ha^{-1}) followed by vested forest (199.97 kg ha^{-1}) and ecologically fragile land (180.69 kg ha^{-1})

14. The comparison of available phosphorous across three land use systems revealed that vested forest had high phosphorous content (59.90 kg ha^{-1}) followed by section 5 land (42.37 kg ha^{-1}) and ecologically fragile land (21.91 kg ha^{-1}).

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Appendices

Appendix I: Result of ANOVA for comparing Sand fraction

Source	Degrees of freedom	Sum of Squares	Mean square	F-value
Type	2	1.333	0.667	21.117**
Depth	2	12.146	6.073	192.389**
Type x Depth	4	1.017	0.254	8.055**
Error	18	0.568	0.032	
Total	26	15.065		

Appendix II: Result of ANOVA for comparing Silt fraction

Source	Degrees of freedom	Sum of Squares	Mean square	F-value
Type	2	9.852	4.926	3.325^{ns}
Depth	2	76.741	38.370	25.900**
Type x Depth	4	155.259	38.815	26.200**
Error	18	26.667	1.481	
Total	26	268.519		

Appendix III: Result of ANOVA for comparing Clay fraction

Source	Degrees of freedom	Sum of Squares	Mean square	F-value
Type	2	41.407	20.704	3.777*
Depth	2	42.741	21.370	3.899*
Type x Depth	4	161.481	40.370	7.365**
Error	18	98.667	5.481	
Total	26	344.296		

Appendix IV: Result of ANOVA for comparing Bulk density (dry weight)

Source	Degrees of freedom	Sum of Squares	Mean square	F-value
Type	2	1.669	0.834	212.525**
Depth	2	0.036	0.018	4.563*
Type x Depth	4	0.003	0.001	0.176^{ns}
Error	18	0.071	0.004	
Total	26	1.778		

Appendix V: Result of ANOVA for comparing Bulk density (Wet weight)

Source	Degrees of freedom	Sum of Squares	Mean square	F-value
Type	2	2.750	1.375	254.959**
Depth	2	0.127	0.063	11.766**
Type x Depth	4	0.007	0.002	0.319^{ns}
Error	18	0.097	0.005	
Total	26	2.981		

Appendix VI: Result of ANOVA for comparing Soil pH

Source	Degrees of freedom	Sum of Squares	Mean square	F-value
Type	2	0.470	0.235	7.309**
Depth	2	1.500	0.750	23.348**
Type x Depth	4	0.212	0.053	1.647^{ns}
Error	18	0.578	0.032	
Total	26	2.759		

Appendix VII: Result of ANOVA for comparing Organic carbon

Source	Degrees of freedom	Sum of Squares	Mean square	F-value
Type	2	1.333	0.667	21.117**
Depth	2	12.146	6.073	192.389**
Type x Depth	4	1.017	0.254	8.055**
Error	18	0.568	0.032	
Total	26	15.065		

Appendix VIII: Result of ANOVA for comparing Available potassium

Source	Degrees of freedom	Sum of Squares	Mean square	F-value
Type	2	23488.50	11744.25	3.855*
Depth	2	330904.31	165452.16	54.309**
Type x Depth	4	28638.53	7159.63	2.350^{ns}
Error	18	54836.70	3046.48	
Total	26	437868.05		

Appendix IX: Result of ANOVA for comparing Available phosphorous

Source	Degrees of freedom	Sum of Squares	Mean square	F-value
Type	2	974.89	487.45	11.276**
Depth	2	3532.00	1766.00	40.852**
Type x Depth	4	1507.36	376.84	8.717**
Error	18	778.12	43.23	
Total	26	6792.38		

FLORISTIC AND EDAPHIC ATTRIBUTES OF THREE LAND USE SYSTEMS IN WAYANAD, KERALA

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The present study was conducted in Thollayiram area of South Wayanad Forest Division of Wayanad district. The objective of the study is to compare the various floristic and edaphic attributes of three land use systems, *viz* an ecologically fragile land (EFL), a section 5 land (as per section 5 of Kerala Preservation of Trees Act (1986) and vested forest found in South Wayanad Forest Division. A total area of one hectare was surveyed in each of the three land use systems. The floristic study revealed that species richness of these land use systems were 40, 26 and 32 respectively. The major associations of trees in the ecologically fragile land were *Melicope lunu-ankenda- Litsea oleoides- Litsea wightiana* and *Diospyros nilagirica*. In section 5 land, the major associations are *Litsea wightiana- Dillenia bracteata* and *Diospyros nilagirica* whereas the vested forest is dominated with *Palaquium ellipticum, Myristica beddomei, Dimocarpus longan* and *Mesua ferrea*. Total basal area of vested forest is 44.56 m^2 followed by ecologically fragile land (37.47 m^2) and section 5 land (33.60 m^2). By comparing the Shannon –wiener index of these land use system, vested forest recorded the highest value (2.96) followed by ecologically fragile land (2.93) and section 5 land (2.80) whereas Simpson indices are 0.93, 0.91 and 0.92 respectively. Regarding vegetation structure, a typical three storeys was noticed for ecologically fragile land and vested forest but section 5 land has only two storeys. Texture analysis revealed that soil texture of these land use systems are sandy loam. The pH values of the soil ranges from 3.84 to 4.79. The higher value of bulk density was recorded for section 5 land (1.46 g cm^{-3}) followed by ecologically fragile land (1.34 g cm^{-3}) and vested forest (0.88 g cm^{-3}). There is no significant difference in the values of organic carbon and available potassium across three land use systems whereas available phosphorous was significantly higher in vested forest. The information regarding diversity of ecologically fragile land in Thollayiram will be helpful to the state forest department in designing better strategies for the long term conservation of this ecosystem.