Plant Ecological Studies on Gavi Forests; an Unlogged Tropical Rain Forest Ecosystem, Southern Western Ghats of India.

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Original Article

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Abstract

Analysis of vegetation of Goodrical Reserve forests shows that unlogged area harbours 65 arborescent species of 590 individuals /ha. On the other hand in logged area, number of species were 54 out of 579 individuals /ha. Simpson and Shannon Weiner indices of unlogged and logged area were H'- 3.08, CD-0.092 and H'- 3.60, CD-0.032 respectively. This study also shows that high endemism is seen in Goodrical R.F. and species like, *Actinodaphne malabarica, Baccaurea courtallensis, Drypetes elata, Cullenia exarillata, Palaquium ellipticum etc.* are quite common. Threatened species like, *Anacolosa densiflora* and *Memecylon subramanii* are not common in logged area and common in unlogged area. It is quite probable that these species have been extracted extensively during selection felling, till when the selection felling procedure was completely stopped in 1987, and that is why they are absent in logged area.

Key words: Endemics, Species diversity, Threatened species

Introduction

Tropical Rainforests are the largest treasures of Biodiversity. Tropical forests cover only seven percent of the earth's surface but contain 60-70 % of all living species (Myers, 1988) and among the 34 hot spots in the world two are in India *viz.* Himalayas and Western Ghats(Huge Synge, 2005). The conservation of genetic diversity of the world is possible only through sustainable maintenance and management of natural ecosystems. Anthropogenic interactions are the biggest cause in forest degradation which later leading to habitat destruction. The current rate of tropical forest loss and disturbances will result in 5- 10% loss of all tropical species per decade over the next quarter century (Mcneely *et.al.,* 1990). The rich and diverse vegetational wealth of India, undoubtedly due to its immensely varying climatic and geographical conditions with varied ecological habitats, is unique. It is therefore essential to have a reasonably fair assessment of floral and faunal components of the biodiversity for optimum utilization of resources. The multifarious human activities are destroying and diminishing earth's carrying capacity to support life that exists on this planet. Today is the outcome of evolutionary process, which is continuing over 5 million years involving speciation, selection and migration and preserve species diversity most effectively. The implementation of proper management plans must preserve the habitats and landscape structure needed by the target species, rather than ex-situ preservation of RET species.

Thus habitat conservation gained importance and we are witnessing areas set aside as National Parks, Wild Life Sanctuaries etc aiming conservation. For effective forest management and bioresource assessment, authentic and scientific studies are essential which include vegetation analysis, habitat identification, restoration of rare and endangered taxa etc. In Ranni Forest Division of Kerala, 32,535 acres of land were under selection felling and as a part of selection felling system, 27 species were identified including *Mesua ferrea, Cullenia exarillata, Myristica malabarica* etc as potential species for selection felling. The process of selection felling is practiced up to 1987 in Goodrical reserve forests and a number of rare and endangered species might have been felled during these period (Raghavan Nair, 1991). Balasubaramanian (1987) conducted a study which clearly describes that selection felling affects the phenology, dynamics of vegetation, succession etc. Based on this study in 1987, the Kerala Government had imposed a moratorium on selective logging. (Govindan Kutty, 1987).

Plant Ecological studies have a key role in the identification of gene pool and its conservational measures. A study has

been conducted during the year 2005 to gather information on ecology of plant communities in Gavi forest area, Goodrical R.F, Ranni Forest Division, Kerala with special reference to conservation aspects.

Study area

Goodrical R.F. lies between 9° 10' to 9° 30'N latitude and 76° 55' to 77° 17'E longitude in Kerala, the hill chains of Western Ghats. Two sites were selected for vegetation studies in the Goodrical R.F. Gavi forest area is unlogged in nature with less human interactions and to compare with this ecosystem another area was selected; Kullar (Selection Felled) area with similar vegetation type. The average annual rainfall received by these areas is 2000-3500 mm with high precipitation during both the South-west and the North-east monsoons with maximum rainfall in July and minimum during January. These hills belong to the crystalline rocks of Arachean age, comprising chiefly charnokites with narrow bands of Pyroxene granulites and Magnetite quartz (GSI, 1976). The soil is an oxisol, with high contents of iron, aluminium and manganese and with low contents of calcium and magnesium. Based on Chandrasekharan (1962) and Champion and Seth (1968), the vegetation of the area fall under West Coast Tropical Evergreen Forests.

Material and Methods

Stratified random sampling method was adopted for the present study. Ten, 0.1ha quadrats were established in the two study sites. In each quadrat the tree species having >30.1 cm GBH (girth at breast height) were measured and recorded (Chandrasekhara, 1998). In order to express dominance and ecological success of any species, the Importance value index (IVI) was worked out (Curtis and McIntosh, 1950). The ratio of abundance to frequency (AB/F) was also worked out to interpret the distribution pattern of the species. The values are used for categorizing the nature of distribution as, regular (<. 025), random (0.025 to 0.05), and contagious (>0.05) distribution (Curtis and Cottom 1956). Species diversity is one of the most important characteristic of a community and this was determined as per Shannon and Wiener (1963). Species dominance values were measured by following Simpson's Index (1949).

Law of frequency for homogeneity was according to Raunkier (1934), where percentage frequency values from all transects were grouped into five frequency classes and values were tested using the formula A>B>C < = > D>E.

In order to find out the girth class distribution pattern, enumerated trees were grouped into different classes *viz.* D1 (30-59.9), D2 (60-89.9), D3 (90-119.9), D4 (120-149.9), D5 (150-179.9) and D6 (>180) according to their girth at breast height.

Results and Discussion:

In Gavi, 65 arborescent species belongs to 590 individuals were recorded from one-hectare area (Table-1.) and the most

Table .1- Structural Analysis of Gavi forest area

Species	D	F	BA	IVI	AB/F
Acronychia pedunculata	150.00	40.00	232.53	5.32	0.094
Actinodaphne campanulata	10.00	10.00	240.63	1.25	0.100
Actinodaphne malabarica	30.00	20.00	312.38	2.31	0.075
Agrostistachys borneensis	1390.00	80.00	253.70	28.67	0.217
Alseodaphne semecarpifolia	70.00	40.00	602.08	4.74	0.044
Anacolosa densiflora	20.00	10.00	588.32	2.15	0.200
Antiaris toxicaria	80.00	50.00	2785.34	10.08	0.032
Antidesma menasu	70.00	40.00	130.94	3.75	0.044
Aphanamixis polystachya	20.00	10.00	121.92	1.17	0.200
Aporusa lindleyana	10.00	10.00	276.90	1.32	0.100
Artocarpus heterophyllus	10.00	10.00	1718.90	4.36	0.100
Bhesa indica	160.00	30.00	551.29	5.59	0.178
Calophyllum polyanthum	10.00	10.00	673.27	2.16	0.100
Canarium strictum	10.00	10.00	4971.59	11.22	0.100
Canthium rheedi	30.00	20.00	178.22	2.03	0.075
Cedrella toona	150.00	80.00	295.99	7.74	0.023
Cinnamomum keralense	10.00	10.00	658.72	2.13	0.100
Cinnamomum malabatrum	20.00	20.00	78.93	1.65	0.050
Clausena indica	10.00	10.00	97.44	0.95	0.100
Cryptocarya anamalayana	10.00	10.00	161.08	1.08	0.100
Cullenia exarillata	530.00	100.00	2396.32	19.75	0.053
Dimocarpus longan	120.00	50.00	358.86	5.65	0.048
Dimorphocalyx lawianus	10.00	10.00	389.77	1.56	0.100
Diospyros bourdillonii	20.00	10.00	100.25	1.12	0.200
Diospyros candolleana	50.00	30.00	445.06	3.50	0.056
Diospyros paniculata	10.00	10.00	717.90	2.25	0.100
Dysoxylum malabaricum	60.00	30.00	2070.44	7.09	0.067
Drypetes elata	430.00	100.00	722.47	14.53	0.043
Elaeocarpus serratus	110.00	20.00	186.06	3.40	0.275
Filicium decipiens	10.00	10.00	2548.72	6.11	0.100
Garcinia gummi-gutta	40.00	10.00	127.27	1.52	0.400
Garcinia morella	140.00	60.00	276.90	6.39	0.039
Gomphandra coriacea	120.00	50.00	220.99	5.36	0.048
Gordonia obtusa	10.00	10.00	3676.99	8.49	0.100
Gouania microcarpa	10.00	10.00	76.44	0.90	0.100
Heritiera papilio	10.00	10.00	2218.44	5.42	0.100
Holigarna arnottiana	10.00	10.00	1164.63	3.20	0.100
Holigarna beddomei	10.00	10.00	305.77	1.39	0.100
Hydnocarpus pentandra	10.00	10.00	423.90	1.63	0.100
Knema attenuata	120.00	70.00	812.78	7.75	0.024
Litsea ligustrina	50.00	30.00	1090.76	4.86	0.056
Litsea oleoides	30.00	30.00	683.07	3.66	0.033

Species	D	F	BA	IVI	AB/F
Macaranga peltata	30.00	20.00	375.07	2.44	0.075
Mallotus tetracoccus	10.00	10.00	1789.77	4.51	0.100
Mastixia arborea	30.00	10.00	140.32	1.38	0.300
Meiogyne pannosa	80.00	10.00	103.81	2.15	0.800
Meliosma simplicifolia	10.00	10.00	154.00	1.07	0.100
Memecylon deccanense	20.00	20.00	157.52	1.81	0.050
Memecylon subramanii	10.00	10.00	77.43	0.90	0.100
Memecylon umbellatum	40.00	20.00	196.88	2.24	0.100
Mesua ferrea	100.00	50.00	1254.86	7.20	0.040
Mesua thwaitesii	50.00	40.00	361.36	3.89	0.031
Myristica dactyloides	10.00	10.00	127.27	1.01	0.100
Myristica malabarica	30.00	20.00	625.37	2.97	0.075
Neolitsea sp	10.00	10.00	81.45	0.91	0.100
Ostodes zeylanicus	10.00	10.00	346.50	1.47	0.100
Otonephilium stipulaceum	40.00	20.00	612.50	3.11	0.100
Palaquium ellipticum	740.00	100.00	1102.52	20.58	0.074
Schleichera oleosa	300.00	60.00	301.35	9.15	0.083
Syzygium gardneri	60.00	30.00	1132.76	5.12	0.067
Syzygium laetum	40.00	30.00	173.85	2.76	0.044
Syzygium munronii	10.00	10.00	81.45	0.91	0.100
Turpinia malabarica	10.00	10.00	1145.45	3.15	0.100
Trichilia connaroides	20.00	10.00	103.09	1.13	0.200
Vateria indica	60.00	30.00	1061.16	4.97	0.067
Total	**5900.00**	**1750.00**	**47449.71**	**300.00**	**7.180**

D-Density, **F**-Frequency, **BA**-Basal area, **AB**-Abundance, **IVI**-Importance Value Index.

dominant species in top canopy, based on IVI (value in parenthesis), are *Agrostistachys borneensis* (28.67) followed by *Palaquium ellipticum* (20.58), *Cullenia exarillata.* (19.75) and *Drypetes elata* (14.53). The study site Kullar harbours 54 species out of 579 individuals/ hectare (Table-2.) The most

Table .2- Structural Analysis of Kullar forest area

Species	D	F	BA	IVI	AB/F
Actinodaphne campanulata	120.00	30.00	736.91	4.66	0.130
Aglaia lawii	240.00	50.00	178.22	6.65	0.100
Alstonia scholaris	30.00	30.00	97.44	2.00	0.030
Apodytes dimidiata	30.00	30.00	114.86	2.03	0.030
Aporusa lindleyana	220.00	80.00	103.61	7.49	0.030
Artocarpus hirsutus	30.00	30.00	11913.44	22.41	0.030
Atalantia racemosa	410.00	50.00	117.83	9.48	0.160
Baccaurea courtallensis	260.00	100.00	149.99	9.14	0.030
Cedrela toona	80.00	50.00	583.20	4.58	0.030
Cinnamomum keralense	30.00	30.00	86.63	1.98	0.030
Cinnamomum malabatrum	20.00	20.00	190.99	1.55	0.050
Clerodendrum viscosum	30.00	30.00	161.08	2.11	0.030
Croton malabaricus	30.00	30.00	114.86	2.03	0.030
Dillenia pentagyna	30.00	30.00	81.45	1.97	0.030
Diospyros paniculata	270.00	50.00	621.72	7.93	0.110
Dipterocarpus bourdillonii	30.00	30.00	267.59	2.30	0.030
Drypetes elata	90.00	30.00	517.61	3.76	0.100
Dysoxylum malabaricum	290.00	70.00	1282.99	10.30	0.060
Elaeocarpus tuberculatus	110.00	50.00	1306.98	6.35	0.040
Flacourtia montana	90.00	30.00	286.36	3.36	0.100
Garcinia gummi-gutta	210.00	30.00	462.92	5.74	0.230
Garcinia morella	20.00	20.00	223.44	1.61	0.050
Heritiera papilio	30.00	30.00	183.27	2.15	0.030
Holigarna arnottiana	30.00	30.00	1386.00	4.23	0.030
Holigarna nigra	30.00	30.00	367.82	2.47	0.030
Hopea parviflora	30.00	30.00	13371.59	24.93	0.030
Hopea racophloea	20.00	20.00	127.27	1.44	0.050
Hydnocarpus pentandra	290.00	80.00	311.58	9.06	0.050
Ixora brachiata	160.00	20.00	159.29	3.92	0.400
Knema attenuata	230.00	80.00	729.77	8.74	0.040
Leea indica	60.00	40.00	88.38	2.94	0.040
Lepisanthes erecta	60.00	30.00	305.77	2.88	0.070
Lophopetalum wightianum	40.00	40.00	673.27	3.61	0.030
Macaranga peltata	150.00	30.00	644.32	5.02	0.170
Mallotus philippensis	210.00	100.00	385.01	8.68	0.020
Mallotus tetracoccus	30.00	30.00	114.86	2.03	0.030
Myristica dactyloides	50.00	50.00	363.50	3.68	0.020
Myristica malabarica	40.00	20.00	1024.72	3.34	0.100
Nothopegia colebrookeana	20.00	20.00	876.99	2.74	0.050
Olea dioica	90.00	30.00	101.19	3.04	0.100
Otonephilium stipulaceum	110.00	50.00	218.11	4.47	0.040
Polyalthia fragrans	310.00	100.00	342.78	10.33	0.030
Schleichera oleosa	60.00	30.00	179.47	2.66	0.070
Strombosea zeylanica	240.00	70.00	633.03	8.31	0.050
Strychnos nuxvomica	40.00	20.00	187.11	1.89	0.100
Symplocos rosea	50.00	50.00	122.23	3.27	0.020
Syzygium elatum	30.00	30.00	215.09	2.21	0.030
Terminalia paniculata	40.00	20.00	3040.25	6.82	0.100
Tetrameles nudiflora	50.00	50.00	1550.19	5.73	0.020
Turpinia malabarica	240.00	80.00	567.41	8.63	0.040
Vateria indica	240.00	50.00	803.43	7.73	0.100
Vitex altissima	30.00	30.00	9033.90	17.44	0.030
Xanthophyllum arnottianum	90.00	70.00	95.60	4.79	0.020
Zanthoxylum rhetsa	20.00	20.00	86.63	1.37	0.050
Total	**5790.00**	**2280.00**	**57890.01**	**300.00**	**3.48**

dominant species are *Hopea parviflora*.(24.93), followed by *Artocarpus hirsutus* (22.41) and *Vitex altissima*. (17.44). It is evident from the study that eventhough species density wise there is not much differences from logged and unlogged localities, selection felling and its impacts made changes in species composition (Table 1&2).

Basal area refers to the ground, actually occupied by the stems, and is one of the chief character that determine the dominance. Maximum basal area at the Gavi was shown by *Canarium strictum* (4971.59cm^2 /ha) and *Gordonia obtusa* (3676.99cm^2 /ha) respectively (Table-1.) where as, in Kullar location maximum basal area was recorded with *Hopea parviflora* (13371.5959cm^2 /ha), *Artocarpus hirsutus* (11913.44cm^2/ha) and *Vitex altissima* (9033.90cm^2 /ha) (Table-2.).

Percentage Frequency denotes, occurrence of a given species in the sample plots. In Gavi, *Palaquium ellipticum, Cullenia exarillata, Cedrela toona, Drypetes elata* etc. are the most frequent species (Table-1), whereas in Kullar, *Baccaurea courtallensis ,Mallotus philippensis, Polyalthia fragrans* etc. showed more frequency (Table.2). Floristic studies have also resulted in locating an, endangered and endemic plant, *Anacolosa densiflora* , and was reported only from two places and considered to be endangered (Table.3).

Table 3. Status of conservational categories

Endemicspecies	Number In Gavi	Number In Kullar	Remarks
Actinodaphne campanulata	0	12	Rare
Actinodaphne malabarica	1	0	Rare
Anacolosa densiflora	2	0	Endangered
Artocarpus hirsutus	0	3	
Cinnamomum keralense	1	3	
Cinnamomum malabatrum	2	2	
Cryptocarya anamalayana	1	0	Endangered
Cullenia exarillata	53	0	
Diospyros bourdillonii	2	0	Critically endangered
Diospyros paniculata	1	27	
Drypetes elata	43	9	Rare
Dysoxylum malabaricum	6	29	
Gordonia obtusa	1	0	
Holigarna arnottiana	1	3	
Holigarna beddomei	1	0	Vulnerable
Holigarna nigra	0	3	Rare
Hydnocarpus pentandra	0	29	
Knema attenuata	12	23	
Litsea ligustrina	1	0	Vulnerable
Memecylon deccanense	2	0	
Memecylon subramanii	1	0	Rare, Endangered
Myristica malabarica	1	4	Vulnerable
Nothopegia colebrookeana	0	2	
Palaquium ellipticum	74	0	
Polyalthia fragrans	0	31	
Symplocos rosea	0	5	
Syzygium laetum	4	3	
Turpinia malabarica	1	24	
Total	**160**	**204**	

Regarding the distribution pattern, the Gavi study area was characterised by preponderance of contagious distribution (50 species) and the rarity of regular species (2 species), as it is evident from the ratio of abundance to frequency. All others show random distribution (in total, 13 species) - (Table-4).

At Kullar area, random distribution is more, with 32 species, followed by 17 contagious. Five species are regular distribution (Table-4).

Table 4. Distribution pattern.

TYPE	CATEGORY	LOCALITY	REGULAR	RANDOM	CONTAGIOUS
EVERGREEN	Trees	GAVI	3.13	20.31	76.56
EVERGREEN	Trees	KULLAR	9.26	59.26	31.48

According to Odum (1971) contagious distribution is the most commonest pattern in nature, random distribution occurring in the uniform environments, and regular distribution in areas where severe competition between individuals exists.

As expected, Kullar shows less species richness (R1-8.33) than Gavi (R1-10.03) (Table-5). The species diversity (H') was more in Kullar (3.60), as compared to Gavi (3.08), because the logged area will have more number of species due to canopy break and thereby establishment of light demanding species. Thus the pioneer species of the forest type was changed gradually to secondary species, ultimately changing the species composition. It was also observed that the dominance (CD) was more in Gavi (0.092) than (0.032) - (Table-5).

Table 5. Biodiversity Indices

Sites	Shannon's Species Diversity(H')	Simpson's Dominance (CD)	Margaleff's speciesrichness (R1)
Gavi	3.08	0.092	10.03
Kullar	3.60	0.032	8.33
Gavi	3.08	0.092	10.03

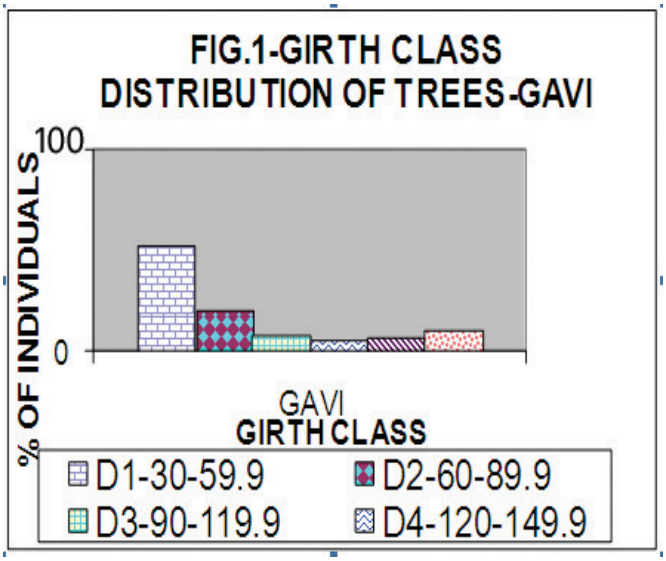
The nature of distribution was worked out and based on the study of frequency classes, both of the study areas showed heterogenous type of distribution (Table.6).

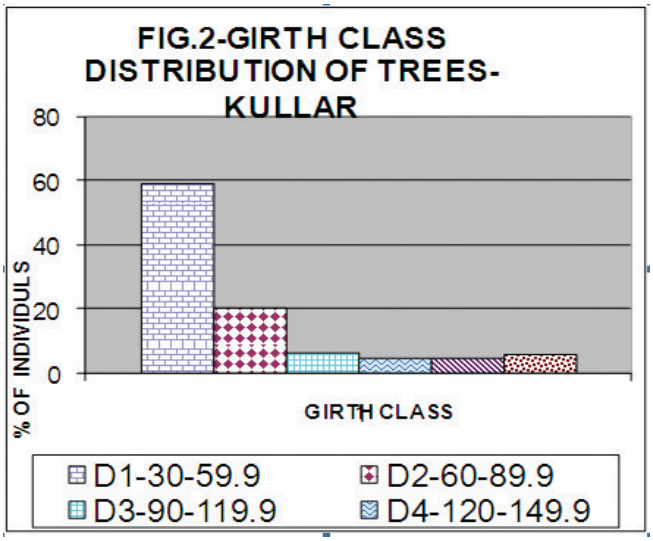
Table-6. Frequency classes evergreen forests

LOCALITY	A (0-20)	B (21-40)	C (41-60)	D (61-80)	E (81-100)	NATURE
GAVI	41	12	6	3	3	HETERO GENOUS
NILAKKAL	9	25	10	6	3	HETERO GENOUS

'L' shaped curve of girth class distribution indicates that the forest was undisturbed (Menon and Balasubramanian, 2006). The girth class distribution curve of Gavi showed the nature of undisturbed forest, as it was actually an unlogged forest ecosystem

In one of the previous study, Menon and Balasubramanian (2006) obtained 106 species of saplings/ha and 119 species of seedlings/ha from selection felled area of West coast tropical evergreen forests of Goodrical range. The non selection felled area showed the presence of 34 species of saplings/ha and 46/ha species of seedlings for West coast tropical evergreen forests. This shows that in the selection felled areas, the succession is still going on and unlogged areas it is almost saturated due to climax nature of forest species. (Fig.1 and Fig.2).





The endemic species in the flora of a geographical region, represent the biogeography of the area, centre of speciation and adaptive evolution (Nayar, 1996 and 1997). There are 1,923 taxa of flowering plants, endemic to Peninsular India (Ahmedullah and Nayar, 1987). Among the estimated 4,679 species of flowering plants in Kerala, 1637 are endemic to the Southern Western Ghats; of which 263 are reported to occur only in Kerala (Sasidharan, 2004). Nayar (1997) prepared a list of endemic plants in the study area, along the lines of IUCN (2000)- (Table-5) and the individual percentage of endemics and Rare Endangered and Threatened species were calculated. The vegetation study in Gavi area showed that out of 38.64% of total individuals represented, endemics in the category of rare, endangered and threatened are of 2.88%, and for for Kullar it was 5.01%, among 41.45% of total individuals represented (Table-5). The emergence of light demanding species is an indicator of canopy openings and forest degradation in tropical evergreen forests. The percentage representation of secondary species was 0.51% of individuals in Gavi and 11.57% of individuals in Kullar. Thus, the logged area of Kullar exhibits much higher numbers of secondary species and there by confirming its degraded nature.

Conclusion:

This study evaluates the Phytosociological aspects of Gavi forest area and the interrelationship of the tree species. *Palaquium ellipticum* and *Cullenia exarillata* association was observed at evergreen forest type of Gavi area, whereas in Kullar, *Hopea parviflora* and *Artocarpus hirsutus* association was observed.

In the case of species richness and diversity, the trend is reverse, as exemplified by the Shannon and Simpson Index. As a general rule in unlogged areas, the girth class normally follows 'L' shaped curve. This is true, in the case of Gavi area which is pristine in nature. In the selection felled areas this pattern is not encountered, and the curve shows ups and down.

The study also reveals the distribution pattern of the species. Contagious distribution is more in Gavi, which is the commonest pattern in nature. The majority of plant species shows random distribution in Kullar site. The floristic study shows that the study area harbours a large number of endemic plants and other categories of conservation importance *viz*. endangered, rare, vulnerable plants etc. As expected, the logged area housed more number of secondary species than the unlogged ones, and this could be because of the emergence of light demanding species in logged areas and thereby suppressing the growth of primary shade loving species. Normally in logged forest, species like *Macaranga peltate, Clerodendrum viscosum, Leea sp.* etc. are found at the expense of other shade loving species.

The percentage of secondary species observed in unlogged area was 0.51% as against logged area, where it was 11.57%, indicating the change in species composition in selection felled area. From this it can be inferred that in Goodrical area, even after selection felling, vegetation has recouped in better way with respect to structural status, may be due to inaccessibility , rugged and hilly terrain nature and low anthropogenic influence; but species composition has changed to secondary species from primary species.

The study also reveals that species diversity and species richness are more in logged areas as against pristine ones due to the fact that pristine forests are of climax type.

Acknowledgments:

The author is extremely thankful to Director KFRI for excellent support and Kerala State Forest Department for Financial assistance.

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Article Information	
Article history	
Received	21 October 2012
Received in revised form	21 November 2012
Accepted	2 December 2012