KFRI Research Report 152

ECOLOGICAL AND SOCIAL IMPORTANCE OF CONSERVATION OF SACRED GROVES IN KERALA

U.M. Chandrashekara
S. Sankar

KERALA FOREST RESEARCH INSTITUTE
PEECHI, THRISSUR

August 1998 Pages: 43

CONTENTS

ABSTRACT

In Kerala, based on ownership patterns, sacred groves (Kavu in the regional language, Malayalam) can be broadly categorised into three groups namely those managed by individual families, group of families and the statutory bodies for temple management (Devaswom Board). Ollur Kavu, S.N. Puram Kavu and Iringole Kavu, which represent above mentioned management systems respectively were studied for their tree species composition, vegetation structure, biomass production and nutrient cycling pattern. The study was also designed to assess the strengths and weaknesses of present management systems and role of different stakeholder groups in conserving the sacred groves.

Of the three sacred groves, the one managed by individual family (Ollur Kavu) is highly disturbed as indicated by low density of mature trees (367 ha-I) and poor regeneration potential with a ratio of 1:0.4 between mature trees and saplings. Aboveground biomass of the tree components in Ollur Kavu was also significantly lower than those recorded in other two sacred groves.

In order to quantify the level of disturbance, Ramkrishnan index of stand quality (RISQ) was calculated. The values obtained for all three tree layers (i.e., mature trees, saplings and seedlings) in single family managed sacred grove (Ollur Kavu) was between 2.265 -2.731. This indicates the dominance of light demanding species in the population and in turn, suggests that the grove is highly disturbed one. Iringole Kavu and S.N. Puram Kavu are least disturbed as indicated by lower 'RISQ values (between 1.319 and 1.648).

Estimation of nutrient pool in the aboveground biomass and litter indicated that the quantity of elements either in the biomass or in litter is a function of the absolute weight of biomass and litter respectively. However, significant difference in the weighted average nutrient concentration of biomass/litter was recorded between disturbed and relatively undisturbed sacred groves. In addition to this, larger relative turnover rate and enrichment exhibited by potassium, than by other elements both in vegetation and soil in Ollur Kavu may indicate that potassium accumulates and recycles very rapidly in early secondary succession and slowed later when the forest matures and was relatively undisturbed. It is also obvious that the reorganisation of nutrient pools varied widely among the elements analysed. Macronutrients most directly involved in metabolism and less in structure, such as potassium recycle rapidly in disturbed sites. Therefore, the present study also reveals that for a complex entity like an ecosystem, there are multiple measures for determining the effects of disturbance and ecosystem recovery processes.

Iringole Kavu and S.N. Puram Kavu were compared with some other evergreen forests of the Western Ghats of India for the parameters like stand density, basal area and species diversity of trees (gbh > 10.1 cm). Values obtained for these parameters in the two sacred groves are within the range obtained for other forests.

Stakeholder Importance Value index (SIVI) was calculated based on attributes like the proximity of the stakeholder to the sacred grove, contribution of stakeholders in managing the sacred grove, benefits being enjoyed by the stakeholder due to involvement with sacred grove and attitude of the stakeholder group towards the conservation and management of sacred grove. Stakeholder Importance Value Indices obtained for different stakeholder groups indicated that local people, temple trust and/ or sacred grove **owners** are the major stakeholders, while some other stakeholder groups such as youth clubs, schools, forest department, municipality and local Panchayat with lower SIVI are in general neutral in conserving and managing the groves.

Based on the case studies conducted in three sacred groves and discussion held in the interaction meeting of managers of several other sacred groves of Kerala. certain strategies were identified for effective management of sacred groves for the conservation of sociocultural and biological diversity existing in them. They include (a) self-imposed complete ban on the removal of biomass for maintaining the sustainability of ecosystem in perpetuity, (b) creation of awareness among local people and all stakeholder groups, (c) identification of the type of contribution a stakeholder group can offer in managing the sacred grove, and (d) encouragement of all stakeholders in management of sacred groves taking into consideration the wisdom and interest of the major stakeholder groups.

1. INTRODUCTION

The practice of assigning a patch of forest as the abode of God or Goddesses is not new. The societies of Greece, Roman, Asia and Africa had long preserved sections of the natural environment as sacred groves to God and Goddesses (Gadgil and Vartak, 1975; Khiewtam and Ramakrishnan, 1989; Hughes, 1994; Ramakrishnan, 1996). In spite of a very high land to man ratio, sacred groves which are the relicts climax vegetation have survived under a variety of ecological situations in India and they represent hot spots of biodiversity (Rao, 1996). Regardless of whether the responsibility of managing the sacred grove is under one or few families or is fully assigned to a statutory body for temple and sacred grove management, it has been a fact that many stakeholders have an interest and role to play for ensuring effective management of such systems. However, due to changing socioeconomic conditions as well as landuse systems many sacred groves are now threatened and altered in terms of size, vegetation structure and species composition. Therefore, specific objectives of the present study comprising of sacred groves of different management systems were: (a) a comparative assessment of vegetation structure biomes production and nutrient cycling pattern as influenced by the level of disturbance. (b) identification of all important stakeholder groups, (c) evaluation of present strengths and weaknesses of stakeholder groups, and d) identification with stakeholder involvement the possible potential role which could be played by individual stakeholder group for effective conservation and management of sacred groves.

The present study was also aimed to create an opportunity for the managers of sacred groves to interact among themselves and with those working on various aspects of sacred groves by conducting a meeting. The objectives of the meeting were to understand the social, ecological and economic role of different sacred groves as identified by the local people and to analyse the strength and weaknesses of present management systems as well as to chalk out the future programmes to be developed for strengthening the management and conservation efforts.

2. STUDY AREA AND METHODS

2.1. Study area

In Kerala, based on ownership patterns, sacred groves can be categorised into three types. They are, sacred groves managed by individual families, by groups of families and by the statutory agencies for temple management (Devaswom Board). Three sacred groves namely Sri Bhagavathi Kavu at Iringole (hereafter Iringole Kavu), Sri

Shangukulangara Bhagavathi Kavu at Narayana Puram (here after S.N.Puram Kavu) and a Sarpa Kavu at Ollur (here after Ollur Kavu) which are located within a radius of about 40 km were selected for the study (Figure 1) to represent each kind of management. While the Iringole Kavu is managed by a temple trust in association with the Devaswom Board), the S.N. Puram Kavu is managed by a committee comprising of a group of families and the Ollur Kavu is by an individual owner. The area of Iringole Kavu is about 10 ha and that of S.N. Puram Kavu and Ollur Kavu are about 2 ha and 1 ha respectively. These sacred groves lie between 10^{o} 10' and 10^{o} 43' N latitude and 76^{o} 15' and 76^{o} 53'E longitude. The average annual rainfall in these sites is between 2500 mm and 2680 mm. May and October are the wet months while November to April is relatively dry. Relative humidity is always greater than 55% and attains 100% during rainy season. Mean maximum temperature is between 25^{o} C to 30^{o} C while mean minimum temperature is about 18^{o} C. The soil is sandy loam to laterite and acidic with pH value ranging from 4.8 to 5.2.

2.2. Ecological analysis of sacred groves

2.2.1. Phytosociological studies

The density, frequency and basal area were estimated for tree seedlings (individuals with girth <10.0 cm and height <1 m), saplings (individuals with 10.1-30.0 cm gbh) and mature trees (individuals with gbh more than 30.1 cm). The size of the quadrats placed for studying mature trees and saplings was 10 m X 10 m while that for seedlings was I m X 1 m. In each case, the number of quadrats placed in the Iringole Kavu, S.N. Puram Kavu and Ollur Kavu was 100, 24 and 20 respectively. These quadrats were equally distributed in four sub-plots marked in each of the sacred groves. Girth at breast (gbh at 1.37 m aboveground) of all trees and saplings in each quadrat was measured for each species. For trees with larger buttresses, girth was measured at a height 2-2.5 m to avoid the buttressed part. The vegetational data were analysed for relative frequency, relative dominance and relative density. The sum of relative frequency, relative dominance and relative density represented Importance Value Index (IVI) for individuals species (Kershaw, 1973). Species diversity was calculated using a formula given by Shannon and Wiener (1963) as:

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

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

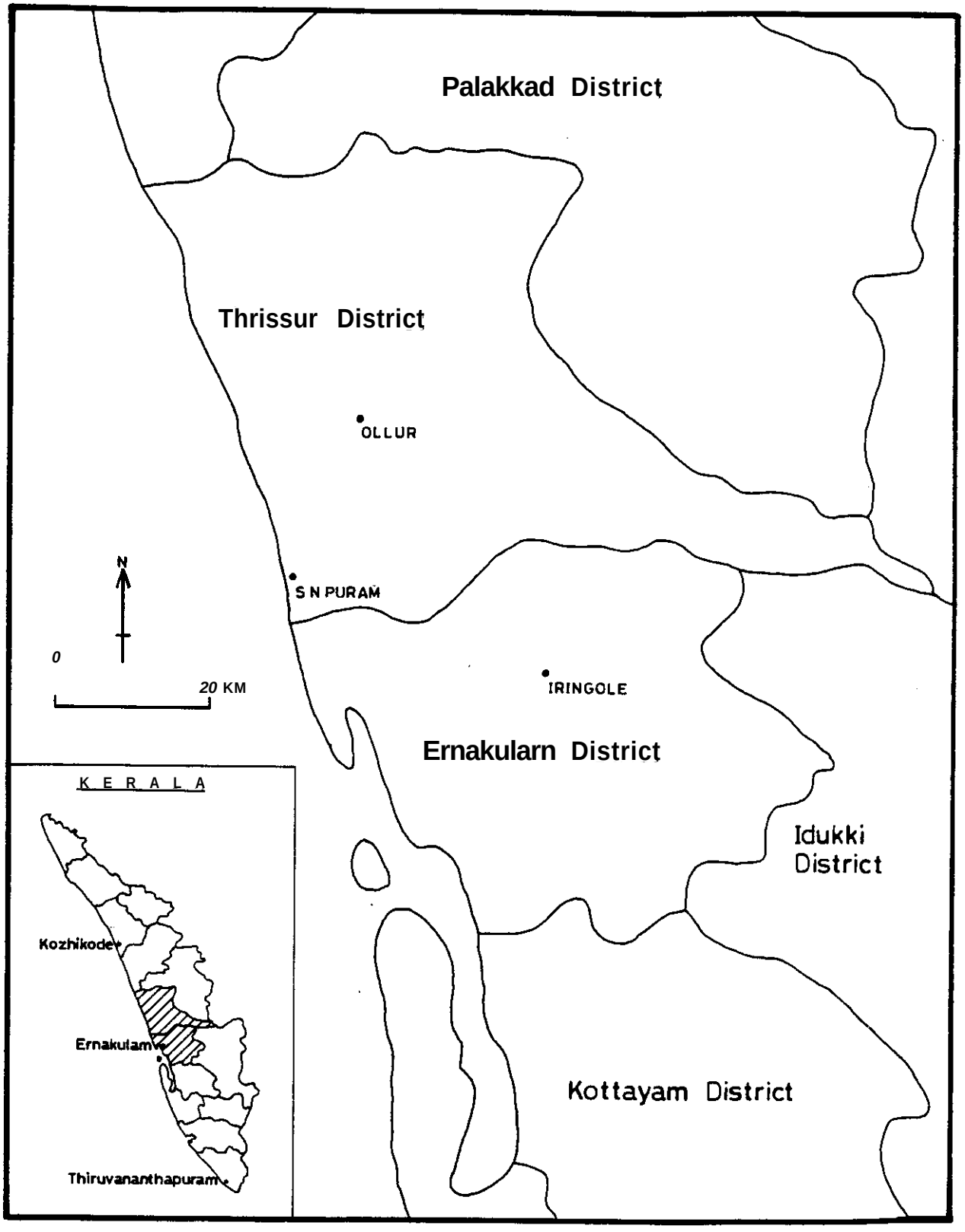

Figure 1. Locations of the Study Areas

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

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

here C is the Simpson's index of dominance, ni and N being the same as in the Shannon index of general diversity.

2.2.2. Determination of stand quality

Considering the life history patterns, tropical evergreen forest species can be categorised into primary species (shade-tolerant species), late secondary species and early secondary species (strong light demanders). Based on the available literature (Gamble,l928; Chandrasekharan,l960; Rai, 1979; Rai and Proctor,1986; Pascal 1988; Chandrashekara and Ramakrishnan,l994), species encountered in all the three sacred groves were categorised into three groups, each group with a number, the pioneer index of 1 for the group requiring a small gap for regeneration and 3 for the group of strong light demanders, with a strong canopy disturbance requirement (Appendix 1). The procedure to calculate the mean pioneer index of the forest stand given by Whitmore (1989) is modified (Chandrashekara, 1998) as:

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

where, RlSQ = Ramakrishnan Index of Stand Quality (name is given in honour of Prof. P.S. Ramakrishnan, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, India); ni and N being the same as in the Shannon index of general diversity; Pioneer Index is 1 for the species whose seedlings establish in closed canopy area but need small canopy gaps to grow up, Pioneer Index is 2 for the species whose seedlings establish in small gaps but need small to medium size gaps to grow up, and Pioneer Index is 3 for the species whose seedlings need larger canopy gaps for both establishment and growth (Appendix

The Ramakrishnan's Index of Stand Quality of a given site can vary from 1.0 (all stems of group 1 species; forest stand is undisturbed) to 3.0 (all stems are of strong light-demanding species, group 3; forest stand is highly disturbed).

2.2.3. Biomass, productivity and nutrient cycling

As already mentioned, in each sacred grove, four sub-plots were marked. In each sub-plot, biomass of tree seedlings, saplings and mature trees of each species was estimated. based on the regression equations already derived in the earlier studies carried out in the Western Ghats of India (Rai, 1983; Swamy, 1989; Chandrashekara,

1991). Those species for which regression equations are not available biomass estimation was based on the general allometric equations for tree species of Karnataka (Rai,1983). Biomass estimated in each of the four sub-plots was considered as the replicate value.

In case of Iringole Kavu, SN Puram Kavu and Ollur Kavu, 24. 12 and 8 litter traps respectively were laid out in such a manner that in a given sacred grove equal number of litter traps are distributed in four replicate sites. The size of the litter trap was I m x I m with sides 15 cm high. Litter was collected at monthly intervals (except during the rainy season when fortnightly collections were made) from March 1997 to February 1998 and categorised into leaf and non-leaf litter and then leaf litter was further separated into dominant species. The dry weight of litter produced was based on the constant weight attained after ovendrying the samples at 80°C.

The annual increment in biomass was estimated by using a 2.058% increment in the basal area (Rai. 1984). The annual litter production was added to the annual biomass increment to obtain net primary productivity. No data on herbivory were collected.

Soil sampling from four replicate sites in each sacred grove was done in March 1997 at depth of 0-10 cm, 10-20 cm and 20-30 cm. Five random samples were collected from each replicate site and a composite sample was prepared for each depth. The air-dried soil was ground, passed through a 2-mm sieve and stored in plastic containers. The sand, silt and clay contents in 2 mm air-dried soil samples were estimated by preparing soil suspensions with a dispersant (sodium carbonate + sodium hydroxide) and measuring the density of suspension at stipulated times using a standardised hydrometer.

The pH of soil was determined electrochemically in a soil-water suspension (1:2.5 by weight) using a glass electrode. Chemical analyses were done following standard procedures (Jackson, 1968; Allen et.al, 1974; Association of Official Analytical Chemists, 1980). Total nitrogen was determined by the micro-Kjeldahl method, by digestion of the soil with sulphuric acid and Kjeldahl distillation of the ammonium sulphate, which was formed. Exchangeable calcium and magnesium were extracted using 1m ammonium acetate solution (pH 7) and estimated by EDTA titration. Exchangeable potassium was extracted with sodium acetate extractant (Morgan's reagent) and estimated using **a** flame photometer.

The weight of each element in the soil was calculated using bulk density estimates (the quotient of the dry weight of the soil to the total volume it occupies in the field) from the air-dried mass of a known field volume.

For the elemental analyses of vegetation, the samples of fifteen trees species, five each from categories like primary, late secondary and early secondary were considered. In each case leaves, branches and main stems were analysed separately. Litter samples were also separated into leaf and non-leaf parts and leaf litter was further categorised as primary, late secondary and early secondary species.

Oven dried plant and litter samples were ground and passed through a 0.5 mm sieve and analysed following standard procedures (Allen et. al.,1974). Nitrogen was determined from Kjeldahl digestion. After wet digestion with triple acid, calcium and magnesium were estimated titrimetrically, while potassium was estimated by the flame photometry method. Species already studied by Chandrashekara (1991) for the nutrient contents in their biomass and litter were not chemically analysed; instead available data were used.

The quantities of the various elements in the biomass were estimated based on the biomass values obtained for the tree components at each replicate site. In the same way, amounts of various nutrients returned through the litter were computed based on the annual litter production.

In the present study only the cycling of elements between the soil and tree components was considered. The fractional annual turnover of each element was calculated as the quotient of the weight that left the compartment and the weight held in the compartment expressed as percentage (Reiners and Reiners, 1970). Thus for the vegetation, the weight of a given element lost through litterfall was divided by the weight of that element held in the vegetation. Similarly, for the soil, the weight of an element taken up by the tree component was divided by the weight of that element held in the soil. To compare the rates at which elements were incorporated into the vegetation, the enrichment ratio was calculated for each element as the ratio between the annual rate of uptake of an element divided by its amount stored in the biomass (Woodwell et.al.. 1975). Cycling of a given element in the soil was calculated by dividing the amount of element input annually through litterfall by the amount of the element stored in the soil.

2.2.4. Statistical analysis

Statistical analyses between three sacred groves for each of the parameter studied were examined through analysis of variance (ANOVA). If the ANOVA value was found to be significant ($P \leq 0.05$ -0.001), the parameter mean value were compared using Fisher's least significant difference (LSD) test.

2.3. Sociological analysis of sacred groves

2.3.1. Identification of stakeholders

People, organisations and institutions enjoying benefits and helping or are potential to help in conservation and management of these sacred groves were identified based on surveys and semi-structured interviews. These surveys and interviews were also designed to identify criteria, which could be attributed in relative terms to each of the stakeholder group. These criteria include (a) proximity of the stakeholder *to* the sacred grove, (b) direct material and nonmaterial benefits as well as indirect benefits being enjoyed by the stakeholder, (c) man-power, financial and other contribution of stakeholders in managing the sacred grove and (d) attitude of stakeholders towards the conservation and management of the sacred grove. In Table 1 is given the methods employed in scoring each stakeholder for the given attribute.

2.3.2. Derivation of Stakeholder Importance Value Index (SIVI)

This is a new method used for assessing the role, interests, characteristics and circumstances of stakeholder groups in conserving and effective management of a natural resource. The scores given for all the stakeholders for each attribute were summed and the relative value obtained for a given attribute by each stakeholder was calculated. The sum of the relative values obtained for all the attributes by a given stakeholder group was its SIVI. Higher the SIVI of a stakeholder group more is its importance among all stakeholder groups.

2.3.3. Derivation of Stakeholders' Role Index (SRI)

In order to compare the role played by stakeholders in different sacred groves, Stakeholders' Role Index (SRI) value was **calculated. For the purpose, attributes such as benefits enjoyed by the stakeholder groups, contributions of stakeholders in managing the sacred grove and the attitude of stakeholders towards conservation and management of sacred grove were considered. First, the Number**

Table 1. Attributes of stakeholders of the sacred grove and their rating

Attributes		Score
1.	Proximity	
1.1.	Stakeholder group residing within 1 km radius of the sacred grove	2
1.2.	Stakeholder group residing farther (>I km radius of the sacred grove)	1
2	Direct benefits	
2.1.	Direct material benefits	
2.1.1.	As the major source of livelihood	3
2.1.2.	Due to highest investment for the management of sacred grove	2
2.1.3.	Without investing directly for the management of sacred grove	1
2.2	Direct non-material benefit	
2.2.1.	If stakeholders feel that they are receiving blessings of God, peace of mind and happiness due to visit to sacred grove	2
2.2.2.	If stakeholders are indifferent	1
3.	Contributions	
3.1	Manpower contribution	
3.1.1	Active in manpower contribution for the protection and management of the system	1
3.1.2	Otherwise	0
3.2	Financial contribution	
3.2.1	Relatively high financial contribution	2
3.3.3	Relatively moderate financial contribution	1
3.1.1	No financial contribution	0
3.3	Other contribution	
3.3.1	Capable of influencing in decision making level to deal with problems and issues related to sacred grove management	1
3.3.2	Otherwise	0
4.	Attitude	
4.1.	Showing greater interest with sincerity and dedication to work for sacred grove management	2
4.2.	Working due to commitment	1
4.3.	Neutral or passive attitude	0

of stakeholder groups to obtain the expected maximum total for a given attribute multiplied maximum value assigned to each attribute. Total real value obtained for the given attribute was divided by its expected total value. Such values obtained for all attributes were added together and represented in percentage as the Stakeholders' Role Index (SRI). Higher the SRI value, better the role of stakeholders in using and managing the sacred grove.

2.4. Interaction meeting of sacred grove holders

A list of addresses of sacred groves in Kerala was prepared with the help of certain NGOs and people. Invitations were sent to the managers of about 40 sacred groves to participate in the interaction meeting. The managers were also asked to prepare a write-up about the extent of their sacred grove, vegetation type, present management systems, problems and prospects in managing their sacred groves.

3. RESULTS

3.1. Phytosociology of tree species

In Iringole Kavu, totally 51 tree species were recorded. *Hopea ponga* and *Artocarpus hirsutus* were the dominant species in all three stages namely, mature phases (individuals with girth <10.0 cm and height <1 m), sapling phase (individuals with 10.1-30.0 cm gbh) and seedling phase (individuals with girth <10.0 cm and height <1 m) (Table 2). Out of 18 species represented in mature phase 11 were also seen in sapling and seedling phases. *Adenanthera pavonina, Celtis timorensis, Macaranga peltata, Trema orientalis* and *Vitex altissima* observed in the mature tree and sapling phases were absent in seedling phase. In S.N. Puram Kavu, while *Hopea ponga* and *Memecylon umbellatum* were the dominant species in mature tree phase and sapling phase, *Memecylon umbellaturn, Artocarpus hirsutus* and *Hopea ponga* were dominant in seedling phase. In the case of Ollur Kavu, *Strychnos nux-vomica* was the dominant species in mature phase and seedling phases while *Tabernaemontana heyneana* was dominant at sapling stage. Total number of tree species recorded in S.N. Puram and Ollur Kavu were 17 and 24 respectively. Values for the density and basal area of mature trees (more than 30.1 cm gbh) were higher in S.N. Puram Kavu than in Iringole Kavu (Table **3).** On the other hand, in the case of sapling and seedling phases these values were more in Iringole Kavu followed by S.N.Puram Kavu and Ollur Kavu. The ratio between the density of mature trees, saplings and seedlings were 1: 4:165, 1:2:32 and 1:0.4:73 respectively in Iringole, S.N.Puram and Ollur. The size

Table 2. Tree species and their Importance value indices values in Iringole Kavu, S.N. Puram Kavu and Ollur Kavu, in Kerala, India

	Iringole Kavu	S.N.Puram Kavu	Ollur Kavu
Mature trees			
Adenanthera pavonina L.	0.6		
Ailanthus triphysa (dennst.) Alston			5.9
Alstonia scholaris (L.) R.Br.			19.6
Anacardium occidentale L.			8.7
Areca catechu L.			9.0
Aporosa bourdillonii Stapf.***	3.8		
Aporosa lindleyana (Wt.) Baill.		1.6	
Artocarpus hirsutus Lamk.***	64.7	9.8	
Borassus flabellifer L.			16.6
***Bridelia retusa* (L.) Spreng.**			4.7
***Celtis timorensis* Spanoghe**	0.7		
Cinnamomum malabathrum (Burm.f.)Bl.**	0.6		
Cocos nucifera L.			6.7
Eriodendron pentandrum Kurz.			4.6
Ficus benghalensis L.		4.7	
Ficus microcarpa L.f.			48.1
Ficus mysorensis Heyne	0.7		
Garcinia gummi-gutta (L.)Robs.		8.1	
Holigarna arnottiana Hk.f.***	7.7	3.0	
Hopea parviflora Bedd.***	39.0		
Hopea ponga (Dennst.) Mabbef**	83.0	166.1	
***Hydnocarpus pentandra* (B.-H.)Ok**		1.5	
Litsea laevigata (Nees) Gamble	4.1		
Macaranga peltata (Roxb.) *M.* -A.	2.4		
Mammea suriga (B.-H. ex Roxb.)Koster.	5.7		
Mangifera indica L.			40.8
Memecylon umbellatum Burm.f.		67.1	
Mesua ferrea L.***	21.4		
Morinda tinctoria Roxb.ex DC.			9.0
Moringa oliefera Lamk.			4.3
Myristica malabarica Lamk. ***	1.2		
Naringi crenulata (Roxb.) Nicolson			14.1
Olea dioica Roxb.		2.0	
Pajanelia longifo/ia (Willd.) *K.S.*	0.6		
Plumeria alba L.			4.5
Polyalthia fragrans* (Dalz.)Bedd.	10.9		

*, Endemic to peninsular India; **, Endemic to Western Ghats, India; Endemic to South-western Ghats, India.

Table 2 (Cont'd). Tree species and their Importance value index values in Iringole Kavu, S.N. Puram Kavu and Ollur Kavu, in Kerala, India

	Iringole Kavu	S.N.Puram Kavu	Ollur Kavu
Mature trees (cont'd)			
Prunus ceylanica (Wt.) Miq.	0.7		
Quassia indica (Gaertn.) Nooteb.		3.1	
Schleichera oleosa (Lour.) Oken			4.2
Strychnos nux-vomica L.	0.6		75.2
Syzygium caryophyllatum (L.) Alston		14.5	
Syzygium cumini (L.) Skeels	4.2		10.2
Syzygium rubikundam Wt. & Arn.	1.6		
Tamarindus indica L.			4.8
Trema orientalis (L.) Bl.	5.6		
Vateria indica L.***	37.3	1.5	
Vitex altissima L.	2.4	1.6	
Xanthophyllum flavescens Roxb.		15.4	
Tree saplings			
Adenanthera pavonina L.	0.9		
Aglaia elaeagnoidea Juss.*	0.5		
Antiaris toxicaria (Pers.) Lesch.**	0.9		
Antidesma menasu Miq.ex Tul.	0.5		
Antidesma zeylanicum Lamk.	1.3		
Aporosa bourdillonii Stapf.***	27.4		
Aporosa lindleyana (Wt.) Baill.	0.2	12.8	
Artocarpus hirsutus Lamk.***	82.5	29.4	
Canthium umbellatum Gamble	0.2		
Caryota urens L.	0.3		
Cassia fistula L.			13.9
Celtis timorensis Spanoghe	0.2		
Cinnamomum malabathrum (Burm.f.)Bl.**	3.1	7.5	
Dichapetalum gelonioides Engl.		1.6	
Elaeagnus kolaga Schlecht	0.2		
Ficus tsjahela Burm.f.	0.2		
Ficus virens Ait.	0.2		
Flocourtia montana Grah.	0.8		
Garcinia gummi-gutta (L.)Robs.		12.1	
Holigarna arnottiana Hk.f.***	25.5	10.9	

----cont'd----

*, Endemic to peninsular India; **, Endemic to Western Ghats, India;

***, Endemic to South-western Ghats, India.

Table 2 (Cont'd). Tree species and their Importance value index values in Iringole Kavu, S.N. Purarn Kavu and Ollur Kavu, in Kerala, India

	Iringole Kavu	S.N.Puram Kavu	Ollur Kavu
Tree saplings (cont'd)			
Hopea parviflora Bedd.***	2.0		
Hopea ponga (Dennst.) Mabber***	83.0	119.8	
Hydnocarpus pentandra (B.-Ham.)Oken***	0.3	6.9	
Ixora brachiata Roxb.	0.9		
Litsea laevigata Nees) Gamble***	6.0		
Macaranga peltata (Roxb.) M. -A.	3.4		
Mallotus tetracoccus (Roxb.) Kurz.	0.2		
Mammea suriga (B.-H. ex Roxb.)Koster.	22.0		
Memecylon umbellatum Burm.f.		91.6	
Mesua ferrea L.***	0.8		
Mimusops elengi L.	0.5		
Morinda tinctoria Roxb.ex DC.			29.3
Myristica malabarica Lamk. ***	4.8		
Naringi crenulata (Roxb.) Nicolson			31.3
Olea dioica Roxb.		3.4	
Polyalthia fragrans (Dalz.)Bedd.***	5.2		
Prunus ceylanica (Wt.) Miq.	1.9		
Santalum album L.			25.8
Streblus asper Lour.	0.2		
Strychnos nux-vomica L.			76.9
Syzygium caryophyllatum (L.) Alston		2.6	
Tabernaemontana heyneana Wall.**	1.0		125.3
Trema orientalis (L.) Bl.	0.3		
Vateria indica L.***	22.2		
Vitex altissima L.	0.3		
Wrightia tomentosa Roem. & Schult.	0.7		
Xanthophyllum flavescens Roxb.		10.1	
Zanthoxylum rhetsa (Roxb.) DC.	0.3		
Tree seedlings			
Ailanthus triphysa (Dennst.) Alston			29.2
Antidesma menasu Miq.ex Tul.	0.7		
Antidesma zeylanicum Lamk.	31.8		
Aporosa bourdillonii Stapf.***	7.8		
Aporosa lindleyana (Wt.) Baill.	0.2		
Arenga wightii Griff.**	0.5		

---cont'd---

*, Endemic to peninsular India; **, Endemic to Western Ghats, India;

***, Endemic to South-western Ghats, India.

Table 2 (Cont'd). Tree species and their Importance value index values in Iringole Kavu, S.N. Puram Kavu and Ollur Kavu, in Kerala, India

	Iringole Kavu	S.N.Puram Kavu	Ollur Kavu
Tree seedlings (cont'd)			
Artocarpus hirsutus Lamk.***	43.1	49.3	
Borassus flabellifer L.			33.8
Canthium umbellatum Gamble	3.2		
Caryota urens L.	2.8		
Cinnamomum malabathrum (Burm.f.)Bl.***	34.5	14.6	
Garcinia gummi-gutta (L.)Robs.	0.3	29.0	
Holigarna arnottiana Hk.f.***	8.3	10.8	
Hopea parviflora Bedd.***	11.9	23.4	
Hopea ponga (Dennst.) Mabber***	52.8	35.2	
Hydnocarpus pentandra (B.-Ham.)Oken***	0.2	18.8	
Ixora brachiata Roxb.	19.2		
Litsea laevigata Nees) Gamble***	0.5		
Mallotus tetracoccus (Roxb.) Kurz.	0.5		
Mammea suriga (B.-H. ex Roxb.)Koster.	25.1		
Memecylon umbellatum Burm.f.		83.2	
Mangifera indica L.	0.3		
Memecylon sp.	23.5		
Mimusops elengi L.	0.2		
Myristica malabarica Lamk. ***	0.2		
Naringi crenulata (Roxb.) Nicolson			47.4
Nothopegia beddomei Gamble **	3.9		
Olea dioica Roxb.	1.5	5.5	61.0
Persea macrantha (Nees) Kosterm.	1.2		
Photinia integrifolia Lindl.	0.2		
Polyalthia fragrans (Dalz.)Bedd.***	21.9		
Quassia indica (Gaertn.) Nooteb.		3.6	
Strychnos nux-vomica L.			128.6
Tabernaemontana heyneana Wall.**	0.2		
Theobroma cacao L.	0.2		
Vateria indica L.***	2.4		
Wrightia tomentosa Roem. & Schult.	0.2		

*, Endemic to peninsular India; **, Endemic to Western Ghats, India;

***, Endemic to South-western Ghats, India.

Table 3. General characterisitcs of the tree strata of Iringole Kavu, S.N.Puram Kavu and Ollur Kavu in Kerala, India

Parameters	Location		
	Iringole Kavu	S.N. Puram Kavu	Ollur Kavu
Number of species			
Mature trees	23	14	20
Saplings	37	12	6
Seedlings	31	11	4
Density (trees ha^{-1})			
Mature trees	657	665	367
Saplings	2682	1178	130
Seedlings	108536	21000	26678
Basal area (m^2 ha^{-1})			
Mature trees	31.6	51.4	45.5
Saplings	5.7	1.8	0.09
Seedlings	41.2	15.3	10.1
Species diversity (H)			
Mature trees	3.102	2.140	3.579
Saplings	3.117	2.529	2.206
Seedlings	3.640	3.017	2.093
Species dominance (C)			
Mature trees	0.163	0.364	0.120
Saplings	0.178	0.126	0.270
Seedlings	0.102	0.152	0.272
Ramakrishnan Index of Stand Quality (RISQ)			
Mature trees	1.319	1.404	2.265
Saplings	1.439	1.648	2.731
Seedlings	1.407	1.610	2.368

Seedlings: GBH< 10.0 cm and height <1m ; Saplings: GBH 10.1-30.0 cm ; Mature trees: GBH > 30.1 cm.

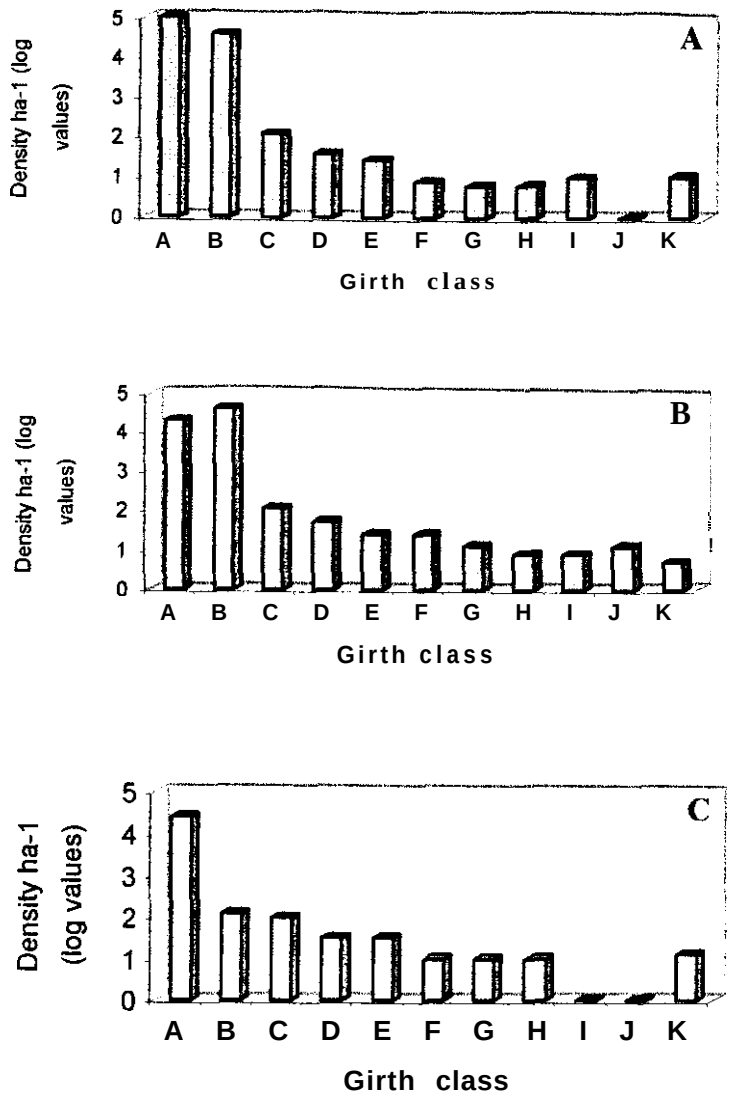

Figure 2. Density (plants ha-I) distribution of tree seedlings, saplings and mature trees into size-classes in Iringole Kavu (A), SN Puram Kavu (B) and Ollur Kavu (C), Kerala, India. Size classes: A, tree seedlings (girth <10.0 cm and height >1m); B, saplings (gbh 10.1-30.0cm); C-L, mature trees, gbh 30.1-60.0, 6-.I-90.0, 90.1-300.0 and>300.1 cm respectively.

class distribution of seedlings, saplings and mature trees in Iringole Kavu and S.N. Puram showed a typical negative exponential distribution with a clear preponderance of stems of small girth classes (Figure 2). Whereas in case of Ollur Kavu such a sharp 'L' shaped curve was not seen.

Shannon index of diversity for all three phases has a higher values in Iringole Kavu than in other two sacred groves (Table 3). The values for Ramakrishnan Index of Stand Quality (RISQ) for mature trees, saplings and seedlings are within the range between 1.319 to 1.439 in case of Iringole Kavu. between 1.402 to 1.648 in case of S.N. Puram Kavu and between 2.368 to 2.731 in case of Ollur Kavu.

3.2. Biomass, litter production and nutrient cycling

Total aboveground biomass and the annual increment in aboveground biomass by the tree components were more in Iringole Kavu followed by SN Puram Kavu and Ollur Kavu (Table 4). However, annual litter production was more in SN Puram Kavu followed by Ollur Kavu and Iringole Kavu.

The quantities of elements in the aboveground biomass were essentially a function of the biomass (Table 5). In general, the trend of the rate of nutrient release through litter fall in three sacred groves followed the litter production patterns except for potassium whose release was more in Ollur Kavu followed by SN Puram Kavu and Iringole Kavu. Uptake of potassium was also more in Ollur Kavu than in other sacred groves (Figure 3). The general trend of element accumulation, release and uptake in the three sacred groves was N>Ca>K>Mg.

The fractional annual turnover and the enrichment quotient of elements in vegetation are more in Ollur Kavu followed by SN Puram Kavu and Iringole Kavu. The general trend of turnover and enrichment of elements in Iringole Kavu and SN Puram Kavu was Mg>N>Ca>Kwhere asin Ollur Kavu it was K>Mg>Ca>N (Figure 4). Soils of SN Puram Kavu are sandier compared the soils other two sacred groves (Table 6). No significant difference between soils of three sacred groves was recorded for their and the amount of extractable magnesium. However, soils of SN Puram Kavu are richer in organic carbon, while available nitrogen and extractable potassium are more in the soils of Iringole Kavu. The fractional annual turnover and cycling of N and K in the soil were higher in Ollur Kavu while those of Ca and Mg in SN Puram Kavu. The trend of fractional turnover and cycling of elements in the soil with respect to three sacred groves showed higher values for K followed by Ca or N (Figure 5).

Table 4. Aboveground biomass (Kg ha^{-1}), annual litter production (Kg ha^{-1} yr^{-1}), annual increment in biomass (Kg ha^{-1} yr^{-1}) and net primary productivity (Kg ha^{-1} yr^{-1}) of tree components in three sacred groves in Kerala, India. Values are Mean ± S.E. N=4. S.E. are given in parentheses.

Parameters	Sites		
	Iringole	SN Puram	Ollur
Aboveground biomass (Kg ha^{-1})	7,72,884 (18,316)	5,18,514 (6,601)	3,70.452 (14,714)
Annual litter production (Kg ha^{-1} yr^{-1})	10,933 (247)	15,702 (321)	12,656 (175)
Annual increment in biomass (Kg ha^{-1} yr^{-1})	8,084 (189)	7.049 (144)	5.722 (79)
Net primary productivity (Kg ha^{-1} yr^{-1})	19,000 (430)	22,751 (464)	18,378 (254)

Table5 Quantity of elements in aboveground biomass (Kg ha^{-1})of tree components in three sacred groves in Kerala, India. Values are Mean ± S.E. , N=4. S.E. are given in parentheses.

Elements	**Sites**		
	Iringole	**SN Puram**	**Ollur**
Nitrogen	1,580.6 (37.4)	1,060.4 (13.5)	757.6 (30.1)
Potassium	966.9 (22.9)	648.7 (8.3)	463.4 (18.4)
Calcium	1,297.7 (30.8)	870.6 (11.1)	622.0 (22.7)
Magnesium	296.8 (7.0)	199.1 (2.5)	142.3 (5.7)

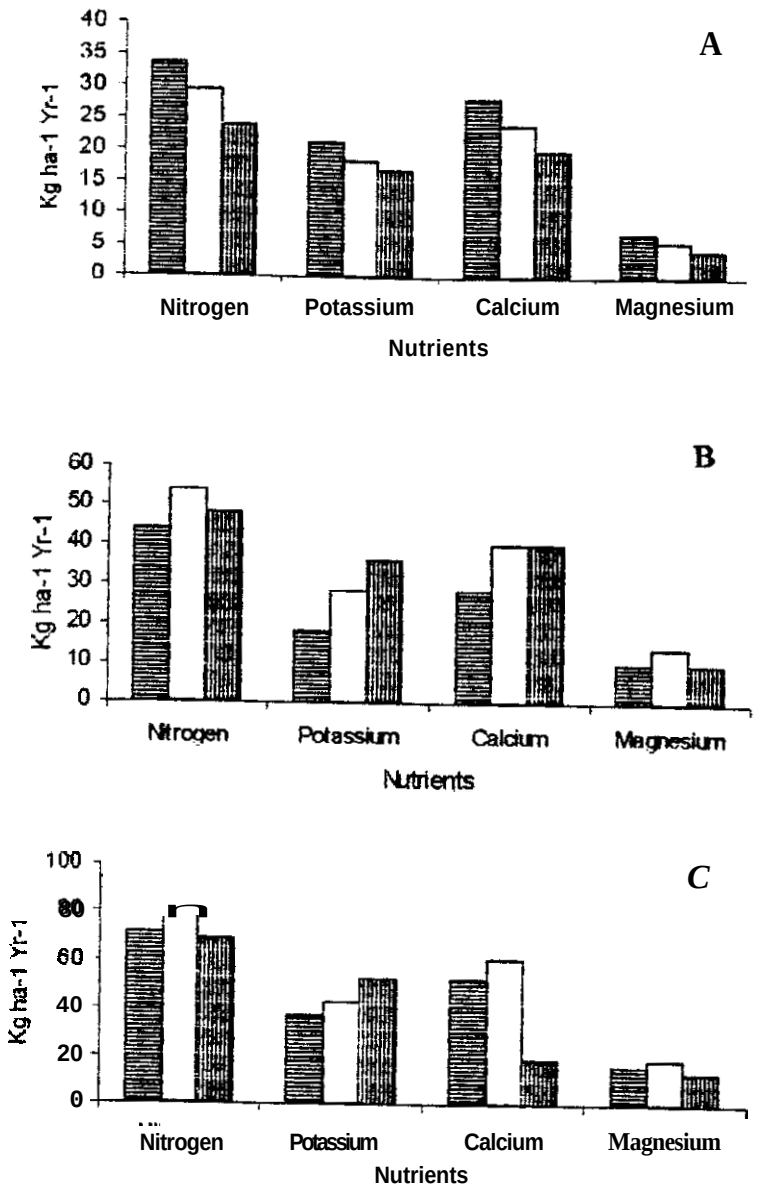

Figure 3. Annual rate of nutrient accumulation in the biomass (A), nutrient release through litter fall (B) and nutrient uptake (C) of tree components in Iringole Kavu (▤), SN Puram Kavu (▢) and Ollur Kavu (▦), Kerala, India

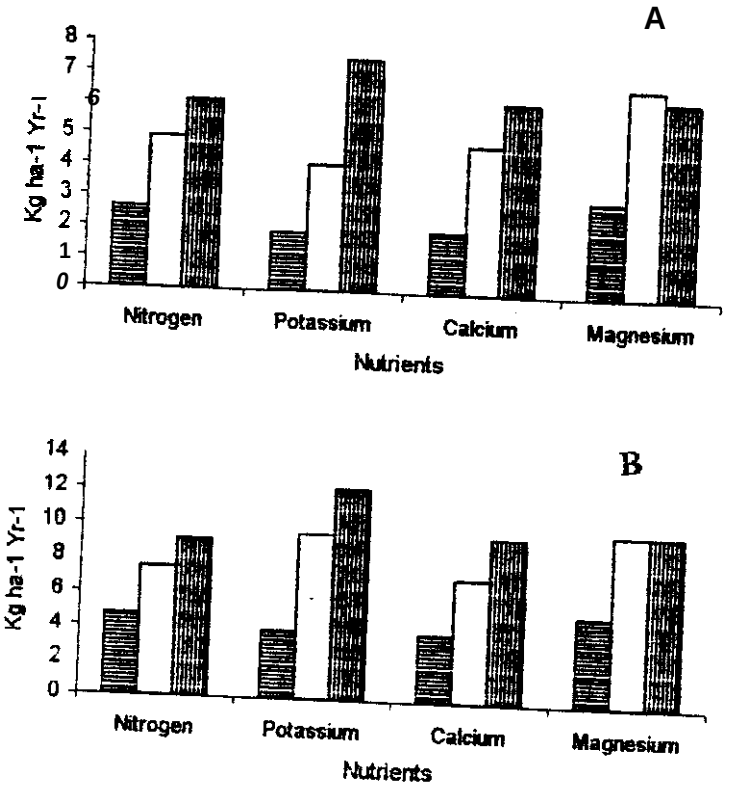

Figure 4.Fractional turnover rate of elements (A) and enrichment of ratio of elements (B) in tree components in Iringole Kavu (▤), SN Puram Kavu (□) and Ollur Kavu (▥), Kerala, India. Values in percentage

Table 6. Soil physical and chemical properties in three sacred groves in Kerala. Values are mean ± S.E., N=4. S.E. are given in parentheses.

Parameters	Sites		
	Iringole	SN Puram	Ollur
Sand (%)	72.5 (3.5)	81.8 (0.9)	61.5 (1.8)
Silt (%)	6.1 (1.4)	16.9 (1.1)	7.0 (1.6)
Clay (%)	21.3 (2.4)	1.3 (0.6)	23.5 (2.4)
pH	4.82 (0.33)	5.08 (0.17)	5.02 (0.24)
Organic Carbon (%)	0.74 (0.24)	1.65 (0.79)	0.58 (0.18)
Available nitrogen (%)	0.059 (0,019)	0.027 (0.007)	0.014 (0.003)
Extractable potassium (%)	0.0121 (0.001)	0.0033 (0.001)	0.0021 (0.0005)
Extractable calcium (%)	0.022 (0.010)	0.021 (0.006)	0.059 (0.017)
Extractable magnesium (%)	0.011 (0.005	0.012 (0.008)	0.009 (0.002)
Organic carbon (Kg ha $^{-1}$)	27,972 (2,381)	57,420 (3,514)	19.662 (610)
Available nitrogen (Kg ha^{-1})	2,230 (293)	940 (99.6)	475 (41.6)
Extractable potassium (Kg ha $^{-1}$)	458 (25.7)	114 (12.7)	71 (6.9)
Extractable calcium (Kg ha^{-1})	832 (72.7)	731	2,000 (235)
Extractable magnesium (Kg ha^{-1})	397 (78.8)	418 (113)	305 (28.2)

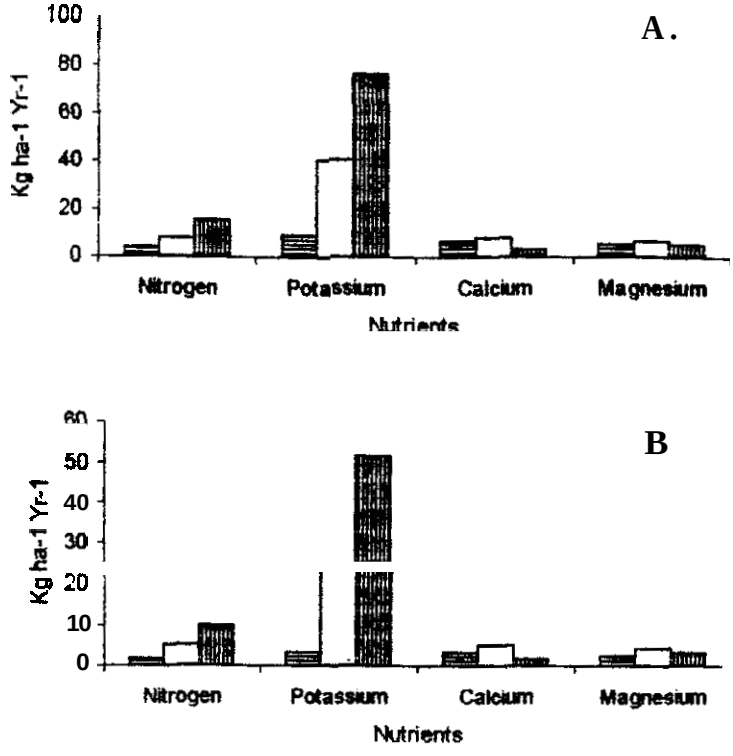

Figure 5. Fractional turnover rate of elements (A) and cycling of elemcnts (B) insoil inlringole Kavu ( ), SN Puram Kavu ( ) and Ollur Kavu ( ), Kerala India Values are in percentage

3.3. Stakeholder analysis

Among the various stakeholder groups identified local people and temple trustees are two major stakeholder groups in the Iringole Kavu with Stakeholders' Importance indices (SIVIs) 339.12 and 175.24 respectively. In case of S.N. Puram Kavu and Ollur Kavu. owners of the sacred groves (SIVI= 355.03 and 251.53 respectively) followed by local people (SIVI= 140.73 and 126.53 respectively) were the major stakeholders (Table 7 and Appendix 2, 3, and 4). Youth clubs, schools. Forest Department, Municipality and local Panchayat recorded lower stakeholder importance values. Stakeholder role index value (SRIV) of the three sacred groves is also calculated in order to know the present contribution of all stakeholders of a given sacred grove for its conservation and management. The SRIV of these three sacred groves ranged from 11.4 % to 20.7% only (Table 8).

3.4. Interaction meeting

With the support of The Iringole Temple Advisory Committee and the Friends Youth and Sports Club, Iringole, a one-day interaction meeting was orgnised on 30 September 1997 at Iringole, Perumbavur, Kerala. Participants representing various groves elaborated the socio-economic and ecological importance of their sites. Issues related to managing and conserving sacred groves were also explained by the them (Table 9). Grazing, soil erosion, encroachment of the sacred grove land by neighburing private parties, tree felling and anti-social activities by the non-believer of sacred grove are some of the problems are listed by the representative of some of the sacred groves. At present, different types of institutions such as single family, family trusts, local temple trust, revenue board, Devaswom Board are involving sacred grove management. Regardless of whether a sacred grove is managed by any one of the above mentioned institutions, participants are of the opinion that for effective management of sacred groves and organisation of cultural and religious activities related to sacred groves, the role of village committee and local temple trust are important. Taking into consideration the interest of the people in protection and conservation of sacred groves on one side and threats of encroachment on the other, a fencing method (mechanical fencing, live fencing or social fencing) suitable and acceptable by the local people has to be selected. Participants also felt that active involvement of local people with community-based conservation concept can bring out positive and desired results. Another approach suggested by the participants was the rehabilitation of degraded sacred groves or part of sacred groves with location-specific, ecologically and valued species, mainly already growing in the sacred groves.

Table 7. Stakeholder Importance Value Index (SIVI) of different stakeholders in three sacred groves in Kerala.

Stakeholders	Stakeholder Importance Value Index (SIVI)		
	Sacred groves		
	Iringole Kavu	SN Puram Kavu	Ollur Kavu
Local People	339.52	40.73	126.53
Trustees	175.24	NA	NA
Owners	NA	355.03	251.53
Devaswom	82.86	NA	NA
Priests	NA	123.40	75.00
Shop owners	58.58	48.40	101.53
Tourists	68.58	81.73	NA
Youth clubs	41.91	23.40	9.10
School	13.33	9.10	9.10
Forest Department	6.67	9.10	9.10
Municipality	6.67	NA	9.10
Panchayat	6.67	9.10	9.10
Total	800.00	800.00	600.00

N A Not applicable.

Table 8. Stakeholders' Role Index Value (SRIV) in different sacred groves of Kerala

Location	Attribute of stakeholders							
	Relative direct benefit		Relative indirect benefit (1*)	Relative contributions				
	Material (3*)	non-material (2*)		Man-power (1*)	Financial (2*)	Other (1*)	Relative Attitude (2*)	
	Real total value/expected total value							SRIV(%)**
Iringole	0.20	0.15	0.20	0.10	0.35	0.10	0.35	20.5
SN Puram	0.15	0.22	0.22	0.11	0.17	0.11	0.38	19.4
Ollur	0.15	0.22	0	0.11	0.11	0	0.22	11.4

*, Maximum value assigned to the attribute.

**. Total score of attribute considered X 100/Number of attributes considered.

Table 9. Summary of the write-up prepared by the representatives of different sacred groves Kerala participated in the one-day interaction meeting held at Iringole, Kerala.

Information	Informants
I. Socio-economic importance of sacred groves	
1. Good forest of sacred grove is boon to local people	Kuppolkkavu
2. Water for irrigation is plenty for the paddy fields situated around sacred groves	Nakrikkavu
3. Local people are experiencing .good weather and getting good yield due to existence of sacred groves	Poomalkkavu
4. Sacred grove is a eco-pilgrimage centre of the region	Pongalattukkavu
II. Problems in managing sacred groves	
1. Cattle grazing	Payyankulankkavu, Poomalkkavu, Aravanchalkkavu
2. Destruction of the quality of sacred grove due to activities of anti-social elements	Pongalattukkavu
3. Absence of clear boundary and resulted disturbance by cattle grazing, felling and encroachment	Parakkavu
4. Soil erosion due to removal of soil from adjoining private lands	Sankukulangara Kavu
5. Biomass of extraction by the local people	Kammadathukkavu
III. Present management institutions	
1. Local temple trusts/ Village committees	Kuppolkkavu, Poomalkkavu, Payankulamkkavu, Kottakatukkavu, Pongalattukkavu, Aravanchalkkavu, Parakkavu
2. Revenue board	Nakrakkavu
3. Single family	Thaduppakkavu
4. Family trust	Sankukulangara Kavu
5. Devaswom Board	Kammadathukkavu
IV. Ways and means suggested/identified by the representatives for effective conservation of their sacred groves	
* Construction of compound wall, planting in degraded sites, awareness programmes	Kuppolkkavu
* Involve local people for conservation programmes	
* Village committee and Revenue board should take over the charge of management of the sacred grove which under the control of a single family management	Nakkarkkavu
* Clear marking of sacred grove boundary and fencing are needed	

----cont'd----

Table 9 (cont'd). Summary of the write-up prepared by the representatives of different sacred groves Kerala participated in the one-day interaction meeting held at Iringole, Kerala.

Information	Informants
IV. Ways and means suggested/identified by the representatives for effective conservation of their sacred groves (Cont'd)	
* At present temple trust and sacred grove trust are working separately. For effective management both should work together * Board of management should be supported to take action against anti-social elements responsible for sacred grove degradation * Construction of fencing or compound wall	Poomalkkavu
* Planting in degraded parts of the groves * Awareness classes for people * Government lands situated around the sacred groves should be given to private parties as it leads to encroachment and/or degradation of sacred groves	Payyankulamkkavu
* Compound wall or barbed wire fencing around sacred groves to prevent anti-social activities	Pongalattukkavu
* Planting in sacred groves with local species and with people's involvement * Construction of fencing or compound wall * Construction of a pond to facilitate water availability for planting activities * Government permission to cut old trees in the grove to use for the temple repair etc.	Aravanchalkkavu
* Construction of compound wall * Construction of a well and supply of a motor to lift water * Supply of medicinal plants and tree seedlings to plant during favourable season * Appoint a person to supervise planting and for managing	Parakkavu
* Construct bunds to control soil erosion * Support existing management without reducing its strength and activities	Sankukulangara Kavu
* Interaction between different groups working for the management and conservation of sacred groves * Problems related to land tenure should be solved by the Govemment immediately	Kammadathkkavu
* Construct steps for the canal which is passing through the sacred grove * Make sitting arrangements at the boundary of the grove for the visitors * Help committee and local people to protect biodiversity	Kottakatukkavu

However, the participants have also identified the fact that lack of a database on the ecology, sociocultural aspects and management of the sacred groves are the major limiting factors to go forward with awareness programme. Thus, preparation of data base of as many sacred groves as possible is of immediate requirement.. This will give an insight into aspects such as: (a) contribution of a given sacred grove in conservation of culture, tradition and biodiversity, (b) factors responsible for the present vegetation structure in the sacred grove, (c) strength and weaknesses of each stakeholder groups in effectively managing the groves, and (d) specific action plans, if necessary, to be drawn for effective conservation and management of sacred groves.

4. DISCUSSION

4.1. Comparison and measures of disturbance

Of the seventy three tree species recorded from the three sacred groves, thirteen are endemic to south-western Ghats, three are endemic to Western Ghats and one is endemic to peninsular India. *Myristica malabarica, Nothopegia beddomei* and *Antiaris toxicaria* are rare and threatened species while *Aporosa bourdillonii* is a vulnerable species (Ahmedullah and Nayar,1987; Nayar, 1996). Therefore, the present study support the view expressed by various workers (Gadgil and Vartak, 1976; Unnikrishnan,l995) that sacred groves are the treasure houses of rare and endemic species.

The forests associated with these sacred groves are also different in their vegetation structure and species composition. For example, the density of mature trees and saplings are higher in lringole Kavu and S.N. Puram Kavu than in Ollur Kavu. Although the basal area of mature trees in Ollur Kavu is within the range recorded for other two sacred groves, that of saplings and seedlings is relatively low. This may be attributed to the fact that the disturbance occurred to the vegetation of the Ollur Kavu in recent past. Similarly, the size class distribution of trees in lringole Kavu and S.N.Puram Kavu showing a typical negative exponential curve with a clear preponderance of stems of small girth classes indicates the better regeneration potential of the sites. On the other hand,the population curve is less typical in the case of Ollur Kavu reveals the poor regeneration of trees in the site. In Ollur Kavu the ratio between density of mature trees and saplings is 1:0.4.This observation also an indicator of the poor recruitment of trees in the site due to repeated disturbance.

Several studies indicate that in relatively undisturbed evergreen forest patches both the number and density (individuals ha-1) of primary tree species are

comparatively more than those of late secondary and early secondary species (Bazzaz, 1984; Brokaw, 1985; Chandrashekara and Ramakrishnan, 1994). However, if the forest is disturbed, species number and density of late and early secondary species would increase and the increase will depend on the intensity and frequency of disturbance (Whitmore, 1984; Pascal, 1988; Chandrashekara and Ramakrishnan, 1994). This kind of information, are useful to assess whether a given forest patch has been subjected to disturbance or not. However, such information are too general and inadequate to investigate differences within and between floristic types of forest, and to relate these to canopy disturbance, and also to explore variations through time. It may also be pointed out here that the quantitative methods such as estimation of coefficient of similarity proposed by Sorenson (1948) and the continuum approach (Curtis and Mclntosh, 1951) are based only on either the presence or absence of a few common species or the abundance values recorded for such species in a set of stands compared. In these methods other aspects like the group of species which are indicators of disturbance, the spatial distribution pattern and contribution to the total basal area of the forest stand by these and all other constituent species are ignored. In this context, the new method of estimating Ramakrishnan Index of Stand Quality (RISQ) considering the life history, density, basal area and distribution pattern of all constituent species is useful to determine the stand quality i.e. whether the stand is disturbed or not and if disturbed to measure the level and frequency of disturbances occurred to the vegetation. For example, in the sacred grove at Ollur, higher values were recorded for all three tree layers (Table 3). This could be attributed to the vegetation changes occurred due to extensive canopy disturbance both in the past and in the recent past at Ollur. Generally, in relatively undisturbed sites slightly higher values might be obtained for the seedlings and saplings than for the mature trees as evidenced in the Ollur Kavu and S.N. Puram Kavu. This is due to the recruitment of some of the species belonging to pioneer index 2 and 3 along with those belonging to pioneer index 1 due to canopy gap formation, and their presence for a short duration (up to 10-15 years). These species in general fail to become trees of higher girth classes and hence absent in mature tree layer. However, in already disturbed sites, as in the case of the Ollur Kavu, higher 'RISQ values for saplings and seedlings than for mature trees mean further disturbance or failure of shade-bearers to establish in such sites. Presence of stumps of trees of both larger and smaller girth classes and trampling of seedlings by cattle is the clear evidence of repeated disturbance to the vegetation of the Ollur Kavu. Therefore, it appears that the Ollur Kavu is degenerating further instead of recovering from the past disturbances. Adoption of proper management strategies for the eco-restoration of this sacred grove is needed.

4.2. Biomass and nutrient cycling

Available literature on tree biomass of low land and premontane tropical rainforests indicate that the value ranges from 270 t/ha to 925 Vha (Tanner 1980; Edwards and Grubb, 1977). In semi-evergreen forests in the Western Ghats of Karnataka tree biomass recorded were 479 t/ha (Rai, 1984) and 465.4 Vha (Swamy, 1989). Biomass estimated in three sacred groves (370 t/ha, 518.5 t/ha and 772.9 t/ha in Ollur Kavu. SN Puram Kavu and Iringole Kavu respectively) are within the range reported for the tropical evergreen and semi-evergreen forests. Comparatively lower value for biomass recorded in Ollur Kavu than in other two sacred groves also reflects poorer density and basal area of tree layer in the site. It is interesting to note that the annual litter production is significantly more in Ollur Kavu than in Iringole Kavu suggesting that sites dominated by early and late secondary species produce more litter per unit area than sites dominated by primary species. In fact, litter production is also determined by the species combination, soil fertility and soil water retention within the same climatic range (Facelli and Pickett, 1991). Comparatively higher litter production in SN Puram Kavu than in other two sacred groves could be due to these factors.

The quantity of elements either in the biomass or in litter is a function of the absolute weight of the biomass and litter respectively. However, as biomass accumulation shifts from canopy components such as young, leaf bearing branches and foliage as in case of disturbed sites to wood and bark as in relatively less disturbed and mature forests, weighted average nutrient concentration of biomass may alter. Larger relative turnover rate and enrichment exhibited by potassium than by other elements both in vegetation and soil in Ollur Kavu may indicate that K accumulates and recycles very rapidly in early secondary succession and slowed later when the forest is matured and relatively undisturbed. Comparison of nutrient accumulation and release pattern in Ollur Kavu (disturbed sacred grove) with those in relatively less disturbed sacred groves (Iringole Kavu and SN Puram Kavu) are calculated as simple ratio of Ollur Kavu values compared with either Iringole or SN Puram Kavu expressed as a percentage (Table 10). It is obvious that the reorganisation of nutrient pools varied widely among the elements analysed. Macronutrients most directly involved in metabolism and less in structure such as potassium recycle rapidly in disturbed sites. Rapid recycling of elements like potassium in the initial stages of secondary succession is also reported for several other forests (Reiners and Reiners, 1970; Chandrashekara, 1991). Therefore, the present study also reveal that for a complex entity like an ecosystem, there are multiple measures for determining the effects of disturbance and ecosystem recovery processes. However, these variables change at different rates but in certain regular pattern.

4.3. Biodiversity

One of the characteristic features of the humid tropical forest ecosystem is its high species richness (Parsons and Cameron, 1974). Considering solely the species of trees > 30 cm gbh, over 140 species have been recorded for the Malaysian forests (Whitmore, 1984). Similarly, the tree species number for the humid tropical forests of Nelliampathy (Chandrashekara and Ramakrishnan, 1994) and Kakachi (Ganesh et.al., 1996) in the Western Ghats of India were 30 and 90 respectively. According to Proctor et al.(1983) and Whitmore (1984), in tropical evergreen forests tree species counts range from 20 to a maximum of 223. The tree species number in the S.N. Puram Kavu (14 species per ha) is below this range when that of the evergreen mixed forest of Iringole Kavu (23 species per ha) is at lower part of the range.

Density, basal area and number of species recorded for saplings and mature trees together (gbh > 10.1 cm) in Iringole Kavu and S.N. Puram Kavu are compared with those given for other lowland and mid-elevation evergreen forests of the Western Ghats of India (Pascal, 1988; Chandrashekara and Ramakrishnan, 1994). For these forests, the range of stem density is from 663 ha-I to 3341 ha-I while the range of basal area is from 37.37 m2 ha-I and 83.83 m2 ha-I. The stem density value obtained for Iringole Kavu is higher than for the other forests of the region. Whereas values for basal area of trees in S.N. Puram Kavu and Iringole Kavu are within the range recorded. Similarly, the number of tree species per ha in Iringole Kavu and S.N.Puram Kavu is also within the range (from 12 to a maximum of 56) recorded for other evergreen forests of the Western Ghats of India.

The mature tree species diversity index in the Iringole Kavu and S.N. Puram Kavu is 3.102 and 2.140 respectively. These values are lower than those recorded in a tropical rainforest of Barro Colorado Island (4.8; Knight, 1975), in Silent Valley, India (4.89; Singh et.al., 1981) and in Nelliampathy, India (4.0; Chandrashekara and Ramakrishnan, 1994). On the other hand, the values obtained for the concentration of dominance for the tree layer (0.163 for Iringole Kavu and 0.3643 for S.N. Puram Kavu) in the present study are higher than the range (0.06- 0.14) recorded for tree layers in the Silent Valley (Singh et.al., 1981) and Nelliampathy (Chandrashekara and Ramakrishnan, 1994). The higher values for the concentration of dominance and lower values for the species diversity index indicate that the present study sites are essentially mixed type of tropical forest with less dominance by a few species.

Table 10. Comparison of some ecosystem properties between disturbed sacred grove (Ollur Kavu) and relatively undistrubed sacred groves (Iringole Kavu and SN Puram Kavu) in Keraia, India.

Ecosystem property	Ollur Kavu x100 / Iringole Kavu	Ollur Kavu x 100 / SN Puram Kavu
Annual increment in biomass	70.78	81.17
Annual rate of nutrient accumulation in biomass		
Nitrogen	70.48	81.25
Potassium	82.18	94.32
Calcium	70.59	80.67
Magnesium	70.97	75.60
Annual rate of litter production	15.76	80.60
Annual rate of nutrient release through litterfall		
Nitrogen	116.18	89.77
Potassium	194.56	132.59
Calcium	147.01	99.49
Magnesium	97.87	65.71
Fractional annual turnover rate of elements in vegetation		
Nitrogen	244.19	126.50
Potassium	409.47	187.02
Calcium	309.70	140.53
Magnesium	205.66	107.03
Element enrichment ratio in vegetation		
Nitrogen	200.85	121.76
Potassium	311.56	127.05
Calcium	227.88	130.58
Magnesium	188.21	100.61

Above mentioned observations indicate that the Iringole Kavu and S.N.Puram Kavu are comparable to other evergreen formations in the Western Ghats of India in terms of species richness, stem density and basal area distribution and regeneration potential. Thus preservation of these sacred groves is crucial for maintaining the biodiversity.

4.4. Cultural aspects

Associated with faiths, taboos and believes over years local people have developed a strong aftinity towards the temple and the sacred grove. The local people of each sacred grove in general also believe that their livelihood, security and cultural existence are complementary to the blessings of their deity. However, the stakeholder importance values of local people in three sacred groves differ significantly. This is because, in the case of Iringole Kavu, the local people strongly feel that they are enjoying benefits and at the same time contributing man-power, money etc. with dedication and commitment. At the same time, unlike the S.N.Puram Kavu and Ollur Kavu where they are either single owner property or the property of a few families, the Iringole Kavu is community-based property. In case of the S.N.Puram Kavu also local people are allowed to participate in all festivals connected to the sacred grove and they are also allowed to visit the grove throughout the year. However, the management or the owners of the grove are reluctant to receive any financial contribution from other sources, even from local people towards the protection and maintenance of the system. The only source of financial contribution from other groups are in the form of offerings to the temple by the local people and tourists. The man-power and other contributions for the maintenance are contributed exclusively from the family members of the owners. They do not also encourage other group member to involve in the management activities of the temple and its functions. This is the case with many other sacred groves of Kerala too (Prasad and Mohanan, 1995).

Collection and removal of any material from the sacred grove is prohibited and is strictly ensured by the management in the case of Iringole Kavu and S.N. Puram Kavu. This strong positive attitude of the managers which is supported by the local people is responsible for the conservation of the forest associated with the temples. Similar observation has been made for several other sacred groves in Kamataka, Kerala (Gadgil, 1987; Unnikrishnan, 1995) and in north-eastern States of India (Khiewtam and Ramakrishnan, 1989). However, in case of the Ollur Kavu, biomass in the form of green manure, leaf litter, naturally fallen wood and branches as well timber harvested by the Owner of the sacred grove is removed. This kind of repeated disturbance of the sacred

grove by its owner and the local people is responsible for its degradation as also recorded by Prasad and Mohanan (1995).

Discussion with stakeholder groups indicated that better management of the sacred grove by the stakeholders can offer them direct monetary benefits even without the extraction of biomass of the grove. For example, in the case of Iringole Kavu and S.N. Puram Kavu, several stakeholders such as temple trustees, priests, Devaswom Board and shop owners mentioned that they are getting direct benefits because of their involvement with the sacred grove in one way or the other. The economic or material benefits are coming through the tourists, devotees and visitors. All these stakeholder groups are having opportunity to obtain higher SIVI values by increasing their relative values mainly in attributes such as manpower, financial and other contributions and changing their neutral or positive attitude towards sacred grove to more positive attitude towards the conservation and management of this natural resource. This kind of shift in their attitude can also increase the benefits they are going to get due to involvement with sacred groves.

The local people and other stakeholder groups who are proximate to the sacred groves mentioned that they are enjoying indirect benefits of the dense vegetation. According to them, the presence of sacred grove with dense forest has the function such as amelioration of microclimate, wind shelter belt effect, protection and regulation of local hydrology, maintenance of visual quality and fresh air. They also appreciate enhancement of mental peace during the visit to the temple and recreation. These benefits were felt clearly and more prominently by the stakeholders of the Iringole Kavu and S.N. Puram Kavu than by those of Ollur Kavu.

Table 7 also shows that youth clubs, schools, Forest Department, Municipality and local Panchayat possess lower stakeholder importance values. This is mainly because their contributions for the management of the sacred grove is poor and their present attitude towards the conservation and management of the grove is either negative or neutral.

Identification of all important stakeholders and assessment of their present interests and characteristics in conservation and sustainable management are needed. Participatory Rural Appraisal (PRA) techniques are the common methods employed for identification of stakeholders and their role in resource management. However, these techniques and methods do not clearly assess, on the basis of certain criteria, the relative role and importance of stakeholders (Grimble and Chan, 1995). Such kind of assessment of relative interests and role of stakeholders oflen required for

prioritising interests of important stakeholders, develop strategies to ensure Cupertino of all stakeholders and to resolve or control the conflicts between stakeholders, whenever arise (Kothari, et al., 1997). In this context, a new method developed to calculate the Stakeholder Importance Value indices (SIVI) considering all major role and features of each stakeholder and the Stakeholder Role Index Values (SRIV) for a given ecosystem is found useful. The present study undertaken in this direction indicated the necessities of more involvement of all stakeholder groups for a common goal of conservation and sustainable management of sacred groves. Subsequent discussion with the stakeholder groups also highlighted the fact that the participation of groups in management and conservation of the resource may be of different types. For example, in the sacred grove, self-imposed complete ban on removal of biomass, as was done in the S.N.Puram, would certainly help in revitalisation of ecosystem and its importance in the locality. Misuse or abuse of the land under sacred grove by the local people should be discouraged. It is worth to mention here that the young and active members among the owners of the S.N.Puram Kavu have formed a committee to safeguard the maintenance and protection of the sacred grove. They have a strong positive attitude towards conservation and management of the grove. Recently they have organised a workshop involving local people and resource persons from outside for creating awareness about the functional role and importance of sacred groves. This strategy of holding awareness campaigns can help to attract more stakeholder groups to participate and jointly chalk out plans to manage and conserve the existing systems in the light of any possible threats like encroachment and habitat destruction in future.

During stakeholder analysis different stakeholder groups made an attempt to identify their future in conservation and management of sacred groves, For example, youth clubs of the locality felt that they can become an active stakeholder by organising people and conducting seminars, exhibitions and coaching/training for the conservation of the sacred groves. Similarly, local schools identified their role of organisation of excursions and field trips for children from other areas for creating awareness about the importance and management of sacred groves. Agencies such as Forest Department, Municipality and Panchayat recognised their role in participation in activities such as awareness campaigns etc., which will also help in framing effective management strategies in future. This will also be a helping hand for the local committee members, in bringing their issues and problems at the decision and policy making authorities. However, becoming the active stakeholders any one group should not either directly or indirectly adversely affect the ecosystem as well as the management systems. Therefore, careful analysis of present management system and development of future strategies which will not adversely affect the interest and role of different

stakeholder groups but help in conservation and management of these natural resources are required.

5. CONCLUSIONS

Based on the case studies conducted in three sacred groves and discussions held in the interaction meetings it is clear that sacred groves are the hotspots of biological and sociocultural diversity. It is also evident that many of the sacred groves are threatened regardless they are under one or few families or are fully managed by the communities. Since the management of sacred groves is influenced by various types of social and economic factors, it is difficult to draw certain specific strategies to be adopted for their effective conservation. However, some of the common approaches, which could be adopted with necessary modifications to suit the requirements of a given sacred grove management, are as follows:

a) self imposition of complete ban on the removal of biomass for maintaining the sustainability of ecosystem,

b) creation of awareness among local people and the stakeholder groups,

c) identification of the type of contribution a stakeholder group can offer in management of sacred groves, and

d) encouragement of all stakeholders to participate in the management of sacred groves considering the wisdom and interest of the major stakeholder groups.

References

Ahmedullah, M. and Nayar, M.P., 1987. **Endemic Plants of the Indian Region.** Botanical Survey of India, Calcutta.

Allen, S.E., Grimshaw, H.M., Parkinson, J.A. and Quaramby, C., 1974. **Chemical Analysis of Ecological Materials.** Blackwell, Oxford.

Association of Official Analytical Chemists, 1980. **Official Methods of Analysis.** 13th Ed. AOAC, Washington DC.

Bazzaz, F. A., 1984. Dynamics of wet tropical forests and their species strategies. In: **Physiological Ecology** of **Plants of the Wet Tropics** (E.Medina, H.A. Mooney, and C. Vazquez - Yanes, eds). W.Junk Publishers, the Haque: 233-243.

Brokaw, N.V.L., 1985. Gap phase regeneration in a tropical forest. **Ecology,** 66 : 682-687.

Chandrasekharan, C., 1960. **Forest Types of Kerala State.** Special paper submitted for Diploma in Forestry. New Forest, Dehra Dun, India.

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

Chandrashekara, U.M., 1998. Ramakrishnan Index of Stand Quality (RISQ): An indicator for the level of Forest Disturbance. In: **Proceedings** of **the Tenth Kerala Science Congress** (ed. A.D. Damodaran), State Committee on Science, Technology and Environment. Trivandrum: 398-400.

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

Curtis, J. T. and Mclntosh, R. **P.,** 1951. An upland forest continuum in the prairies-forest border region of Wisconsin. **Ecology,** 32:476-496.

Edwards, P.J. and Grubb, P.J., 1977. Studies of mineral cycling in a montane rain forest in New Guinea. I. the distribution of organic matter in the vegetaion and soil. J. **Ecol.,** 65: 943-969.

Facelli, J.M. and Pickett, S.T.A., 1991. Plant litter: its dynamics in northern hardwood forest ecosystem, Hubbard Brook experimental forest, NH. **J.Ecol.,** 82: 533-548.

Gadgil, M., 1987. Diversity: cultural and biological. **Trends in Ecology and Evolution,** 2: 369-373.

Gadgil, M. and Vartak, V.D., 1975. Sacred groves of India: a plea for continued conservation. **J. Bombay Nat. History Soc.,** 72: 314-320.

Gadgil, M. and Vartak, V.D., 1976. Sacred groves of Western Ghats of India. **Econ. Bot.,** 30: 152-160.

Gamble, J.S., 1928. **Flora of Presidency of Madras, 3 volumes.** Adlard and Son Ltd. London.

Ganesh, T., Ganesan,R., Soubadra Devy, M., Davidar, P. and Bawa. K.S., 1996. Assessment of plant biodiversity at a mid elevation evergreen forest of Kalakad-Mundanthurai Tiger Reserve, Western Ghats, India. Current Science, 71:379-392.

Grimble, R. and Chan Man-Kwun.1995. Stakeholder analysis for natural resource management in developing countries. Natural Resources Forum, 19: 113-124.

Hughes, J.D., 1994. Pan's Travail: Environmental Problems of the Ancient Greeks and Romans. The Johns Hopkins University Press, Baltimore.

Jackson, M.L., 1968. Soil Chemical Analysis. Prentice-Hall, New Delhi.

Kershaw, K.A., 1973. Quantitative and Dynamic Plant Ecology. Edward Arnold, London.

Khiewtam. R.S. and Ramakrishnan. P.S.. 2989. Socio-cultural studies of the sacred groves at Cherrapunji and adjoining areas in northeastern India. Man in India, 69: 64-71.

Knight, D.H., 1975. A phytosociological analysis of species rich tropical forest on Barro, Colorado Island. Panama. Ecol.Monogr., 45:259-284.

Kothari, A,, Anuradha, R.V. and Neema Pathak, 1997. Community- based Conservation: Issues and Prospects. Paper presented at the Regional Workshop on Community-based Conservation:Policy and Practices. 9-11 February 1997, New Delhi. India.

Nayar, M.P., 1996. Hot Spots of Endemic Plants of India, Nepal and Bhutan. Tropical Botanical Garden and Research Institute, Palode, Kerala, India.

Parsons, R.F. and Cameron, D.S., 1974. Maximum plant species diversity in terrestrial communities. Biotropica, 6: 202-203.

Pascal, J.P., 1988. Wet Evergreen Forests of the Western Ghats of India: ecology, structure, floristic composition and succession. French Institute of Pondicherry, Pondicherry, India.

Prasad, G.A., and Mohanan, C.N. (1995). The sacred groves of Kerala and biodiversity conservation. In: Proceedings of the 7th Kerala Science Congress (ed; P.K.lyengar). State Committee on Science, Technology and Environment, Thiruvananthapuram, Kerala: 125-126.

Proctor, J., Anderson, J.M., Chai, P. and Vallack, H.W., 1983. Ecological studies of four contrasting lowland rain forest types of Gunung Mulu National Park, Sarawak. I. Forest environment, structure and floristics. J. Ecol., 76: 320-340.

Rai. S.N., 1979. Gap Regeneration in Wet Evergreen Forest of Karnataka. Karnataka Forest Department Research Paper, KFD-2, 15 p.

Rai., S.N., 1983. Productivity of Tropical Rain Forests of Karnataka. Ph.D. Thesis. University of Bombay.

Rai, S.N., 1984. Above-ground biomass in tropical rain forest of Western Ghats, India. Indian Forester 10 : 198-211.

Rai, S.N. and Proctor, J., 1986. Ecological studies on four rainforests in Karnataka, India. I. Environment, structure, floristics and biomass. J. Ecol., 74: 439454.

Ramakrishnan, P.S., 1996. Conserving the sacred: from species to landscapes. Nature and Resources, 32: 11 -19.

Rao, P., 1996. Sacred groves and conservation. WWF India Quarterly, 7: 4-7

Reiners. W.A. and Reiners, N.M., 1970. Energy and nutrient dynamics of forest floors in three Minnesota forests. J.Ecol., 26; 625-633.

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

Simpson, E.H., 1949. Measurement of diversity. Nature (London), 163:688

Singh, J.S., Singh, S.P., Saxena, A.K. and Rawat, Y.S., 1981. The Silent Valley Forest Ecosystem and Possible Impact of Proposed Hydroelectric Project. Reports on the Silent valley Study. Ecology Research Circle. Kumaun University, Nainital. India.

Sorenson, T., 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Bilo. Skr. 5:1-34.

Swamy. R.H.,1989. Study of Organic Productivity, Nutreint Cycling and Small Watershed Hydrology in Natural Forests and in Monoculture Plantations in Chikmagalore District, Karnataka. Report submitted by Sri.JCBM College, Sringeri. Karnataka to the Ministry of Environment and Forests, Government of India.

Tanner, E.V. J., 1980. Studies on the biomass and productivity in a series of montane rain forests in Jamaica. J.Ecol., 68: 571-588.

Unnikrishnan, E., 1995. Sacred Groves *of* North Kerala : An Eco- folklore Study. Jeevarekha. Thrissur, Kerala, India. (in Malayalam).

Whitmore, T.C., 1984. Tropical Rain Forests of the Far East (2nd edition). Oxford University Press, Oxford.

Whitmore, T.C., 1989. Changes over twenty-one years in the Kolobangara rainforests. J. Ecol., 77: 469-483.

Woodwell, G.M., Whittaker, R.H. and Houghton, R.A., 1975. Nutreint concentrations in plants in the Brookehaven oak-pine forest. Ecology, 56: 318-332.

Appendix 1. Classification of tree species based on the their pioneer index

Species with Pioneer index 1

Seedlings establish in closed canopy area but need small canopy gaps for grow up.

Aglaia elaeagnoidea
Cinnamomum malabathrum
Garcinia gummi-gutta
Holigarna arnottiana
caryophyllatum
Hopea parviflora
Hopea ponga
Ixora brachiata
Litsea laevigata
Mammea suriga
Mesua ferrea
Myristica dactyloides
Polyalthia fragrans
Quassia indica
Scheichera oleosa
Syzygium cumini
Syzygium
Syzygium rubikundam
Vateria indica

Species with Pioneer index 2

Seedlings establish in small gaps but need small to medium size gaps for grow up

Antidesma menasu
Antidesma zeylanicum
Apomsa bourdillonii
Apomsa lindleyana
Artocarpus hirsutus
Canthium umbellatum
Dichapetalum gelonioides
Xanthophyllum flavescens
Ficus benghalensis
Ficus mysorensis
Ficus tsjahela
Ficus virens
Hydnocarpus pentandra
Mangifera indica
Memecylon umbellatum
Mimusops elengi
Olea dioica
Prunus ceylanica
Santalum album
Strychnos nux-vomica
Tamarindus indica
Vitex altissima

Species with Pioneer index 3

Seedlings need larger canopy gaps for both establishment and growth

Adenanthera pavonina
Ailanthus triphysa
Alstonia scholaris
Antiaris toxicaria
Borassus flabellifer
Bridela retusa
Cassia fistula
Flocourtia montana
Macaranga peltata
Mallotus
Morinda tinctoria
Naringi crenulata
Pajanelia longifolia
Plumeria alba

Appendix 2. Stakeholder Importance Value Index (SIVI) of different stakeholders of a sacred grove at Kerala. Values in parentheses are scores assigned for attributes.

Stakeholders	Attributes of stakeholders								SIVI
	Relative Proximity	Relative direct benefit		Relative Indirect benefit	Relative Contributions			Relative attitude	
		Material	non-material		Man-power	Financial	Other		
Local people	13.33 (2)	0 (0)	33.33 (1)	50.0 (1)	100 (1)	14.29 (1)	100 (1)	28.57 (2)	**339.52**
Trustees	13.33 (2)	50 (3)	3.33 (1)	50.0 (1)	0 (0)	14.29 (1)	0 (0)	14.29 (1)	**175.24**
Devaswom Board	6.67 (1)	33.33 (2)	0 (0)	0 (0)	0 (0)	28.57 (2)	0 (0)	14.29 (1)	**82.86**
Tourists	6.67 (1)	0 (0)	33.33 (1)	0 (0)	0 (0)	14.29 (1)	0 (0)	14.29 (1)	**68.58**
Shop owners	13.33 (2)	16.67 (1)	0 (0)	0 (0)	0 (0)	14.29 (1)	0 (0)	14.29 (1)	**58.58**
Youth clubs	13.33 (2)	0 (0)	0 (0)	0 (0)	0 (0)	14.29 (1)	0 (0)	14.29 (1)	**41.91**
School	13.33 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**13.33**
Forest Department	6.67 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**6.67**
Municipality	6.67 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**6.67**
Panchayat	6.67 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**6.67**
Total	100 (15)	100 (6)	100 (3)	100 (2)	100 (1)	100 (7)	100 (1)	100 (7)	800

Appendix 3. Stakeholder Importance Value Index (SIVI) of different Stakeholders of a sacred grove at S.N. Puram Kavu, Kerala. Values in parentheses are scores assigned for attributes.

Stakeholders	Attributes of stakeholders								SM
	Relative Proximity	Relative direct		Relative Indirect benefit	Relative Contributions			Relative attitude	
		Material	non-material		Man-power	Financial	Other		
Local people	18.10 (2)	0 (0)	25 (1)	50 (1)	0 (0)	33.33 (1)	0 (0)	14.3 (1)	140.73
Owners	18.10 (2)	0 (0)	25 (1)	50 (1)	100 (1)	33.33 (1)	100 (1)	28.6 (2)	355.03
Priests	9.1 (1)	75 (3)	25 (1)	0 (0)	0 (0)	0 (0)	0 (0)	14.3 (1)	123.40
Shopowners	9.1			0 (0)	0 (0)	0 (0)	0 (0)	14.3 (1)	48.40
Youth clubs	9.10	0	0	0 (0)	0 (0)	0 (0)	0 (0)	14.3 (1)	23.40
School				0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9.10
Forest Dept.	9.10	0	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9.10
Tourists.	9.10 (1)	0 (0)	25 (1)	0 (0)	0 (0)	33.33 (1)	0 (0)	14.3 (1)	81.73
Panchayat	9.10 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9.10
Total	100 (11)	100 (4)	100 (4)	100 (2)	100 (1)	100 (3)	100 (1)	100 (7)	800.0

Appendix 4. Stakeholder Importance Value Index (SIVI) of different Stakeholders of a sacred grove at Ollur, Kerala. Values in parentheses are scores assigned for attributes.

Stakeholders	Attributes of stakeholders								SIVI
	Relative Proximity	Relative direct benefit		Relative Indirect benefit	Relative Contributions			Relative attitude	
		Material	non-material		Man-power	Financial	Other		
Local people	18.20 (2)	25 (1)	25 (1)	0 (0)	0 (0)	33.33 (1)	0 (0)	25 (1)	126.53
Owners	18.20 (2)	50 (2)	25 (1)	0 (0)	100 (1)	33.33 (1)	0 (0)	25 (1)	251.53
Priests	0 (0)	25 (1)	25 (1)	0 (0)	0 (0)	0 (0)	0 (0)	25 (1)	75.00
Shop owners	18.20 (2)	0 (0)	25 (0)	0 (0)	0 (0)	33.33 (1)	0 (0)	25 (1)	101.53
Youth clubs	9.10 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9.10
School	9.10 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9.10
Forest Dept.	9.10 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9.10
Municipality	9.10 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (0)	0 (1)	9.10
Panchayat	9.10 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9.10
Total	100 (11)	100 (4)	100 (4)	100 (1)	100 (1)	100 (3)	0 (0)	100 (4)	600.0