ELSEVIER

Forest Ecology and Management 112 (1998) 165–177

Forest Ecology and Management

Ecology and management of sacred groves in Kerala, India

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Received 10 September 1997; accepted 5 May 1998

Abstract

In Kerala, based on management systems, sacred groves can be categorised into three groups namely those managed by individual families, by groups of families and by the statutory agencies 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 and vegetation structure. 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 stem density of mature trees (367 ha^{-1}) and poor regeneration potential with the ratio between mature trees and saplings is 1:0.4. In order to quantify the level of disturbance in these sacred groves, Ramakrishnan index of stand quality (RISQ) was calculated. The values obtained for all the three tree layers (i.e., mature trees, saplings and seedlings) in single family managed sacred grove (Ollur Kavu) was between 2.265 and 2.731, an indicator of the dominance of light demanding species in the population, suggested that the grove is highly disturbed one. Whereas, other two sacred groves are less disturbed as indicated by lower 'RISQ' values (between 1.319 and 1.648). Iringole Kavu and S.N. Puram Kavu were compared with some other evergreen forests of the Western Ghats of India for the parameters like stem density, basal area and species diversity of trees (gbh$\geq$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 the 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. This indicated that local people, temple trust and/ or sacred grove owners are the major stakeholders, while in general some other stakeholder groups such as youth clubs, schools, forest department, municipality and local Panchayat with lower SIVI are comparatively neutral in conserving and managing the groves. Some of the major strategies to be adopted are self-imposed complete ban on the removal of biomass for the revitalisation of ecosystem, creation of awareness among local people and all stakeholder groups, identification of the type of contribution a stakeholder group can offer in managing the sacred grove and encouragement of all stakeholders to participate without either directly or indirectly adversely affecting the ecosystem as well as the wisdom and interest of the major stakeholder groups.

Keywords: Sacred groves; Vegetation structure; Ramakrishnan index of stand quality (RISQ); Stakeholder importance value index (SIVI); Stakeholder role index value (SRIV)

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0378-1127/98/$ – see front matter
PII: S0378-1127(98)00326-0

1. Introduction

The practice of assigning a patch of forest as the abode of Gods 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 Gods and Goddesses (Gadgil and Vartak, 1975; Khiewtam and Ramakrishnan, 1989; Hughes, 1994; Ramakrishnan, 1996). In spite of a general very high land to man ratio, sacred groves which are the relics of vegetation which have survived under a variety of ecological situations in India and they represent hot spots of biodiversity (Rao, 1996). Sacred groves in India are known under different names in different parts of the country as 'Dev' in Madhya Pradesh, 'Deorais or Deovani' in Maharashtra, 'Sarnas' in Bihar, 'Oran' in Rajasthan, 'Devarakadu' in Karnataka, and 'Sarpa Kavu or Kavu' in Tamil Nadu and Kerala. Sacred groves have always been a part of the cultural life of the Meghalaya (Tiwari et al., 1995). At the global level sacred groves have been reported from Afro-Asian countries like Nigeria, Syria, Turkey, Indonesia, Sri Lanka and Malaysia. According to Aumeeruddy (1994), in the Kerinci Valley of Sumatra, sacred village forests fulfil a range of function – economic, religious, social and environmental. Examination of the contribution of the sacred forests to biodiversity conservation offers perspective on the sacred forests as a model for environmental protection (Camara, 1994). Thus the role of natural sacred sites, particularly sacred groves, is attracting increasing interest in international organisations and conservation organisations such as UNESCO, the WWF and has significant relevance for the implementation of article 8j of the Conservation of Biological Diversity which stresses more on the use of traditional wisdom and practices for conservation and sustainable use of biological diversity.

Regardless of whether the responsibility of managing the sacred grove is under one or few families or is fully assigned to a statutory agency 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 the changing socio-economic conditions and landuse systems many sacred groves are now threatened and altered both in terms of size, vegetation structure and species composition. Therefore, specific objectives of the present study considering sacred groves of different management systems are (a) a comparative assessment of vegetation structure 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 the effective conservation and management of sacred groves.

2. Study area and climate

In Kerala, based on management systems, 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 (here after Iringole Kavu), Sri Shangukulangara Bhagavathi Kavu at Sree 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 (Fig. 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 by an individual owner. The area of Iringole Kavu is about 20 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°10′N and 10°43′N latitude and 76°15′E and 76°53′E longitude. The average annual rainfall in these sites is between 2500 and 2680 mm. May and October are the wet months while November–April is relatively dry. Relative humidity is always greater than 55% and attain 100% during rainy season. Mean maximum temperature is between 25°C and 30°C while mean minimum temperature is about 18°C. The soil is sandy loam to laterite and acidic with pH value ranging from 4.8 to 5.2.

3. Methods

3.1. Phytosociological analysis of tree species

The density, frequency and basal area were estimated for tree seedlings (individuals with girth

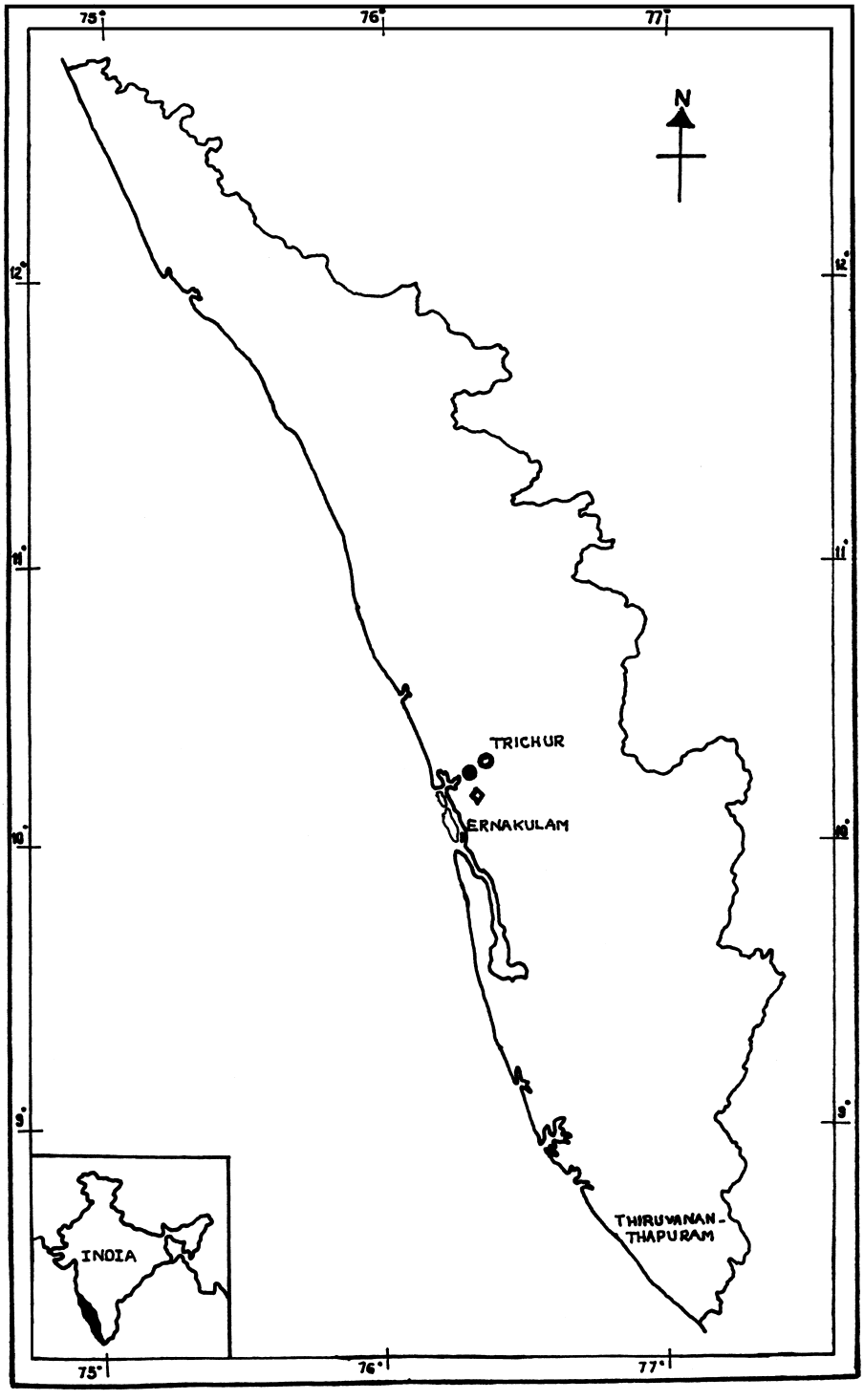

Fig. 1. Locations of the study area. Iringole Kavu (◇), S. N. Puram Kavu (●) and Ollur Kavu (○).

<10.0 cm and height <1 m), saplings (individuals with 10.1–30.0 cm girth at 1.37 m above-ground) and mature trees (individuals with more than 30.1 cm girth at 1.37 m above-ground level or at a height 2–2.5 m in the case of buttressed individuals). The size of the quadrats placed for studying mature trees and saplings was 10 m×10 m while that for seedlings was 1 m×1 m. In each case, the number of quadrats placed in the Iringole Kavu, S.N. Puram Kavu and Ollur Kavu were 100, 25 and 20, respectively. The vegetational data were analysed for relative frequency, relative dominance and relative density and the sum of values for these parameters represented importance value index (IVI) for various species (Kershaw, 1973). Species diversity was calculated using a formula given by Shannon and Wiener (1963) as:

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

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

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

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

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

3.2. 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, 1928; Chandrasekharan, 1960; Rai, 1979; Rai and Proctor, 1986; Pascal, 1988; Chandrashekara and Ramakrishnan, 1994a), species encountered in all the three sacred groves were categorised into three groups, each group with a number, its 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. The procedure to calculate the mean Pioneer index to the forest stand given by Whitmore (1989) is modified by (Chandrashekara, 1998) as:

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

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

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

3.3. Stakeholder analysis

3.3.1. Identification of stakeholders, their interest and characteristics

People, organisations and institutions enjoying benefits and helping or have the potential to help in conservation and management of these sacred groves were identified based on surveys and semi-structured interviews. These surveys and interviews also were 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 non-material 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.

3.3.2. 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

Table 1
Attributes of stakeholders of the sacred grove and their scoring

Attributes	Score
1. Proximity	
Stakeholder group residing within 1 km radius of the sacred grove	2
Stakeholder group residing farther (>1 km radius of the sacred grove)	1
2. Direct benefits	
Direct material benefits	
As the major source of livelihood	3
Due to highest investment for the management of sacred grove	2
Without investing directly for the management of sacred grove	1
Direct non-material benefit	
If stakeholders feel that they are receiving blessings of God, peace of mind and happiness due to the visit to sacred grove	2
If stakeholders are not in a position to tell whether they are receiving this kind of benefit or not	1
3. Stakeholders' contributions	
Man-power contribution	
Active in man-power contribution for the protection and management of the system	1
Otherwise	0
Financial contribution	
Relatively high financial contribution	2
Relatively moderate financial contribution	1
No financial contribution	0
Other contributions	
Capable of influencing in decision making level to deal with problems and issues related to sacred grove management	1
Otherwise	0
4. Attitude	
Showing greater interest with sincerity and dedication to work for sacred grove management	2
Working due to commitment	1
Neutral or passive attitude	0

stakeholders for each attribute were added and later the relative value, in percentage, 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 the stakeholder groups.

3.3.3. Derivation of stakeholders' role index values (SRIV)

To represent the cumulative role played by all stakeholders in terms of use and management of a given sacred grove, stakeholders' role index value (SRIV) 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 the stakeholders towards conservation and management of sacred grove were considered. Maximum value assigned to each attribute was multiplied by the number of stakeholder groups to obtain the expected total value for a given attribute. Then 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 value (SRIV). Higher the SRI value, better the role of stakeholders in using and managing the sacred grove.

4. Results

4.1. Phytosociology of tree species

In Iringole Kavu, totally 51 tree species were recorded with *Hopea ponga* and *Artocarpus hirsutus* as the dominant species in all three stages namely, mature phases, sapling phase and seedling phase

(Table 2). In S.N. Puram Kavu, while *Hopea ponga* and *Memecylon umbellatum* were the dominant species in mature tree phase and sapling phase when *Memecylon umbellatum*, *Artocarpus hirsutus* and *Hopea ponga* were dominant in seedling phase (Table 3). In 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 (Table 4). Total number of tree species recorded in S.N. Puram and Ollur Kavu were 17 and 24 respectively.

Values for the stem density and basal area of mature trees (more than 30.1 cm gbh) were more in S.N. Puram Kavu than in Iringole Kavu (Table 5). 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 size 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 (Fig. 2). Whereas in case of Ollur Kavu such a sharp 'L' shaped curve was not seen. The values for Ramakrishnan index of stand quality (RISQ) for mature trees, saplings and seedlings were within the range between 1.319 and 1.439 in case of Iringole Kavu, between 1.402 and 1.648 in case of S.N. Puram Kavu and between 2.368 and 2.731 in case of Ollur Kavu.

4.2. Stakeholder analysis

Among the various stakeholder groups identified, local people and temple trustees were the two major stakeholder groups in the Iringole Kavu with stakeholders importance index values (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 6). 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

Table 2
Pioneer index of tree species and species importance value index of different tree species in mature tree phase, sapling phase and seedling phase in Iringole Kavu, Kerala

Species	Pioneer index[a]	Importance value index (IVI)		
		Mature trees	Saplings	Seedlings
Adenanthera pavonina L.	3	0.6	0.9	–
Aglaia elaeagnoidea Juss.[b]	1	–	0.5	–
Antiaris toxicaria (Pers.) Lesch.[c]	3	–	0.9	–
Antidesma menasu Miq.ex Tul.	2	–	0.5	0.7
Antidesma zeylanicum Lamk.	2	–	1.3	31.8
Aporosa bourdillonii Stapf.[d]	2	3.8	27.4	7.8
Aporosa lindleyana (Wt.) Baill.	2	–	0.2	0.2
Arenga wightii Griff.[c]	3	–	–	0.5
Artocarpus hirsutus Lamk.[d]	2	64.7	82.5	43.1
Canthium umbellatum Gamble	2	–	0.2	3.2
Caryota urens L.	3	–	0.3	2.8
Celtis timorensis Spanoghe	3	0.7	0.2	–
Cinnamomum malabathrum (Burm. f.) Bl.[d]	1	0.6	3.1	34.5
Garcinia gummi-gutta (L.) Robs.	1	–	–	0.3
Elaeagnus kolaga Schlecht	3	–	0.2	–
Ficus tsjahela Burm. f.	2	–	0.2	–
Ficus mysorensis Heyne	2	0.7	–	–
Ficus virens Ait.	2	–	0.2	–
Flocourtia montana Grah.	3	–	0.8	–
Holigarna arnottiana Hk. f.[d]	1	7.7	25.1	8.3
Hopea parviflora Bedd.[d]	1	39.0	2.0	11.9
Hopea ponga (Dennst.) Mabber[d]	1	83.0	83.0	52.8

Table 2 (*Continued*)

Hydnocarpus pentandra (B.-Ham.) Oken[d]	2	–	0.3	0.2
Ixora brachiata Roxb.	1	–	0.9	19.2
Litsea laevigata (Nees) Gamble[d]	1	4.1	6.0	0.5
Macaranga peltata (Roxb.) M. -A.	3	2.4	3.4	–
Mallotus tetracoccus (Roxb.) Kurz.	3	–	0.2	0.5
Mammea suriga (B.-H. ex Roxb.) Koster.	1	5.7	22.0	25.1
Mangifera indica L.	2	–	–	0.3
Memecylon sp.	2	–	–	23.5
Mesua ferrea L.[d]	1	21.4	0.8	–
Mimusops elengi L.	2	–	0.5	0.2
Myristica malabarica Lamk.[d]	1	1.2	4.8	0.2
Nothopegia beddomei Gamble[c]	1	–	–	3.9
Olea dioica Roxb.	2	–	–	1.5
Pajanelia longifolia (Willd.) K.S.	3	0.6	–	–
Persea macrantha (Nees) Kosterm.	2	–	–	1.2
Photinia integrifolia Lindl.	2	–	–	0.2
Polyalthia fragrans (Dalz.) Bedd.[d]	1	10.9	5.2	21.9
Prunus ceylanica (Wt.) Miq.	2	0.7	1.9	–
Streblus asper Lour.	3	–	0.2	–
Strychnos nux-vomica L.	2	0.6		–
Syzygium cumini (L.) Skeels	1	4.2		–
Syzygium rubikundam Wt. and Arn.	1	1.6		–
Tabernaemontana heyneana Wall.[c]	3	–	1.0	0.2
Theobroma cacao L.	3	–	–	0.2
Trema orientalis (L.) Bl.	3	5.6	0.3	–
Vateria indica L.[d]	1	37.3	22.2	2.4
Vitex altissima L.	2	2.4	0.3	–
Wrightia tomentosa Roem. and Schult.	3	–	0.7	0.2
Zanthoxylum rhetsa (Roxb.) DC.	3	–	0.3	–

[a] Pioneer index is 1 for the species whose seedlings establish in closed canopy area but need canopy gaps to grow up; Pioneer index is 2 for the species whose seedlings establish in small gaps but need medium size gaps to grow up; Pioneer index is 3 for the species whose seedlings need larger canopy gaps for both establishment and growth.
[b] Endemic to peninsular India.
[c] Endemic to Western Ghats, India.
[d] Endemic to Southwestern Ghats, India.

sacred grove for its conservation and management. The SRIV of these three sacred groves ranged from 11.4% to 20.7% only (Table 7).

5. Discussion

Of the 73 tree species recorded from the three sacred groves, 13 are endemic to Southwestern 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 (Nayar, 1996). Therefore, the present study supports the view expressed by various workers (Gadgil and Vartak, 1976; Unnikrishnan, 1995) that sacred groves are the treasure houses of rare and endemic species.

With drastically increasing anthropogenic perturbations, one of the most conspicuous spatial phenomena of a given landscape is the habitat fragmentation. For example, based on the investigation on floristic pattern and composition of sacred groves of Kerala (Rajendraprasad et al., 1996), it was observed that there is a longitudinal continuity of the flora of Kerala. Thus human alterations of the previously continuous forested landscapes and retention of sacred grove forests have resulted in forest fragments that are surrounded by a matrix of agricultural and urban lands. In fact, both anthropogenic and natural

Table 3
Pioneer index of tree species and species importance value index in mature tree phase, sapling phase and seedling phase in S.N. Puram Kavu, Kerala

Species	Pioneer index	Importance value index (IVI)		
		Mature trees	Saplings	Seedlings
Aporosa lindleyana (Wt.) Baill.	2	1.6	12.8	34.5
Artocarpus hirsutus Lamk.[c]	2	9.8	29.4	49.3
Cinnamomum malabathrum (Burm.f.) Bl.[c]	1	–	7.5	14.6
Dichapetalum gelonioides Engl.	2	–	1.6	–
Ficus benghalensis L.	2	4.7	–	–
Garcinia gummi-gutta (L.)Robs.	1	8.1	12.1	29.0
Holigarna arnottiana Hk.f.[c]	1	3.0	10.9	10.8
Hopea parviflora Bedd.[c]	1	–	–	23.4
Hopea ponga (Dennst.) Mabber.[c]	1	166.1	119.8	35.2
Hydnocarpus pentandra (B.-H.)Oken[c]	2	1.5	6.9	10.8
Memecylon umbellatum Burm.f.	2	67.1	91.6	83.2
Olea dioica Roxb.	2	2.0	3.4	5.5
Quassia indica (Gaertn.) Nooteb.	1	3.1	–	3.6
Syzygium caryophyllatum (L.) Alston	1	14.5	2.6	–
Vateria indica L.[c]	1	1.5	–	–
Vitex altissima L.	2	1.6	–	–
Xanthophyllum flavescens Roxb.	2	15.4	10.1	

[a] Pioneer index is 1 for the species whose seedlings establish in closed canopy area but need canopy gaps to grow up; Pioneer index is 2 for the species whose seedlings establish in small gaps but need medium size gaps to grow up; Pioneer index is 3 for the species whose seedlings need larger canopy gaps for both establishment and growth.
[b] Endemic to peninsular India.
[c] Endemic to Western Ghats, India.
[d] Endemic to Southwestern Ghats, India.

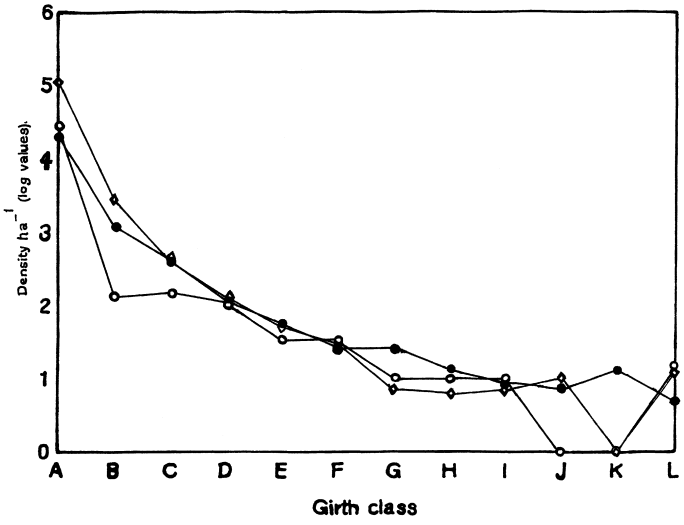

Fig. 2. Density (plants ha^{-1}) distribution of tree seedlings, saplings and mature trees into size-classes in Iringole Kavu (◇), S.N. Puram Kavu (●) and Ollur Kavu (○), Kerala, India. Size classes: A, tree seedlings (girth <10.0 cm and height <1 m); B, saplings (gbh 10.1–30.0 cm); C-L, mature trees, gbh 30.1–60.0, 60.1–90.0, 90.1–120.0, 120.1–150.0, 150.1–180.0, 180.1–210.0, 210.1–240.0, 240.1–270.0, 270.1–300.0 and >300.1 cm respectively.

Table 4
Pioneer index of tree species and species importance value index in mature tree phase, sapling phase and seedling phase in Ollur Kavu, Kerala

Species	Pioneer index[a]	Importance value index (IVI)		
		Mature trees	Saplings	Seedlings
Adenanthera triphysa (dennst.) Alston	3	5.9	–	29.2
Alstonia scholaris (L.) R.Br.	3	19.6	–	–
Anacardium occidentale L.	3	8.7	–	–
Areca catechu L.	3	9.0	–	–
Borassus flabellifer L.	3	16.6	–	33.8
Bridelia retusa (L.) Spreng.	3	4.7	–	–
Cassia fistula L.	3	–	13.9	–
Cocos nucifera L.	3	6.7	–	–
Eriodendron pentandrum Kurz.	3	4.6	–	–
Ficus microcarpa L.f.	2	48.1	–	–
Hydnocarpus pentandra (B.-H.) Oken[d]	2	4.5	–	–
Macaranga peltata (Roxb.) M.-A.	3	4.5	–	–
Mangifera indica L.	2	40.8	–	–
Morinda tinctoria Roxb.ex DC.	2	9.0	29.3	–
Moringa oliefera Lamk.	3	4.3	–	–
Naringi crenulata (Roxb.) Nicolson	3	14.1	31.3	47.4
Olea dioica Roxb.	2	–	–	61.0
Plumeria alba L.	3	4.5	–	–
Santalum album L.	3	–	25.8	–
Schleichera oleosa (Lour.) Oken	1	4.2	–	–
Strychnos nux-vomica L.	2	75.2	25.8	128.6
Syzygium cumini (L.) Skeels	1	10.2	–	–
Tabernaemontana heyneana (Wall.)Cook[c]	3	–	125.3	–
Tamarindus indica L.	2	4.8	–	

[a] Pioneer index is 1 for the species whose seedlings establish in closed canopy area but need canopy gaps to grow up; Pioneer index is 2 for the species whose seedlings establish in small gaps but need medium size gaps to grow up; Pioneer index is 3 for the species whose seedlings need larger canopy gaps for both establishment and growth.
[b] Endemic to peninsular India.
[c] Endemic to Western Ghats, India.
[d] Endemic to Southwestern Ghats, India.

disturbance regimes in the sacred groves have differentially affected the forest composition as clearly demonstrated through the present study. For example, the density of mature trees and saplings are higher in Iringole 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 large scale disturbance occurred to the vegetation of the Ollur Kavu in recent past. The size class distribution of trees in Iringole 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. In these two sacred groves, it was recorded that canopy gap formation is by natural means and such canopy gaps are generally small in size (less than 200 m^2). The importance of gap dynamics in the maintenance of high species diversity, better regeneration of canopy species in the tropical forests providing a varied resource base has also been emphasised repeatedly in recent times (Hartshorn, 1978; Denslow, 1980; Brokaw, 1985; Chandrashekara and Ramakrishnan, 1994a). On the other hand, absence of a sharp L-shaped size class distribution curve, and lower value for the ratio between the density of mature trees and saplings (1:0.4) recorded in the case of Ollur Kavu reveal the poor regeneration of trees in the site due to repeated and large scale disturbance. Many other studies have also showed that man made disturbance may change the vegetation structure, composition and

Table 5
General characteristics of the tree strata of three sacred groves of Kerala

Parameters	Locality		
	Iringole Kavu	S. N. Puram Kavu	Ollur Kavu
Number of species			
Mature trees	23	14	20
Sapling	37	12	6
Seedlings	31	11	4
Density (Trees/ha)			
Mature trees	657	665	367
Saplings	2682	1178	130
Seedlings	108536	21000	26678
Basal area (m^2/ha)			
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

Table 6
Stakeholder importance value index of different stakeholders in three sacred groves in Kerala

Stakeholders	Stakeholder importance value (SIVI)		
	Iringole Kavu	S.N. Puram Kavu	Ollur Kavu
Local people	339.52	140.73	126.53
Trustees	175.24	–	–
Owners	–	355.03	251.53
Devaswom	82.86	–	–
Priests	–	123.40	75.00
Shop owners	58.58	48.40	101.53
Tourists	68.58	81.73	–
Youth clubs	41.91	23.40	9.10
School	13.33	9.10	9.10
Forest Dept.	6.67	9.10	9.10
Municipality	6.67	–	9.10
Panchayat	6.67	9.10	9.10
Total	800.00	800.00	600.00

ecosystem energitics in ways different from natural disturbances (Vitousek, 1985; Mackie et al., 1986; Chandrashekara and Ramakrishnan, 1994b).

Ramakrishnan index of stand quality (RISQ) was estimated for all the three sacred groves studied by considering the life history, density, basal area and distribution pattern of all constituent species. In the sacred grove at Ollur, higher values for RISQ are recorded for all three tree layers (Table 5). 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. Higher 'RISQ' values for saplings and seedlings than for mature trees in Ollur

Table 7
Stakeholder role index value in different sacred groves of Kerala

Location	Real total value/ expected total value							SRIV (%)[b]
	Attributes of stakeholders							
	Relative direct benefit		Relative indirect benefit (1[a])	Relative contributions			Relative attitude (2[a])	
	Material (3[a])	Non-material (2[a])		Man-power (1[a])	Financial (2[a])	Other (1[a])		
Iringole Kavu	0.20	0.15	0.20	0.10	0.35	0.10	0.35	20.5
S.N. Puram Kavu	0.15	0.22	0.22	0.11	0.17	0.11	0.38	19.4
Ollur Kavu	0.15	0.22	0	0.11	0.11	0	0.22	11.4

[a] Maximum value assigned to the attribute.
[b] Sum of score of all attributes considered×100/number of attributes considered.

Kavu also indicate repeated 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 are the clear evidence of continuous disturbance to the vegetation in this sacred grove. 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.

One of the characteristic features of the humid tropical forest ecosystem is its high species-richness (Parsons and Cameron, 1974). In tropical evergreen forests the range of tree species count per ha is from 20 to a maximum of 223 (Whitmore, 1984). The tree species number in the S.N. Puram Kavu (14 species per ha) is below this range while that of the Iringole Kavu (23 species per ha) is at lower part of the range. However, in the lowland and mid-elevation evergreen forests of the Western Ghats of India (Pascal, 1988; Chandrashekara and Ramakrishnan, 1994a), the range of stem density for saplings and mature trees together (gbh>10.1 cm) is from 663 ha^{-1} to 3341 ha^{-1} while the range of basal area is from 37.37 $m^2 ha^{-1}$ to 83.83 $m^2 ha^{-1}$. 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.

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, 1994a). 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, 1994a). 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 little dominance by a few species. 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. Present systems of conservation and management of these sacred groves and strengths and weaknesses of such systems are discussed below.

Associated with faiths, taboos and believes over years local people have developed a strong affinity 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. However, the man-power and other contributions for the maintenance are contributed exclusively from the family members of the owners. This is the case in many other sacred groves of Kerala (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 Karnataka and Kerala in south India (Gadgil and Vartak, 1976; Unnikrishnan, 1995) and in northeastern States of India (Khiewtam and Ramakrishnan, 1989). Discussion with stakeholder groups in these sacred groves 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. 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. 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 are 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 in some other sacred groves by Prasad and Mohanan (1995).

Table 6 showed 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.

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 the removal of biomass, as was done in the S.N. Puram, would certainly help in revitalisation of ecosystem and its importance in the locality. Organisation of awareness campaigns on the functional role and importance of sacred groves is another strategy which also 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 as the active 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.

Acknowledgements

We are grateful to Dr. K.S.S. Nair, Director for his keen interest and encouragement. Prof. P.S. Ramakrishnan and Dr. K.G. Saxena of School of Environmental Sciences, Jawaharlal Nehru University, New Delhi are gratefully acknowledged for their support and valuable suggestions. We wish to thank Dr. B. Mohan Kumar, Kerala Agricultural University and Dr. F. Houllier, French Institute of Pondicherry for their useful comments on the earlier version of the manuscript. Thanks are due to Mr. P.C. Anil, Mr. Sathian P. Joseph and Mrs. V. Sreedevi for their assistances in the field works and data analysis. The study is supported by the UNESCO, India.

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