The Tropical Dry Evergreen Forest of Tamil Nadu:

Temple Groves, Evergreenness and Spatial Variation

Abstract

Woody and climbing species were inventoried at 60 tropical dry evergreen forest sites (43 temple groves, 9 Reserve Forests, 7 charnockite hillocks and one unclassified site) in northern coastal Tamil Nadu. The vegetation in Reserve Forests and hillocks was similar, while the temple groves showed greater variation and were dissimilar from the Reserve Forest/hillock formation. The most common species in temple groves were more evergreen and arborescent than those of Reserve Forests/hillocks, and contained a consistently greater proportion of evergreen species (48.15 - 84.50% compared to 45.95 – 67.65%). The predominence of evergreen species and relative infrequency of deciduous species in all sites justifies the previously disputed classification of this vegetation as 'evergreen'. The contrasting nature and wide geographical range of the temple groves illustrates the importance of their inclusion in any classification of the regional vegetation formations. A further examination of the species composition of the temple groves found considerable variation connected to geographical location, enabling a description of some broad trends of species distributions. Further studies are recommended to examine the causes of the differences between temple groves and Reserve Forests, and the nature and causes of the variation between the temple groves.

Introduction

The Tropical Dry Evergreen Forest (TDEF) as named by Champion and Seth (1968) is confined in India to a narrow belt along the Coromandel coast that receives both summer and winter monsoons in a tropical dissymmetric rainfall regime (Meher-Homji 1973). Annual rainfall for the region ranges between 1000–1500 mm, with the majority falling at the end of the year (Meher-Homji 1974b). This rainfall pattern together with the occurrence of dew from November until March has been described as important in determining the noticeably evergreen vegetation formations of the area (Meher-Homji 1974b, Sprangers and Balasubramaniam 1978). Throughout the coastal region the distribution of the rains varies on a gradient from south to north and east to west. Along this gradient the importance of the summer south-west monsoon increases, while the total annual rainfall, importance of the winter north-east monsoon and the difference between the two monsoons decrease (Meher-Homji 1974b).

The natural vegetation of the area is mostly found on red ferrallitic or ferruginous sandy loam (Meher-Homji 1974a, Meher-Homji 1976, Parthasarathy and Karthikeyan 1997, Visalakshi 1995) derived from Cuddalore sandstone (Sprangers and Balasubramaniam 1978, Meher-Homji 1974a). North of Kaluveli tank vegetated hillocks made of charnockite boulders rise from the plains. The more fertile alluvial and black clay soils in the region are mostly under cultivation (Meher-Homji 1977), but many temple groves have been protected from agricultural development due to their sacred status and so are still found on these economically valuable soils (Visalakshi 1995).

Temple groves represent relict fragments of original climax forest that are protected by religious sentiment (Reddy 1998, Chand Basha 1998). However, gradually

the reverence with which groves are held is decreasing as religious beliefs weaken (Reddy 1998, Gadgil and Meher-Homji 1975) resulting in increased levels of encroachment and destruction (Chand Basha 1998). With the few protected areas of TDEF being situated in the areas of poorer soil, the remaining groves along this coastal tract represent the only extant formations of the TDEF under different soil conditions.

Until the 1990's the majority of studies on the TDEF focussed on Reserve Forests (with a few hillocks and other sites but no temple groves). It was stated in several such papers that a forest formation in this region no longer existed (Meher-Homji 1973, Puri *et al.* 1989, Blasco and Legris 1972), and that the vegetation rather consisted of scrub woodland (Meher-Homji 1974a and 1984, Puri *et al.* 1989), or more or less dense thickets with few evergreen species (Blasco and Legris 1972, Meher-Homji 1976). Some studies of predominantly Reserve Forests provided phytosociological classifications of the coastal vegetation. These were:

i) the *Manilkara hexandra* series (Gaussen *et al.* 1961).

ii) the *Manilkara hexandra – Drypetes sepiaria – Chloroxylon swietenia – Memecylon umbellatum* series (Legris 1963).

iii) the *Manilkara hexandra – Memecylon umbellatum – Drypetes sepiaria – Pterospermum suberifolium – Carmona microphylla [= C. retusa]* facies of the *Albizia amara* community (Meher-Homji 1973).

iv) the *Manilkara hexandra – Chloroxylon swietenia* vegetation type within the *Albizia amara* zone (Meher-Homji 1984).

Detailed accounts of the vegetation and population structure of three temple groves described the vegetation as dense and continuous forest with substantial

undergrowth (Parthasarathy and Karthikeyan 1997, Parthsarathy and Sethi 1997, Visalakshi 1992 and 1995), while one contrasted this structure with that of a nearby Reserve Forest which showed poor tree recruitment and growth and an open scrubby form (Visalakshi 1992). As yet no vegetation survey including more than a few different sites, whether Reserve Forests, temple groves or any other category, within the TDEF range has been made.

The proportion of natural TDEF forest remaining under forest cover was estimated at 5% in 1992 (Meher-Homji) and 4% in 2002 (Wikramanayake *et al.*). It has been described as bioregionally outstanding in terms of biological distinctiveness, and its conservation status assessed as critical (Wikramanayake *et al.* 2002). Several authors have stressed the need for further conservation measures to be taken (Meher-Homji 1977, Parthasarathy and Karthikeyan 1997, Parthasarathy and Seth 1997).

This study aims (a) to demonstrate the importance of both Reserve Forests and temple groves in the understanding and conservation of the TDEF, (b) to demonstrate its predominantly evergreen nature, (c) to demonstrate the geographical variation within the vegetation type, and (d) to highlight areas of further study required to develop a more complete understanding of the TDEF and its conservation needs.

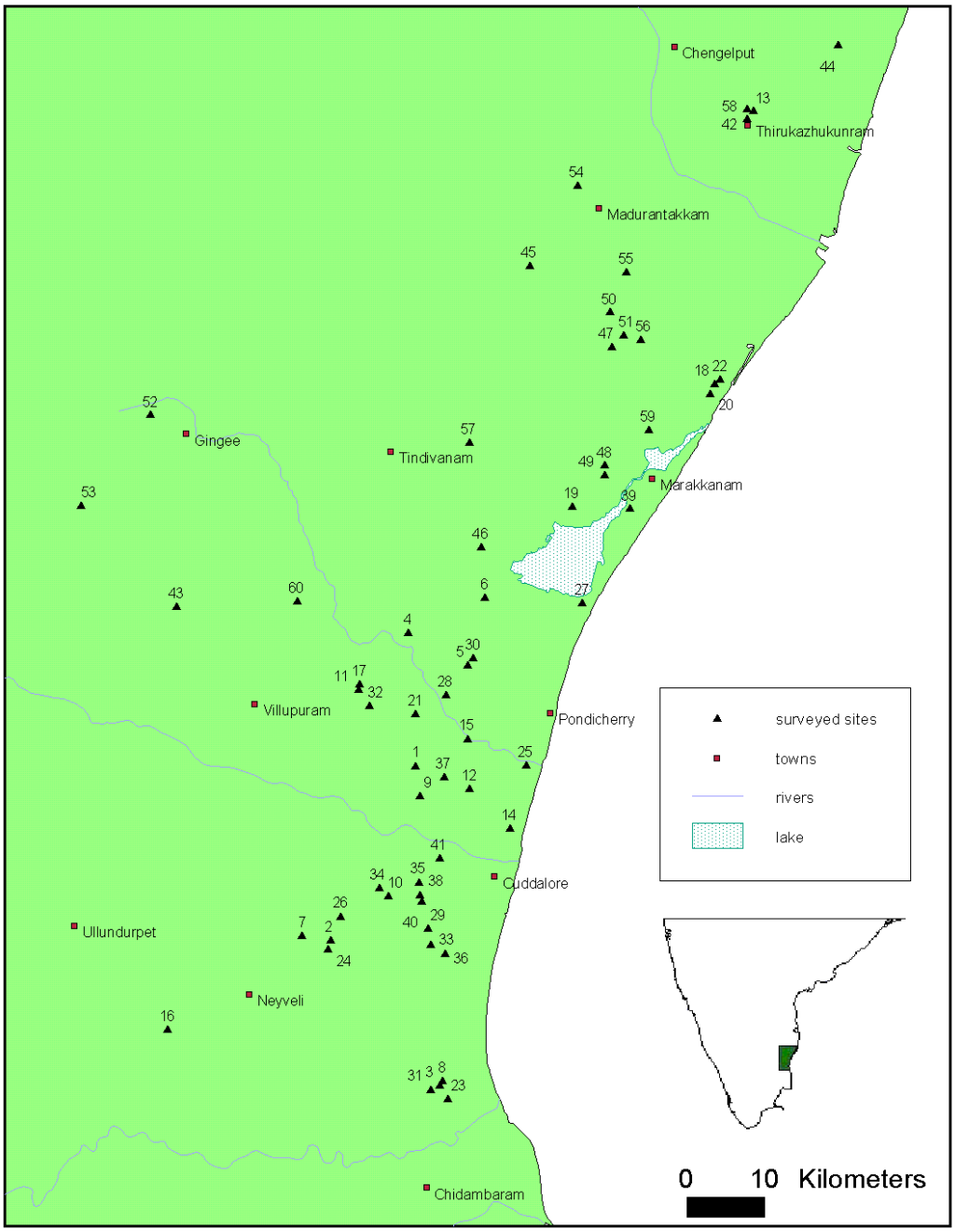

Figure 1. Map of study area showing surveyed sites. Sites are numbered according to Appendix A.

Methods

a) Study Area. The study area extended between Thirukazhikundram in the north and Nagapattinam in the south, to a maximum of 60 km inland (Gingee) (see Figure 1). A total of 60 sites were studied – 43 temple groves, 9 Reserve Forests, 7 hillocks and 1 site (Kiliyanur) which did not fall into any category. The list of sites and their co-ordinates is given in Appendix A.

b) Temple groves. The temple groves vary in size from 0.25 ha to 8 ha, and are distributed throughout the studied range although in lower numbers in the northern area. The following sources of disturbance have been noted in the groves, although the intensity of their pressure varies greatly from site to site:

i. Expansion of temple infrastructure and activity (temple compound, access roads and pathways, clearing of undergrowth, plastic and other litter)
ii. Encroachment by surrounding agriculture.
iii. Grazing of cattle and goats.
iv. Fuelwood collection.
v. Planting of exotic species (of religious significance or practical use).

c) Reserve Forests. Reserve Forests are situated mostly in the northern part of the study area, and cover areas exceeding 200 ha. Large proportions of some of the protected areas are planted with exotic plantation species, most commonly *Eucalyptus sp.,* although indigenous species are regenerating under the older plantations. More scattered, generally exotic species have often been planted as reforestation measures by the Forest

Department. The Reserve Forests are under heavy pressure from livestock grazing and fuelwood collection, with many tree species showing evidence of repeated coppicing.

d) Hillocks. The hillocks are abrupt outcrops of charnockite boulders up to 120 m in altitude in a scattered range from north of Marrakanum towards Maduranthakum. They vary considerably in the intensity of human disturbance, largely depending on their proximity to villages and towns.

e) Field methods. Sites were searched thoroughly to obtain a complete list of all species present (all woody and climbing species). The species were subjectively assigned to one of four frequency categories (present/ occasional/ common/ very common) in order to obtain an quick approximation of the diversity and structure of the site.

f) Data analysis. Detrended Correspondence Analysis (using the multivariate analysis package PCOrd) was performed in order to assess the scale and patterns of vegetation change in the dataset. Default actions such as downweighting of rare species were used.

Results and discussion

a) Site types

The DECORANA scatterplot of all sites and their site types presented in Figure 2 shows that the species composition of the temple groves is considerably different from that of the Reserve Forests and hillocks. Reserve Forests and hillocks are grouped together (at the lower ends of Axes 1 and 2), indicating that they are similar in their

species composition. The groves are more varied, being spread throughout the majority of the scatterplot, but are absent from the area dominated by the Reserve Forests and hillocks. The variety shown in the groves reflects the wide geographical range in which temple groves are found. The natural vegetation in the coastal region is typically found on the less fertile red ferrallitic or ferruginous soil (Meher-Homji 1976) because of the pressure of agriculture in more fertile areas. Temple groves, however, have been protected from agricultural development by their sanctity and fear of the presiding deity, so do not follow this trend but are found throughout the region on all soil types.

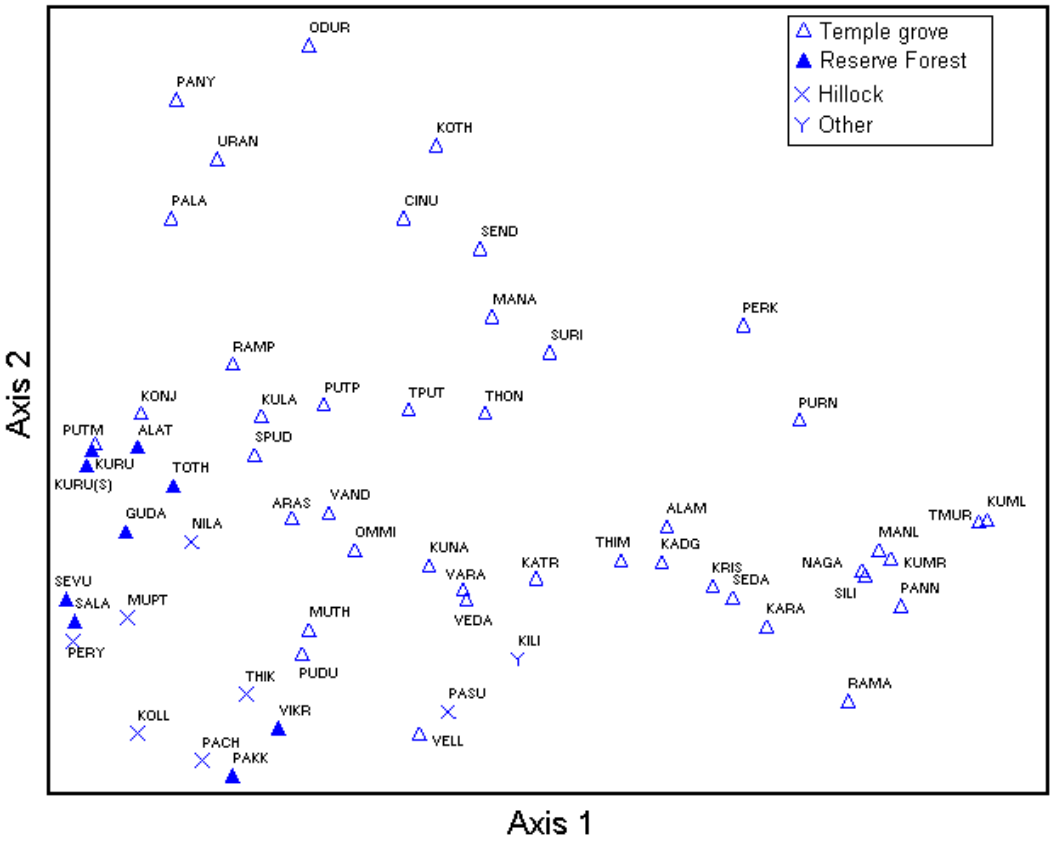

Figure 2. DECORANA scatterplot showing All Sites and their Site types. (Abbreviations of site names are according to Appendix A)

The Reserve Forests and hillocks are mostly situated in the same limited geographical area (except Pachai amman kovil, Pakkamalai and Vikravundi) where few groves have been found (see map Figure 1). It therefore remains possible that the difference between the groves and Reserve Forests/hillocks is due to factors relating to their geographical location (soil type, rainfall etc.) rather than their site type. In a study of the temple grove of Puthupet and the nearby Reserve Forest at Marrakanum, Visalakshi (1992) compared the luxuriant growth of Puthupet, which had a heterogeneous vegetation with substantial undergrowth and dense forest cover, with that of Marrakanum where the impact from fuelwood collection and grazing had resulted in poor tree recruitment, stunted growth and an open forest. In this comparison the disparity between the Reserve Forests and the temple grove is explained by heavier anthropic pressure on the Reserve Forest. However, more detailed studies comparing Reserve Forests and groves on similar soils are needed to be able to define accurately the cause of these differences, since many temple groves are also subject to considerable disturbance by man (Chand Basha 1998). The relative importance of various types of disturbance differs between Reserve Forests and temple groves – in groves useful or sacred exotic species are planted, pressure from grazing and fuelwood collection is present but generally less than the Reserve Forests, and forest areas are often cleared for temple expansion. In Reserve Forests exotic species are planted, but the greatest pressure is from grazing and fuelwood collection.

Groves				Reserve Forests/Hillocks			
	Species	**Type**	**EG**		**Species**	**Type**	**EG**
1	Glycosmis mauritiana	s	E	1	Jasminum angustifolium	cl	
2	Azadirachta indica	t	B	2	Ziziphus oenoplia	cl	
3	Lepisanthes tetraphylla	t	E	3	Carissa spinarum	s	E
4	Atalantia monophylla	t	E	4	Diospyros ferrea	s	E
5	Borassus flabellifer	t	E	5	Azadirachta indica	t	B
6	Memecylon umbellatum	s	E	6	Atalantia monophylla	t	E
7	Cissus quadrangularis	cl		7	Allophylus cobbe	st	
8	Morinda pubescens var. pubescens	t	E	8	Benkara malabarica	s	B
9	Phoenix pusilla	ss		9	Carmona retusa	s	E
10	Lantana camara var. aculeata	s	D	10	Flacourtia indica	s	E

Table 1. 10 most common species in Temple Groves and Reserve Forests/hillocks

t = tree
s = shrub
ss = subshrub
cl = climber
st = straggler
E = Evergreen
D = Deciduous
B = Brevideciduous

The difference between groves and Reserve Forests/hillocks is illustrated by examining their most common species (Table 1). The 10 most common species found in temple groves include four evergreen trees and shrubs (#1 *Glycosmis mauritiana*, #3 *Lepisanthes tetraphylla*, #4 *Atalantia monophylla,* #6 *Memecylon umbellatum*) that are typically found within dense forest. In Reserve Forests/Hillocks there is only 1 interior forest species - #6 *Atalantia monophylla* - whereas there are five pioneer species (#2 *Ziziphus oenoplia,* #3 *Carissa spinarum*, #8 *Benkara malabarica*, #9 *Carmona retusa*, #10 *Flacourtia indica*), of which four are thorny. These species are characteristic of open areas where they commonly form scrubby thorny thickets. It therefore appears that the groves tend to contain more arborescent and evergreen vegetation forming a dense closed forest, compared to a more thorny and open vegetation type typical of the Reserve Forests and hillocks. This conclusion is supported by field observations, and by the only study which has compared temple grove vegetation with that of a Reserve Forest (Visalakshi 1992, 1995).

Two species that have been repeatedly used in phytosociological studies to describe the TDEF vegetation, *Chloroxylon swietenia* and *Manilkara hexandra* (Meher-Homji 1973, 1984, Legris 1963, Gaussen *et al.* 1961, Sprangers and Balasubramaniam 1978) were not among the most common species found in either the Reserve Forests or temple groves. In this study *Chloroxylon swietenia* and *Manilkara hexandra* are both ranked (in frequency of occurrence) 84th in All Sites, 102nd and 128th respectively in groves, and 69th and 50th respectively in Reserve Forests/hillocks. It appears that in the region as a whole, compared to the locations in which the classificatory studies were made, they are not a significant species.

Most of the studies of the vegetation in the TDEF region have been made in Reserve Forests (Balasubramaniam and Bole 1993, Blasco and Legris 1972, Daniel and Rae 1989, Hussain *et al.* 1985, Meher-Homji 1973, Sprangers and Balasubramaniam 1978), some of which have resulted in classifications of the regional vegetation type (Meher-Homji 1973, Sprangers and Balasubramaniam 1978). The temple groves, although of much smaller size, are relict stands of the original climax vegetation (Gadgil and Meher-Homji 1975) and their species composition reflects a different form and structure to that of the Reserve Forests (Figure 2, Table 1, and Visalakshi 1992). Therefore a classification of the local vegetation that does not incorporate both Reserve Forests and temple groves would be incomplete.

b) Evergreenness

Figure 3 compares the proportion of species with certain characteristics in the entire species list with those of the 50 most common species. 101 out of a total of 229

species of trees and shrubs were evergreen (44.1%), compared with 22 out of the 30 trees and shrubs included in the 50 most common species (73.3%). Likewise the proportion of deciduous species in the total list is double that of the most common species (41.5% compared to 20.0%). Thus the evergreen species found throughout the region are more common than the deciduous, of which a greater proportion are rare.

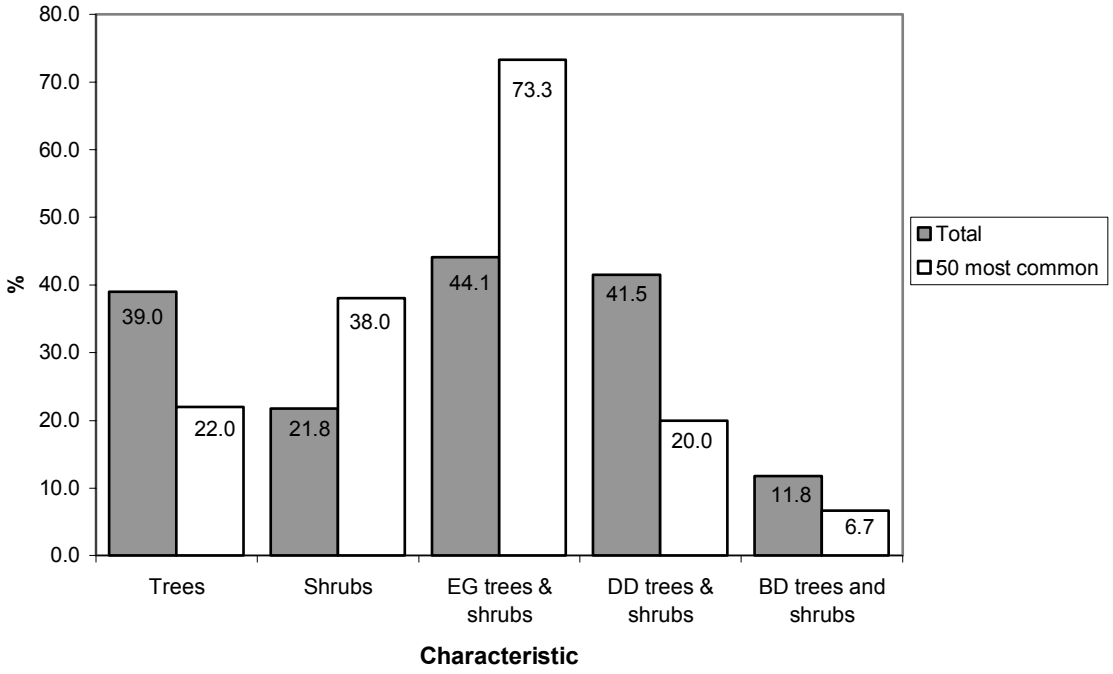

Figure 3. Summary of species characteristics of the complete species list and the 50 most common species

This apparently predominantly evergreen nature of the vegetation is confirmed in Figure 4, which shows the balance between evergreen and deciduous species in groves and Reserve Forests/hillocks. Evergreen species clearly predominate in both groves and Reserve Forests. The proportion of evergreen species is greater in groves (from 48.15% to 84.50%) than Reserve Forests/hillocks (45.95% to 67.65%), while that of deciduous species follows the opposite pattern (groves: 4.55% to 37.50%, Reserve Forests/hillocks:

25.40% to 42.34%). A prevalence of evergreen species was also found in Point Calimere (61% (Hussain *et al.* 1985) and 60% (Balasubramaniam and Bole 1992)) and in Puthupet (Parthasarathy and Karthikeyan 1997). In contrast, an earlier study found the majority of species to be deciduous (Meher-Homji 1966).

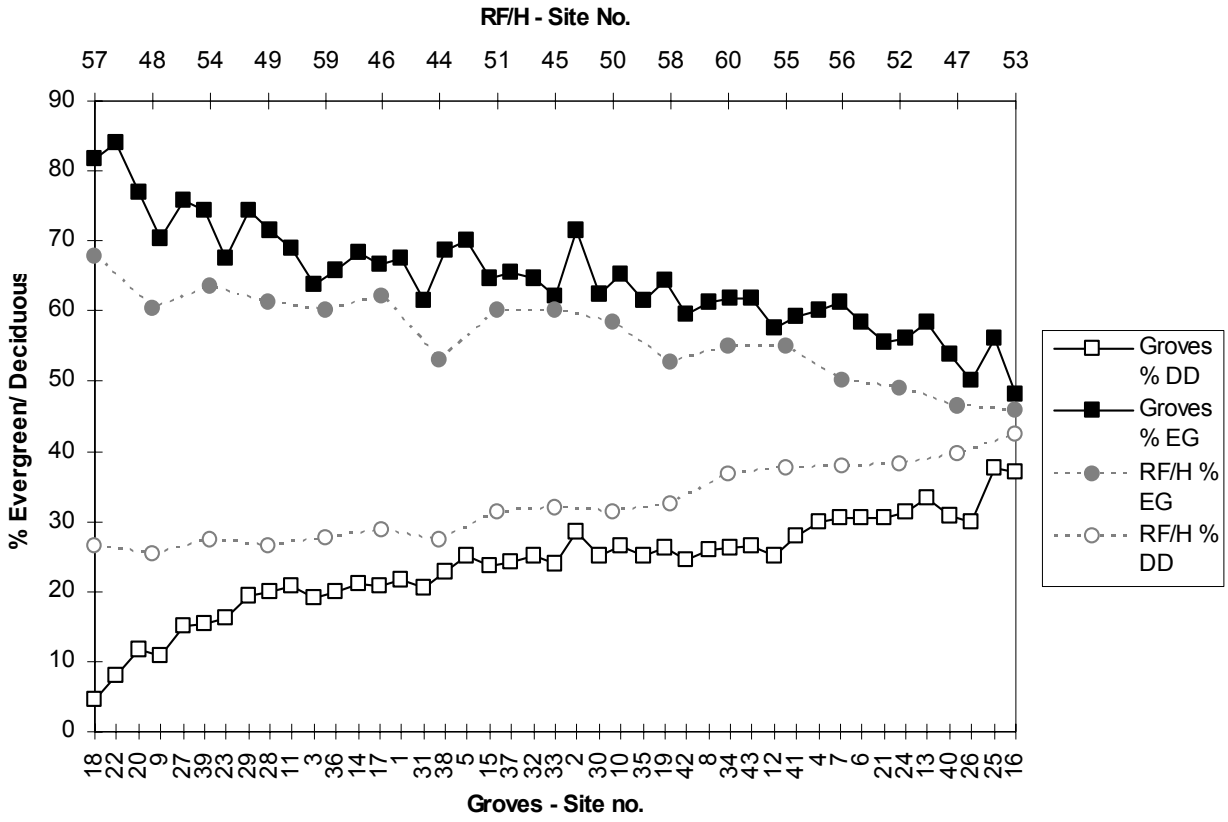

Figure 4. Percentage of Evergreen and Deciduous species in temple groves and Reserve Forests/Hillocks.
(DD = Deciduous; EG = Evergreen; RF/H = Reserve Forests/hillocks. Sites are numbered according to Appendix A.)

The tendency for more deciduous species to be found in Reserve Forests than groves is also reported in other studies. In analyses of Marrakanum RF and Point Calimere RF the listed dominant species tended to be deciduous – species such as *Lannea coromandelica, Albizia lebbeck, Albizia amara, Dalbergia paniculata*

(Visalakshi 1995, Hussain *et al.* 1985) although evergreen species were also present. In the temple groves of Puthupet, Thirumanikuzhi and Kulanthaikuppam the dominant species were listed as *Memecylon umbellatum, Flacourtia indica (=Drypetes sepiaria*, an error in identification), *Tricalysia sphaerocarpa* and *Lepisanthes tetraphylla* (Parthasarathy and Karthikeyan 1997, Visalakshi 1992). Several hypotheses may explain the greater occurrence of deciduous species in Reserve Forests. For example, the open forest created by poor soil or high levels of disturbance may favour recruitment of deciduous rather than evergreen species; evergreen species may be less robust in their ability to recover from anthropic activities such as browsing and lopping; growth rates of deciduous species may be higher than evergreen species in open areas and after lopping.

c) Variation in species distributions

i) Temple groves

It is already clear from Figure 2 that the Reserve Forests/hillocks are similar in terms of species composition, and their large size and consequent high numbers of species may distort the variation expressed in the temple groves. Hence the temple groves are studied separately to ascertain the variation between them. Figure 5 illustrates this variation and identifies the groves that are similar and those that differ in their species composition.

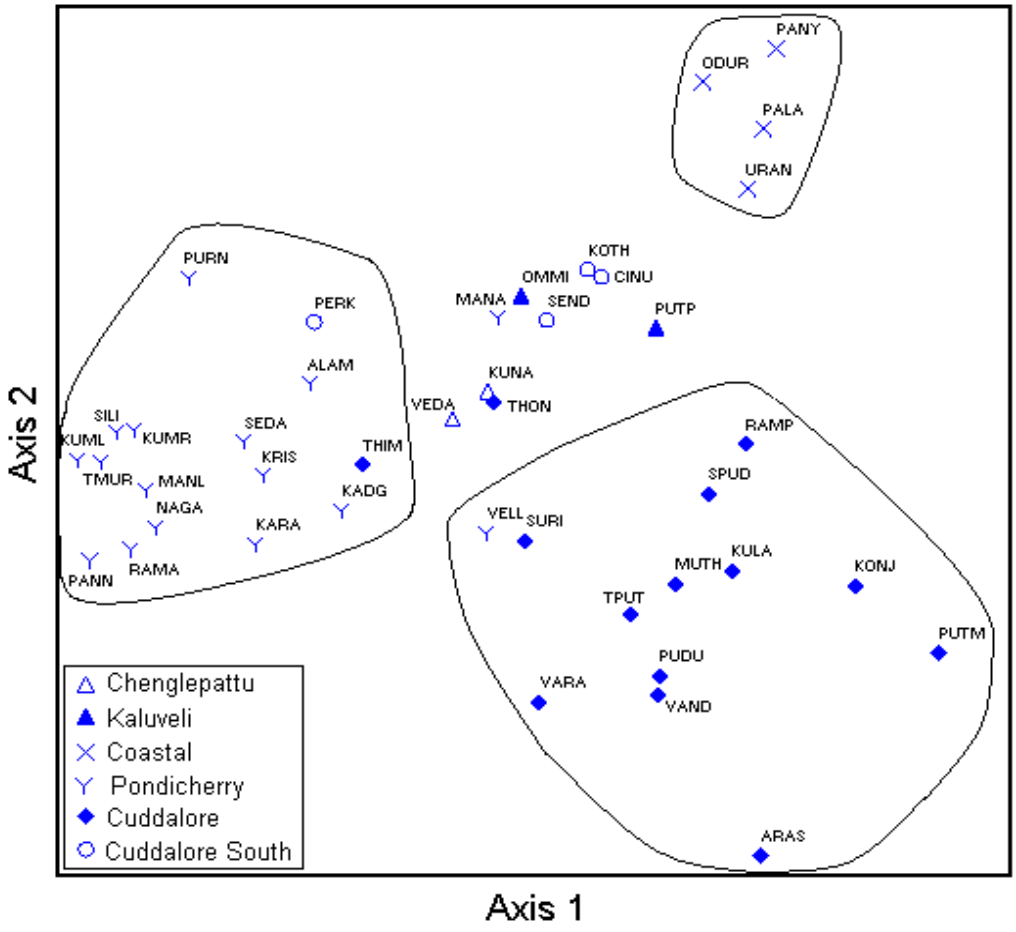

Figure 5. DECORANA scatterplot of temple groves showing their geographical grouping. Sites are abbreviated according to Appendix A

The factors determining the variation expressed in axes 1 and 2 have yet to be ascertained, but the correlation between sites' proximity on the scatterplot and their geographical proximity suggests that there are certain species assemblages common to certain areas, most notably the Cuddalore, Pondicherry and coastal areas (the groups circled in Figure 5). The Cuddalore area as used here extends west to Panruti and south to the limit of the study area; the Pondicherry area includes the groves predominantly west

and south of Pondicherry, while those further north than Sedarapattu are included in the Kaluveli region.

Geologically these areas also differ, with the Cuddalore area based on sandstone with clay, the Pondicherry area of fluvial origin and the coastal area marine (Gopalakrishnan *et al.* 1995). Thus the differences in species compositions may be at least partly attributable to the contrasting geological substrates and the resulting different soil conditions.

ii) All sites

Figures 2 and 5 shows that there is considerable variation in species composition within even this limited area of the TDEF range, and that this variation follows a certain pattern relating to geographical location. This initial study cannot identify the precise complex of factors determining the gradients of species distributions, but it can describe some broad trends:

- A number of species are relatively widespread but are extremely rare or absent in the area around Pondicherry, such as *Diospyros ebenum, Memecylon umbellatum, Hugonia mystax, Cassia fistula, Psydrax dicoccos.* In contrast, *Pamburus missionis* and *Azima tetracantha* are very common in this area and rare elsewhere.
- Species common only in coastal areas or on sandy soils include *Garcinia spicata* and *Calophyllum inophyllum*, with *Eugenia bracteata* occurring in all coastal sites but no inland sites.

- Certain species are almost totally confined to the northern part of the surveyed area, from Kaluveli to Thirukazhikundram, namely *Diospyros chloroxylon, Diospyros melanoxylon, Manilkara hexandra, Ziziphus xylopyra.*
- *Cadaba trifoliata, Symphorema involucrata* and *Tricalysia sphaerocarpa* are clearly confined to the area around Cuddalore.
- *Chloroxylon swietenia* shows an interesting distribution in that it is found in abundance in the Cuddalore area (in temple groves but also along roadsides and on open land) and in lesser numbers in the northern areas, but is absent everywhere else.

More detailed studies are needed to ascertain the precise nature of the gradients in species distributions that have been identified in this study, and to investigate the importance of soil types, anthropogenic influences (temple grove encroachment, introduction of exotic species, browsing, fuelwood collection) and other factors in determining them.

Conclusion

The vegetation found in temple groves and Reserve Forests is predominantly evergreen, although the dominance of evergreen species is more pronounced in the temple groves. The description of this vegetation as 'evergreen' is therefore justified. The groves and Reserve Forests/hillocks differ considerably in terms of dominant species, evergreenness and structure. More work is needed to identify the causes of these differences, whether they relate to soil and other environmental conditions, anthropogenic disturbance pressures or a combination of both. Whatever the cause it is clear that both

groves and Reserve Forests must be included in efforts to further understanding and conservation of the TDEF.

The TDEF is not a uniform vegetation type throughout the region. Considerable variation in species composition relating to geographical location has been found, with Pondicherry, Cuddalore and coastal areas the most noticeably contrasting. The variation within this small yet unique vegetation type must be understood and documented to enable effective conservation measures to be taken that protect all of its forms.

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APPENDIX A

All surveyed sites, their site numbers, codes, type and co-ordinates.
T = Temple grove, R = Reserve Forest, H = Hillock, O = other.

No.	Site	Code	Typ	Latitude	Longitude	No.	Site	Code	Typ	Latitude	Longitude
1	Alamarathakuppam	ALAM	T	11º 52.356'	79º 40.818'	21	Pannakuppam	PANN	T	11º 55.862'	79º 40.823'
44	Alathur	ALAT	R	12º 41.729'	80° 09.740'	22	Panayur	PANY	T	12º 18.792'	80º 1.651'
2	Arasadikuppam	ARAS	T	11º 40.358'	79º 34.994'	54	Pasumbur	PASU	H	12º 32.127'	79º 51.841'
3	Chinnakumatti	CINK	T	11º 30.411'	79° 42.450'	23	Periyakumatti	PERK	T	11º 29.508'	79° 43.040'
45	Gudalur	GUDA	R	12º 26.600'	79º 48.600'	55	Periyaveli	PERV	H	12º 26.196'	79° 55.238'
4	Kadagampattu	KADG	T	12º 01.398'	79º 40.294'	24	Pudur	PUDU	T	11º 39.751'	79º 34.770'
5	Karasur	KARA	T	11º 59.168'	79º 44.401'	25	Purnankuppam	PURN	T	11º 52.380'	79º 48.320'
6	Katrampakkan	KATR	T	12° 03.805'	79° 45.476'	26	Puthupallayam	PUTM	T	11º 42.017'	79º 35.687'
46	Kiliyanur	KILI	O	12º 07.325'	79° 45.310'	27	Puthupet	PUTP	T	12º 03.467'	79º 52.200'
47	Kollatannalur	KOLL	H	12º 21.026'	79º 54.245'	28	Ramanathapuram	RAMA	T	11º 57.123'	79º 42.895'
7	Konjikuppam	KONJ	T	11º 40.696'	79º 33.029'	29	Ramapuram	RAMP	T	11° 41.187'	79° 41.688'
8	Kothattai	KOTH	T	11º 30.725'	79° 42.632'	56	Salaiyur	SALA	R	12º 21.550'	79º 56.200'
9	Krishnavaram	KRIS	T	11º 50.283'	79º 41.078'	30	Sedarapattu	SEDA	T	11º 59.658'	79º 44.738'
10	Kulanthaikuppam	KULA	T	11º 43.401'	79º 38.930'	31	Sendirakillai	SEND	T	11º 30.131'	79° 41.838'
11	Kumulam	KUML	T	11º 57.534'	79º 36.905'	57	Sevur	SEVU	R	12º 14.500'	79º 44.500'
12	Kumaramangalam	KUMR	T	11º 50.790'	79º 44.526'	32	Silikeripallayam	SILI	T	11º 56.418'	79º 37.613'
13	Kunathammankovil	KUNA	T	12º 37.226'	80º 3.915'	33	S Pudur	SPUD	T	11° 40.060'	79° 41.868'
48	Kurumpuram (Marrakanum)	KURU	R	12º 12.900'	79º 53.700'	34	Suriyanpet	SURI	T	11º 43.983'	79º 38.320'
49	Kurumpuram South	KURS	R	12º 12.253'	79º 53.700'	58	Thirukazhikundram	THIK	H	12º 36.660'	80º 03.530'
14	Manapattu	MANA	T	11º 48.036'	79º 47.202'	35	Thirumanikuzhi	THIM	T	11º 44.370'	79º 41.050'
15	Mangalam	MANL	T	11º 54.186'	79º 44.394'	36	Thondamanatham	THON	T	11° 39.484'	79°42.810'
50	Mupandal	MUPT	H	12º 23.421'	79º 54.083'	37	T Murthikuppam	TMUR	T	11º 51.555'	79º 42.753'
16	Muthanai	MUTH	T	11º 34.275'	79º 23.813'	59	Tothacheri	TOTH	R	12º 15.330'	79º 56.740'
17	Nagari	NAGA	T	11º 57.882'	79º 36.954'	38	T Puthupallayam	TPUT	T	11º 43.508'	79º 41.130'
51	Nilamangalam	NILA	H	12º 21.710'	79º 55.070'	39	Urani	URAN	T	12º 09.931'	79º 55.474'
18	Odur	ODUR	T	12º 18.475'	80º 1.288'	40	Vandikuppam	VAND	T	11º 43.064'	79º 41.249'
19	Ommiper	OMMI	T	12º 10.076'	79º 51.516'	41	Varakkalpattu	VARA	T	11º 46.030'	79º 42.461'
52	Pachai amman kovil	PACH	H	12º 16.368'	79º 22.612'	42	Vedagreeswararkovil	VEDA	T	12º 37.381'	80º 3.531'
53	Pakkamalai	PAKK	R	12º 10.123'	79º 17.821'	43	Velleripattu	VELL	T	12° 03.224'	79° 24.414'
20	Palayermadam	PALA	T	12º 17.834'	80º 0.992'	60	Vikravandi	VIKR	R	12° 03.598'	79° 32.695'