On the ecological history of the Western Ghats

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Over three millennia of forest utilization and management by traditional societies, and the practice of state forestry, since last 200 years, have moulded the forest ecosystems of the Western Ghats. Major vegetational changes here began with the migrations of agri-pastoral people, beginning in the middle of 4th millennium BP. The pre-colonial times had mostly village oriented traditional landscape management. Since colonial times, the forestry became more state centered, paying scant consideration to traditional management and to other forces of history which moulded the Western Ghat landscapes. The present landscape and vegetation of the region are replete with reflections of history which may be of great ecological interest.

ONE of the 18 biodiversity hot spots[1,2] of the world, the Western Ghats, together with the West Coast, forms an important ecological region. Springing from the Arabian Sea coast to the montane heights of over 2,000 m, and having rainfall ranging from less than 1,000 mm to over 6,000 mm, the landscapes here are very heterogeneous. This paper broadly tracks the ecological history of the Western Ghats–West Coast region, from the days of its first agricultural colonization, over three millennia ago. This paper also highlights the fact that adoption of an historical perspective may be advantageous to ecologists and resource managers. Efforts are made here to integrate information from diverse fields like archaeology and history, palaeo-ecology, ecology, botany and forestry. Central and parts of the southern Western Ghats are covered in this work and history is reconstructed from a vegetational angle.

Agricultural occupation of the tropical forests

People have been living in tropical forests for millennia and very little of these forests, if at all, may be 'pristine'[3]. Farming here may be less than 10,000 years old, but the pre-agricultural phase of vegetational manipulation to promote favoured food plants by hunter–gatherers is older[4]. In New Guinea, 30 to 40,000 years ago, human beings were manipulating the forest by trimming, canopy thinning, and ring barking to increase the natural stands of taro, bananas and yams[5]. In Central America, hunter–gatherers were burning the pre-montane forest by 12,000 years ago[6]. The Asian forests were inhabited by hunter–gatherers more than 10,000 years ago[7]. Agriculture existed during the Holocene in tropical and temperate areas alike. Thus around 9,000 years BP, while grains were being cultivated in Mexico and the Near East, New Guinea farmers were draining wetlands for growing taro and some other crops[8].

Pre-historical Western Ghats

The Western Ghats came under first human influences during the Palaeolithic or Old Stone Age, over 12,000 years BP (Figure 1). Stone tools of this period were dis-

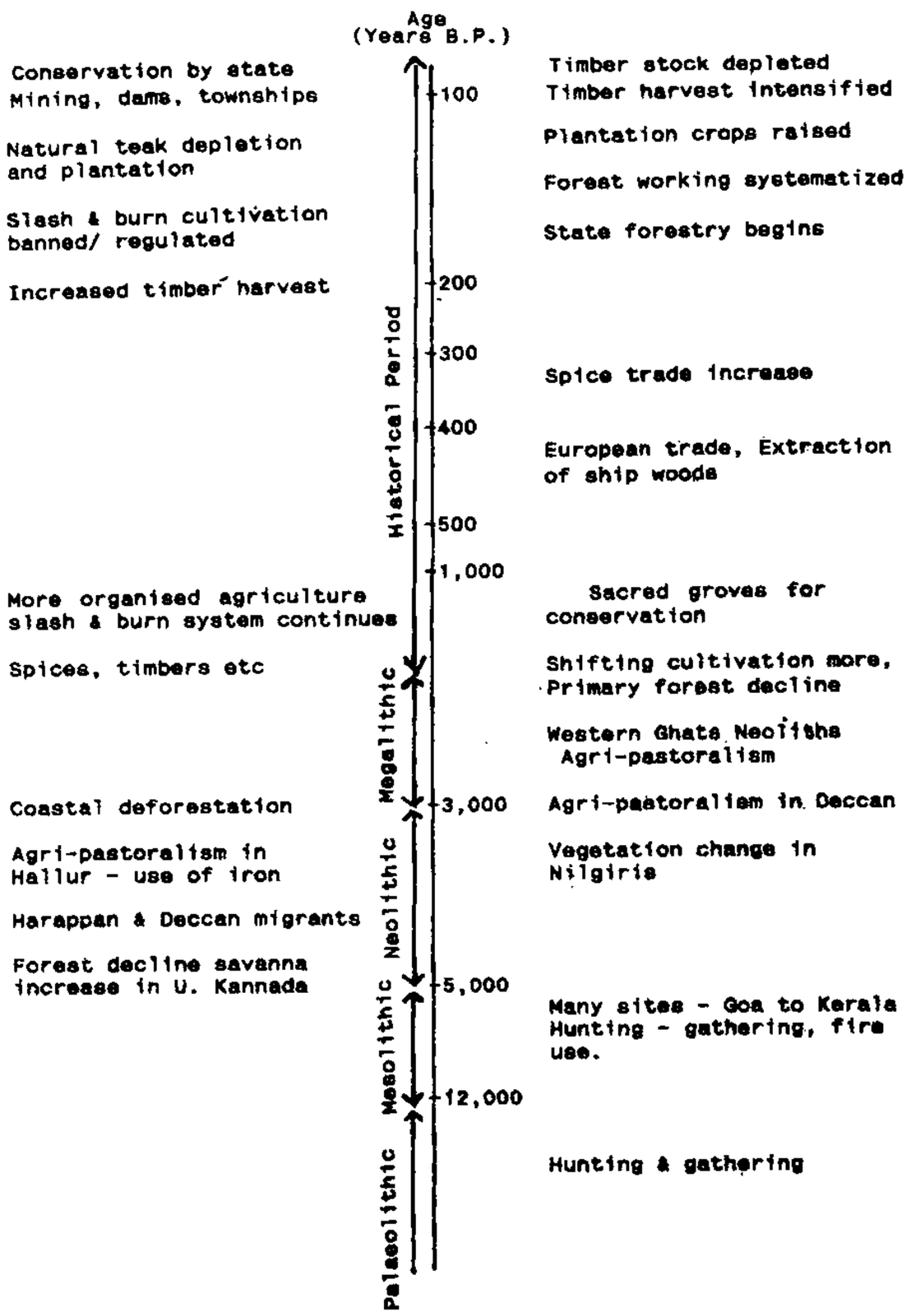

Figure 1. A time chart showing important events in the ecological history of the Western Ghats.

covered from the river valleys of Bharatapuzha (Palakkad dt), Beppur (Malappuram dt), and Netravati (Dakshina Kannada dt)[9,10]. In the western Deccan, Palaeolithic artifacts have been found at Kibbanahalli (Mysore dt), Lingadahalli, Nidaghalla and Kadur (Chikmagalur dt), and Honnalli (Shimoga dt)[11,12]. Being hunter–gatherers, Palaeolithic people would not have caused any serious impact on their natural environment.

Mesolithic or Middle Stone Age (12,000–5,000 years BP) witnessed the transition of hunter–gatherers into food growers. Many Mesolithic sites have been discovered from Mandovi River in Goa to Kerala, such as Karwar and Ankola (Uttara Kannada dt), Netravati Valley (Dakshina Kannada dt), Nirmalagiri (Kannur dt), Chevayur (Kozhikode dt) and Tenmalai (Kollam dt)[9,10,13]. Charcoal of 5,000 years BP, got from trenches in Tenmalai, indicates that the people could have burned forest.

Early agri-pastoralism in the Western Ghats

During the Neolithic or New Stone Age (5,000–3,000 years BP), the Deccan Plateau was waking up to primitive agriculture and pastoralism. About 4,300 years BP animals were domesticated in Kodekal (Gulbarga dt)[14]. In Hallur (Dharwad dt), close to the Western Ghats, cattle, sheep and goat were domesticated 3,800 years BP, and millets and horse-gram cultivated 300 years later[15]. The Jorwe people of Inamgaon, in the western Deccan of Maharashtra, had irrigated rice during 3,400–2,700 years BP. The Jorwes bought marine fish, haematite and shells from the Konkan coast, 200 km to the west[16]. This shows that the Neolithic people of Deccan had some knowledge of the Western Ghats and the coast. Some of the many Neolithic sites in the Western Ghats are Tambde Surla (Goa), Anmod (Uttara Kannada dt), Agumbe (Shimoga dt), hill slopes of Sita River (Udupi), Kodagu and many others in Kerala[9,10,17–19].

The Nilaskal site in Agumbe, being close to the sources of West Coast rivers Sharavati, Chakra and Haladi, was strategic to the Neolithic people, giving them an easy access to the coast. According to Sundara[13], Neolithic people with their stone axes descended from the Western Ghats of Dakshina Kannada to the coast, in the last part of the 4th millennium BP and resorted to cultivation, probably by slash and burn method. Similar westward migration of Neolithic agri-pastoralists from the Deccan could have taken place elsewhere too. Hill cultivation (presumably shifting) in South India may be older to the spread of iron tools here, about 3,000 years back[20].

During the Megalithic Period (3,000–2,000 BP), iron implements were widely used. Use of iron dates back to 3,500 years in Hallur[15]. The West Coast of South India was intensely settled during this Period. Numerous Megalithic burial sites are associated with chambers dug in lateritic plains of the West Coast in Karnataka and Malabar[13,21]. The Megalithic Period would have witnessed intensification of forest clearance by agri-pastorals. The torrential rains of the region would wash away exposed soil from hills and plateaus, exposing the laterite and hastening its weathering.

Fourth millennium BP vegetational changes in the Western Ghats

A palynological study based on a marine core from Uttara Kannada, by Caratini *et al.*[22], shows that about 3,500 years ago there occurred a sharp increase in savanna pollen, mainly from grasses, and a decline of pollen from evergreen and deciduous forest plants, and mangroves. These changes have been attributed to the onset of an arid climate.

A study in the peat bogs of montane Nilgiris, by Sukumar *et al.* shows a shift of C3 vegetation (C3 forest/grassland) towards C4 vegetation (grassland), during 6,000–3,500 years BP, due to lower rainfall and lower CO_2 levels. Predominance of C4 vegetation reflects arid conditions and that of C3 vegetation reflects moist conditions[23].

The climatic change theory effectively explains the expansion of C4 grasslands in the montane Nilgiris, during the 4th millennium BP, where during a similar arid spell 20,000–18,000 years BP also such grasslands had existed[23]. But this theory alone may not explain vegetational changes in Uttara Kannada (mean elevation 600 m). Pascal[24,25] considers savannas in the plains and at moderate altitude in the Western Ghats as essentially the result of fire. Gadgil and Meher-Homji[26] consider the savannas of much of the Indian subcontinent as due to human interventions in the woodland ecosystems.

Chandran[27] suggests that the beginning of agri-pastoralism may be the main cause for the 4th millennium BP changes in Uttara Kannada. In fact almost all the forest species, represented in the pollen sample[22], occur to this day in the region. Of these *Dipterocarpus indicus*, an endemic tree of the Western Ghats, occurs mainly in a few sacred groves or *kans* of Uttara Kannada. Its presence in these *kans* may be correlated to decline of primary forests elsewhere due to human factor and its failure to revive in the secondary forests[27]. In Borneo, Ashton[28] noted the absence of Dipterocarps in secondary forests, where tribes had slashed and burned in the past. We should, therefore, also look into contemporary history as well.

Harappan migration into South India?

Increased aridity in the climate of Indus Valley, salinity rise in the lakes and drying up of the Saraswati River, during 4th millennium BP, may have caused an upstream migration of the Harappans, towards the Siwalik Himalayas[29]. The Western Ghats region, due to its strategic position, could have still been enjoying a relatively humid climate. The biodiversity-rich forests, the abundant water resources, the productive estuaries and the sea, could have attracted the drought stricken Neo and Megalithic agri-pastorals from the Deccan, as well as the Harappans[27] (Figure 2).

The Indus Civilization did not perish suddenly according to Dixit. The Later Harappan Phase survived in Saurashtra, Gujarat, north Maharashtra and in the northern states up to 3,200 years BP (ref. 30). Apart from a more benevolent climate and richness of biological resources, other reasons for a suspected Harappan migration into the south are:

i) Late Harappan culture is said to have intruded into lower Deccan, as far as Daimabad and Upper Krishna Valley in the Belgaum region[31,32].
ii) Harappan culture was not a horse and chariot based one unlike the Vedic culture. The suspected objects of worship in the Indus Valley, the Mother Goddess, a male god – considered a prototype of Siva, the humped bull, the serpent, etc. bring it rather closer to the pre-Vedic cultures, whose survivals today are mainly in the mountainous and hilly regions of India. The main strongholds of Saivism, Shakti (Mother Goddess) worship, snake cults and tree worship are the Western Ghats, the Himalayas and the Central India. The Harappan's was, therefore, not a culture insulated from the rest of India, but one which enjoyed continuity with it.
iii) The art of making terracotta figures, including of the Mother Goddess, was a cardinal trait of the Harappan culture. Many sacred groves of the Western Ghats have a rich deposit of ancient terracotta figures; some communities continue the prehistorical practice of making such figures as votive offerings to their deities. Such figures of the Maurya–Satavahana period were found at Banavasi in Uttara Kannada[33].
iv) Wild or semi-wild rice was possibly adopted by the farmers during the Late Harappan phase[30]. The salt-tolerant wild rice strains of the West Coast could have been ideally domesticated from 3,500 BP. The rice cultivation in the reclaimed estuaries could have perhaps caused the mangrove decline in Uttara Kannada as noticed in the pollen samples[22].

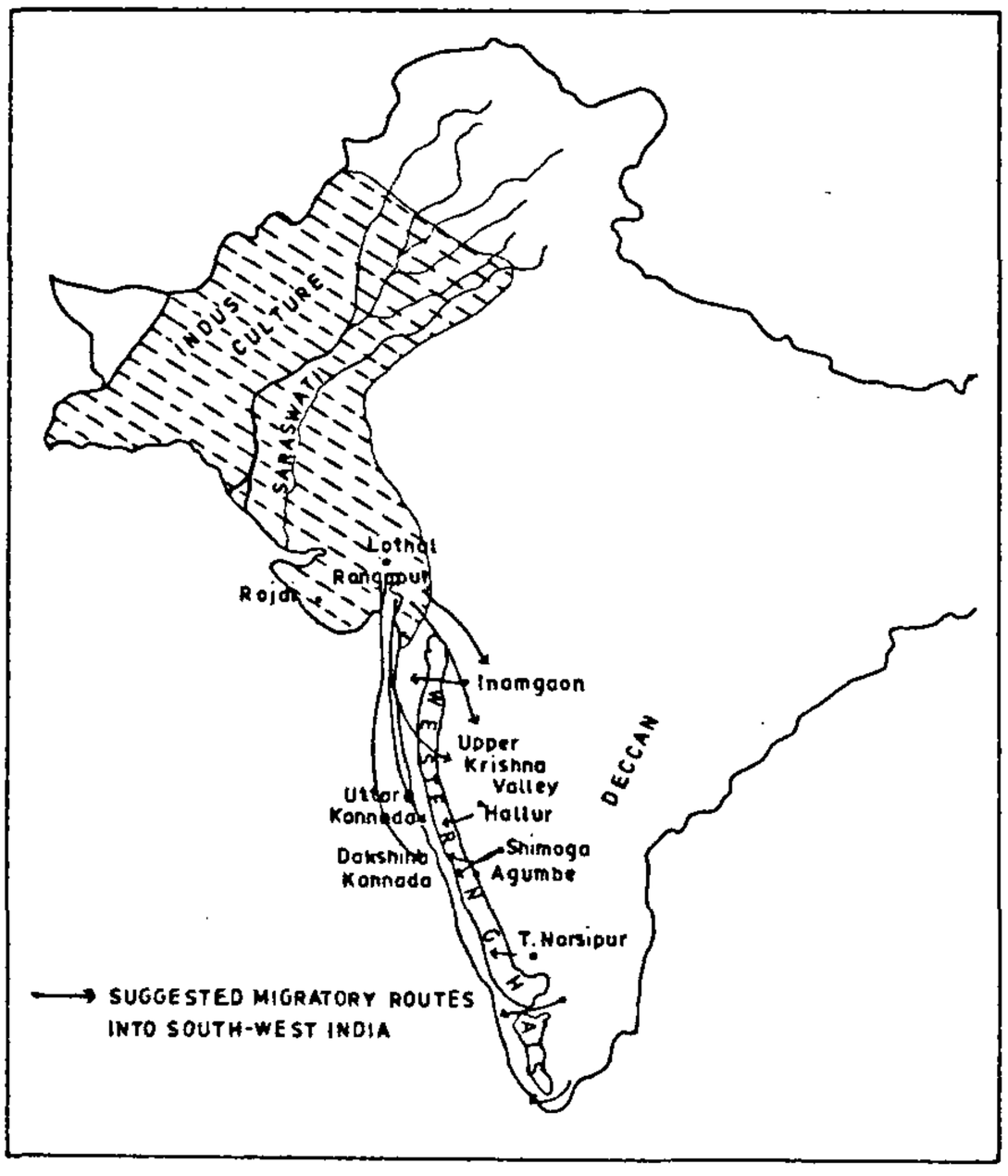

Figure 2. Suggested routes of migration of agri-pastorals from southern Harappa and Deccan Plateau into South-West India during the Neolithic–Megalithic period.

The legend of coastal reclamation

The West Coast could have been, earlier, a maze of hills covered with evergreen forests, estuaries, sandy plains and other lowlands. The beginnings of coastal reclamation may date back to pre-historical period, merging with legends and folklores. *Mahabharata*, *Vishnu Purana* and *Skanda Purana* state that the Sage Parashurama, standing atop the Western Ghats, threw his axe into the Arabian Sea retrieving the West Coast. Some recent findings, in the context of coastal reclamation, are significant:

(i) The land in and around Karwar contain recent Molluscan and micro-faunal shells. The freshness of the Molluscan shells of Mangalore coast suggests that 'this coast can be considered as an emergent shore[34]'.
(ii) Bourgeon[35] considers the fluvio-littoral plains of Uttara Kannada coast as of recent origin. He observed fossilized mangrove soils under nearly two meters of recent sediments. The ferruginous accumulations that he found in such areas are likely to be derived from the iron-rich hill soils used for coastal reclamation. In coastal Uttara Kannada today, commercial exploitation of Molluscan shells buried underneath the rice fields shells is going on.

(iii) A peat deposit recently discovered in the Arabian Sea, off the Uttara Kannada coast by Mascarenhas *et al.*[36] needs to be re-examined in the context of a pre-historical coastal de-forestation. This peat was mixed with flaky materials resembling broken twigs. Its high content of organic carbon, iron and aluminium, and other mineral contents similar to the rocks of Uttara Kannada, may indicate that the peat may be a deposit of slashed and burned land vegetation, mixed with eroded land minerals. In fact the savannization of most of the Uttara Kannada coastal hills had already taken place before the British occupation itself[27].

The Western Ghats in history

The Western Ghats figure early in South Indian history. King Ashoka sent a messenger to spread Buddhism in the Banavasi kingdom in the central Western Ghats, during 3rd century BC (ref. 33). The West Coast had spice trade with the Roman empire. References to rice and millet cultivation in the South Indian hills are found in the 2,000 years old Sangam Tamil literary works.

Hill agriculture and community forestry

Early agricultural settlements along the rivers were perhaps also associated with slashing and burning of forests in the nearby hills, for cultivation. The vegetation maps of Uttara Kannada Western Ghats[37], for instance, show that secondary moist deciduous forests occur along the river courses. Ward and Conner, in their memoir of the survey of Travancore and Cochin States, during 1816–20, mention that each river was rented out for the extraction of teak[38]. That teak and bamboo rich deciduous forests, instead of the climatic evergreen forests, were plentiful along the West Coast rivers, at the time of British occupation[39,40].

Shifting cultivation in the Western Ghats

The shifting cultivators seem to have normally occupied a zone below 1000 m (ref. 40), perhaps avoiding the colder and wind-swept heights. Thin human population and long fallows often permitted the return of the forest[39,40] (Figure 3). Buchanan[41], who travelled through Malabar and Canara in 1801, made detailed studies on pre-colonial land use. At Gokarna he found records of 1450s relating to tax on shifting cultivation. Coastal hills of Uttara Kannada were formed into terraces for cultivation of gingelly and blackgram. In the interior hills, in the first season after burning the woods, were sown ragi (*Eleucine coracana*), red gram (*Cajanus cajan*), and castor (*Ricinus communis*). Next year on the same ground was raised a crop of shamay (*Panicum sumatrense*).

Figure 3. The Western Ghats forests show numerous evidences for past human occupation – like deserted villages, towns, fortresses, slash and burn fields. Here is a wall from remote Kaltigudda evergreen forest of Uttara Kannada (Photo: Author).

Figure 4. Sacred grove and the pond in Sagar taluk of Shimoga. The groves are often associated with water bodies (Photo: Author).

The tribals of Travancore hills planted rice, cowpea, gingelly, tapioca, yams, cucurbits, brinjal, chilli and plantain[40]. Kanis and Arayans planted their surroundings with trees like mango and jack. Each tribe of Travancore hills had a certain tract of country which was considered to belong to it, and no one dared to encroach on the land of another village[40].

Conservation in the pre-colonial days

Indigenous people with a historical continuity of resource use practices often possess a broad knowledge base of the complex ecological systems in their own localities and they do develop a stake in conserving, and in some cases enhancing biodiversity[42]. In the Western Ghats, forest conservation went hand in hand with utilization. Hunting was subjected to many community regulations[43].

Amidst the secondary forests and fallows of Travancore hills, Bourdillon[40] noted: 'Many pieces of forests are left untouched when the surrounding land has been cleared... because they are supposed to be each inhabited by some spirit.' Forest clearance was inevitable for farming; yet there was an overwhelming belief in the sacredness of the woods. To Buchanan in 1801, the people near Karwar conferred[41]: 'The forests are the property of the gods of the villages..., and the trees ought not to be cut without having leave from the Gauda of the village.' Secondary species and heavily savannized tracts were interspersed with lofty evergreen patches, the *menasukans* or pepper forests, where the people tended to the wild pepper. The relics of such *kans* occur to this day in Uttara Kannada and Shimoga. They were important pieces of pre-colonial forest conservation in the Western Ghats. Myriad relics of such groves, exist even today all over the Western Ghats (Figure 4). They may be *devrai* in Maharashtra, *devarakadu* in Coorg and *kavu* in Kerala and Tamil Nadu[10,44,45]. These sacred forests, in the pre-colonial landscape, served many functions like conservation of biodiversity and watershed, moderation of climate, and enhancement of landscape heterogeneity which promoted varied wildlife. The people had also much reliance on subsistence hunting. The village sacred forests ranged in size from few ha to few hundred ha (ref. 44). The *kans* of Sorab taluk in Shimoga, for instance, covered about 13,000 ha or 10% of Sorab's area[46].

Decline in valley forests and freshwater swamps

Rice cultivation in the fertile valleys preceded gardens of early commercial crops like arecanut and pepper. The original vegetation of the ill drained valley bottoms with sluggish streams, in elevations below 1000 m would be often a special formation, the *Myristica* swamp[47]. These swamps, though rare, still occur in Thiruvananthapuram[48]; the northernmost *Myristica* swamps are found in the Siddapur taluk of Uttara Kannada[27]. Rare Western Ghat endemics like *Myristica fatua* var. *magnifica*, *Gymnacranthera canarica*, *Semecarpus auriculata* and a fragile palm, *Pinanga dicksonii* are found growing in such swamps.

Freshwater swamps in Uttara Kannada were being favoured for conversion into arecanut gardens and fields of summer rice[41]. Expansion of traditional agriculture and the spread of particularly rubber, coffee and forest tree plantations would have wiped out large pockets of primary forests in valleys. The *Myristica* swamp may be considered as an endangered habitat. Swamps being sources of streams, their destruction would have diminished the watershed value of the Western Ghats.

State forestry in the Western Ghats

The British occupation of the Western Ghats, from early 19th century, set the tone for forestry operations to date. Traditional forest management systems did not impress the British. The Madras Government banned shifting cultivation in 1860. The Government of Bombay banned it in Uttara Kannada late in the 19th century. The state foresters failed to link the association of teak and other deciduous timbers in the evergreen forest belt of the Western Ghats with old slash and burn fallows. Troup[49], the silviculturist, in 1921, decades after the ban on shifting cultivation, brought this to the notice of the foresters.

The early forest working plans for the evergreen forest belt of South Indian Western Ghats mainly aimed at the extraction of commercial deciduous timbers like teak. However, the diminished role of fire as an ecological factor, following the ban on slash and burn cultivation, favoured the return of the evergreens, as in Uttara Kannada. As large teak was harvested, adequate natural regeneration did not follow under the darkening canopy of the evergreens. The rising demand for teak and its depletion in nature made the foresters to initiate massive vegetational changes in favour of teak monoculture[30,50,51].

The higher altitude forests were, if at all, sparsely populated with tribal people. Following the British occupation began large-scale forest exploitation and wholesale vegetational transformations into commercial plantations of coffee, tea, wattle and *Eucalyptus*. Such commercialization of the high altitudes, as of the Nilgiri plateau, marginalized the small populations of the earlier human groups, the so-called 'ecosystem people' engaged in hunting–gathering, shifting cultivation and pastoralism. The State policies favoured the immigrant 'biosphere people', who controlled natural resources in the Nilgiri area, and extracted and traded them in the markets. The spurt in commercialization of natural resources and commodity production also attracted an exodus of migrant labourers with overall serious ecological consequences on the biota[52]. The high altitudes of Kerala and southern Tamil Nadu also witnessed similar transformations beginning in the mid 19th century.

Decline of the sacred forests

Government reservation of the *kans* of Uttara Kannada as state forests, late in the 19th century, was followed by introduction of contract system for collection of non-wood produce, which replaced the community management[53]. In Shimoga, as the state claimed the timber-rich deciduous forests, the people were required to meet their biomass needs from the evergreen *kans*, which they had conserved through ages as safety forests. Not aware of

the role of *kans* in the traditional land use system of Karnataka Western Ghats, Brandis and Grant[46] wondered: 'Why should a certain locality be covered with evergreen, and another in its immediate vicinity with dry forest?' *Kans* were also released for coffee cultivation.

In Uttara Kannada many *kans* were allotted as leaf manure forests to the arecanut growers as well as added to the category of open access 'minor forests', hastening their destruction. After independence Uttara Kannada *kans* were even subjected to timber and firewood harvesting. Under the influence of a cultural change that has been sweeping through the Western Ghats region, the pre-Vedic deities of the sacred groves are related to the deities of organized Hinduism and temples are being erected to house them, the groves suffering in the process[10,44]. Some notable sides of the state forestry are the restrictions on shifting cultivation, which favoured the return of the evergreens, and the formation of wild life conservation areas and biosphere reserves.

Decline in plant endemism and evergreenness

Most of the Western Ghat endemic plants are associated with evergreen forests[27,54]. The Western Ghats also share several plant species with Sri Lanka. A study of 81 sample plots in Uttara Kannada, by this author, shows that tree endemism, including shared endemism with Sri Lanka, increases with evergreenness of the sample (Figure 5). By evergreenness is meant the proportion of evergreen trees in the total tree population. Slash and burn cultivation, savannization and forestry operations favouring deciduous timbers would have reduced plant endemism in the Western Ghats. The stoppage of slash and burn cultivation, on the other hand, is expected to favour the return of the evergreens[27].

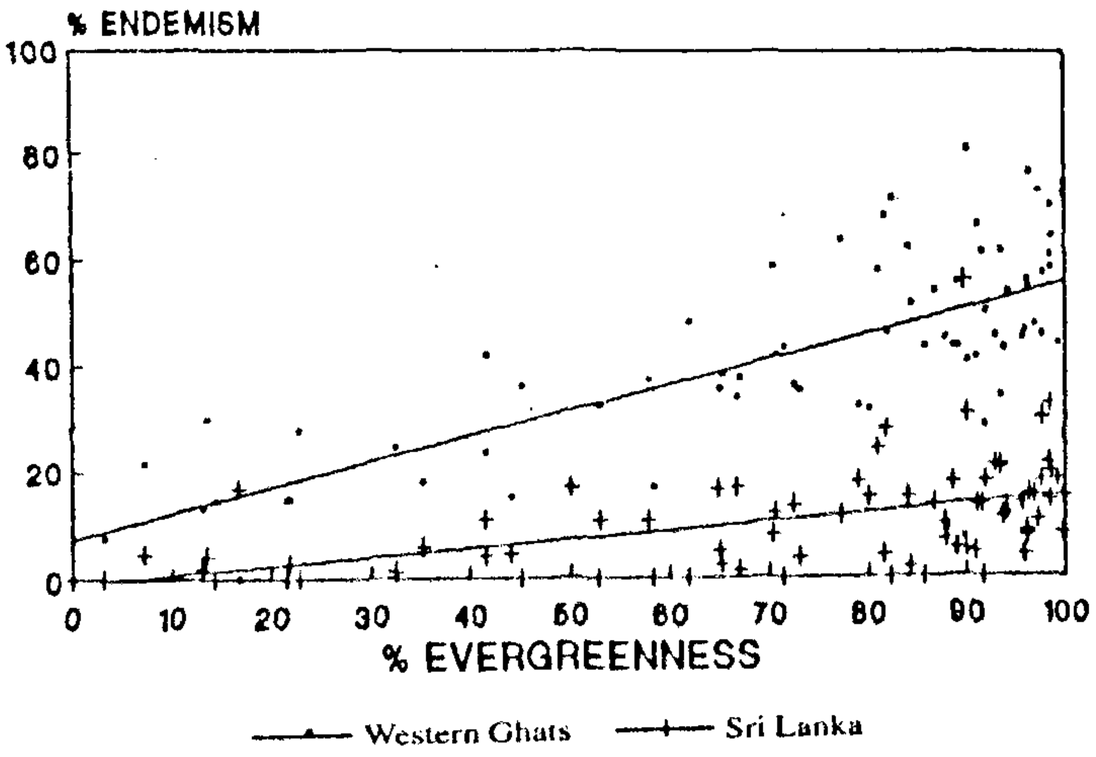

Figure 5. Correlation between evergreenness and endemism [endemic to Western Ghats (dotted), endemic to Western Ghats and Srilanka (plus marks)] in the tree communities of 81 forest samples in Uttara Kannada.

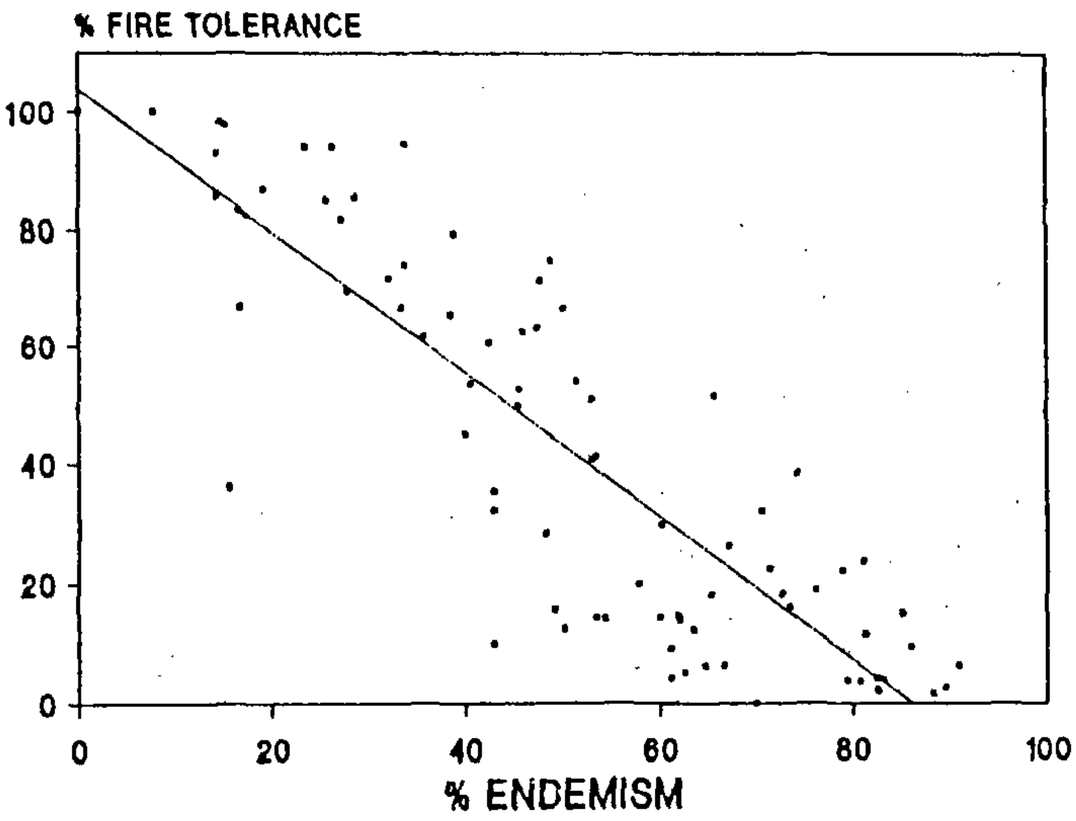

Figure 6. Correlation between fire tolerance and endemism in the tree communities.

Fire and forests

Fire must have played a major role in the vegetational history of the Western Ghats. Fire affects the regeneration, both directly through the burning of seeds, seedlings and trees and indirectly through its action on the soil by increasing surface temperature, reducing organic matter, modifying soil texture and facilitating erosion. Soil physics and chemistry are also affected and fungi and micro-organisms and soil fauna are destroyed[55]. Slash and burn cultivation in the heavy rainfall zone of the Western Ghats, would have favoured the spread of bamboo and hardy leaf shedding trees with thick bark, lighter seeds and high coppicing and propagation through roots. Examples of the fire tolerant are *Acacia catechu, Careya arborea, Dalbergia latifolia, Dillenia pentagyna, Schleichera oleosa, Tectona grandis, Terminalia* spp. and *Xylia xylocarpa*. Figure 6 shows that the percentage of fire tolerance in the 81 forest samples of Uttara Kannada decreases steeply with increase in endemism[27,49]. The ban on shifting cultivation favoured the return of the evergreens to the disappointment of the foresters[50].

The use of fire in the past might have caused the destruction of forests on many exposed, wind-swept, medium elevation mountain tops (800–1600 m) as in Kemmangundi, Kudremukh or Coorg in Karnataka Western Ghats. Forests perhaps failed to return here creating stretches of fire-prone grassy patches which are interspersed with evergreen forests in the folds rich in endemism. These grassland–forest complexes mimic the true shola–grassland complex of the montane Nilgiris and the High Ranges of Kerala.

Reflections of history in the woods

Almost every patch of forest in the Western Ghats has its own unwritten history – history of conservation, inaccessibility, exploitation or transformation. The Uttara Kannada study by this author[27], involving 81 sample sites, tries to recapture the dynamism of forest history in a tangible form. In the absence of fire as an ecological factor we may expect (1) A return of the endemics, mostly fire sensitive trees (Figure 6); (2) Endemics are mostly evergreens with thin bark (Figure 7); (3) Increase in mean seed weight of the forest patch – as the canopy gets darker with recruitment of more evergreens, heavy seeded species increase in the community (Figure 8).

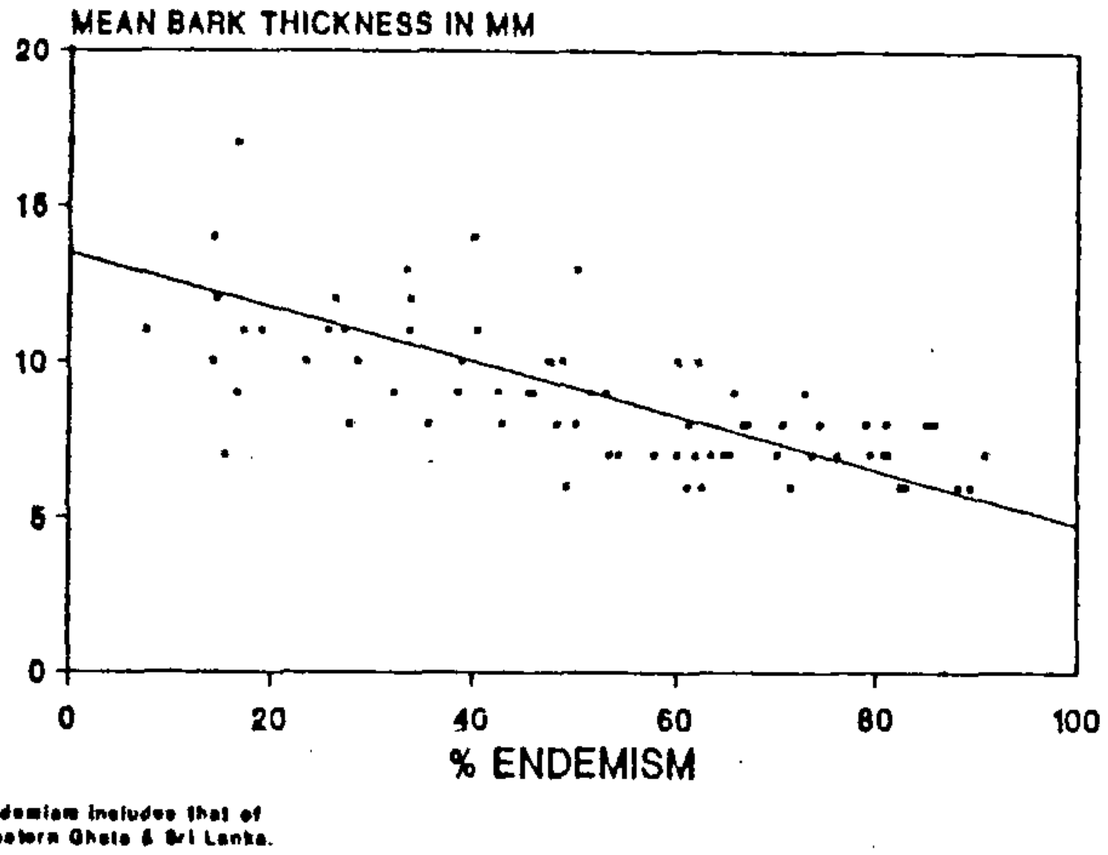

Figure 7. Correlation between bark thickness and endemism in the tree communities.

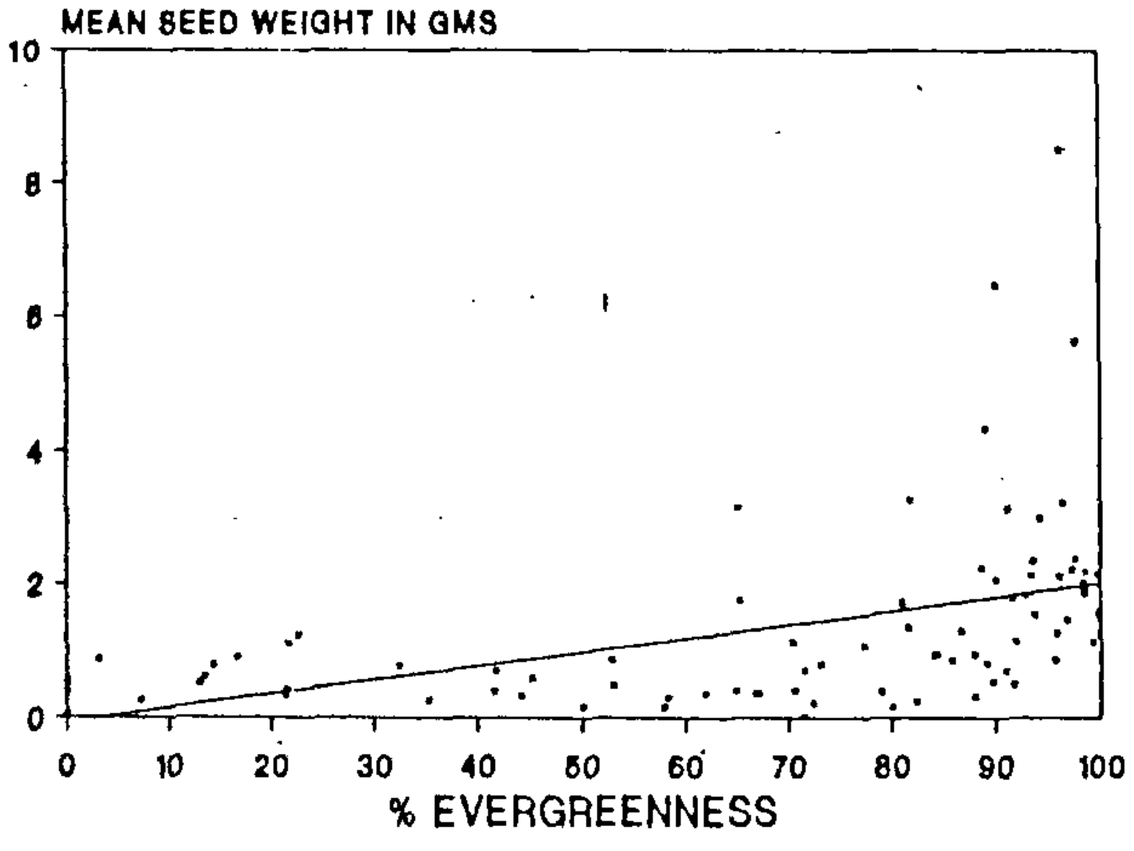

Figure 8. Correlation between evergreenness and seed weight in the tree communities.

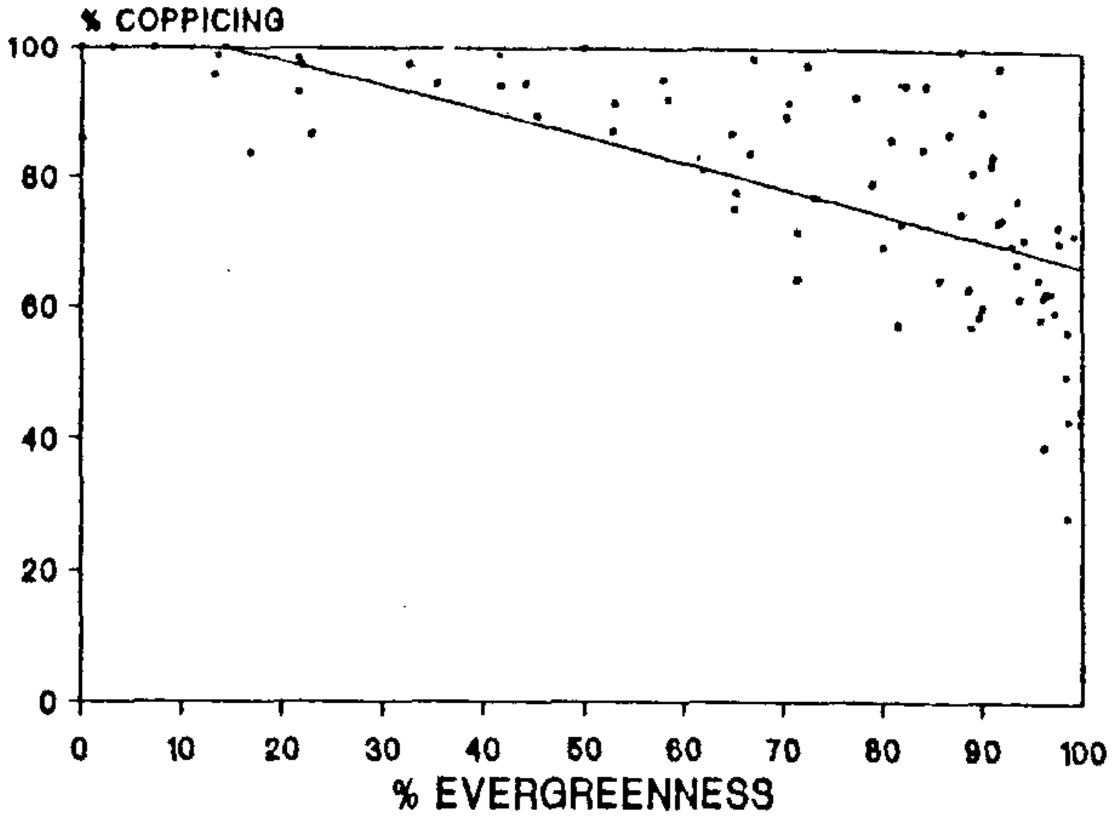

Figure 9. Correlation between coppicing character and evergreenness in the tree communities.

Primary tree species of the tropics, often with animal dispersed fruits, are large seeded, shade tolerant, slow growing and long lived unlike the light seeded and short lived pioneers which thrive in large forest gaps. Late successional trees tend to have heavier seeds[56–58].

Pioneers of large gaps like *Macaranga peltata*, and *Ervatamia heyneana*, are very light seeded (0.048 g for both). Teak seed weighs just 0.044 g; for *Xylia xylocarpa*, a deciduous tree, it is 0.24 g. The seed of *Dipterocarpus indicus*, a climax evergreen tree, weighs nearly 3 g. The heaviest seeds of the samples are for *Myristica malabarica* (13 g). When a forest recovers its evergreenness, the generally light seeded deciduous species are destined to be replaced by heavier seeded evergreens. As the evergreenness increases, coppicing trees (which obviously have accumulated in areas of human disturbances) tend to decline (Figure 9)[27].

Forest history in tree ages

Ring count to estimate tree age is considered inapplicable or unreliable in the tropical rain forests. Nicholson[59] and Rai[60] used annual growth increments to estimate tree ages. Rai's estimates are based on data from forest preservation plots in Karnataka Western Ghats. The annual diameter increment for slow growing evergreen *Myristica malabarica*, for e.g. is only 0.14 cm; that of the deciduous *Terminalia paniculata* is 0.3 cm; for faster growing deciduous tree *Dillenia pentagyna* the d/yr is 0.55 cm (refs 61–63). Although the method is indirect and does not consider the environmental factors, it is useful in unravelling forest history.

In the field studies by this author in Uttara Kannada evergreen forest belt, girth of all the trees in 25 sample

plots, each of 1 ha, was measured. The application of Rai's growth increment formulas for trees in these sites shows that, as expected, most leaf shedding tree species regenerate in deciduous forests or in low evergreen areas. In high evergreen forests, the deciduous, if present, are older individuals whose regeneration may be at stake. The estimated ages of the deciduous trees, for instance, provide clues to the forest historian as to when the last major canopy opening took place, favouring the arrival of the deciduous[27].

Figure 10, for instance, illustrates that *Terminalia paniculata*, a light seeded, thick barked, deciduous timber species capable of coppicing regenerates in forest samples where up to 70% of the trees are evergreen. However, isolated older individuals may occur in high evergreen forests. The youngest of such individuals fall in the age class of 75–100 years. This is significant historically; slash and burn cultivation in Uttara Kannada was almost totally banned towards the close of the 19th

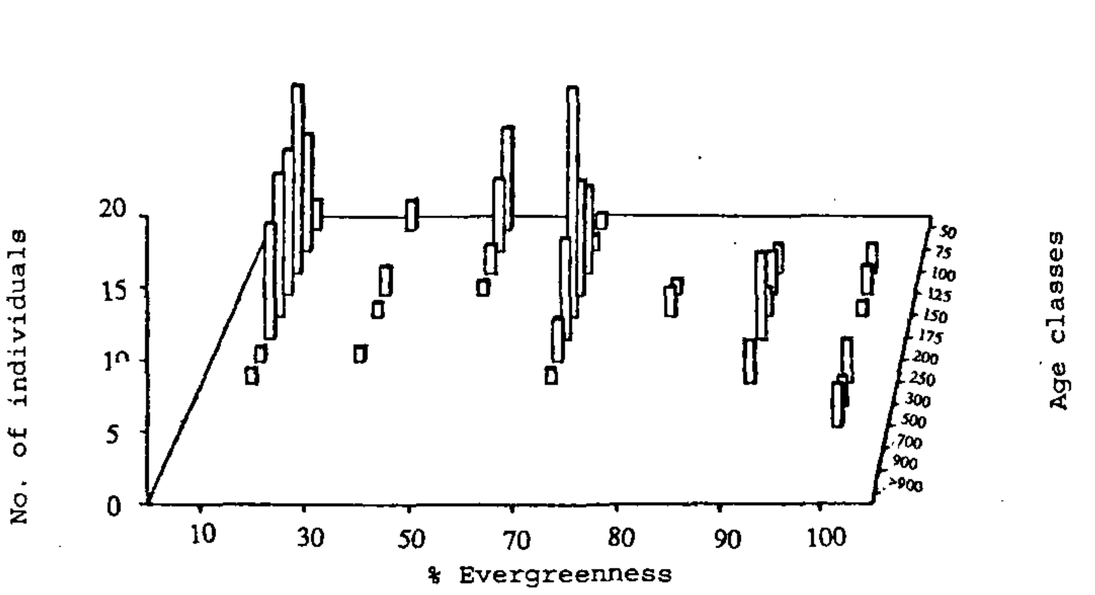

Figure 10. Age classes of *Terminalia paniculata*, a deciduous tree, in 25 one ha forest samples of Uttara Kannada. Note that high evergreen forests have only older trees.

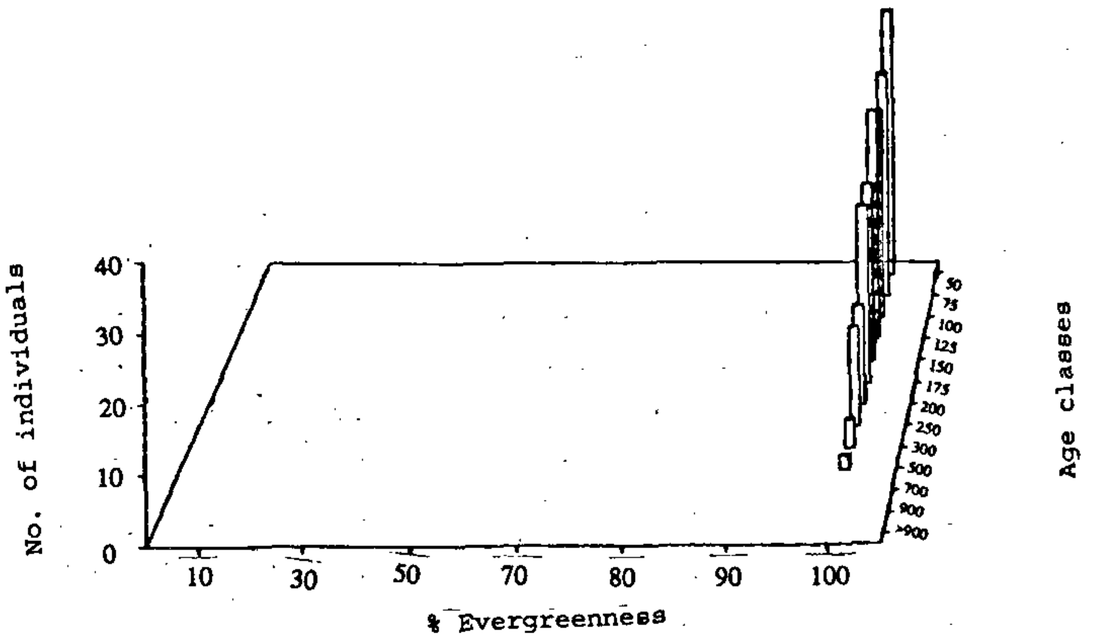

Figure 11. Age classes of *Dipterocarpus indicus*, an endemic evergreen tree of the Western Ghats in 25 one ha samples. Note that the species, in all ages, occur only in high evergreen forest.

Table 1. Estimated ages of some deciduous (D) and some evergreen (E) tree species from a one ha forest plot in Uttara Kannada having 92% evergreen trees

Tree species	No. of trees in different age classes (age × 10 yrs)						
	< 5	5–10	10–15	15–20	20–25	25–30	30–35
Terminalia paniculata (D)	–	1	–	–	2	2	1
Lagerstroemia microcarpa (D)	–	–	–	–	2	1	–
Stereospermum personatum (D)*	–	1	–	–	1	–	–
Vitex altissima (D)*	–	2	4	–	1	–	–
Olea dioica (E)	1	2	5	5	8	2	–
Diospyros candolleana (E)	1	9	9	1	–	–	–
Diospyros ebenum (E)	1	10	7	–	–	–	–
Khema attennuata (E)	–	80	81	22	4	–	–
Myristica malabaricar (E)	–	2	4	4	3	–	1

*Associated with tree fall gaps of evergreen forests.

Table 2. Estimated ages of some deciduous (D) and some evergreen (E) tree species from one ha forest plot in Uttara Kannada having 89% of evergreen trees
Shifting cultivation was reported from the site during 1850–1890 period

Tree species	No. of trees in different age classes (age × 10 yrs)						
	< 5	5–10	10–15	15–20	20–25	25–30	30–35
Terminalia paniculata (D)	–	–	1	1	–	–	–
Lagerstroemia microcarpa (D)	–	4	11	2	1	–	–
Careya orborea (D)	–	–	1	1	–	–	–
Vitex altissima (D)*	1	7	4	–	–	–	–
Diospyros candolleana (E)	15	65	15	–	–	–	–
Hopea wightiana (E)	5	23	7	–	–	–	–
Knema attenuata (E)	–	74	66	5	2	–	–
Olea dioica	2	37	26	10	–	2	–

*A gap species in evergreen forest.

century. Since then evergreens are expected to return. On the other hand, Figure 11 shows that *Dipterocarpus indicus*, a climax evergreen species of the Western Ghats is present only in high evergreen forest[27].

This finding may be supported by tree ages of key deciduous and evergreen species from individual sample sites (see Tables 1 and 2). Table 1 is based on a 1 ha site with unknown history where 92% of trees are evergreen. Some important deciduous elements like *Terminalia paniculata* and *Lagerstroemia microcarpa* are found in older age classes (mostly in 200–300 yrs). The deciduous tree life *Stereospermum persenatum* and *Vitex altissima* are more associated with the tree fall gaps of disturbed evergreen forests.

Table 2 shows the ages of key deciduous and evergreen species from another 1 ha site Kanchimale – a site with known history of slash and burn cultivation up to the close of 19th century. Here 89% of the trees are evergreen and mostly found in all age classes. Most deciduous species are aged over 50 years, reflecting the fact that ban on slash and burn cultivation during the latter part of 19th century has resulted in progressive succession by evergreens, giving very little scope for regeneration of the deciduous. In the absence of any standard universal method of portraying vegetational changes in the complex forests, an indirect method based on tree ages may be of some help.

Concluding remarks

Major human induced ecological changes in the Western Ghats begin with the arrival of agriculture and pastoralism. A climatic change towards the middle of fourth millennium BP, which induced widespread human migrations within the Indian sub-continent is correlated to decline of forests and mangroves in our focal area. The contemporary archaeological scenario of Deccan also permits us to think of the migration of agricultural man into the south-west India. As primary forests were cleared and coastal marshes reclaimed, people also evolved various conservation mechanisms in a decentralized fashion which assured sustainability. However, the process of commoditization of forests from early 19th century, disrupted this balance of local communities with nature as well as created various ecological consequences. The forest ecosystems do bear the imprints of human actions through history. An understanding of ecological history can surely go a long way in promoting more imaginative management of the precious resources of the Western Ghats.

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