KFRI

EVERGREEN

Half Yearly Newsletter of the Kerala Forest Research Institute, Peechi

No. 53 & 54 September 2004-March 2005

Mangroves: the Living Treasure

Mangroves have become a focal theme for discussion among policy makers, academicians, environm entalists and other lovers of nature including many NGOs, and recently the larger public. Now, it is also true that this is being echoed in the higher ups, the policy and decision making bodies and the Government of India has taken initiative to promote mangroves. A distinct conglomerate of '*mangrove research and awareness*' is now identifiable in the environmental pitch as echoed in scientific and environmental gatherings, discussions, writings, and mass communication media and this deserves a meta-analysis why the theme has been thrown in to the forefront of environmental agenda. Kerala being a narrow coastal State with a long and almost denuded coastline replaced with coconut groves, densely packed residential dwellings and artificial shrimp farms, such an analysis has much relevance especially in the context of global warming and the recurring disasters like sea intrusion and tsunami.

Research on mangrove is a current thrust area which is being addressed by the Kerala Forest Research Institute. A summary of the discussion on the topic the Evergreen editorial team had with the scientists of the Mangrove Research Group (Drs. JK Sharma (JKS: Director, KFRI, Programme Leader), C. Mohanan (CM), George Mathew (GM), K.K. Ramachandran (KKR), Thomas P. Thomas, E.A. Jayson (EAJ), K. Mohandas (KM), P.K. Muralaeedharan (PKM), C. Renuka (CR) and K. Swarupanandan (KS)) is presented below:

A magnificent mangrove at Dalil North, Kannur, November 2004.

Issue Highlights

Question: Many people do not have a first hand experience with the mangrove forest and they do not know, how they differ from other forested

A view of degraded mangrove ecosystem

ecosystems. Could the working group please describe it briefly?

KS: '*Mangrove*' vegetation, a synonym for the '*mangal*' forest stand, is a littoral swamp forest restricted to the intertidal areas like shorelines, estuaries, backwaters, lagoons, creeklets, river mouths and river courses that intrude in to the land for some distance. It is characteristically swampy being regularly flushed by brackish water. The height of the tides, the quantum of inflowing water, the duration of water logging, *etc*, are determined by the location, whether it is in the tidal front or farther landward. The tidal inflow also brings in lot of debris and soil particles and the soil being saturated with water is very loose and therefore movement thorough the mangrove forest is not very easy.

Mangroves are salt tolerant plants - the *halophytes*. Halophytes can utilize the saline water and can successfully regenerate and establish in the saline environment. While many of them have specialized rhizomorphs with stilt roots that ensure anchorage in the highly unstable soil, some of them have specialized breathing roots – the *pneumatophores*, that protrude on the ground and augment the breathing ability in the anoxic soil. A few others have specialized glands that excrete the salt contained in the absorbed water. Many of these plants also produce seedlings directly on the mother trees, a phenomenon referred to as *vivipary*, as seen in animals.

Mangrove vegetations show characteristic zonation with highly salt-tolerant and tide- tolerant species with stilt roots towards the tidal front and less tolerant species with pneumatophores distributed further landward.

The characteristic mangrove species found along the West Coast are *Rhizophora mucronata, Avicennia officianlis, A. marina* and *Excoecaria agallocha* are sufficiently large trees. *Aegiceras corniculatum, Kandelia candel and Cerbera manghas*, are trees of medium stature, and *Acanthus ilicifolius*, a gregarious spinescent shrub. *Clerodendrum inerme* is a climbing or straggling mangrove associated shrub. There are places, where the swamp fern, *Acrostichum aureum*, grows gregarious. A species of grass belonging to the genus *Aeluropus* is a pioneer on sandy beds and some species of *Cyperis* and *Elaeocharis* are also pioneers in muddy, more or less stagnant open swamps.

Question: Recently, the mangrove is profusely echoed in scientific and technical discussions, TV and other mass media. What is the reason that mangrove is of great environmental concern?

JKS: There are many reasons why the mangroves have become so important in the current scenario especially after tsunami. The coastal zone is a dynamically unstable system where natural disasters of one or the other kind like sea intrusion, cyclones, tsunami, etc. strike year after year. It is in this context that the role of the mangroves becomes important.

During the last 300 years, there has been a gradual increase and unusual accumulation of carbon dioxide in the atmosphere mainly due to industrial activities. Carbon dioxide in the atmosphere can absorb heat and re-radiate it back to the earth. As a result, a humid situation as experienced in a green house, the '*greenhouse effect*', is experienced and the '*radiative forcing*' is the causal factor of the now experiencing '*global warming*'. Depletion of the ozone umbrella is another serious environmental havoc that we witness through the 20th and 21st centuries. Chloroflurocarbons, carbon dioxide and many other greenhouse gases are the culprits depleting ozone and perforating the umbrella. Depletion of the ozone layer breaks the control over harmful radiations reaching the atmosphere and the result again is an amplification of the greenhouse effect. The greenhouse effect would

tilt the dynamic equilibrium of the atmospheric temperature by several degrees in a skewed way, causing large-scale unnatural melting of the icecaps (high latitude and high altitude). This would bounce up on the oceans to contain more water(s) and would sink coastal and low laying lands and an appreciable reduction of the land is expected.

Mangroves, because of their numerous prop roots do not easily yield to the tidal waves associated with natural disasters mentioned above, as it does not let lose the soil. In other words, the mangrove stands tranquilize the tidal waves and are therefore rightly the *'coast guards'* or *'watch dogs'* of the shoreline geography and geomorphology. The conventional coastline protection activities kike construction of sea walls and bay building are not as effective as the mangroves in calming down the invading sea. All the more, when the global warming reaches its peak, for economic and other reasons also, it is not even practical to build such granite fortifications all around the shore(s). Unlike artificial barriers, a bio-shield like the mangrove is quite effective; the beauty of the mangrove is that it would be self-regenerating and resource limitation would not arise, as the sea-land interface is a nutrient rich environment. Most mangroves are also highly regenerative, without any innate reproductive constraints; all what we need to provide is undisturbed land flushed with saline water!

Question: *Mangroves are often quoted to be immensely useful. Do they really provide much goods and services to man, or are they just one-sided exaggerations?*

PKM: Mangroves provide a variety of uses of economic, ecological and cultural values. These consist of both use and non-use values; the use values may be either direct or indirect (functional benefits). The ecosystem provides firewood, smaller construction timber, tanning material from some trees, some medicinal plants and raw material for traditional fishing gears. The prominent use of the system however is for fisheries, for capture and culture of fishes. These use values of the mangroves, as the editor has rightly pointed out, by and large benefit only a few sections of the society; but the fact is that these sectors are culturally isolated and may not survive if the traditional resource system transforms. The indirect use values of the mangroves like ecological functions, flood control and storm protection, biodiversity conservation, habitat for birds, serving as nature's nursery for the fish fauna, prevention of soil erosion, etc, outweigh the direct use values. These benefits not only go to the coastal populations; although the immediate beneficiaries are the coastal populations, their relayed benefits such as fish-food, and relief on land pressure go to the inland populations too.

Question: *Published literature repeatedly affirms the role of mangrove as 'nature's nursery' for fish and other marine fauna. How far does the empirical data support this?*

KKR: There is a general feeling that mangroves serve as *'nature's nursery'* for a variety of marine fishes and other animals of food value to man. Many saline fishes and shrimp species are believed to migrate to the mangroves, and where they swarm their fingerlings and young ones. It is generally argued that the mangroves are safer sites for the young ones; the rugged geomorphology of the mangrove ground surface due to the intricately ramifying prop roots and the thousands of erect standing breathing roots provide a difficult-to move around three dimensional space, if not a difficult-to-access zone, for larger predators of the fishes and other fauna.

KM: In addition, the litter of the mangroves as they decay in the water get fragmented by the rich crab populations residing inside the numerous little holes in the ground and the so produced detritus is a good food reserve for the fish fingerlings and shrimp spawns. So, a safer site supported with ample supply of food reserves is a congenial niche for the juvenile aquatic fauna to thrive.

Question: *Large migratory bird flocks are said to use the mangroves as a breeding site. Why do they prefer the mangroves offering their young ones the trouble of traveling back to the parental land?*

EAJ: Avian biology clearly documents long distance migration of large bird folks to tropical wetlands where they are known to roost and breed young ones. Many avian species undertake such cross-continental travel from their original homes. By way of this long-distance migration they survive the hostile winter and at the same time find a safe food-rich niche for their young ones. The adult birds go back to their original home leaving the young ones in the migratory sites; the young ones in turn as they grow go back to their parent land, guided by instinct. Here, the mudflats and wetlands are actually the feeding grounds

both for the young ones and the adult birds, and the mangrove trees are safe roosting sites directly overhead their food sources. However, recent studies of avian fauna in the wetlands of Kerala suggest that, the migrant birds arriving our wetlands have worn-out both in species and number, presumably because of the high rates of destruction of the mangrove habitats.

Question: *Mangroves are said to have certain active principles of economic value. Could these be used to value addition of the mangroves?*

CM: Many kinds of microorganisms are found growing associated with the roots, prop roots and the breathing roots of mangroves. These organisms are supposed to have much reciprocal utility to the host as well. In addition, the mesophyll of many mangrove leaves contains endophytic fungi. Fungal entophytes associated with mangroves are diverse, yet fundamental aspects of their interaction with the hosts are unknown; some endophytes have a high metabolic versatility and produce novel secondary metabolites of industrial importance. This is a promising area, where much remains to be done; many of our native species have not been tested for these properties. In the currently ongoing project on mangroves, supported by the Ministry of Environment and Forests (Govt. of India), we intend to study the endophytes associated with different mangrove species and their potential sources of new metabolites. The positive results of the study would definitely help value addition to the mangrove ecosystem.

Question: *To what extent the destruction of the mangroves has already taken place in Kerala?*

JKS: If we go by the recorded information, Kerala had 700 km^2 of mangrove forests that have now narrowed down to about 17 km^2 according to some estimate. But it may not be very reliable as it is not based on any field check. More over the mangroves have become highly fragmented; destruction of the mangrove ecosystem has been so grave that even a good patch of about 1 km^2 is rather difficult to be located. Most of the mangrove patches are under heavy anthropogenic pressure for land transformation.

Question: *From the discussion it appears that the devastation of the mangroves has been passionately fast. What were the driving forces behind this?*

CM: There have been several causal agents to mangrove depletion among which changing land use is the foremost. The high returns from the high-tech aquaculture, especially shrimp farming, has led to rather quick transformation of the mangrove lands to larger water bodies like artificial fish-ponds and pools. Many people sold out the land for high-level investors. The profit motive was the levering force for land transformation and of course, in the initial years a number of investors took advantage of the situation. Unfortunately in later years, devastating viral diseases of shrimps and prawns minimized the aquaculture activities to a great extent. This paved way for a double loss, *i.e.*, in terms of the lump sum investment and the mangrove forest along with its environmental services.

KKR: The second serious threat to the mangroves is land reclamation. Mangroves are distributed mostly along the coastal belt, where population is denser and demand for land is very high.

Question: *The socio-economic limitations of the coastal Kerala are not congenial for the sustenance and re-development of the mangroves. I am not sure, how far this is true?*

PKM: A survey of the ownership records of mangrove areas in the Kannur District showed that about 90% of the lands belong to private ownership. Despite the modalities for the regulation of activities in the coastal zone (CRZ), they have not been effective for various socio-economic and socio-political reasons. As a result, the local people are free to implement their priorities, which of course cannot be on long-term basis, nor it would be environmentally sound. What is necessary at this point of time is that regulations effective in the existing socio-economico-political conditions and at the same time capable of achieving conservation of mangrove ecosystem need to be evolved.

Question: *It seems that Kerala Forest Department has larger programmes for conserving and re-developing mangroves along the West Coast. What is it all about?*

JKS: Yes, having realized the importance of the mangrove forests both in terms of environmental services, India has identified mangroves as a means for bio-remediation of the coastline geography against coastal disasters like tsunami, global warming and its after effects. I gather from Sri. Trivedi Babu, Chief Conservator of Forests, Kerala Forest Department (KFD), that the KFD is launching a massive programme for redevelop-

ment of mangroves in all feasible sites of the West Coast. Land availability is a serious problem for mangrove redevelopment; they are exploring how land could be made available for the purpose and how effectively the mangrove forests could be established in a cost effective and meaningful way. The Department intend to get the work done through the participation of the local communities.

Question: *At what pace do you think that the mangrove redevelopment initiative would work out for Kerala?*

JKS: In the past, mangrove regeneration used to be thought of as totally unfeasible; nevertheless, in the last few decades, owing to multifarious efforts, artificial regeneration of mangroves took a remarkable positive turn, that technically it is no more a difficult problem. Thanks to the MS Swaminathan Research Foundation (MSSRF), Chennai! MSSRF has brought out many successful methods and techniques for mass production of planting stocks of the various mangrove species. Various planting techniques are also available for large-scale raising of mangrove plantations. Successful mangrove plantations and redevelopment have been accomplished in different parts of India like Goa, Eastern Tamil Nadu, Sundarban (West Bengal), etc. In Kerala, the achievements of the Forest Department (KFD) are also praiseworthy. KFD has established large-scale mangrove plantations successfully in the Kannur District. Availability of land is one of the major impediments as most of the potential areas are private lands. Once this is solved by some means, mangrove rehabilitation is only a question of time.

Question: *Can Participatory Forest Management (PFM) be used as an alternate management strategy for the conservation of mangroves?*

PKM: In the management of local natural resources, joint resource management involves the participation of local people, both as beneficiaries as well as decision makers in various capacities. In the forestry field, participatory forest management (PFM) has been experimented with in many locations throughout India. There have been some success stories. Perhaps, leadership issues and the methods of benefit sharing are still to be improved and sharpened further.

Question: *Greening up the West Coast with mangroves requires massive planting operations. Do we have the genetic resources?*

CR: When we look at the mangroves along the Kerala coast we find them existing only as little patches and not sufficient enough to provide the required planting stocks; so large-scale seed sources could be a problem when we want to incorporate more and more species into the programme. Therefore, identification, protection and preservation of sufficiently large enough seed stands for each of the required species would also be necessary.

Nypa fruticans, a palm mangrove is a typical example of extinction of a species from the entire mangrove ecosystem of the West Coast. Instances are many of local extinctions, where, due to detriment done to the ecosystem, species have vanished, although they are still available in other parts of the ecosystem. An effective solution to the problem would be organization of live gene banks of mangrove species at one or more desirable locations. Similar attempts have been done elsewhere in the East Coast and replicating the same would be required along the West Coast also. A few such gene banks distributed along the length of the West Coast would be a spatially viable mechanism.

Question: *With many forest trees, reproductive constraints are involved for their multiplication. Are there many constraints in mangrove rehabilitation also?*

KS: Reproductive biological studies are very important when regeneration and sylvigenesis of wooded stands present erratic pictures. Of course mangrove regeneration is problematic, not necessarily because of the reproductive abnormalities of the plant species, but being affected by anthropogenic pressure. None of the dominant species from the mangroves have been reported to have innate reproductive constraints. Nevertheless, many reproductive ecological aspects can be of immense use in redevelopment and rehabilitation initiatives of the mangroves. In all mangrove redevelopment programmes, we require seed or seedling planting stocks. So far we have little information on the fruiting and seeding episodes of the dominant mangroves.

GM: Recapitulating the point suggested by KS, I may add here that not all plants are pollinated by the same kinds of pollinator agents. Many plants are characteristically attuned to insect pollination. Absence of the right kind of insects often leads to poor reproductive turnover. At the moment we are in dearth of information regarding the insects involved in the pollination

of mangrove species. Only an entomological study would vindicate the details of this aspect.

KKR: During our field trips to mangroves of Kannur, we observed the presence of bats inside the mangroves. Bats are also active pollinators of many plant species that open the flowers during the night, and they are also active agents of dispersal of many fruits.

KS: The longevity of the seeds and seedlings and the distance traveled by these diaspores are also of importance in modeling mangrove regeneration in natural stands, and where natural regeneration can be opted for mangrove redevelopment.

TPT: From the pedological side also, we do not know, whether a given species requires particular soil conditions too?

Question: In forestry, different kinds of re-vegetation techniques are employed. What regenera-tion strategies would you think feasible in the mangrove environment?

KS: A larger mangrove re-vegetation programme can have many different strategies like *natural succession, augmented regeneration, artificial plantation* or a combination of the above in different ways, as might be feasible for given landscapes. The natural succession strategy would be feasible in barren or denuded prospective mangrove sites where protection alone can lead to progressive natural succession, though at an elapsed pace. On the other hand, a degraded mangrove patch can be augment-planted and protected for progressive sylvigenesis. Here, there is the added working cost for augment planting and some minimal technical expertise. In sharp contrast with the above two strategies, a potentially future mangrove area can be completely artificially planted with mangrove species, but where, the higher cost on planting and by way of technical skill would be needed.

Question: I see that most of our mangrove plantations also remain monocultures or rarely of a few species. Is there any scope for improving the diversity of mangrove plantations?

KKR: It is true that in Kerala, artificial mangrove plantations are predominantly monocultures comprising a single species, or at best two or three species. I believe, however, that there is scope for enhancing the species base of the plantations. We generally argue for replenishing the *nature's nursery* through mangroves, but our plantation activities seldom reflect this.

KS: In the Kannur District, the mangrove plantations are composed of two or three species and all these species were found to belong to the viviparous group with long seedling hypocotyls; the non-viviparous species were found excluded from plantation raising. This actually reflects the relative ease with which the long seedlings of viviparous mangroves can be collected and allowed to grow in less expensive containers until the planting season arrives. What would be the result of natural sylvigenetic processes in such even-aged mono/oligo-cultures after a period of time? In other words, it is an open question, why we cannot give due consideration to the zonation of natural mangrove stands in plantation activities too?

Question: In many agricultural systems soil and its biology are considered important components. Would the soil of the mangrove ecosystem also be acquiring importance in the redevelopment programme?

KS: I do not have a ready example to the point. Nevertheless, if we can make our mangrove plantations multiple species based it is likely to take care of nutrient conservation.

In mono- and oligo- species plantations there is high degree of competition for nutrients, the nutrient demand from each plant being the same. There are two types of floral elements in the mangrove vegetation, the *eumangroves,* the cardinal component that can withstand salinity, and the *mangrove associates*, which need not necessarily be salt tolerant. The *eumangroves* make the mangrove physiognomy and are composed of trees belonging to the genera *Rhizophora, Avicennia, Bruguiera, Kandelia, Sonneratia,* etc. On the other hand, certain mangrove associates like *Acanthus ilicifolius* are known to function as nutrient pools, holding large quantities of potassium. So what makes sense here is that, if we can incorporate lessons from natural succession in mangrove planting initiatives it would be useful. Further, at this point of time we are practically blank about the functional role of the mangrove associates in turning the wheels of the ecosystem; this information has to be generated.

Question: Dr. PKM emphasized the need for resolving the socio-economic issues in effective planning for mangrove re-development. Can you please highlight this very important aspect further?

PKM: The mangrove ecosystem and the socioeconomic system are closely interlinked although by no means they are conterminous. For instance, commercialization of fishing often leads to over-fishing, escalation of the price of exportable shrimp harvest leads to more production by clearing mangroves, and in clear felling the mangroves with out replanting, the rates of harvest always exceeds the rate of regeneration, and the like.

In the last few decades there has been significant shift in the traditional resource use pattern within the mangrove system, and this was mounting from the change in the life styles of people on the one hand and the increasing population pressure on the other. Now the trend has changed totally that a number of the activities function on market driven initiatives. It suffices to say that the rate of resource exploitation multiplied manifold. When the mangrove redevelopment initiative is operative, it should be made binding that the direct benefits in terms of labour and materials should go to the local communities the best. Participation of at least an individual from each family in the initiative at some time point of the programme should be ensured in any of the different capacities, as labour, in co-ordination, in organization, in resource mobilization, *etc.* Many public awareness programmes would be required at various magnitudes, at various locations and at various technical levels.

JKS: As I said earlier the mangrove lands at the moment belong to private individuals, communities, or the Revenue Department and the conservation initiative should embrace all these. Policies could be framed for deposition of one or two percent of the tax turnover from the coastal belt solely for mangrove conservation. For existing pristine mangrove lands under private ownership, the Government could relax the taxes and even award some endowments for maintaining them as they are, for long spans of time. For mangrove redevelopment initiatives in private lands the Government may provide financial supports and relaxations to the owner. Under such situations, many of the unproductive and abandoned shrimp farms might turn back to mangrove lands, although slowly and at the same time would slow down mangrove land conversion.

Question: *The discussion has provided many useful details regarding the mangroves. While thanking the scientists, may I request the Director, KFRI, to please summarize the outcomes?*

JKS: First of all let me congratulate the editorial team of "Evergreen" for initiating a discussion on mangroves. As a result of the discussions with the scientists of the Research Group, I have the following remarks.

1. Along the West Coast of India, large extents of mangroves do not exist today, the reasons of which lie in the changing land use pattern, lifestyles and patterns of resource use. Mangroves are environmental buffers offering common ecological and economic services for vast landscapes and people across several generations. Without knowing the exact role of each of the segments of the biosphere we impaired many of them irrecoverably and mangrove ecosystem was one such. Today, we realize that mangroves can play key roles in protecting our shores and coastal lands from the rage of the sea in the scenario of aggravated global warming and disasters like tsunami. The emerging common sense that mangroves have to be redeveloped on large-scale in order to safeguard the life and peace of the people carries weight.

2. Non-availability of land is a bottleneck for large-scale mangrove redevelopment along the Kerala coast. If this is addressed, mangrove redevelopment is only a matter of time, the appropriate regeneration techniques being already available. Policy decisions also have to be formulated in such a way that available mangrove patches are conserved with the participation of the people. Land tax relaxation and offering endowment grants for preserving and growing mangroves might improve the mangrove ecosystem considerably.

3. Mangrove ecosystem being highly niche specific is peculiar in its characteristics, functioning and so also in its resilience capacity. In mangrove redevelopment programmes, many related ecological principles might find practical or applied value. Mangrove ecosystem and the socio-economic system are closely intertwined that a viable mangrove re-development programme should comprehend the facts and characteristics of each of the two domains.

New Infrastructure For KFRI

Silver Jubilee Block- A boost to research and conference facilities
Inaugurated by Hon'ble Chief Minister Shri Oommen Chandy on 29 January 2005.

The Trainees Hostel – Provides modern boarding and lodging facilities to trainees and guests. Has 12 a/c double rooms, 4 non a/c rooms, two dormitories each with 25 a/c cubicles.
Inaugurated by Hon'ble Chief Minister Shri Oommen Chandy on 29 January 2005

Chief Minister on the occasion of the inauguration of new infrastructure with KSCSTE Executive Vice President Dr. E.V. Muthunayagam and KFRI Director Dr. J.K.Sharma.

Training and Extension Block

XVII Kerala Science Congress (2005) held at KFRI

The XVII Kerala Science Congress was held at Kerala Forest Research Institute, Peechi during 29-31 Jan. 2005 and Dr. J.K. Sharma, Director, KFRI welcomed all the participants. The Science Congress was inaugurated by Mr. Oommen Chandy Hon. Chief Minister of Kerala. The inaugural session was chaired by Dr. A.E. Muthunayagam, Executive Vice President of KSCSTE. Dr. K.R.S. Krishnan, Director, KSCTE spoke on the relevance of Kerala science Congress event.

The focal theme of the XVII Kerala Science Congress was - *Medicinal Plants of Kerala: Conservation and Beneficiation*- which is very apt and socially relevant today for sustainable development of our natural resources. Kerala, situated in the Western Ghats – one of the hot spots of mega biodiversity in the world, has nearly 4000 plant species, of which 2000 species are used in classical health systems like Ayurveda and Sidda as well as folk medicines. As these wild medicinal plants form a substantial part of our biodiversity, their conservation and sustainable utilisation is crucial for the health of our ecosystem.

Beside the Special Session on the focal theme, there were nine technical sessions dealing with nine broad Subject areas, viz. 1. Agricultural, Fishery and Veterinary Sciences 2. Biotechnology 3. Chemical Sciences 4. Earth System Sciences 5. Engineering & Technology 6. Forestry, Wildlife & Environmental Sciences 7. Health Sciences 8. Life Sciences and 9. Physical Sciences.

The Key note address, as *Pisharoty Memmorial Lecture*, was delivered by Dr. B.N. Suresh, Director, Vikram Sarabhai Space Centre, Thiruvananthapuram on Indian Remote Sensing and its societal applications.

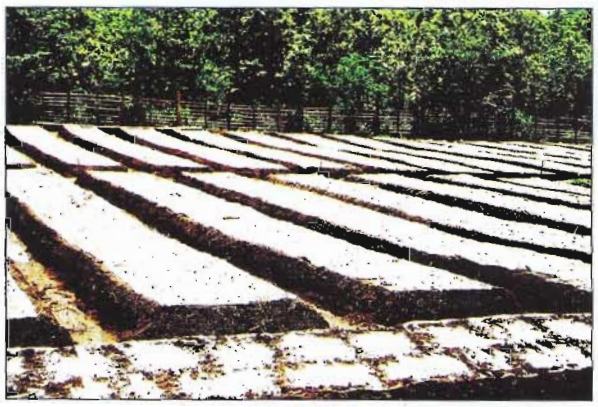
Of the 356 registered delegates, 282 have participated in addition to 15 child scientists. Of the 23 contestants for Young Scientist's Best Paper Awards, 21 speakers presented contest papers in addition to 46 oral papers (out of 74). Of the registered 71 posters, 53 were presented.

Use of Newspaper for Weed Management in Teak Nursery Beds

After sowing the seeds of teak (*Tectona grandis*) in nursery beds, it has been a practice to cover the soil with materials like foliage of gooseberry (*Emblica officinalis*) to avoid the displacement or exposure of germinating seeds. Scarcity of foliage led to use of paddy straw to cover the nursery beds. However, even the availability of paddy straw is becoming less and the cost is also increasing. With this background in mind, an attempt has been made in KFRI Sub Centre to assess the feasibility of using old newspapers to cover the teak nursery beds. The study was also extended to compare the germination percentage and initial height increment of teak seedlings and the initial weed biomass in teak beds covered by paddy straw and old newspaper.

Two thousand four hundred healthy seeds of teak were selected and subjected to pre-sowing treatment (alternate wetting and drying method). Later in 12 nursery beds raised to 0.3 m above ground level, two hundred seeds per bed were sowed. While four beds were covered with paddy straw, other four beds were covered with old news paper and the cover thickness was single sheet. Four beds were not covered and used as control. When the seeds started germination (generally one week after sowing), paddy straw and papers were removed in order to avoid the bending of growing seedlings. Number of teak seeds geminated, seedling height and dry weight of weed biomass in the beds one month and two months after seed sowing were calculated.

We have not recorded significant difference ($P>0.05$) between treatments for the germination percentage and seedling height of teak (Table 1). On the other hand, both one and two months after sowing, the weed biomass was significantly more($P<0.05$) in nursery beds covered with paddy straw followed by control and beds covered with paper (Table 1). Out of 21 species of weeds recorded, 12 species including *Oryza sativa* were exclusively seen in the nursery beds covered with paddy straw (Table 2). The weed biomass in paddy straw covered bed was more mainly because seeds of species like *Oryza sativa*, *Corchorus acutangulus, Mollugo pentaphylla, Ludwigia parviflora, Cyperus rotundus etc.*, entered into the beds along with paddy straw and their seedlings contributed much to the total weed biomass. Comparatively low weed biomass in paper covered beds may be due to poor germination of seeds of weeds due to less availability of light under paper cover.



Teak nursery beds covered with news paper

View of a teak nursery

Table 1. Germination percentage and seedling height of teak and biomass of weeds in teak nursery beds one and two months after sowing. Values are mean ± SE.

	Period since sowing					
	1-month			2-months		
Parameters	Beds not covered after sowing	Beds covered by paddy straw	Beds covered by old news paper	Beds not covered after sowing	Beds covered by paddy straw	Beds covered by old news paper
Germination (%) of teak seeds	58 ± 6	41 ± 4	44 ± 3	86 ± 2	81 ± 2	85 ± 2
Teak seedling height (cm)	11.2 ± 0.4	11.4 ± 0.6	10.5 ± 0.5	20.7 ± 0.5	20.1 ± 0.9	19.5 ± 0.7
Weed biomass (gm m^{-2})	8.9 ± 1.9	4.3 ± 0.8	3.9 ± 0.6	40.4 ± 3.5	50.8 ± 4.3	28.9 ± 1.9

To cover a standard teak nursery bed (12m long x 1.2m wide) it is estimated that about 3.75 kg of paddy straw costing Rs. 12.50/- will be required. On the other hand to cover same area of nursery bed 0.40 kg of news paper costing Rs. 2/- is sufficient. Thus, use of paper to cover nursery bed not only reduces the weed biomass but also economically beneficial as the material cost for covering beds and labour cost for weeding can be drastically minimized.

Table 2. Weedy species recorded in teak nursery beds.

Abrus precatorius	*Ichnocarpus frutiscens*
Aristolochia indica	*Lindernia ciliata**
*Borreria hispida***	*Ludwigia parviflora***
*Cleome viscosa**	*Mimosa pudica**
*Corchorus acutangulus***	*Mollugo pentaphylla**
Cyclea peltata	*Oldenlandia umbellata**
*Cyperus rotundus**	*Oryza sativa**
Desmodium triflorum	*Scoparia dulcis*
*Eclipta alba**	*Synedrella nudiflora*/*
Helictres isora	*Trema orientalis*
Hemidesmus indicus	

* Seen in teak nursery beds covered with paddy straw.

** Seen in teak nursery beds covered with paddy straw and major biomass contributors.

U. M. Chandrashekara and E.C. Baiju
KFRI Subcentre, Nilambur

Changing World and Emerging Opportunities for Carbon Trading

Greenhouse gases such as carbon dioxide are a natural and essential component of the Earth's atmosphere. Atmospheric gases such as water vapour, carbon dioxide, carbon monoxide, methane, and ozone, absorb heat, and keep heat from radiating away from earth into outer space. This effect is much like the way glass traps heat in a greenhouse, therefore the natural warming of Earth by its atmosphere is called the "greenhouse effect".

Carbon dioxide is the most important greenhouse gas, accounting for about half of the greenhouse effect. The natural concentration of greenhouse gases (GHG) has been essential to life as we know it on earth, creating the average temperature of 15° C (59° F). Without the naturally occurring greenhouse effect, the average temperature would be minus 18° C (0° F)!

However, human activities such as burning fossil fuels, the chemical industry, and agriculture and land use changes are increasing the amount of greenhouse gases, especially carbon dioxide, in the atmosphere. The highest annual per capita emissions (tons of CO_2) is recorded in USA (20.1) followed by Germany (10.4), Japan (9.6), UK (9.6), China (2.9) and India (1.1). Various green house gases and their major sources are given in Table 2. Human activities have increased GHG and raised global temperature by 0.5° C over the past 100 years. As a result of human-induced increases in greenhouse gases, the temperature is projected to increase by 1.4 to 5.8° C during the next 100 years (IPCC, 2001a). While this increase may not sound much, the impact could be very dramatic, if not catastrophic, on the climate. For each one degree Celsius increase in temperature, vegetation zones may change dramatically, moving toward the poles by 200 to 300 km. Each one degree global warming-up will also increase water evaporation, leading to about 2% greater mean global precipitation. Corresponding shifts of vegetation zones across altitudes are also expected, owing to the rise in ocean surface.

No.	Greenhouse Gas	Sources
1	Carbon dioxide (CO_2)	Fossil fuels, deforestation, agriculture, cement production
2	Methane (CH_4)	Agriculture, cattle dung, biomass burning, landfills
3	Nitrous oxide (N_2O)	Fossil fuel, industrial, agriculture
4	Hydro fluorocarbons (HFCs)	Industrial, manufacturing
5	Per fluorocarbons (PFCs)	Industrial, manufacturing
6	Suphur hexafluoride (SF_6)	Electricity transformer manufacturing

* Source: WB (2001)

Increased greenhouse gases may lead to extremes in heat waves, droughts and floods (NCRS 2000). The increased frequency of floods and droughts is significant over the last 100 years, correlating with human use of fossil fuels and drastic land use changes from forest/grassland to cropland and urban development. Increased greenhouse gases mean more energy (heat) is available in the atmosphere. This energy is released in the form of intense storms and changing weather patterns causing floods, droughts, and increased fires.

Carbon Balance on Agricultural and Forest Lands

Forest and agricultural producers can help counteract climate change by increasing the storage (or "sequester-

ing") of carbon on such lands. Both soil and vegetation act as carbon sinks, reducing the amount of carbon dioxide in the atmosphere (NRCS 2000). Wise stewardship practices can mean more carbon is sequestered in an agroforestry system than is lost to the atmosphere.

Keeping top-soils intact maintains soil quality and reduce carbon emissions into the atmosphere. Increasing vegetative cover and planting trees is also an important way to store carbon. While usually adopted for other benefits, conservation practices that conserve soil and increase vegetation also increase carbon storage.

Soil Quality and Global Warming

The role of soils in carbon storage has been somewhat overshadowed by tree-planting efforts. While planting trees is important to increase carbon storage, conserving soils is essential. Soils are the largest non-fossil land-based organic carbon reservoir on earth. Global soil carbon content is:

* three times as much as in terrestrial plants and animal,
* twice the amount in the atmosphere, and
* a third of the carbon in fossil fuels.

Soil erosion is a major cause of soil organic carbon loss and increasing greenhouse gas emissions. This takes place by:

a. exposing carbon locked within soil aggregates,

b. mineralizing carbon by oxidation and microbial processes, and

c. decreasing the soil's ability to support vegetation.

Soils ability to support vegetation diminishes by lowering soil fertility, losing water as runoff, decreasing plant-available soil water, burying or flooding crops, and other erosion related effects.

Carbon dioxide additions to the atmosphere are caused not only by burning fossil fuel in agricultural activities, but also by soil organic carbon decomposition, and vegetation burning. Grassland and forest soils tend to lose 20-50% of the original soil organic carbon within the first 50 years of cultivation. Erosion, leaching, methane production, volatilization, and mineralization (decomposition of complex organic compounds to inorganic forms) lead to carbon loss from the soil.

Agroforestry and Plantations to Sequester Carbon

Trees on farms or pastures for reforestation or agroforestry are planted for a number of benefits. They also store carbon, thereby sequestering the CO_2 that would have been increasing in the atmosphere.

Carbon Trading and the Clean Development Mechanism (CDM)

There is a market for mitigating carbon dioxide and other greenhouse gas emissions. This can be made into CERs (Certified Emission Reduction). The Kyoto Protocol of UNFCC offers an opportunity to trade with CERs. The purpose of Carbon trade is to reduce anthropogenic emissions and save mankind from the global warming and climate change phenomena (see Shukla *et al.*, 2002).

What is Kyoto Protocol?

In December 1997, at COP-3 of UNFCC in Kyoto (Japan), the governments of the world agreed to a 5.2% reduction in emissions of GHGs by developed countries (Annexure–1) from the levels existing in 1990 by 2008 to 2012 (called the commitment period). India signed the Kyoto Protocol in December 1997 and ratified the Kyoto Protocol in August 2002.

How to fulfill the commitments?

The Protocol introduced three flexible and market-based mechanisms to fulfill the commitments:

1. Emission Trading (ET)
2. Joint Implementation (JI)
3. Clean Development Mechanism (CDM)

Annexutre-1 countries invest in mitigating GHG emissions in non-annex countries. India has the option to participate in only CDM because we have no emission reduction targets and hence a non-annex country. The country can benefit from the CDM by developing appropriate projects (Table 3).

Who will be the key players in developing CDM projects?

Automobile industries, Electric vehicle industries, Thermal power producers, Iron & Steel, Cement, Paper & Pulp industries, Aluminium, copper, lead, zinc and non-ferrous industries, Pollution control and Monitoring equipment manufacturers, Solar energy related industries, Wind energy related industries, Environmental Engineering Consultancy firms, Hydro Electricity generators, Waste to Energy technology providers, Petroleum products, Chemicals and petrochemicals, Commercial forestry and plantation companies.

Which land use activities are included in the CDM?

Afforestation and reforestation are the

only land use or land use change, and forest (LULUCF) activities eligible under the Clean Development Mechanism of the Kyoto Protocol during the first commitment period of 2008-2012. They are usually called the A/R projects.

There is some uncertainty over which definitions for afforestation and reforestation will be adopted. The strict application of these definitions to CDM, however, would exclude possible benefits arising from CDM land use projects, such as forest rehabilitation, revegetation, enrichment planting and natural regeneration. Developing countries hence might choose in future to adapt definitions for "forest" and forest activities to biome-specific particularities within their country.

Since Marrakech, FAO has joined IPCC, CIFOR and IUFRO in convening a process, through expert meetings (Rome, January and September 2002) and consultation, to identify opportunities for harmonizing forest-related definitions which exist, or are being developed within the various international conventions and forums.

The definitions that have been temporarily adopted by the Marrakech Accords (still valid, as of 2002) for forest and land-use activities within Annex I countries are the following:

Forest: is defined as "a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 metres at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10-30 per cent or tree height of 2-5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest."

Afforestation: is defined as "the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources."

Reforestation: is defined as the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but

Annexure-1 Countries

Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, EU, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lichtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Russian Federation, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, UK, Ukraine, USA

No.	Entity	Benefit
1	Developing country	Promote sustainable development
2	Developed country	Meet Kyoto Protocol commitments
3	Industries	State of art technology, efficient production
4	Insurance companies	Business opportunity
5	NGOs	Development & environment
6	Banks, Financial inst.	Business opportunity
7	Niche companies	Commercial opportunities, diffuse technologies
8	Corporations	Investment opportunity
9	Biosphere	Saved from global warming

that has been converted to non-forested land.

For the first commitment period, reforestation activities will be limited to those lands that did not contain forest on 31 December 1989. Other lands that did not have forest for the last 50 years would be eligible for afforestation under the Kyoto Protocol.

The Rules for CDM

As part of the Marrakech Accords, governments elaborated the rules for the CDM under the Kyoto Protocol, which describe its institutional and operational aspects (see ICFRE, 2005). While several of the detailed procedures to be applied to CDM forestry projects still need a formal agreement, the overall framework is already established for approving projects and accounting for the carbon credits generated.

i. Institutional aspects

Ratification of the Kyoto Protocol: Only Parties that have ratified the Kyoto Protocol - Annex I and non-Annex I - can participate in the CDM.

ENational authority for the CDM: Countries that participate in the CDM are required to establish a national authority for CDM. This authority, called DNA (Designated National Authority)[1] will coordinate all agencies involved in the project. (Presently the DNA in India is located in the Ministry of Environment & Forests, Govt. of India).

The CDM Executive Board: The CDM operates under the authority of the Conference of the Parties (COP) to the UNFCCC and is supervised by an Executive Board (EB), comprised of government representatives serving in a personal capacity. The EB issues Certified Emission Reductions (CERs) on the basis of the certification report provided by a designated operational entity.

Designated operational entities (DOE): They are designated by the COP/MOP, and are accredited by and accountable to the executive board. Designated operational entities can validate project proposals as well as verify and certify reductions of human-induced greenhouse gas emissions from projects.

ii. Operational aspects

Eligible projects: For the first commitment period, only those lands that did not contain forest on 31 December 1989 will meet the CDM definitions of afforestation or reforestation and only projects that started in 2000 or later are eligible.

Quantitative limitation: The market for afforestation and reforestation project activities under the CDM has been limited by governments as part of the Marrakech Accords. Governments agreed that during the first commitment period (2008-2012) of the Kyoto Protocol the amount of project credits resulting from afforestation and reforestation project activities that can be used annually by an Annex I Party cannot exceed one percent of the base year emissions (1990) of that Party.

Qualitative limitation: To avoid that LULUCF activities undermine the environmental integrity of the Protocol, the Marrakech Accords stress the need of qualitative limits for project credits resulting from afforestation and reforestation activities under the CDM. These principles underscore the need for sound science and consistent methodologies, as well as the importance of conserving biodiversity.

Real, measurable and long-term: Emission reductions from projects must be real, measurable and long-term (permanence) and any future emissions that might arise from these stocks need to be accounted for.

Project leakage: Project management plans must address and account for potential leakage, which can be defined as the unexpected loss of estimated net carbon sequestered as a result of unexpected effects resulting from the project activities outside the project area

Additionality: Carbon forestry activities must prove additionality to the business-as-usual scenario, which refers to the case if the project would not have taken place.

Sustainable development: Carbon forestry projects must be in line with sustainable development objectives, as defined by the government that is hosting them and must contribute to biodiversity conservation and sustainable use of natural resources.

Ex ante certification: Project participants including public and private entities must prepare a project design document, using a format agreed by governments. This project document must be submitted to a designated operational entity.

Ex post certification: CDM emission reductions only have a tradable market value if they are certified by an independent party.

Projects need to select a crediting period for activities, either a maximum of seven years that can be renewed at most two times, or a maximum of ten years with no renewal option.

The market opportunities under CDM

1. The market

Afforestation and reforestation activi-

ties under the CDM are a cost-effective means to reduce greenhouse gas (GHG) emissions. Credits that result from these projects removing carbon from the atmosphere can be traded on a global market. A range of private companies and organizations have recognized this new opportunity to invest in projects in developing countries. Since income can potentially be generated by afforestation and reforestation projects, groups in developing countries (e.g. businesses, NGOs and farmers) are also starting to develop and market such projects.

2. Ways of investing

Private investment: Investors can directly fund specific projects that will generate carbon benefits. Unless they have enough experience of project development and implementation, they might consider hiring expertise that is required to deal with carbon-specific and forest-related risks and technical issues.

Investment funds: An alternative to investing directly in specific projects is to participate in an investment fund that purchase shares from a portfolio of different projects.

Trading in carbon offsets: Trade markets for emission reductions are rapidly increasing as the rules for International Emission Trading are being defined. Such flexible markets are usually driven by specialised private brokerage firms and are accessible via Internet. The strength of this market form depends on what reporting procedures are used, and whether there is reliable third party verification.

Conclusions

Experiences made during the past ten years have demonstrated that there exists, indeed, a potential to mitigate climate change and promote sustainable livelihoods through forestry activities. At the same time, it is disheartening to find that no baseline and methodologies for A/R project activities has yet been approved by the EB as on today. This will certainly weaken the interest for the LULUCF projects among the plantation companies and forest managers. However, biofuel projects and fossil fuel replacement projects such as biodiesel etc. will attract a great deal of interest from plantation companies. However, these activities also imply considerable risks and uncertainties relating not only to the question of how long carbon can remain in the biosphere (permanence), but also to other matters, such as accuracy in the accountability of carbon fluxes, the issue of leakage, transaction costs, equity, and negative socio-economic or environmental impacts in both industrialized and developing countries.

***Jatropha curcas*–A promising biodiesel plant**

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Dr Jose Kallarackal

Sustainable Natural and Plantation Forest Management Division

A Forestry Information Database for Kerala

Data on forest resources are needed by a whole consortium of users like administrators, resource planners, policy makers, department staff, protected area managers, environmentalists, educationalists, research institutions, wood based industries, timber dealers and users, dealers of traditional medicines, biodiversity authority, and international traders of forest based resources, international conservation agencies like IUCN, etc. Data on different aspects are also needed for effective planning in the forestry sector and its management.

A number of agencies such as State Forest Departments, Forest Survey of India, Ministry of Environment and Forests, and many other agencies have been publishing data on various aspects of forests. However, there have been no efforts to integrate these into a dynamic database for quick retrieval and use. In fact, recommendations have been there to bring together the forestry statistics into a centralized system.

The forestry information system is in a way comparable to a river system fed by several tributaries and drawing water from sources like glaciers, surface run off, underground resources, and eventually discharging it to the ocean. We have tried to conceive and model such a 'forest information pool' by assembling data sets from various sectors of forestry. The various aspects of this computerized database cum retrieval software, its utility and future expansion possibilities are discussed in the present article.

The Data Sources

The information required for assembling the database was obtained from several secondary sources and by interaction with various agencies working in the field. The major data sources include those from the Kerala Forest Department (KFD), Forest Survey of India (FSI), Department of Economics and Statistics (DES), Directorate of Census and other published reports and articles from various sources.

The Database

Development of forestry database being a new initiative for Kerala, efforts were made towards assembling data required by personnel involved in forestry and related disciplines. The data on many aspects are of the time-series type covering the period from 1980 to 2000.

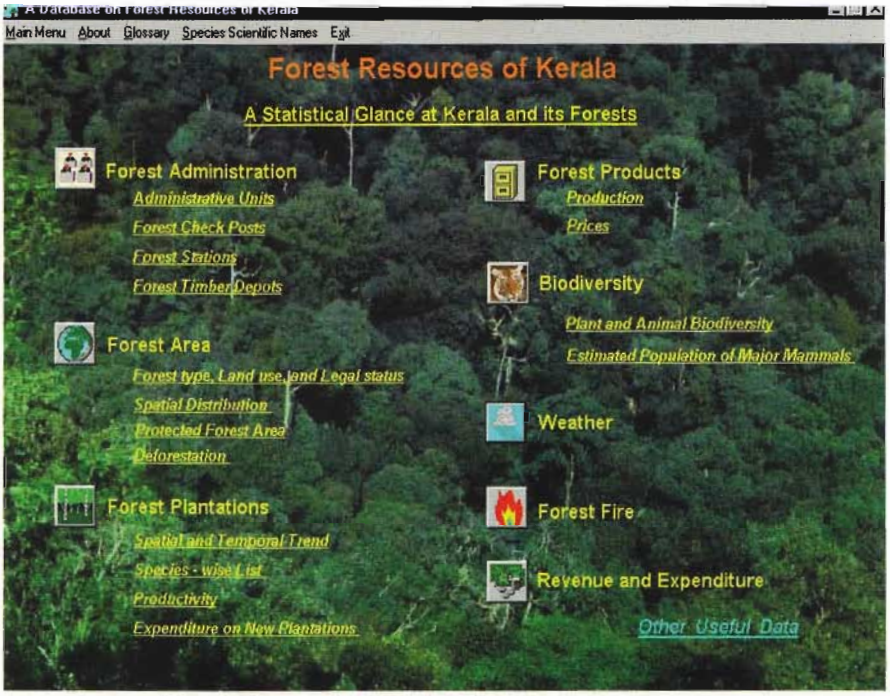
Forest Administration:	• Administrative units
	• Forest stations
	• Forest check posts
	• Forest timber depot.
Forest Area (in respect of)	• Legal status
	• Vegetation type
	• Administrative units (Range, Division and District)
	• Protected forest areas
	• Deforestation
Biodiversity:	• Plants
	• Animals
	• Population of major mammals in the forests
Forest Plantations:	• Species-wise list
	• Division-wise list
	• Productivity of selected species
	• Expenditure on plantations

Forest Products:	• Production of forest products
	• Production of non-wood forest products
Timber price:	• Of various species
Weather data:	• From selected forest divisions
	• From selected wildlife sanctuaries
Forest Fire:	• Number of incidents
	• Area destroyed
	• Financial loss
Revenue and Expenditure of the Forest Department:	• Sector-wise expenditure
	• Revenue from forest products

Development of Computerized Database and Retrieval System

The forestry information database and retrieval system was developed using Visual Fox Pro 6.0. The installation of the software is simple and relevant data can be accessed in two or three clicks itself. A few sample pages of the software presented below would introduce the dynamic capabilities of the software.

Figure 1 displays the *Main Menu*, showing the topics of which data are available in the database. Data access is as simple as clicking on the hypertext topic buttons. For example, the extent of forest area according to forest administrative units can be obtained by clicking on the button Spatial Distribution given under the topic 'Forest Area'. The source for each data set is also indicated in the database anda what is more is that the database is also provided with a support glossary. Good visual performance can be obtained in screens having a display area of 800 by 600 pixels.



Main Menu of the database software

Utility of the Software

Forestry Information Database is a primer that helps to access basic information on forests and the general appraisal of the status of forests of Kerala. We have experimented with it and it has helped us to carry out analysis on certain themes, including spatial and temporal trends in the extent of forest area, forest plantations, production of wood and non-wood forest products, socio-economic causes of deforestation and projection of the future trends in the availability of teak wood from forests based on age structure and productivity of teak plantations under different assumptions and options. Similar experiments with the data available in the database will certainly help to build future forestry scenarios on a near empirical basis and in relation to the past and existing current scenarios.

The potentials of this database are going to be tremendous, especially when the database is expanded. A forest manager could very well play with the database to make a vision of what species he should make a plantation in the unit under his manage-

ment, by looking at the price lists a timber trader could decide whether he should go to buy more teak for his depot, an environmentalist could build a geo-spatial forest scenario and argue for a certain conservation strategy, an administrator could gather the relevant information at his finger tips, a policy maker could paint a picture of the future policies that he might suggest, and so forth.

Future Expansion of the Software

A database, for that matter on any subject, should ideally contain data on every aspect of that subject, as extensively as possible over space and time so that it provides room for statistical and economic analyses and to develop relevant prediction models, which can be used by the planners and decision makers. At present, the scope of the database is being expanded apart from updating it. The additional themes that will find a place in the database are:

- Forest maps by vegetation types and plantations
- Region-wise status of forest soils in natural forests and plantations
- Region specific status of natural resources (incl. non-wood forest products, bamboo, rattan)
- Region specific status of biodiversity (flora and fauna)
- Demand and supply of wood (statistics)
- Forest based industries (number of units, consumption, employment, etc.)
- Information on forest policies and management (incl. Joint Forest Management, Vana Samara kshana Samithies), and Information on tribal population living within and adjacent forests.

M. Sivaram
Division of Forest Information Management System

Malabar Spiny Dormouse a Pest of Hot Black Pepper

A study on Malabar Spiny Dormouse (*Platacanthomys lasiurus*), an endemic rodent found in the southern Western Ghats is being carried out in KFRI. The common English name of the species is 'Pepper rat' and the local Malayalam name is 'Mulleli'. The English name is attributed due to the peculiar feeding habit of the animal. One interesting observation is that, the hot black pepper, which is not fed by other animals, is a delicacy to the Malabar Spiny Dormouse. We have recorded the Malabar Spiny Dormouse feeding on the kernel of black pepper, when the black pepper is in the green stage from the Peppara Wildlife Sanctuary and the adjacent areas.

So far in the literature, only birds have been recorded to feed on the flesh of the black pepper and no damage has been reported by the mammals on the fruits or on the seeds of black pepper. Usually animals avoided feeding on black pepper due to the presence of the pungent chemical called piperin (approximately 5 %), which is responsible for the hotness in pepper.

Black pepper is a native of South India and surprisingly the Malabar Spiny Dormouse is an endemic to the region usually seen in the evergreen forests and in the riverine patches of the moist deciduous forests. The ability of the Malabar Spiny Dormouse to feed on the black pepper kernel might have acquired during the long process of co-evolution of these species. Is it a good example for the phenomenon of co-evolution from the Western Ghats involving a plant and a rodent species.

E. A. Jayson and K. M. Jayahari
Division of Forest Ecology and Biodiversity Conservation

Optimal Management of Teak Plantations

Teak (*Tectona grandis* L. f.) is an important timber species not just in India but also in the whole of tropics. It is valued for its durability, strength, attractiveness, workability and superior seasoning capacity. However, compared to its great potential to the Indian economy and maintenance of healthy environment in terms of carbon fixation, teak plantations receive very little attention in this country. Virtually no post planting operations take place other than initial tending, periodical thinning and occasional removal of mistletoes. Recent studies in KFRI have indicated that substantial gain in yield can be achieved through certain cost effective measures like optimal stand density management, choice of economic rotation age and control of miscellaneous growth in teak plantations. Some of the relevant results of these studies are reported here. More details of the study can be found in Jayaraman and Induchoodan (2005).

Optimum Thinning Schedule

Stand density management is an important operation in the case of teak plantations as it generates intermittent yields and also allows proper growing space for the residual stand from time to time. The basis of the current prescriptions in this regard in India is the All India Yield Tables for teak derived in 1959 (FRI and Colleges, 1970). As there were doubts about the optimality of yield table prescriptions, investigations were undertaken to derive an optimum thinning schedule. Attempts were made first to develop a growth simulation model so that the performance of stands under different management schemes can be easily studied using the model.

Data

The model was developed based on the data gathered from sixty nine permanent sample plots, established in teak plantations in the State of Kerala, India. These plots belonged to selected age-site quality-stocking classes and were distributed throughout the State. The plots were established during 1993-94 and re-measured during 1997, 2000 and 2005. The data consisted of measurements of diameter at breast height on all trees and height on a subsample of trees. Tree volume was predicted using volume equation of Chaturvedi (1973).

Growth Model

The growth model consisted of five modules dealing with the effects of site index, unrestrained growth, aging, density of teak and density of miscellaneous species on the growth of teak. Equations for predicting diameter and volume increments were developed based on Chapman-Richards function. Based on the estimated equations, a growth simulator was developed using SAS software. Simulation runs indicated that the optimal stand density in terms of modified Reineke's index, for maximizing the cumulative volume over a rotation period is 475. Expressed as a ratio of the density level yielding maximum current annual increment (830), the optimal relative density worked out to 0.57.

Modified Reineke's index is a measure of stand density perfected by Zeide (2005). The index is computed as,

$$S = N\left(\frac{D}{25.4}\right)^{b} e^{c(D-25.4)} \quad (1)$$

where N = Number of trees per ha

D = Quadratic mean diameter of trees in cm

b and c are parameters

The parameter b called the index of self-tolerance indicates the ability of trees to compete with trees of same species. For teak, this parameter was estimated as 1.31. The value of c was estimated as 0.003054. When the quadratic mean diameter is 25.4 cm, the index S, is the number of trees per hectare. This index now replaces the number of trees/ha or basal area, which are traditional but inadequate measures of stand density. Expressing it as a ratio of the density that maximizes current annual increment makes it comparable across species.

Thinning Schedule

In the case of teak, density that

maximizes cumulative volume has only a reference value in the density vs. growth relationship. The optimum thinning schedule should be one that maximizes the profit rather than per ha volume or mean diameter. Hence net present value (NPV) of cash flows was used as a criterion for selecting between thinning schedules. The simulator predicts yield from thinning at different years and also final felling for different possible thinning regimes. For any particular thinning schedule, the volume figures were multiplied by corresponding prices, which generated the cash flows. The price figures were obtained from Mammen (2001). As the price varies with the size category of logs or poles, the median price was taken assuming that the conditional distribution of logs or poles for a given mean diameter of the stand is symmetrical. The median prices were Rs. 29,690 per m^3 for timber and Rs. 8,600 per m^3 for smallwood. The said prices are realized when the mean diameter of the stand is 55 cm. The constitution of timber and smallwood per m^3 and thus the price per m^3 changes linearly with the diameter. So, the unit price was allowed to change linearly with diameter at any age. Thus the price per m^3 at any age could be obtained by multiplying the unit price at diameter of 55 cm by the ratio of diameter at that age to 55 cm. NPV of timber and successive yield of thinning up to any particular age was found out by discounting the value at an inflation free interest rate of 5 per cent.

The simulation studies using net present value of cash flows as the basis for selection revealed that starting with a relative density level of 0.3 at 5 years and gradually increasing to 0.47 by 50 years is more economical than maintaining a stationary value of 0.57. As a case of practical implication of this result, the number of trees to be retained in unit area under different site quality classes, in order to keep the relative density at 0.3 at 5 years and changing it by 5 per cent every five years is indicated in Table 1. The number of trees to be retained as per the density standards specified by All India Yield Table for teak for comparable initial diameters is also reported in Table 1. Number of trees below 10 years is not reported as it takes time for the young seedlings to attain competition inducing density levels. The numbers shown under yield table may not match with the numbers reported in yield table because starting values used for diameter are estimated from the data used for the study and not just taken from the yield table. The use of optimal density levels has been found to result in 6 per cent higher returns in terms of net present value when compared to density standards prescribed by All India Yield Table for teak. Although Table 1 indicates a reduction in number of trees every five years, one could stop thinning after 40 years for practical reasons.

Table 1. Number of trees per ha under optimal density in contrast to the numbers corresponding to density standards of yield table for teak.

	Optimal density				Yield table			
Age	SQ I	SQ II	SQ III	SQ IV	SQ I	SQ II	SQ III	SQ IV
10	418	567	826	1357	634	857	1245	2037
15	231	318	473	801	315	433	642	1084
20	163	226	339	581	198	274	410	702
25	130	180	272	469	140	194	293	504
30	111	154	234	405	106	148	223	387
35	99	139	210	366	84	118	178	311
40	92	128	195	340	73	102	155	271
45	87	122	186	325	65	91	139	243
50	84	118	180	315	59	83	127	222

Economic Rotation Age

Examination of the NPV revealed that it attains the maximum around 50 years for all site quality classes for stationary optimum density of 0.57. For the optimal density path, NPV got maximized at slightly less than 50 years.

Effect of Understorey Species

Running the simulation program showed that miscellaneous species significantly retard

the growth of teak. In the absence of any miscellaneous species at long term optimal density, the average diameter at 50 years was about 16 per cent higher than that of stands with miscellaneous species in any site class. The corresponding gain in the mean annual increment in volume was around 25 per cent. The miscellaneous species in the sample plots used for the study was dominated by *Terminalia paniculata*, a close associate of teak in natural forests. In effect, if any thing is to be grown with teak, it should as valuable or more valuable than teak.

Limitations of the study

In spite of the large sample size (125 measurements of increment coming from 69 plots) used for the present study, the adjusted R^2 value for the diameter increment function was only 0.36 implying that a substantial part of the variation in growth happens on account of factors not included in the model. A major effect not included is the incidence of defoliation by teak defoliator. In teak, defoliation by teak defoliator has been found to cause depressive influence on growth. Teak defoliator is a migratory pest and its occurrence could not be recorded during the measurement time. Hence the present study indicates average effects regardless of incidence or otherwise of the pest outbreak. Past studies at KFRI had indicated substantial gains through the control of defoliator pest using (HpNPV, *B.t*).

Certain groups of researchers or forest managers may feel that public sector teak plantations need not be managed with profit motive. They may prefer to have long silvicultural rotation of ninety or hundred years and even opt to convert teak plantations to natural forest as part of a larger policy measure. The findings mentioned in this article do not address such issues.

Potential of Teak Plantations

As per the results of KFRI (1997) the Mean Annual Increment of teak plantations at 50 years is about 3.31 $m^3\ ha^{-1}\ yr^{-1}$ with a terminal diameter of 32.7 cm at 50 years corresponding to a mean site index of 23.7 m. One of the reasons for poor yield was identified to be poor stocking in the teak plantations. Under optimum thinning schedule derived out of Jayraman and Induchoodan (2005), the expected cumulative MAI is 4.77 $m^3\ ha^{-1}\ yr^{-1}$ with a terminal diameter of 42.9 cm under the site index of 23.7 m. The benefits due to control of understorey species and teak defoliator pest and increased availability of area for planting by bringing down the rotation age to 50 years would be much more. Hence it could be concluded that adoption of optimum density levels, economic rotation age, control of understorey species along with the control of defoliator pest will go a long way in enhancing the productivity of teak plantations in the region.

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K. Jayaraman and C. Sunanada

Forest Information Management Division

Transfer of HpNPV Technology to the Forest Department- Training workshop on teak defoliator management using NPV

The training workshop envisaged as part of Project 398/04 entitled " Mass production of the baculovirus, HpNPV for management of the teak defoliator" was conducted on 24th March 2004 at Kerala Forest Research Institute, Subcentre, Nilambur. This workshop being the first phase a series of training programme comprising three phases marked the beginning of the transfer of biocontrol technology involving the nucleopoly-hedrovirus, HpNPV developed by KFRI for management of the teak defoliator to the Forest department. The first phase of the programme was dealt with "monitoring and detecting the teak defoliator populations" A total of 68 Forest Department staff working in the Nilambur North and South forest Divisions attended the training. The participants included Range officers, Foresters, Forest Guards and field watchers.

Trainees in the NPV laboratory

Mr.K.C.Chacko, Programme Coordinator, Training and Extension Division, KFRI welcomed the gathering. He explained the new phase of training and extension activities at KFRI which now has an exclusive group of scientists for the purpose under the Training and Extension Division. The programme was inaugurated Mr. Lakhwinder Singh IFS, CCF, Northern region, inaugurated the training programme. In his inaugural address he suggested that defoliator management has to be mentioned in the working plans so that routine control of the defoliator would become mandatory and the Department could allocate money for the purpose. He wished that the technology would be wholeheartedly accepted by the State Forest Department.

Dr. R.V.Varma, Programme Cordinator, Plant Protection Division, delivered the introductory lecture for the training programme. He recalled the initial steps taken by Entomologists of KFRI as early as 1976 to address the major pest problems in the forests of Kerala. He recollected that a questionnaire survey was made among the Divisional and Range Officers to identify the major problems they faced in the field. Three major problems were reported from all over the State- Termite problem in Eucalyptus plantations, Lorathus problem in teak and to top the list, the defoliator problem in teak. KFRI had at that point of time, recommended not to use any chemical pesticides because it would be counter productive, while regretting the non-availability of a safe control agent for the teak defoliator. Now an absolutely safe product is available in the form of HpNPV. He recalled the excellent support given by the State Forest Department and the Department of Biotecthnology, Govt. of India towards developing this first biopesticide in Indian Forestry.

Mr.P.Pugazhendi IFS, Divisional Forest Officer, Nilambur North Forest Division while addressing the gathering recalled the fact that the productivity of teak plantations in the State of Kerala is on the decline. He asked the participants of the workshop to assimilate the techonology so that the 44%

reduction in growth due to the teak defoliator could be brought down as much as possible.

The first session in the training entitled "***Introduction to teak defoliator and strategies for management***" was led by Dr.V.V.Sudheendrakumar, Scientist, Plant Protection Division. The lecture included biology, habit, life cycle and population dynamics of the teak defoliator and the identity, epizootiology, infection dynamics, transmission, production and application of the HpNPV.The second session on "***Detecting and monitoring teak defoliator attack***" was delivered by Dr. T.V.Sajeev, Scientist, Plant Protection Division. Starting with a comparison of the most serious pest in Indian Forestry -the teak defoliator- with the well known forest pests of the world like the Spruce budworm and the Pine beauty moth, it was shown how fast the NPV of teak defoliator was developed into a biocontrol agent with much less human and monetary resources. The techniques of monitoring and detecting teak defoliator outbreaks were discussed in detail and questions from the participants were answered.

In the post-lunch session, the participants visited the entomology laboratory and acquainted themselves with the various life stages of the teak defoliator, crude and formulated forms of HpNPV and the various sprayers used for applying HpNPV to teak stands of various heights. Dr. V.V.Sudheendrakumar and Dr.T.V.Sajeev led the demonstration, supported by Ms.Mahiba Helen, Research Fellow and Mr. T.O. Simon and Mr. Saji John, technical assistants attached to the Entomology NPV laboratory.

All the participants visited the demonstration plots at the Panayamgode teak plantation, Nilambur forest range. Being at the buffer zone between the plots protected and unprotected against the teak defoliator, the participants could see the difference between the plots with respect to difference in height and girth and also the number of trees forked. The impact of teak defoliator on the growth and form of teak during the first 11 years was well appreciated by the participants.

The primary objective of the workshop was to generate awareness among the field staff regarding the teak defoliator problem and need for its management and to train them to monitor, detect and inform the outbreaks well in time to mount a control operation. They were informed about the biocontrol technology developed by KFRI to manage the teak defoliator. The workshop generated good response by way of participation and active involvement in discussions. It is interesting to note that even though ground level staff like Foresters, Guards and field watchers were intended to attend the training, all the Forest Range Officers who attended the inaugural function showed interest to attend the whole programme. As envisaged, the workshop came up with the following plan of action for the year 2004-05.

The forest department staff will monitor all teak plantations below the age of 10 years and any outbreak will be reported to the Entomology Laboratory at Nilambur Subcentre. Application of HpNPV will be undertaken under the project 398/04 and efficiency would be evaluated jointly by KFD and KFRI.

As part of the transfer of biocontrol technology developed by KFRI for management of the teak defoliator using the biopesticide HpNPV, a training workshop on teak defoliator management was organized on 24th March 2004 at KFRI Subcentre, Nilambur. The first phase of the training was dealt with "monitoring and detecting the teak defoliator populations" A total of 68 Forest Department staff working in the Nilambur North and South forest Divisions attended the training. The participants included Range officers, Foresters, Forest Guards and field watchers. A broacher containing te details of the life history of the teak defoliator, *Hyblaea puera* infestation characteristics etc. was prepared and distributed to the participants.

Subsequent to the training based on the information received from the forest field staff, defoliator control operations were demonstrated to them in teak plantations. During the year about 34 ha of teak plantations were protected from defoliator using HpNPV.

KFRI RESEARCH REPORTS

Alternative income generation for farmers in the Western Ghats through introduction and promotion of edible shoot producing rattans. *KFRI Research Report No. 259* (Renuka, C., 2004).

Two common edible rattan species, one from Lao PDR, *Calamus* species and another from North East India, *Calamus tenuis* were introduced to Kerala and demonstration plots were established at KFRI Field Research Centre at Veluppadam and KFRI Subcentre at Nilambur. The production of new shoots started after an year of outplanting and an average of one shoot per plant could be extracted during the season when production was at the maximum. At Veluppadam the maximum production was noticed during the period from October to January and at Nilambur from July to October.

Studies on the species of *Calamus* occurring in the Western Ghats viz; *C. thwaitesii, C. hookerianus* and *C. rivalis* under different light conditions show that light intensity definitely has an effect on the survival percentage, growth and on the number of shoots produced. Under full sunlight all species registered low survival percentage and low rate of growth. In *C. hookerianus* maximum survival was under 75 per cent light while in *C. thwaitesii* and in *C. rivalis* it was under 50 per cent light. The number of shoots produced was greater under 50 per cent light in all the species. Hence these species can be promoted among farmers as understorey crop in agroforestry systems.

In general, the rattan species studied contain considerable amount of protein, when compared to other palm shoots and leafy vegetables. Among mineral nutrients, calcium, manganese and iron contents are higher which are important elements in human metabolic activities. When compared to well accepted edible species of rattans, the Western Ghats species studied are equally good in their nutrient status. Three-month-old shoots are best suited for consumption. Rattan shoots can be preserved in dry condition or in salt or sugar solutions.

A cost benefit analysis was done. Of the three species, *C. rivalis* and *C. thwaitesii* were found to be economically feasible. Hence these two species can be promoted among farmers in the Western Ghats for getting an alternative income.

A study of wood boring beetles in the Kerala part of Nilgiri Biospehere Reserve. *KFRI Research Report No. 260* (George Mathew, 2004).

Beetles are economically very important as pests of wood and wood products. They are also important ecologically and play important role in the functioning of tropical forest ecosystems. The main objective of the project is to gather basic information on the timber beetles in the Kerala part of Nilgiri Biospehere Reserve and to study their role in the functioning of the ecosystem. Detailed surveys were carried out in various habitats in Kerala part of Nilgiri Biospehere Reserve and observations were made on the nature and intensity of attack by various other timber beetles to standing trees and fallen timber by walking along a transect in the forest. Sampling of insects were done by examining fallen logs lying on the forest floor as well as observing dead or drying standing trees. Presence of borer holes and frass as well as gum exuding from the affected wood were taken as signs of potential borer infestation. The intensity of damage was qualitatively scored into low (5-10%), medium (11-50%) and heavy (>50%). The association of other wood inhabiting organisms was also recorded.

About 60 species of wood boring beetles belonging to 8 families have been recorded from various host timbers. Beetles belonging to the families Cermbycidae, Curculonidae and Scolytidae were frequently found to attack fresh fallen trees. Of these Platypodidae is the first to invade the fallen trees. Most of the trees susceptible to attack by more than one species. The species most frequently attacked were Palaquim ellipticum and *Cullenia exarilleta* (in Silent Valley) *Grevia tilifolia* and *Xylia xylocarpa* (in Wayanad) and *Xylia xylocarpa* (in New Amarambalam). Among various borers recorded, the highest incidence was Platypodidae.

Many parasitic predacious insects were seen associated with wood boring beetle. Species of the family Histeridae *(Platysoma sp.)* and Cleridae (*Clerus sp.*) were most common and are considered to prey on beetles belonging to the family Scolitidae and Platypodidae. A few hymenopterans like Icneumonnids, Bracondids and Chrysidids were

found to parasitise the larvae of the beetles. In the present study, it was observed that the primary cause of tree mortality in Kattimudi at Silent Valley was due to infestation by certain unidentified Creambycid beetles. However, in Muthenga and Wayanad, the major cause for tree mortality was due to the activity of elephants. The uprooted trees left in the forest provide favourable conditions for the establishment and spread of wood-boring beetles. On the other hand disintegration of dead wood is important in the nutrient cycling, information generated in this aspect has ecological significance.

Maintenance of permanent plots to demonstrate the effect of protecting teak plantations from the teak defoliator. *KFRI Research Report No. 26* (Sajeev, T.V., Varma, R.V., Sudheendrakumar, V.V. and Mohanadas, K., 2004).

The main objectives of the project were to demonstrate the effect of protecting teak trees from the defoliator and to integrate teak defoliator control operations with teak plantation management practices. Two plots, half a hectare each, were established at Nilambur in 1993 to demonstrate the impact caused by the teak defoliator on the growth of teak. While routine management practices were adopted in both the plots, teak leaves in one of the plots were protected from the teak defoliator through pesticide spray while those in the other plot were left unprotected. In the current project, both the above plots were maintained during the period 1998 - 2002. At the end of the experiment period, there was 39.39 per cent additional height increment and 21.88 per cent additional GBH increment in the protected plot as compared to the unprotected plot.

Timber quality of teak grown in home garden forestry. *KFRI Research Report No. 262* (Bhat K.M., Thulasidas, P.K., 2004).

Trees grown outside forests especially homesteads play an increasing role in the industrial supply of timber in Kerala. The present study evaluates the timber quality of 35-year-old teak grown in homesteads representing wet and dry localities of Kerala in comparison with that grown in forest plantation of Nilambur (of the same age group), which is widely reputed as Malabar teak.

Grading of 88 logs (of 35-year-old trees) from wet and dry localities reveals that teak timber from homesteads qualifies only for Grade II or III specified in Indian Standard (IS 4895). Grade I timber was not available from either of the two homesteads. The 35-year-old home garden trees from wet site produced timber of average DBH 39.6 cm indicating their potential of producing the log diameter similar to that of Site Quality I (SQ I) prescribed in the All India Yield Table (1970). In contrast, teak from dry site produced smaller dimensional timber of average DBH 24 cm, which qualifies only to SQ II/III with the major share of logs comprising pole sizes. Pole sized logs were less frequent in wet sites than in dry localities. Therefore the sawn wood out turn from wet site was significantly higher than dry and plantation sites. The log form was poor with eccentric growth possessing bends and frequent knots probably due to lack of standard silvicultural regime like spacing/thinning in home garden forestry.

The heartwood proportion at BH level was 71%, 64% and 73% in wet, dry and forest plantation sites respectively. Although stem diameter of the trees differed significantly, the heartwood percentage did not show significant variation with tree size and locality of the planted site. This means that homesteads of wet site areas produce larger diameter logs without adversely affecting the heartwood yield compared to dry localities and plantation sites.

The quantitative measurement of colour, as per the international standard, indicates that wood from wet sites of homesteads is paler with less yellowness and colour saturation. No significant differences were observed between the samples of different localities with regard to brightness and redness. The results suggest that the paler colour of wet site teak wood is one of the causative factors of lower in wet than in dry site. The paler colour of wet site sample was attributed to lower extractive content. The decorative black streaks of dry site wood sample were probably due to the presence of higher (16%) and more well defined zones of extractive content. The decorative black streaks of dry site wood sample were probably due to the presence of higher (16%) and more well difined zones of extractive distributin. The heartwood of plantation specimen also often displayed a similar pattern (13%) with uniform golden brown colour.

No significant differences were noticed in wood basic density, moisture content and volumetric shrinkage values among the homesteads of wet and dry localities as well as the forest plantation site in Nilambur. Excepting slightly higher longitudinal compressive stress of dry site home garden

teak, no significant variation was encountered in timber stiffness (modulus of elasticity) and bending strength among the samples of homesteads and forest plantation. This implies that teak wood grown in homesteads has almost the same dimensional stability and strength as the plantation grown teak of forest sites.

The accelerated laboratory tests revealed that significant differences existed in natural decay resistance between wet and dry localities. While the two brown rot fungi caused more severe weight loss in wet site samples than in dry and plantations sites, the three white rot fungi did not show significant differences among the sites. In general, *Polyporus palustris* was the most aggressive fungus followed by *Gloeophyllum trabeum*, both belonging to the group of brown rot fungi. The higher susceptibility of wet site home garden teak was attributed to the lower extractive content of the wood.

With a mean value of 2.2 cm, bark was thicker in trees grown in wet locality than in dry (0.8 cm) and plantation (1.1 cm) sites. While thicker bark from wet locality displayed higher moisture content (228%) and lower basic density (263 kg/m^3), thinner bark from dry locality was heaviest with a mean basic density of 640 kg/m^3. Bark from plantation was intermediate with 400 kg/m^3 of basic density and 172% of moisture content on dry weight basis.

The study concludes that teak wood grown in homesteads differs from forest plantation grown timber in certain properties such as log form, extent of natural defects, appearance/wood colour and grain as well as natural durability depending on the dry or wet locality although wood density and strength properties are almost similar. These differences in timber quality may influence the price factor of teak wood coming from homesteads especially of wet localities.

Assessing vulnerability and climate change impact on the vegetation structure and composition in wet evergreen and shoal forests of Kerala part of Western Ghats. *KFRI Research Report No. 263* (Chandra sekhara ,U.M., 2004).

The Western Ghats located in the Indian sub-continent, is one of the biologically and bio- geographically richest hill ranges in the world and is considered as a mega-centre of biodiversity. Like in other regions of the world, here also it is predicted that the global climate change, particularly in the form of increasing atmospheric temperature and rainfall, and rising sea level, would alter the forest structure and floristic composition. In the present study, attempts were made to predict the possible impact of climate change in three forest types, namely, the low elevation evergreen forests, mid elevation evergreen forests and shola forests. For each forest type, plots were selected along the altitudinal gradients and comparative analyses were made for species diversity and phytosociological features.

A comparative study carried out in a swamp forest (altitude 76 m above mean sea level) and in a forest patch located at an altitude 372 m above mean sea level indicated that in both the plots, tree species such as, *Knema attenuata*, *Myristica dactyloides* and *Polyalthia fragrans* are dominant. However, contribution by these species to the total Importance Value Index (IVI) is relatively less in the higher altitude forest patch. In addition, these species show certain morphological features such as, stilt roots and breathing roots only when they are growing in the swampy areas. In higher altitude forest patch, comparatively high species diversity is recorded and this can be attributed to two factors, namely, the low dominance of Myristicaceous species and partitioning of resources by species characteristic to a wide range of elevation. It is clear from this study that the Myristica swamps represent a distinct plant association in lowlands of Kerala. The climate change in India, which is expected to increase the water table in the low-lying areas, may not directly alter habitats and the vegetation structure and composition in myristica swamps located here. However, the loss of coastal land due to inundation and intrusion of salinity as a consequence of climate change may lead to the encroachment of Myristica swamps and their conversion for agriculture, construction, industrial uses etc.,

Possible impact of climate change in mid elevation forests and high elevation forests (shola forests) is in the form of increase in atmospheric temperature and rainfall. It is also expected that the temperature in a forest patch located at a given altitude could rise to the level of temperature being experienced in the lower altitude forests. In this context, in a given forest type, comparison of vegetation structure and composition of forest patches located in the relatively higher altitude with those in the lower altitude was made, to provide an indication of possible species composition and other phytosociological features in the higher altitude forest patches. Study indicated that in the relatively undisturbed forest patches, located in an

altitudinal gradient which were selected to represent the medium elevation evergreen forest type, *Palaquium ellipticum*, *Mesua ferrea* and *Cullenia exarillata* remained as the dominant tree species. Thus, climate change may not alter the vegetation to an extent where the vegetation alters drastically. However, number of species, density and values obtained for species diversity index, both in tree and seedling communities are more in high altitude forests. Therefore, possible impact of climate change on relatively high altitude forests could be the reduction in species diversity and density of tree and seedling communities. A clear increasing trend in density, basal area and contribution to the total species importance index values by *Mesua ferrea* and the family Lauraceae with increase in elevation was noticed. Thus, it is also possible to predict that due to climate change, in higher elevation forest patches, current dominance of *Mesua ferrea* and Lauraceae may be reduced.

Shola forest patches along the altitudinal gradient are different from each other in terms of dominant species in their tree communities. In this forest type, as the elevation increases, the dominance of *Cinnamomum perrottetii* and *Microtropis ramiflora* increased respectively in tree and seedling communities. In addition, the species composition in higher altitude forests are significantly different from the plots located in lower elevation shola forests as indicated by the similarity index values obtained for tree and seedling communities. Thus it can be predicted that, due to climate change, in the higher altitude shola forests, the dominance of *Cinnamomum perrottetii and Microtropis ramiflora* may be reduced and species composition may be changed into that being seen in lower altitude sholas. Currently, in higher altitude shola forest patches, density of tree and seedlings are more than those in lower altitude shola forest patches. Even the height of the trees is also relatively less. Thus, it can also be predicted that due to climate change, density of trees and seedling and height of the trees could increase in the higher elevation sholas.

Preparation of biodiversity register - A model study in Panancherry Panchayat in Thrissur District of Kerala. *KFRI Research Report No. 264* (Sasidharan, N. (2004).

The main objective of the study was to prepare a biodiversity register of Pananchery Panchayath. An elaborate survey was carried out to collect details on the biodiversity and the associated knowledge. A training programme was conducted for the volunteers involved in data collection.

The information gathered on the history and social life of people in Pananchery reveals much about the present situation. The migration of farmers from different regions of Kerala to Pananchery has greatly changed the social life of the people. Geographical peculiarities, climatic conditions and irrigation facilities are the major factors which have promoted the agriculture sector. In recent times, areas under agricultural crops like paddy are getting reduced while there is an increase in the cultivation of plantation crops like rubber.

The forest areas of Pananchery are rich in biodiversity which includes rare species of plants (*Aglaia malabarica*, *Palaquium ravii*,...), animals (Nilgiri langur, Nilgiri tahr, Slender loris,...), birds (Ceylon frogmonth), fishes (Kerala loach, Asiatic snakehead, Stinging catfish, Common rashora), reptiles, insects etc.

Farmers are aware of the technological development in agriculture and use new agricultural practices, hybrid seeds, agricultural implements and irrigation facilities to improve the yield. In the biodiversity register, all the varieties of agriculture/horticulture/cash/plantation crops and domestic animals were listed with their peculiarities. Among the crops, local and hybrid varieties of mango, paddy, coconut, and banana are the widely cultivated ones. "Kannara Local" amaranth and "Mudikkode Local" cucumber of Pananchery are very popular among farmers of Thrissur. Farmers select crops which are suited to localities considering the geographical factors and irrigation facilities. Animal husbandry has an important role in the economy of the Panchayath. A small percentage of people are engaged in fishing.

An important part of the study was to list out the local health practices among the people. The older people of the Panchayath are very knowledgeable about local health practices. The study has compiled details of such health practices. It was found that about 110 species of plants/plant products and nine animal products are being used for local health care.

Field trials for controlling *Mikania* infestation in forest plantations and natural forests in Kerala. *KFRI Research Report No. 265* (Sankaran K.V., 2004).

Mikania micrantha H.B.K. (mikania), the perennial invasive weed of neotropical origin, is a menace in natural forests, forest plantations and agricultural systems in Kerala. The

apparent negative impacts of the weed include reduction in yield of subsistence and cash crops, loss of native biodiversity and prevention of forest regeneration. An ecological survey conducted during 1999-2002 in the State revealed that the weed is widespread in Kerala and is still expanding its range. The spread of the weed to the neighboring States, where it is currently absent, appears imminent.

A total of 402 different localities (including natural forests, forest plantations and agricultural systems) were surveyed in Kerala for the occurrence and severity of infestation by the weed. Of these, 244 (61%) were with various levels of infestation. The invasion was the most severe in the central zone of the State (72%) compared to southern, northern and high range zones. Spread of the weed was observed in all the districts except Kasaragod. The survey showed that mikania infested sites were more in the moist deciduous forests (64%) compared to evergreen (54%) and semi-evergreen forests (58%). Shola forests and grasslands were free from infestation.

Of the forest plantations surveyed, teak had the maximum number of plantations infested (78%). Young (1- to 3-yr-old) plantations of teak were particularly heavily affected. In agricultural systems, although 65 per cent of the surveyed sites were infested, only a few were severely affected. The major agricultural crops susceptible to the weed were pineapple, banana, coconut, cassava and ginger. The survey also revealed that highly disturbed forests are more prone to invasion than undisturbed/less disturbed. In evergreen forests, where canopy is more or less closed, infestation was either absent or scarce.

Herbicidal trials to control mikania were carried out in plantations of teak and eucalypt and a natural reed growing area. Of the herbicides tested, triclopyr + picloram @ 1.75 – 3.5 l/ha and triclopyr @ 0.5 – 1 l/ha showed the highest weed control efficacy (WCE) compared to the other herbicides. Glyphosate @ 2.5 – 5 l/ha and diuron @ 1 – 1.5 kg/ha were also effective in controlling the weed. Since the former two herbicides are not yet available in the Indian market, use of glyphosate or diuron at the given concentrations is recommended for mikania control in forest plantations and natural reed growing areas in the State. The herbicidal applications need preferably be done before flowering/seed setting stage of the weed (August-September) for maximum efficacy. Though a single application of either of the herbicides will provide long-term control of the weed, repeated yearly applications may be necessary wherever re- invasion is a problem through wind-borne seeds.

The efficacy of paraquat and 2,4-D is apparently short-lived and hence may not be suitable for control of mikania. Also, animal toxicity of 2,4-D and its long and persistent residual action preclude use in any environment. Addition of adjuvants viz., ammonium sulphate and urea improved WCE of both the herbicides. Likewise, combinations of glyphosate/paraquat/diuron exhibited higher WCE compared to application of each herbicide individually.

Mechanical weeding (knife weeding) of mikania in forest plantations and natural forest areas is more labour intensive and expensive compared to a single application of the recommended herbicides. However, it is cautioned that continuous use of herbicides in any ecosystem is environmentally hazardous and may cause toxicity if used in food crops. Hence, the suggested herbicides may only be used as a short-term measure until alternative cost-effective and eco-friendly methods for mikania control are developed. Great caution is also warranted while using the herbicides; application may be avoided near settlements, cattle grazing areas and water bodies.

An annotated bibliography on teak (Tectona grandis Linn. F.). Peechi, Kerala Forest Research Institute. *KFRI Research Report No. 266* (Sarojam, N., 2005).

The sterling qualities of teak wood, considered as the queen of timbers, are well known. Teak plantations are grown extensively not only in its native home range covering India, Myanmar, Thailand, Laos and Indonesia but also in many other countries in Asia, Africa, Central and South America and the Carribbean Islands. Intensive work has been carried out on different aspects of the species like genetic improvement, provenance trials, selection criteria for superior phenotypes, improved seed strategy, phenology, flowering and pollination processes, seed germination, vegetative propagation and tissue culture, plantation raising and management, properties, treatment and utilization of the timber. Now the research is mainly focusing on producing quality wood in a short period. The research results are published in different forms like journal articles, reports, books, theses, conference proceedings, etc. and are widely scattered. An effort has been made to cover the details of all

these publications in the form of a bibliography. A total of 4781 references have been compiled in this bibliography. The references included date back to year 1856 to the present. This bibliography being brought out after a gap of 30 years, the last one being by Krishna Murthy (1974), will fill a long felt gap in access to information on teak and will be useful to researchers, forest officials and all those who are interested in teak wood.

This bibliography can be used in several ways. One can browse through the contents to locate the topic of interest and get an idea of the work carried out under the subject. The references are arranged alphabetically by author's name under broad subject categories. A short abstract is given for most of the references. Separate author and subject indexes have been provided. The numbers given against each author correspond to the serial number of the reference in the bibliography. The permuted subject index provided at the end of the document will help to locate the exact information provided in the document.

All the available bibliographies on teak (Krishna Murthy, 1974; Mathur, 1973, FAO, 1973) were referred for preparing this document. Forestry Abstracts, Forest Products Abstracts, Chemical Abstracts, Biological Abstracts, Current Contents and AGRIS database were also referred for the latest references. Some of the websites were also useful for getting recent references. All the available documents in KFRI Library were scanned through for the purpose of updating the bibliography.

Genetic improvement of teak. *KFRI Research Report No. 267* (Indira E.P., 2004).

Fifty plus trees of teak and 750 ha of seed stands were selected in main teak growing Forest Divisions of Kerala during 1980-'82 in cooperation with the Forest Department. Three pilot teak seed orchards were also established in the northern, central and southern parts of Kerala in a total area of 6.1 ha. A production seed orchard in 28 ha was also established by Forest Department with the technical expertise from KFRI. Though clonal seed orchard establishment progressed very well, low flowering and low fruit production hampered the teak improvement programmes. However, as an interim measure, improved seeds from seed stands are made available. Some of the plus trees selected earlier were felled or fallen and hence, the number of trees are not enough to have a broad genetic base. Also, progeny trial establishment and evaluation of plus trees were not attempted in a systematic way.

This project was initiated to select a few more plus trees and to establish a progeny trial for evaluation of plus trees for their breeding value. This report is on the first phase of the twenty year Teak improvement programme planned for increasing the productivity. Thirty three of the total 50 teak plus trees selected in Kerala during early 1980s were relocated and marked. Sixty two new plus trees were selected from plantations which had crossed half the rotation period and also from natural forests. On an average the selection differential estimated is about 37 per cent for total height and clear bole height and about 32 per cent for girth at breast height. At least 5 to 15 per cent increase in volume is expected by selecting the best families or individuals. A progeny trial was established at Nilambur with 74 families so as to evaluate the plus trees for their breeding value. In the nursery, progenies of plus trees from Konni area have shown better performance, but in the field trial, the same trend was not seen. However, it is too early for an evaluation. The maintenance of the field trial and its evaluation are still continuing in the second phase of the genetic improvement programme. This trial can be converted to a seedling seed orchard after proper evaluation and thinning or can be retained as a breeding population.

Isozyme analysis was initiated with limited number of plus tree clones. The study shows that there is no diversity between the few selected plus trees of Nilambur origin.

Transpiration measurements in rubber and coconut. *KFRI Consultancy Report No. 13* (Jose kallarackal, 2004).

Evapotranspiration consists of transpiration from the leaves, interception of water by the canopy and evaporation from the ground. Sap flow in rubber trees were measured during the different seasons or weather conditions in a rubber plantation in Kozhikode District of Kerala. There were differences in the quantity of water transpired during these periods. Transpiration rates of individual trees were extrapolated to the stand transpiration. Similarly, the year was divided into four different seasons (according to the weather conditions especially the rainfall) and the daily transpiration in each season was extrapolated to annual values. The total annual stand transpiration comes to 1231 mm, which is 36.7 per cent of the annual average rainfall obtained at the study location. The other losses through evapotranspiration, namely,

interception and soil evaporation were estimated using model equations from known parameters. Thus the interception of rainfall on an annual basis works out to 331 mm and the evaporation from the soil 451 mm. The total evapotranspiration from the rubber plantation works out to 2013 mm annually. This is 60 per cent of the annual rainfall, which is 3350 mm for this location.

The extrapolation of transpiration from soil moisture measurements in coconut was not successful because the soil surrounding the coconut trees had a thick mat of coconut tree roots which prevented the insertion of the TDR probe into the soil.

State of Environment of Kerala: Nature and Biodiversity. KFRI Extension Report No.16.

The report deals with the current status of natural and artificial ecosystems of Kerala State and the biodiversity they contain. It is prepared in the DPSIR format, ie. Driving forces, Pressures, State of affairs, Impacts and Responses. As introduction, the place of the two aspects in the policy cycle of the State is elucidated with the support of available statistics. This is followed by the status description of forest and non-forest ecosystems and wild and domesticated/cultivated plant and animal diversity of the State. The DPSIR on the nature and biodiversity is broadly classified into the three physiographic zones of the State, ie. Lowlands, Midlands and Highlands, as they are the entities dominated by different ecosystems and the biodiversity they contain. Each component of the dpsir is dealt with separately supported by data, examples and illustrations. Data gaps, policy issues and recommendations follow to conclude the report. The report along with few other aspects related to the state of environment of Kerala State, prepared by other agencies, were combined and brought out as a book by the kscste which was released by the Chief Minister of Kerala on 5 June 2005, ie. the World Environment Day

NEW RESEARCH PROJECTS INITIATED

Externally funded projects (National Intuitions)

KFRI 452/2004: Mapping biodiversity of the Myristica swamps in Southern Kerala (Vijayakuaran Nair, P., 2004 April-2007 March, MoENF, Govt. of India).

KFRI 453/2004: Micropropagation of *Bambusa balcooa* and *Dendrocalamus giganteus* (Muralidharan, E.M., 2004 May-2007 April, DBT, Govt. of India).

KFRI 454/2004: Ecological studies to conserve and rehabilitate the mangrove vegetation in the coastal landscapes of Kerala (Swarupanandan, K., 2004 May-2007 April, MoENF, Govt. of India).

KFRI 455/2004: Forest and agricultural ecosystem analysis to assess ecosystem health and to identify rehabilitation strategies in the Kerala part of Nilgiri Biosphere Reserve (Chandrasekhara, U.M., 2004 May-2007 April, MoENF, Govt. of India).

KFRI 457/2004: Field performance of mirco and macro propagated planting stock of selected five commercially important bamboo species (Sharma ,J.K.,2004 July-2007 June, DBT, Govt. of India).

KFRI 459/2004: Biotechnological approaches for the improvement of plant species withspecial reference to pulp and paper (Bhat, K.M., Muralidharan, E.M. and Thulasidas P.K., 2004 September-2006 August, CSIR (NMITI)).

KFRI 460/2004: Production of quality planting materials for rare medicinal plants of commercial importance (Sasidharan, N., Muralidharan, E.M., Chacko, K.C., 2004 November-2007 October, National Medicinal Plant Board).

KFRI 461/2004: Use of bioprotectant against fungal deterioration of rubber wood (Maria Florence, E.J., Balasundaran,.M., December 2004-Novemeber 2007, DBT. Govt. of India).

KFRI 463/2004:Mapping and quantitative assessment of geographic distribution and the population status of plant resources of Western Ghats (Sharma, J.K, Menon, A.R.R., and Renuka, C., December 2004 –November 2008, DBT, Govt. of India).

KFRI 465/2005: Ecology and behaviour of owls in the Western Ghats and developing a habitat model for their conservation (Jayson, E.A., 2005 February 2008 -January, MoENF, Govt. of India).

KFRI 469/2005: Integrating Cultural and Biological Diversity into the Conservation of Agastyamala Biosphere Reserve (Anitha, V., 2005 February-

2006 January, UNESCO, New Delhi).

Externally funded projects (State)

KFRI 427/2004: Ethno Zoological studies on the tribals of Palghat and Malappuram Districts of Kerala (Padmanabhan, P., 2004 April- 2006 March, Planning & Economic Affairs (E) Dept).

KFRI 428/2004: Conservation of critically endangered tree *Syzigium palgjatensis.* Gamble (Myrtaceae) of the Western Ghats of Kerala (Yesodharan, K., 2004 April-2007 March, Planning & Economic Affairs (E) Dept.).

KFRI 429/2004: Computerized Database on Kerala Forest Resources and Data Retreival System (Sivaram, M., 2004 April-2007 March, Planning & Economic Affairs (E) Dept).

KFRI 430/2004: Potential of using coir geo-textiles in a highly degraded area in the Western Ghats improving the soil and productivity (Balagopalan, M., 2004 April-2007 March, Planning & Economic Affairs (E) Dept.).

KFRI 431/2004: Modeling the growth of teak in relation to soil conditions in the Kerala part of the Western Ghats (Rugmini, P., 2004 April-2007 March, Planning & Economic Affairs (E) Dept.). KFRI 432/2004: Establishment of Ex-situ Gardens of species of *Dalbergia* and monocotyledons in the bioresources nature trail in the Kerala part of Western Ghats (Chandrasekhara, U.M., 2004 April-2009 March, Planning & Economic Affairs (E) Dept.).

KFRI 433/2004: Micropropagation of superior clones of teak for the Western Ghats of Kerala (Muralidharan, E.M., 2004 April-2007 March, Planning & Economic Affairs (E) Dept.).

KFRI 434/2004: Vegetative propagation of selected medicinal plants for enrichment of resources. (Surendran, T., 2004 April-2007 March, KFD).

KFRI 435/2004:The raw drugs requirement of Ayurvedic medicine manufacturing industry in Keala (Sasidharan, N., 2004 April- 2006 March, State Medicinal Plant Board, Govt. of Kerala).

KFRI 456/2004: Preparation of a primer for training Vana Samrakhana Samitis (VSS) in sustainable management of non-timber forest products (Sankar, S., 2004 May -2004 October, KFD).

KFRI 458/2004: Water use by Eucalyptus grandis in comparison with rice fields and grass lands located in the downhill area of Mannavan Shola in the Western Ghats of Kerala (Kallarackal, J., 2004 September 2005- August, KFD).

KFRI 462/2004: Bamboo sector in Kerala: Baseline data generation for developing an action plan (Muraleedharan P.K., Krishnanankutty C.N., Sankar, S., Anitha,V., Seethalakhmi, K.K. and Gnanaharan, R., December 2004-November 2005, Kerala Bureau of Industrial Promotion).

KFRI 464/2005: Calibration of volume prediction equations for different clones of rubber based on random parameter models (Jayaraman, K., January 2005- July 2005, Rubber Research Institute of India, Kottayam).

KFRI Plan Grant

KFRI 436/2004: Development. of equipment suitable for low-cost micro propagation (Muralidharan, E.M., 2004 April-2006 March).

KFRI 437/2004: Genetic variability in teak clones using DNA marker technology (Balasundaran, M., 2004 April-2007 March).

KFRI 438/2004: Improvement of teak through genetic evaluation (Indira, E.P., 2004 April-2007 March).

KFRI 439/2004: Growth of field planted teak clones at Karulai (Surendran, T., 2004 April-2007 March).

KFRI 440/2004: Enriching of live collections of wild orchids and ferns of Kerala and preparation of an illustrated manual (Muktesh Kumar, M., 2004 March-2007 April).

KFRI 441/2003: Enrichment of Insect and Microbial Culture Collections at KFRI (George Mathew., 2004 April-2007 March).

KFRI 442/2004: Habitat enrichment in the butterfly garden at KFRI campus, Peechi (George Mathew., 2004 April-2007 March).

KFRI 443/2004: Strengthening and computerization of KFRI Herbarium (Yesodharan, K., 2004 April-2007 March).

KFRI 444/2004:Strengthening and enriching the Palmetum (Renuka, C.. 2004 April-2007 March).

KFRI 445/2004: Strengthening medicinal plants garden in the Peechi campus (Sasidharan, N., 2004 April-2005 March).

KFRI 446/2004: Ecology and behaviour of arboreal mammals of Nelliampathy forests (Ramachandran. K.K.,2004 April-2007 March).

KFRI 447/2004: Forest dynamics in four one-hectare permanent plots in natural forests (Swarupanandan, K., 2004 April-2006 March).

KFRI 448/2004: A Handbook of lesser known timbers (Bhat, K.M., 2004 April-2006 March).

KFRI 449/2004: Participatory forest management and ecodevelopment alternatives: initiatives and challenges in Kerala (Mammen Chundamannil, 2004 April-2007 March).

KFRI 450/2004: Comparison of prediction models developed by statistical and neural network techniques in applied forestry research (Sivaram, M.,2004 April-2007 March).

KFRI 451/2004: Digitisation of KFRI scientific papers and research reports, 201 to 250 (Sankara Pillai, K., 2004 April-2005 March).

KFRI Plan Fund (Chief Minister's one year programme)

KFRI 466/2005: Cost effective soil and water conservation –establishment of a demonstration area with people's participation (Sankar, S., 2005 January- 2005 December).

KFRI 467/2005: Establishment of a pilot scale clonal plantation of promising plus trees of Teak (Surendran, T., 2005 January-2005 Decemeber).

KFRI 468/2005: Livelihood improvement of marginal bamboo dependants: artisans and farmers of Thenkurussi Panchayat, Palakkad (Seethalakshmi, K.K., 2005 January-2005 December).

Extension and Consultancy Projects

KFRI Ext.50/04: Orientation course for high school teachers in remote sensing and GIS. A.R.R. Menon (Funded by Education Department, Govt. of Kerala).

KFRI Ext./02: Wood quality evaluation of Bhadrachalam clones of eucalypts. K.M. Bhat, H. D. Kulkarni, K. R. Venkatesh, P. Santhakumar and M. Sivaram (Funded by ITC Ltd. Sarapaka, A.P).

KFRI Ext.57/05: Preparation of management plan for newly constituted Shola National Parks. A.R.R. Menon, N. Sasidharan, M. Balagopalan, George Mathew, K.K. Ramachandran and E.A. Jayson (Funded by Kerala Forest Department).

KFRI Ext.4/05: Impact of Tsunami on mangroves of the Kerala coast, with particular reference to the maxim impact zones. R.C.Pandalai, K.Swarupanandan, A.R.R.Menon and A. Mohandas (Funded by KSCSTE).

KFRI Ext.45/04: Study on status of regeneration in ANR, RDF1 and RRB treatment areas of Achencoil Division. U.N. Nandakumar and A.R.R. Menon (Funded by Kerala Forest Department).

KFRI/Extn.49/2004. Preparation of State of Environment Report for Kerala (SoER): Nature and Biodiversity (Participating institutions: TBGRI, Kerala Forest Department-Biodiversity Cell, Central Marine Fisheries Institute, Kerala Agricultural University, INTAC, etc) Co ordinator-K.K.N. Nair.

CAMPUS NEWS

Publications

Papers in journals

Abhilash, E. S., Menon, A.R.R. and Balasubramanian, K. 2005. Regeneration status in natural habitats of Nageia wallichiana (Presl.) O.Ktz., Goodrical reserved forests of Western Ghats of India. *The Indian Forester* 131(2):pp.183-200.

Anitha, V., Muraleedharan, P. K. and Binilkumar, A. S. 2004. Human dimensions in protected area management : tracing synergies of conservation and livelihood. *International Journal of Environment and Development* 1 (2): 265-280.

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Bhat, K. M., Thulasidas, P. K., Maria Florence, E. J. and Jayaraman, K. 2005. Wood durability of home garden teak against brown rot and white rot fungi. *Trees – Structure and Function* (Internet version).

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Gene Encoding Primers. BMC Ecology 5:1 (02 Feb 2005) (Online)

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Kallarackal, J., Jeyakumar, P. and George S. J. 2004. Water use of irrigated Oil Palm at three different arid locations in Peninsular India. Journal Of Oil Palm Research (Malaysia) 16:45-53.

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Mendham, D.S., Kumaraswamy, S., Balasundaran, M., Sankaran, K.V., Gerbeels, M., Grove, T.S., O' Connell, A.M. and Rance, S.J. 2004. Legume cover cropping effects on early growth and soil nitrogen supply in eucalypt plantation in South-Western India. Biology and Fertility of Soils 39: 375-382.

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Hands books/information bulletins

Kumar, M. 2004. Field Guide: The Bamboo Book, NMBA, TIFAC, Department of Science and Technology, New Delhi. 58p.

Seminar/workshop/Conference attended

National

Dr. Mukteshkumar prticipated in the *Ntional Sminar on Food, Medicine IK and IPR* held at Thiruvanthapuram on 12-13 March 2004. He also participated in the *VIIth World Bamboo Conference*, Organized by the World Bamboo Society, and Ministry of Agriculture & Department of Science & Technology, Government of India, held during February 27th to 4th March 2004, at Ashoka Hotel, New Delhi

Dr. U.M. Chandrasekhara participated in the *National Workshop on Conservation of Sacred Goves* held in Kozhikode on 16-18 September 2004 and presented a paper entitled "Conservation of sacred groves of Kerala-necessities, ways and means.

Dr. M. Balasundaran attended the *National Seminar on Coir Research 2004* at Central Coir Research Institute, Alleppey during 11-13 August 2004 and presented a paper on "Coir Pith Compost as a Component of Potting Media in Forest Nurseries".

Dr. M. Sivaram participated in the *Workshop on Data Needs and Tools for Data Interpretation for Decentralized Planning* held on 17 August 2004 organized by the National Informatics Centre and Planning Board at the Government Guest House, Thiruvananthapuram.

Dr. C.Renuka attended the *Workshop on Regional Cooperation on Conservation of Biodiversity Hotspots of the Indian Subcontinent and Taxonomic Databases for Conservation* organised by ATREE, Bangalore during August 30th – September 1st 2004 and the National workshop on *Information Management of Biodiversity Resources in Botanic Gardens of India* organized by NBRI, Lucknow during 6- 9 September 2004

Dr Jose Kallarackal participated in the *Workshop on Water Productivity Networking* organised by the Indian Council of Agricultural Research. on 14-15 October 2004 in New Delhi.

Dr. U.M. Chandrasekhara Participated in the *Workshop on Gums and Resins* organized by Keystone Foundation, Kotagiri on 21-23rd December 2004 and presented a paper entitled "Density and distribution pattern of gums and resin yielding species in the Forests of Kerala".

Dr. M. Balasundaran participated in the ICAR *National Symposium on "Biotechnological Interventions for Improvement of Horticultural Crops – Issues and Strategies"* held at Kerala Agricultural University, Vellanikkara, Trichur during 10-12 January 2005 and chaired the session on Molecular Markers.

Dr. J. K. Sharma and Dr. V.V. Sudheendrakumar attended the *National Seminar on Emerging Scenario of Patent's Protection, Valuation and Commercialization* organized by NRDC, New Delhi on 9 February, 2005.

Dr. K. K. N. Nair attended the *Prithvi–2005 Conference* held at Trivandrum

during 19-22 February 2005.

Dr. M. Sivaram participated in the *International Workshop on "MATLAB"* conducted during 17-18 March 2005 at St. Thomas College, Pala.

Dr. Jose Kallarackal participated in the *National Workshop on Drought Management in Plantation Crops* held in KFRI on 22-23 March 2005. He chaired a session and also presented a paper entitled, "Physiological performance of oil palm in relation to weather parameters in three Indian states" authored by J. Kallarackal, P. Jeyakumar and S.J. George.

International

Dr. V. Anitha attended *International workshop on the "Rehabilitation of Degraded Tropical Forests* at Forest and Forestry Products Research Institute (FFPRI), Tsukuba, JAPAN, March 3-4, 2004

Dr. K.K. N. Nair attended the *IUFRO Division I Conference on Meeting the Challenge: Silvicultural Research in a Changing World* at Montpellier, France during 14-18, June 2004 and presented the paper entitled 'Plantation technology and field performance of selected tree species of multiple end uses indigenous to Indian Peninsula authored by K. K. N. Nair, C. Mohanan and George Mathew.

Dr Jose Kallarackal participated in the *IUFRO Forest Hydrology workshop on Forests and Water in Warm, Humid Asia* held on 10-12 July 2004 in Kota Kinabalu, Malaysia and presented a paper entitled," Transpiration differences between tree species as an important factor in estimating water balance from tropical catchments authored by Jose Kallarackal and C. K. Somen

Dr. R. V. Varma participated in the *International Workshop on Developing an Asia Pacific Strategy for Forest Invasive Species – Bridging Agriculture and Forestry* from 22-25 February 2005 at Ho chi Minh city, Vietnam and presented the paper entitled " The invasive insects and weeds: the agricultural –forestry connection, examples from India".

Extension activities undertaken

In response to a request from the Director, Vigilance and Anti- Corruption Bureau, Govt. Kerala, Dr. C. N. Krishnankutty prepared a report on estimation and valuation of the missing quantity of Kumbil timber allotted to the Hindustan Newsprint Limited from Malayattur Forest Division.

Dr. M. Mukteshkumar provided details on ferns and orchids of Kerala to NBRI, Lucknow as a part of the consultative group meeting of the Botanical Garden to be recognized by them: A checklist of ferns and orchids was prepared and sent to NBRI, Lucknow, for compilation; Ten species of ferns and 15 species of orchids were identified for the Forest Department from Waynad; Details were provided to the Chief Engineer (C-IPDS), KSEB, Trivandrum on the lower groups of Plants occurring in the Chalakudy River basin during February 2005.

Dr. A. R. R. Menon and Dr. P. Vijayakumaran Nair prepared a map of the area under encroachment in Kuttampuzha using GPS and established the feasibility of using hand held GPS for survey work.

Dr. P. Vijayakumaran Nair prepared maps and posters on bamboo for the Forest Department.

Dr. M. Balasundaran gave technical advice to the Research Range Officer, Central Nursery, Nilambur for the vegetative multiplication of *Acacia* and *Eucalyptus* clones planted in clonal multiplication area of the Forest Department and to the MP State Agro Industries Development Corporation Ltd for cultivation of *Acacia* species and their wood quality.

Dr. K.K.N. Nair gave inputs to District Tourism Promotion Council, Idukki, on establishing an Arboretum and Botanic Garden at Munnar, Kerala; provided all information pertaining to the plants Agathi, Karanj, Punna and Marotti were given to planters of Kottayam District; Facilitated the officials from the Ministry of External Affairs, GOI, for making film on protected areas in India for exhibiting abroad and gave an interview on biodiversity of Silent Valley for inclusion in the documentary.

V. V. Sudheendrakumar and T.V. Sajeev Visited M/s Choudhary Plantations, Dongaria Village, Kesda, Raipur in Chattisgarh during 22-23 September 2004 and extended advice on teak defoliator management using NPV.

Matters of general interest

Training received

Dr.M.P. Sujatha attended a training course on *Land Degradation and Sustainable Rural Livelihood: Field Assessment* conducted by Overseas Development Group at University of East Anglia, Norwich, U.K and Centre for Soils and Applied Biology of the Segura region, Murcia, Spain during 20 April 2004- 2 May 2004.

Dr. V.V. Sudheendrakumar attended the training on *Patent Protection* or-

ganized by NRDC, New Delhi on 6 February, 2005.

Dr. P. Padmanabhan attended a refresher course on *Animal Behaviour* at Department of Animal Behaviour and Physiology, School of Biological Sciences, Madurai Kamaraj University during December 8-21, 2004.

Training imparted

Dr. A.R.R. Menon imparted training on remote Sensing to school children during 16-19th Aug. 2004 at KFRI.

Dr. R. V. Varma took a class on "Pest and Disease Management of Medicinal Plants" on 25th September 2004 for the participants of the training course in "Conservation and Cultivation of Medicinal Plants" held in KFRI fom 18-19 September 2004.

Dr. R .V. Varma served as a resource person for in-service course for college teachers organized by the UGC Academic Staff College , University of Kerala and gave a talk on" Invasive Insects and Weeds of Economic Importance in Forestry", on 5th march 2005.

A two week summer training in Biotechnology was conducted by Dr. Balasundaran for Ms. G. Swetha, and Mr. P.K.M. Ahammed Basheer, M.Sc. Environmental Biotechnology students of Cochin University of Science and Technology during June 2004.

Visit abroad

Dr. K.K.N. Nair conducted orientation course on Arboretum, Palmetum and Germplasm for the students of The Centre of Career Development, Thrissur on 22-04-2004.

Research guidance

Ms. P.K. Reeja, M. Sc., Physics student, Dhanalakshmi Srinivasan College of Arts and Science for Women, Peramballur, Tamil Nadu successfully completed her project work entitled, "Measurement of absorption and reflection characteristics of solar radiation in different surfaces" under the guidance of Dr. Jose Kallarackal.

Ms. T.K. Divyalakshmi, M. Sc., Microbiology student, Karpahgam Arts and Science College, Coimbatore successfully completed her project work entitled " Pathogenicity of a *Beauveria bassiana* isolate to the teak defoliator, *Hyblaea puera*" under the guidance of Dr. V.V.Sudheendrakumar

Ms. Anupama C., M. Sc., Industrial Biotechnology student, Karpagam Arts and Science College, Coimabtore and Priya Ann Oommen M.Sc. (Biotechnology) student, Holy Cross College, Bharathidasan University completed their project works entitled "Molecular characterization of *Corticium salmonicolor* using RAPD markers" and "Genetic fingerprinting of seven eucalypts clones using RAPD markers" respectively under the guidance of Dr. M. Balasundaran.

Visit Abroad

Dr J.K. Sharma, Mr. K.C. Chacko, Dr Jose Kallarackal and Dr K. Swarupanandan visited the major forestry research institutions in Japan under the training and Visiting Programme of Japan International Cooperation Agency (JICA) during 26 January to 7 February 2004

Dr. M. Balasundaran and Dr. M. Balagopalan visited Guatemala and Panama during March 19-30, 2004 as consultants to investigate soil and disease problems of teak plantations of Ecoforest S.A., Panama and Guatemala, and recommend remedial measures.

Patents filed

A process of manufacture of a biopesticide based on a naturally occurring nucleopolyhedrovirus of the group Baculovirus and use thereof for the management of the teak defoliator pest *Hyblaea puera* (V.V.Sudheendrakumar, R.V.Varma and T.V.Sajeev). (Filed in the Patent Office, Chennai).

Expertise given

Dr Jose Kallarackal participated in the brainstorm meeting on *Drought management in Kerala* organized by the Cochin University of Science and Technology held on 16 April 2004.

C. N. Krishnankutty served as a resource person in a workshop on *'DISNIC-PLAN Project, ICT for Micro level Planning in the State of Keral1a'*, 16-17 August, 2004, organised by the State Planning Board, Govt. of Kerala, and National Informatics Centre, Govt. of India. He also served as a resource person for lectures on *'Evidence gathering and analysis techniques'* in the Training Course on 'Performance Audit', 21 December 2004, at the Office of the Principal Accountant General, Thiruvananthapuram.

Dr. R. V. Varma served as a resource person for in-service course for college teachers organized by the UGC Academic Staff College , University of Kerala and gave a talk on "Invasive Insects and Weeds of Economic Importance in Forestry", on 5th March 2005.

Dr. K.K.N. Nair gave technical inputs to District Tourism Promotion Council, Idukki, on establishing an Arboretum and Botanic Garden at Munnar, Kerala.

Ph. D Awarded

Mr. R. Jayakumar, Research Fellow was awarded Ph. D. for the thesis entitled 'Studies on the angiosperm flora and its diversity in the new Amarambalam reserved forests of Nilgiri Biosphere Reserve, Western Ghats of India' from FRI Deemed University. He worked under the guidance of Dr. K.K.N. Nair.

Mr. N. Unnikrishnan, Lecturer, Botany Department, N.S.S. College, Vazhoor, Kottayam, was awarded Ph.D. degree for the thesis entitled: "Taxonomic Studies on the Bamboos of South India" from Calicut University in August 2004. He worked under the guidance of Dr. M. Mukteshkumar.

Smt. Mary Anto, Research Fellow, Entomology Division was awarded Ph.D for her thesis entitled "Studies on the Ecology and Conservation of the Southern Birdwing Butterfly, *Troides minos* Cramer (Lepidoptera:Papilionidae" from University of Calicut. She worked under the guidance of Dr. George Mathew.

Mr. Stephen Sequiera, Research Fellow, Botany Division, was awarded Ph.D. degree for the thesis entitled " Taxonomy and Ecology of Lichens of Silent Valley National Park, Southern Western Ghats, India" from FRI Deemed University in November 2004. He worked under the guidance of Dr. M. Muktesh Kumar.

Mr. K.R. Sasidharan, Scientist, IFGTB, Coimbatore was awarded Ph.D from FRI Deemed University, Dehra Dune in February 2005. The topic of Research was " Studies on the insect pests of *Casuarina equisetifolia* L. in Tamil Nadu and their management. He worked under the guidance of Dr. R.V.Varma.

Mr. Sibichan Varghese, Research Fellow was awarded Ph. D for his thesis entitled "Impact of natural and man-made disturbances on vegetation structure and diversity in shola forests of Kerala, India" from FRI Deemed University, Dehra Dun. He worked under the Guidance of Dr. U.M. Chandrashekara.

Congratulations

Dr. K. K. Seethalakshmi, Scientist SNPFM Division received National Award for Development of Women through application of Science and Technology for the year 2004 from Department of Science and Technology, Government of India. The award was presented to her on 11th March 2005 at New Delhi.

NEW RELEASES

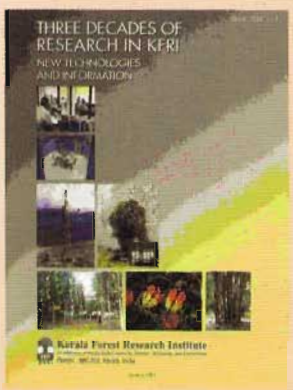
Quality Timber Products of Teak from Sustainable Forest Management

Eds: K.M. Bhat, K.K.N. Nair, K.V. Bhat, E.M. Muralidharan and J.K. Sharma

The book is the proceedings of the international conference on Quality Timber Products of Teak from Sustainable Forest Management held at Peechi during 2-5 December 2003. It contains 95 papers on various aspects of teak classified under the themes, Status of teak in producer countries; Sustainable forest management with special reference to teak; Quality Timber Products of Teak from Sustainable Forest Management; Genetic aspects of teak wood production; Clonal propagation and genetic improvement; Health of cultivated teak; Growth, wood production and productivity; Economics of teak plantations and policy issues; teak timber trade and wood industry; and Institutions, investments and net working.

Hard bound; 18 x 24 cm; 668 pages; Rs.1000/-/US $ 80 (ISBN81-8-85041-63-6)

Three Decades of Research in KFRI- New Technologies and Information

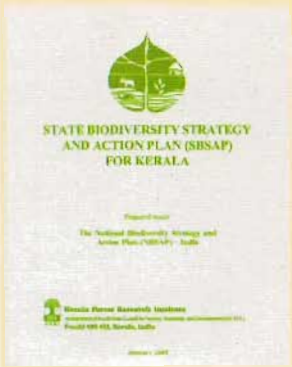


Compiled by K.C. Chacko, Mohammed Kunhi and Thomas P Thomas

The book is a compilation of the technologies developed by Scientists of KFRI over the past three decades. Many of the technologies are suitable for adoption or readily uasable by different clients such as forest managers, wood based industries, farmers, researchers etc. A number of them are new while some are improvement over the existing technologies. The book is expected to play a great role in the transfer of technologies and dissemination of information to forest departments and other stake-holders.

Hard bound, 21 x 28 cm; 287 pages; Rs.200/-/US $ 20 (ISBN81-8-85041-64-4)

State Biodiversity Strategy and Action Plan (SBSAP) for Kerala



This document on state Biodiversity Strategy and Action Plan (SBSAP) is based on inputs received from several persons including subject experts, members of the Steering Committee and Thematic Working Groups during workshops/meetings/public hearings. THere are six main chapters in the SBSAP. The first chapter on Introduction deals with background, scope, objectives, methodology and format of the Report. The second chapter provides information on Kerala State's history, physiography, climate, agroclimatic zones, soils, agriculture, irrigation, landuse patterns, developmental programmes, industrial, socio-economic, political fields in relation to biodiversity.

The third chapter deals with domesticated and wild biodiversity of Kerala State. The fourth chapter deals with the causes for the loss of wild and domesticated biodiversity as well as an overview on effectiveness of biodiversity related laws in preventing biodiversity loss. The fifth chapter discusses and highlights major initiatives and key actors involved in the conservation of wild and domesticated biodiversity. The sixth chapter deals with various strategies and actions under separate issues required for conservation, sustainable use and equitable access and sharing of benefits for both wild and domesticated biodiversity under each Thematic Group.

Soft bound, 21 x 28 cm; 405 pages; Rs.300/-/US $ 30 (ISBN81-8-85041-53-9)

KFRI PUBLICATIONS: PRICE LIST

	Bamboo	Price	
		Rs.	US$
1.	An Annotated Bibliography on Bamboos of the World	550.00	50.00
2.	Bamboo Resource Development and Utilization in Kerala	25.00	10.00
3.	Bamboo: A Crop (CD-ROM)	250.00	25.00
4.	Commercial Bamboos of Kerala	50.00	10.00
5.	Field Identification Key to Native Bamboos of Kerala	100.00	10.00
6.	KFRI CD4: An Annotated Bibliography on Bamboos of the World	200.00	20.00
7.	Micropropagation of Bamboo and Rattan	50.00	10.00
8.	Nursery and Silvicultural Techniques for Bamboos	150.00	15.00
9.	Policy and Legal Issues in Cultivation and Utilization of Bamboo, Rattan and Forest Trees in Private and Community Lands	400.00	40.00
10.	Preservative Treatment of Bamboo and Bamboo Products	50.00	10.00
	Rattan (Cane), Plams		
11.	A Manual on the Rattans of Andaman and Nicobar Islands	175.00	20.00
12.	Annotated Bibliography on Rattans of the World	350.00	35.00
13.	Commercial Rattans of Kerala	50.00	10.00
14.	Field Identification Key for Rattans of Kerala	125.00	15.00
15.	Nursery and Silvicultural Techniques for Rattans	50.00	10.00
16.	Oil Curing Technology for Value-added Rattan (Cane) Products	50.00	10.00
17.	Palms of Kerala	200.00	20.00
18.	Protection of Rattan against Fungal Staining and Biodeterioration	50.00	10.00
19.	Rattan Management and Utilisation	300.00	30.00
20.	Rattans of the Western Ghats: A Taxonomic Manual	100.00	10.00
21.	Structure and Properties of South Indian Rattans	75.00	10.00
	Teak		
	KFRI CD2: Bibliography on Teak	500.00	50.00
22.	Quality timber products of teak from sustainable forest management (Seminar Proceedings)	1000.00	80.00
23.	Teak Bibliography (Print)	700.00	70.00
24.	Teak (Information Bulletin)	25.00	10.00
25.	Teak (Seminar Proceedings)	200.00	20.00
26.	The Teak Defoliator (CD-ROM)	250.00	25.00
	Plantation Management		
27.	Compost for Container Seedlings Production in Forest Nurseries	100.00	10.00
28.	Litter Dynamics, Microbial Associations and Soil Studies in Acacia auriculiformis Plantations in Kerala	75.00	10.00

EVERGREEN

A Newsletter of the

Kerala Forest Research Institute

(An Institution of Kerala State Council for Science, Technology and Environment)

Peechi, Thrissur, Kerala, India

ISSN 0254-6426

Editor

Dr.V.V.Sudheendrakumar

Associates

Dr.K.Swarupanandan

Dr.T.V.Sajeev

Mr.K.H.Hussain

Mr.Subash Kuriakose

Evergreen the KFRI Newsletter is brought out in March and September is intended for free private distribution to individuals and institutions connected with forestry activities. The views expressed in the newsletter are those of the authors and do not necessarily reflect the views of the Institute. All readers are invited to send their comments and opinions. The Newsletter committee reserves the right to choose among the contributions and edit wherever necessary .

Address all communications to:

The Editor
Evergreen
Kerala Forest Research Institute
Peechi-680653, Thrissur, Kerala, India

Phone: +91 (0)487 2699061-63
Email: kfri@kfri.org

KFRI TRAINING PROGRAMMES IN TROPICAL FORESTRY

KFRI offers specialized training courses in various aspects of tropical forestry to meet the requirements of various stakeholders. It is also proposed to provide tailor-made training depending upon spaecific needs of the stakeholder.

For more details contact:

The Director
Kerala Forest Research Institute
Peechi-680653
Thrissur, Kerala
India

Phone: +91 (0) 487 2699061-63
Email: training@kfri.org
Web: www.kfri.org

Thanks to the readers of Evergreen !!!!!

We have received overwhelming response from the readers by way of returning the readership survey form expressing their comments on the newsletter and suggestions to improve. We consider it as very valuable.

Editorial board
Evergreen