PROTOCOL FOR RAISING, PROPAGATING AND PLANTING ENDANGERED TREES OF THE WESTERN GHATS

Selecting the trees-

Identify and prioritise species based on the list of selected endangered trees. Each restoration hub will be encouraged to take up a maximum of 10 species. The selection will be based on criteria like suitability of habitat, availability of seeds and seedlings, proximity to planting sites etc. A common protocol to study the species in the wild will be established and ecological studies on the species will be taken up across all sites and for all species. Table 1 gives the list of the species that have been selected based on the need to spread our work across the Western Ghats.

Ecology of selected trees-

Studying the ecology of the selected species in order to know the structure of the forest where the species is located naturally. Forest assessments will be undertaken to record the stand structure, species diversity and richness. This will improve our understanding of the habitat by knowing what other plants grow along side, understand which successional stage it occupies (pioneer, secondary, tertiary) and document whether it is an edge species or occupies a specific storey in the forest structure. A document on the ecology and conservation needs of each species will be produced along the course of this project.

Looking for seeds and planting material-

If the phenology of the species is already known then it will be verified with field observations since we expect there will be regional and climatic variations. In case it is not known then efforts will be made involving local communities to track the phenology and record fruiting periods. This will be done by choosing a minimum of five adult trees which will be monitored using a basic data sheet to record phenology every 15 days. Once the seed setting period is identified efforts will be made to collect seeds and seedlings from a genetically diverse pool. When dealing with endangered plants care will be taken to remove only those seeds and seedlings that have fallen by the wayside or have taken root in plantations and related sites where the chances for their survival are poor. If such planting material is not to be found then seeds will be collected from the tree and care will be taken not to take more than a certain number of seeds. Again this number can only be ascertained depending on species and site characteristics. Seeds will be selected for quality and will be transferred to the nursery at the earliest. A best practises document for seed collection will be developed as part of the project activities.

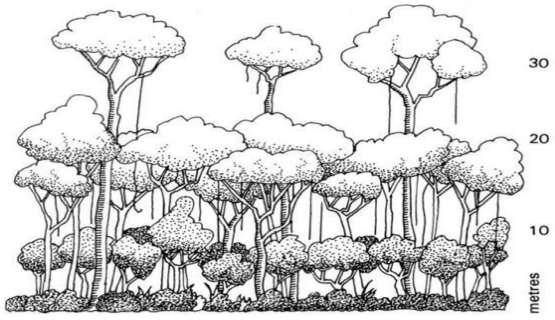


Table 1 List of Endangered Trees Selected for Restoration in the Western Ghats

#	***Species***	**Family**	**Red List Status**	**Habitat**	**Distribution**	**Notes**
1	*Hydnocarpus alpinus Wight*	Achariaceae	NE	Evergreen forest	Western Ghats- Tamil Nadu, Kerala, Karnataka)	Medicinal, harvested from wild, estimates AOO/EOO < 20km
2	*Hydnocarpus macrocarpa (Bedd.) Warb.*	Achariaceae	VU (reassessment needed)	Evergreen forest	India (Tamil Nadu, Kerala)	not in IUCN RLA
3	*Nothopegia castaneifolia (Roth) Ding Hou*	Anacardiaceae	CR (Reassessment needed)	Evergreen	India (SW. Maharashtra, NW. Karnataka)	
4	*Bentinckia condapanna Berry ex Roxb.*	Arecaceae	VU	Shola forests and along rock cuttings in grasslands	Southern Western Ghats	Inflr used in religiuos ceremony
5	*Commiphora wightii (Arn.) Bhandari*	Burseraceae	CR	Arid and semi arid	S. Arabian Peninsula, S. Pakistan to Central India.	resin-gugulused in incense and vedic medicine
6	*Capparis nilgiriensis G.V. Subba Rao, G.R. Kumari & V. Chandrasekaran*	Capparaceae	NE	Moist Deciduous to Evergreen Forests	Western Ghats- Tamil Nadu	
7	*Euonymus crenulatus Wall. ex Wight & Arn.*	Celastraceae	NE	Evergreen forest	Western Ghats- Kerala and Tamil Nadu	
8	*Cycas annaikalensis*	Cycadaceae	CR	Moist deciduous	Kerala	2010
9	*Cycas circinalis L.*	Cycadaceae	EN	Moist deciduous, evergreen forest	India (Tamil Nadu, Kerala, Karnataka)	
10	*Dipterocarpus indicus Bedd.*	Dipterocarpaceae	EN	Evergreen and semi-evergreen forests (reassessment needed)	Karnataka, Kerala, Tamil Nadu.	Timber value, Traded
11	*Hopea ponga (Dennst.) Mabb*	Dipterocarpaceae	EN	Evergreen forest	India (Tamil Nadu, Goa, Kerala, Maharashtra, Karnataka)	
12	*Shorea roxburghii G. Don*	Dipterocarpaceae	VU(regional assessment needed)	Evergreen	India and South East Asia	
13	*Diospyros candolleana Wight*	Ebenaceae	VU	Evergreen, semi-evergreen and moist deciduous forest	Peninsular India	Timber, Medicinal
14	*Kingiodendron pinnatum (DC.)Harms*	Fabaceae	EN (Reassessment needed)	Evergreen	Southern Western Ghats- Kerala, Tamilnadu, Karnataka	Oleo-resin, Timber Medicine; traded

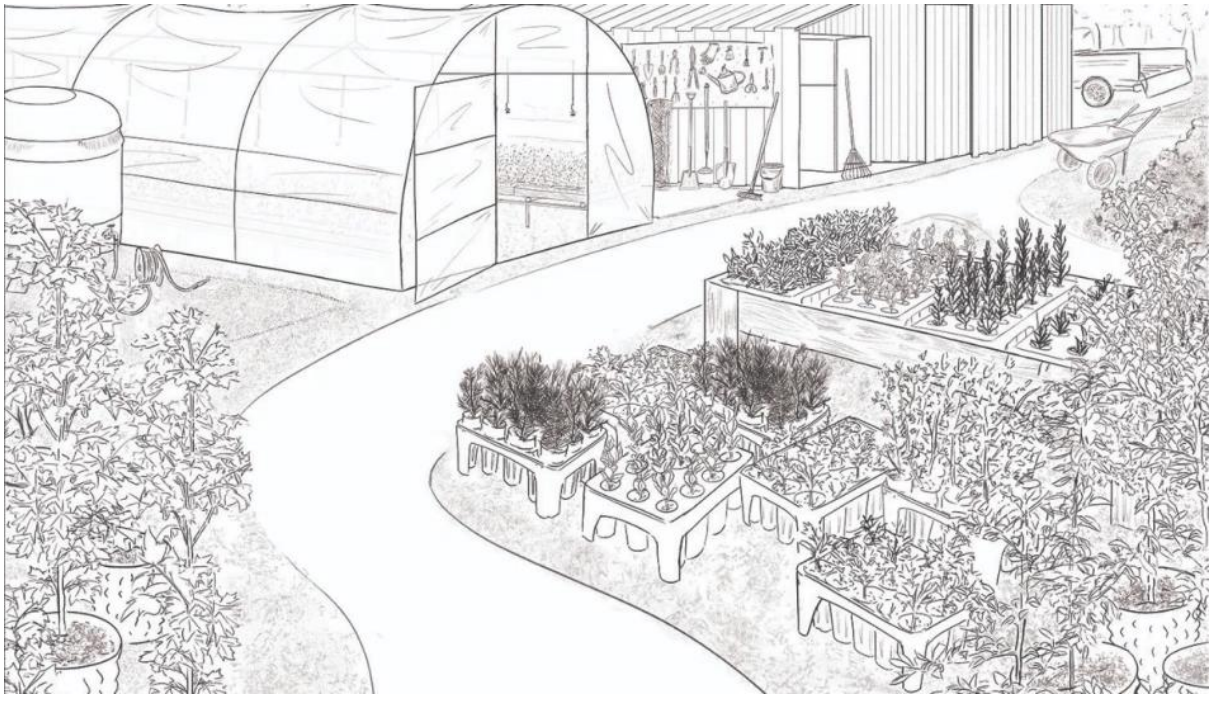
15	*Saraca asoca (Roxb.)Willd.*	Fabaceae	VU	Semi-Evergreen	India, Sri Lanka, Bangladesh, Myanmar	Cultivated; ornamental
16	*Hydnocarpus pentandra (Buch.-Ham.) Oken*	Flacourtiaceae	VU	Dry /moist deciduous forest	India (Tamil Nadu, Maharashtra, Kerala, Karnataka, Karaikal, Goa)	medicinal, traded
17	*Cinnamomum wightii Meisn.*	Lauraceae	EN	Montane evergreen forests	India (Tamil Nadu, Kerala, Karnataka)	Medicainl; harvested from wild
18	*Cryptocarya beddomei* Gamble	Lauraceae	VU	Evergreen forest	South Western Ghats- Karnataka, Kerala and Tamilnadu	
19	*Magnolia nilagirica (Zenker) Figlar*	Magnoliaceae	VU	Shola forest	India (Karnataka, Kerala, Tamil Nadu); Sri Lanka	
20	*Memecylon edule Roxb.*	Melastomataceae	NE	Evergreen forest	Peninsular india	
21	*Gymnacranthera canarica (*Bedd. *ex* King*)* Warb.	Myristicaceae	NE	Swamp Marshes	Western Ghats - Karnataka	
22	*Syzygium bourdillonii (*Gamble*)* Rathakr. *&* Nair	Myrtaceae	EN	Evergreen	South Western Ghats- Kerala and Tamilnadu	re assessment
23	*Syzygium occidentale (*Bourd.*)* Ghandhi	Myrtaceae	VU	Riverine	Western Ghats- Kerala and Karnataka	re assessment
24	*Syzygium parameswaranii* Mohanan *&* Henry	Myrtaceae	EN	Evergreen	Southern Western Ghats(Kerala)	re assessment
25	*Syzygium tamilnadensis* Rathkr. *&* Chitra	Myrtaceae	NE	Evergreen, montane evergreen forest	Southern Western Ghats	assessesd as threatened -N page

References-
https://www.iucnredlist.org/species/32604/9716556
https://www.iucnredlist.org/species/31199/9608095
https://indiabiodiversity.org

Raising in the nursery-

In the case of the restoration hubs we will be working with established nurseries and projects that have more than 10 years of experience with raising native plants. A portion of the nursery will be set aside for raising the endangered trees. This will be demarcated and maintained distinctly with signage. Seeds will be treated as per standard protocols available with each hub based on field experiences. The seeds will be planted directly in nursery bags or buried in germination trays or beds. Larger seeds will be put directly into bags while smaller ones may be in germination trays as a first step. Several manuals and protocols are already published like the NCF manual on Rainforest Restoration and the PHCC manual on Forest species and these are important resources that will be used as standards.

In the case of highly dormant seeds and slow growing trees the seeds may take up to at least a year to germinate. We are not yet sure of this and we will be learning about each species as we take this project forward. Once the germination has taken place depending on the rate of growth to sapling stage we will take a decision whether to plant them in the subsequent monsoon. Out planting early is advantageous since it causes less damage to the tap root though this will vary based on the species and its ecological status. A fast growing secondary species may be easier to outplant within two years but a slow growing understorey tree may need to be nurtured in the nursery before putting it out in the forest. We will also prefer to keep them in the nursery till the second year so that they are prepared and ready for the out planting. Initially seedlings and saplings are watered daily in the nursery and slowly this is reduced to make the plants hardy to withstand forest conditions. Applying bio inputs or organic manure will not be done except in the initial stages when the seeds are planted. Our focus will be on making the young saplings hardy, mimicking forest conditions so that their survival chances are higher.

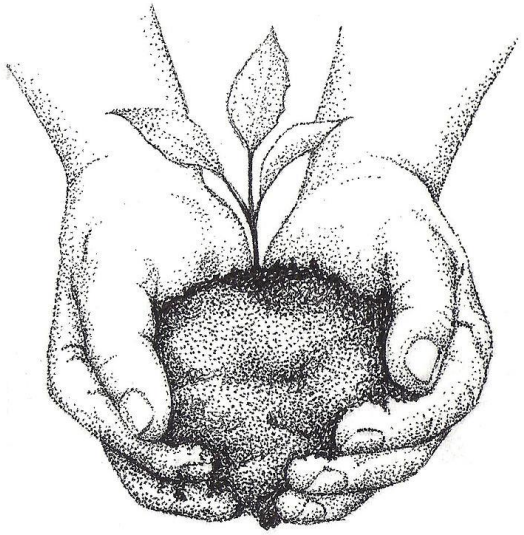


Selecting sites for planting-

Sites for planting can vary from forest areas where the species is found naturally, to protected gardens, private lands adjoining forest areas etc. Once a suitable site is located for the planting, care will be taken to clean the site and remove invasive plants if they are present. Some guiding criteria for site selection will be ecological suitability, protection assurance, tenural consideration (since we need to have access for monitoring) etc. At the site pP\its of standard sizes will be dug and appropriate planting medium will be placed in the pits. Planting will happen to the middle of the second year. Each sapling will be tagged for monitoring purposes and geo spatial co- ordinates will be recorded. If the site is suitable for a complete fencing this will depend on the ownership of the land and availability of resources, a solar powered fence may be installed. Usually in the planting in forest areas individual tree guards made either of shade mats or metal meshes are placed to safe guard the saplings from herbivores both wild and domesticated. The planting will also be done in the monsoon period.

Tending endangered trees-

Maintenance of planting sites through bi monthly visits to ensure plant survival and assess damage will be undertaken. Removal of invasive plants which will recur in the habitat will be taken up twice a year. Monthly monitoring of the sapling in the first three years after out planting will be taken up. Subsequently the monitoring frequency will be lowered based on the survival rate. In the case of damaged saplings, they will be replaced in the subsequent monsoon period. A certain proportion of the trees will also be raised in protected gardens and conservatories in and around sites.



Raising endangered trees: the story of *Cycas circinalis* and *Canarium strictum*

At Keystone Foundation which is located in the Nilgiri biosphere reserve we have been engaged in eco development work with indigenous communities who are dependent on the local forests. In the course of our work since 1993 we have worked extensively to build nurseries for crop plants to support diversity on farms and encouraging agro ecological methods. The nurseries were designed for village sites and local people were trained to manage them. Coffee, fruit trees, vegetable and medicinal plants were raised in these nurseries. Since 2002 we started to diversify the nurseries to incorporate native trees and climbers especially those that were known to the indigenous people and used by them as sources of non timber forest products (NTFP). People were consulted in each village to determine the list of plants and their numbers that were to be raised. These lists were generated by asking questions like 'which plants in the forest do you use and for what' or 'is there a plant that has now become harder to find'. In a span of 5 years we had gained a rich experience of inventories of native plants. These led to a seed collection of more than a 1000 varieties across altitudinal ranges of 30 to 2200msl. The seed collection also leads to the development of the field guides to the plants of the Nilgiri biosphere reserve - a compendium of seven volumes.

The question about plants that were 'harder to find' and about those that had specific cultural and ecological roles to the lives of indigenous people took us to two trees that have since then become the story of a community based conservation approach.

Cycas circinalis L. a gymnosperm, one of the only members of the Cycadacae to be found in the Western Ghats is important to many indigenous people viz. the Kurumba and Kattunayakas. Found growing upto an elevation of 1000msl in dry and wet forests of the Nilgiri biosphere reserve, the tree with its palm like structure has been at the forefront of our conservation program.

Seed collection was done with mature seeds and in large numbers (upto 5000 seeds every year for a period of three years). The seeds when matured were harvested as an NTFP and sold in the local market. It was challenging to get mature seeds since the harvesters always got to it before us! There were no ready manuals on raising these plants from seed so we learnt through conversations with experts and observations in the forest.

We noticed that seeds consumed by bats and flying squirrels were found regurgitated in parts of the forest and germinating in the monsoon rain. One time we found that somebody in the village had forgotten about the seeds they had harvested and left them in a gunny bag outside their home. These seeds had started to germinate in a month's time. At the nursery we soaked the seeds in cold water for a day and then planted them in nursery bags. Care was taken to keep the seeds horizontal since the apical and root tip cannot be easily distinguished. Seeds were also left at the surface of the bags and not buried deep. Then it was time to wait and be patient! In our low elevation nursery at Appankappu in Kerala the seeds germinated in one month. At the higher elevation nursery at Velleri combei , Tamil Nadu they took upto 3 months to germinate. On an average 60% of the seeds germinated in the nursery. No rodents were observed predating on the seeds, the seeds that stayed longer than 3 months would start to attract fungal growth and appearance of a single leaf usually indicated the germination, this would be followed by two more leaves. We also observed that every year the sapling would put out a whorl of new leaves (while in the nursery the whorl would not be more than 3 or 5 leaves) while the older ones wilted away. Each leaf persisted for a year atleast.

The slow growing Cycas saplings would be shifted around in the nursery to ensure the tap root would not get into the soil. The saplings were planted out after a year in the nursery. Sites for planting were selected in natural forests, along riparian stretches and also along village boundaries adjoining the forest. Survival rate is quite high in these planted saplings, since no herbivores would browse or graze on the plant. Occasionally the saplings would suffer damage because of trampling. In 5 years we have seen the plant attaining good growth indicated by increased number of leaves in each whorl. Since there was a demand for the leaf by the floriculture industry we had to protect our plants from clandestine harvesters. In one of the village areas where the leaves got stolen the most one of the team members came up with a brilliant idea. The leaves would only fetch a good price if they were whole, so with a pair of scissors we cut off the tips of the leaf and this ensured that none of the leaves were stolen!

By observing the Cycas plants in their natural forests and studying their population dynamics we were able to learn how to raise, propagate and restore these endangered trees. Seeds we learnt were not viable beyond a year, seeds germinate better with some treatment and plants needed to be tended only for a year before planting out or else the root would be damaged in transplantation. Again since the species is dioecious (male and female flowers are present in separate individuals) we were not sure if the plants turn out male or female. Our oldest surviving individual is 15 years old since we planted and we are waiting to see when it will flower.

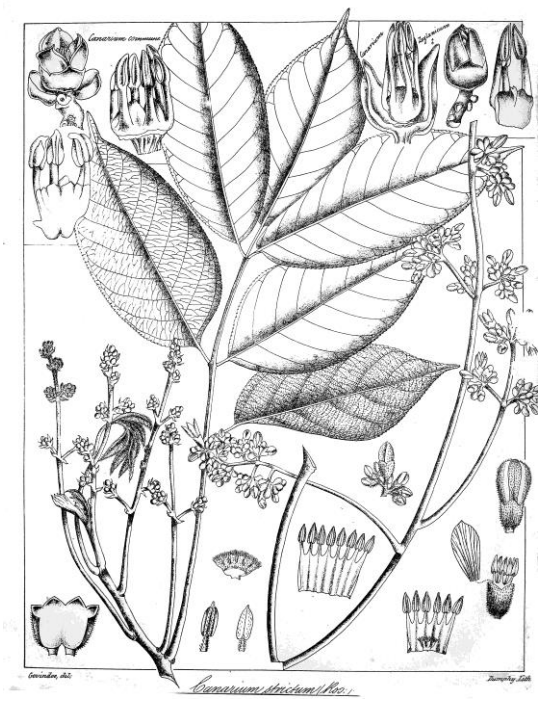
Canarium strictum Roxb. is a member of the Burseraceae family of resin yielding plants. This tall stately tree grows in the semi evergreen and moist deciduous mid elevation forests. They are also present along river stretches. The resin from the tree is a prized NTFP and an important part of the culture and belief system of local indigenous people of the Nilgiri biosphere reserve.

We learnt from the indigenous people that the resin was very important to them and in some of the areas the trees were becoming harder to see. People mentioned that it is a softwood and in the past decades when timber logging was permitted several of these trees were logged for the matchstick industry. People also told us that these trees fall easily in the forest when there is a storm.

Finding seeds was not difficult since there are still many adult trees in the forests around the indigenous villages. Seeds regurgitated by birds could be found in abundance under the trees but often these would have been predated and therefore not viable for nursery. We needed to find seeds that had fallen to the ground mature and not after they were consumed by any animal.

We did do an experiment and took some of the seeds and planted it in the forest in pre marked sites. We buried them under different shade and light conditions close to the mother tree. Every 15 days over a period of six months we watched for signs of regeneration. We gave up after 6 months when we saw no signs of germination. When we dug up the seeds we found that our experiment had not succeeded since all the seeds were predated by some rodents!

At the nursery we had better results. Seeds were treated to cold water soaking for 24hours so that the fruit could be removed and then the hard woody seeds would be left to dry in bright sunshine. Within a few hours the woody seed coat would crack after which we would bury them on the surface of a sand tray or directly into bags for germination. Within two weeks germination would occur and the first signs of life would emerge. The first two leaves look like the leaves of a maple tree and this is followed by the mature leaves of the Canarium tree.



Raising Canarium saplings were relatively easy and germination rates were upto 80%. Saplings did very well in the nursery and were outplanted after a year in the nursery. Being a secondary species the plants tend to shoot up fast in the first years of their growth and the saplings were more than 3 feet in the first year.

Local people also indicated places in the forest where the tree was found in the past and these sites were also chosen for planting. The saplings planted near water sources survived the best of all. Once again major threat to the saplings was not from browsing or grazing only from trampling and breakage of stems. The quick growing saplings were easily broken off is branches of other trees fell on them. Many of the saplings were planted in the farmlands of the local people especially along forest boundaries. After a period of 10 years the first trees that were planted started to produce resin. Though we are yet to see them flower or fruit. *Canarium strictum* trees are known to be dioecious and also exhibit a slightly more complex gender differentiation some trees have been observed to change their sex in the course of their growth.

Studying the Canarium trees for their population dynamics and habitat characteristics gave us an insight into their life history and ecological role in the ecosystem. We found that rare birds like the Imperial Pigeons, Great Hornbills, and arboreal mammals like the Giant squirrels feed on their seeds. Since the trees would grow wide with broad buttress roots and have giant cavities –the trunk served as homes for arboreal small mammals like the flying squirrel, civets and martens. In the case of the Canarium seeds owing to predation it was better to collect mature fallen seeds than those dispersed by animals. Also as all secondary species the tree tends to grow fast in the initial years competing for light and therefore it was not practical to keep the species in the nursery beyond two years.

Key takeaways for restoration of endangered trees

When setting out to restore endangered trees it is important that we spend adequate time learning about the species in it's natural habitat and understanding the ecology of the species. The success of our reintroduction and restoration efforts will be highly dependent on this knowledge.

Studying the life history of the species will lead to a better understanding of what threats and barriers have led to the endangered status of the species. Eg: it could be that the flowers have highly specific pollinators and their absence will lead to production of non-viable seeds. It could also be as in the case of the Canarium trees that the seeds are predated upon and hence only a small percentage germinates in the wild. Other threats to the species from harvest and over exploitation can be gathered through social surveys with local forest dependent communities. Interviewing forest managers will be key to understanding the conservation efforts or logging practises of the past. If there is local research or educational institutions in the area, it is good to find out if they have some experience with the species. Very often student dissertations are not published and can only be accessed through visiting the institution libraries.

The ecological role of the species and other species that depend on it give valuable knowledge about interactions that may be specific and unique. In the case of the Cycads we learnt later about a mutualistic relationship between a species of ants and the larvae of the plains cupid butterfly which completed its life cycle on the new leaves of the Cycas. The significance of these interactions can only be established with long term studies and research. These provide vital links to understanding threats that species face in the wild.

Finally, while undertaking restoration of endangered trees importance will be given to building our understanding on the species which in turn will guide us on best practises to be adopted for conservation. The efforts are not to raise a large number of saplings which can be distributed widely through tree planting schemes. The effort of our work with endangered trees will be to establish a scientific protocol for restoring species, monitoring their survival and growth and ensuring their long term conservation in their natural habitats.