International Journal of Science, Environment and Technology, Vol. 2, No 6, 2013, 1335 – 1352

ISSN 2278-3687 (O)

Syzygium travancoricum (GAMBLE)-A CRITICALLY ENDANGERED AND ENDEMIC TREE FROM KERALA, INDIA- THREATS, CONSERVATION AND PREDICTION OF POTENTIAL AREAS; WITH SPECIAL EMPHASIS ON *Myristica swamps* AS A PRIME HABITAT

Roby T.J.[1], Joyce Jose*[2] and P. Vijayakumaran Nair[1]
[1]Kerala Forest Research Institute, Peechi Trissur, Kerala
[2]Dept of Zoology, St. Thomas College, Thrissur, Kerala
E-mail: joyceofthejungle@gmail.com (**Corresponding Author*)

Abstract: *Syzygium travancoricum* (Gamble) is a critically endangered tree endemic to the South Western Ghats, India. It has been associated with *Myristica* swamps of Western Ghats, a naturally fragmented, restricted endemic ecosystem with anthropogenic threats to its existence. Randomly selected 17swamps were sampled. IVI and response to selected abiotic parameters were calculated and girth class distribution plotted. Observations on germination, regeneration and growth were recorded. Forest areas in Kerala having a potential to host a *Myristica* swamp were predicted. Ground truthing was done. The possible number of *S. travancoricum* individuals was calculated and IUCN categorization re-examined. 153 trees in 60 swamp patches were counted but only 20 trees were present in 17 transects. Density was 11 trees/ hectare. *S. travancoricum* was the sixth most important tree in the swamps (IVI = 0.1198). Girth class analysis and field observations indicate a recent threat in the survival of the species. Trees in the lower girth class comprising the immature trees show a decline of upto 90%. Seedling responded well to treatment with fungicide and 300 survived in nursery as against zero in the wild after one year. Seven transplanted seedlings (KFRI arboretum) showed 100 % survival after six years. PCA showed that *S. travancoricum* was tolerant to inundation when compared with the other *Syzygium* species. 11.76 trees/ 0.01km^2 or 1176.47 trees per km^2 is possible in terms of density. In 148 km^2 area with a potential for *Myristica* swamps in Kerala, 174788.15 *S. travancoricum* trees are theoretically possible. *S. travancoricum* remains in the critically endangered category but the criteria may be changed to A1 e. Steps should be taken to ascertain the true population of S. *travancoricum* and conserve its natural habitat.
Keywords: *Syzygium travancoricum*, *Myristica* swamps, Conservation, Regeneration.

Introduction

Syzygium travancoricum (Gamble) is a critically endangered tree endemic to the South Western Ghats, India. According to IUCN Redlist 2010, 2012 & 2013 only 200 trees are found in Western Ghats. *S. travancoricum* is an evergreen tree growing upto 25 m in height with white flowers belongs to the family Myrtaceae. *S. travancoricum* was first discovered in the swampy lowlands (altitude less than 65 m) of Travancore by Bourdillon in 1894. Gamble

*Received Nov 4, 2013 * Published Dec 2, 2013 * www.ijset.net*

(1935) described it in 1918 in the Kew Bulletin and in the Flora of the Presidency of Madras in 1919. *S. travancoricum* are present in evergreen, semi-evergreen forests and a few scared groves in Thiruvanthapuram, Kollam, Pathananthitta, Alapuzha and Thrissur districts (Sasidharan, 2006). They have also been reported from freshwater swamps dominated by trees belonging to the family *Myristica*ceae, particularly two species *viz. Myrisitica magnifica* and *Gymnacranthera farquhariana* and are therefore referred to as *Myristica* swamps.

Krishnamoorthy (1960) first reported *Myristica* swamps from the Travancore region of South Western Ghats. Champion and Seth (1968) classified such swamps under a newly introduced category '*Myristica* Swamp Forests' under the Sub Group 4C. Other descriptions of in India Myristica swamps include(Varghese 1992;Chandran *et al*., 1999;Santhakumaran *et al.,* 1995; Dasappa, 2000; Ravikanth *et al*., 2004; Nair et a 2007) As special abiotic conditions (Chandran and Sivan, 1999)are prerequisites for the development of *Myristica* swamp forests, these swamp forests have become highly restricted and fragmented.

Anthropogenic interferences have further threatened the existence of this ecosystem. Pascal (1988) reported conversion of these swamps to paddy fields and Rodgers and Panwar (1988a; 1988b) highlighted the systematic destruction of these swamps and called for Priority I level implementation of their proposed *Myristica* swamp Wildlife Sanctuary. Recent studies (Joyce *et al.,* 2007a, b and c; Roby 2011, Nair et al 2007) have also outlined many threats to this ecosystem. Ramesh and Pascal (1997) considered *Myristica* swamps as unique areas at the ecosystem level and pointed out that though species poor, most species found in and around the swamps are endemics.

The present study focuses on the distribution and quantification of *S. travancoricum* in the *Myristica* swamps of Southern Kerala, its phenology, regeneration and, threats faced at various stages of growth. We also predict forest areas that have a potential to be a habitat for *S. travancoricum* and while justifying the IUCN classification of 'Critically Endangered' call for a revision in the light of our studies.

Study Area

The study area, *Myristica* swamps of Kulathupuzha region is located in Southern Kerala between the geo co-ordinates 8.75° to 9.0° N and 76.75° to 77.25° E. It is at the confluence of three revenue districts namely Thiruvananthapuram, Kollam and Pathanamthitta. The swamps are scattered in three forest ranges namely Kulathupuzha and Anchal forest ranges, and Shendurney Wildlife Sanctuary (Fig.1). *Myristica* swamp forests are located along the first order tributaries of the west flowing rivers, Kallada and Itthikkara

(Nair *et al.,* 2007). Roby and Nair (2006) and Nair *et al.* (2007) have mapped sixty swamp patches having a cumulative area of 149.75 ha which is 0.0039% of Kerala's land area (38,864 km^2) and 0.01348% of Kerala's forested lands (11,126.46 km^2). The climatic and edaphic factors are discussed in methodology for prediction. Fieldwork in *Myristica* swamps was done from November 2004 to March 2007. Ground truthing surveys in non *Myristica* swamps forests were done from March 2007 onwards. Selected swamps in Uttara Kannada (Darbejaddy, Nilkuntha, Thorbe, Kathelekan) were visited in 2008. Observations for regeneration studies were continued till February 2011.

Materials and Methods

Morphological description of *S. travancoricum* as given by Sasidharan (2006) was accepted as no significantly different observations were made during the study. The bark, leaves and friuts are shown in Figures 2 and 3 respectively.

Data and Data Collection

1. Quantitative vegetation analysis

The quantification of data was done only in randomly selected 17 swamps of Kulathupuzha forest range and presence of *S. travancoricum* recorded from the all other swamps including Anchal and Shendureney WLS. Standard sampling methods (Mueller and Dombois, 1974) were adopted for the vegetation sampling. using sample plots of 100 x 10 m (0.1ha) divided into ten 10 x 10 m quadrats in each individual swamps was done. Trees in each quadrat were enumerated, identified and GBH (Girth at Breast Height (1.5m above ground)) of trees with above 10 cm circumference recorded. Tree seedlings (GBH below 10cm) were enumerated from the sample plots to determine the regeneration status of tree species in the *Myristica* swamps.

Density, Frequency, Abundance and IVI (Importance Value Index), were calculated using suitable software (Invent-NTFP) (Sivaram *et al*., 2006). Based on the presence absence of *S. travancoricum* a kernel density map was produced using PAST (software).

Based on the GBH, trees were grouped into different class intervals as 10-30cm = saplings, 30-60 cm= poles, 60-90cm= small tree, 90-180=medium tree and above 180=large tree. and Girth class distribution was graphically plotted.

2. Phenological, germination and regeneration studies

Various reproductive phenological stages such as flowering, fruiting, seed germination of *S. travancoricum* trees found in different *Myristica* swamps in Kulathupuzha were observed every month for two years using a binocular (10X40). The growth and survival rate of 500

seeds of *S. travncoricum*, germinated in natural habitat were studied. At the same time 510 seedlings of two leaf stage below 10 cm height were collected from the study site and transported to KFRI nursery in root trainer. They were treated with fungicide and proper organic fertilizers and irrigated as needed. Surviving seedlings were transferred to KFRI arboretum for further growth observation and seven were selected at random for measuring growth stages in field conditions.

Three plants within one metre distance from a stream and the other four at more than one metre distance from a stream Girth and height of plants were recorded for six years. Two tailed paired Student's T test was used to find significant difference using XLSTAT 2010.

3. Response to environmental factors

The effect of various environmental factors such as area under inundation, inundation depth, temperature, relative humidity, canopy cover, area covered by litter, litter depth, area with undergrowth, area covered by stilt root, area covered by knee root, GBH classes of trees10-30, 30-60, 60-90, 90-180, above 180, gravel%, sand%, silt%, clay%, soil pH and soil OC content on *S. travancoricum*, was studied by using a PCA using XLSTAT 2010.

4. Prediction of potential swamp forest areas that are a prime habitat *Syzygium travancoricum*

In our study we found *S. travancoricum* very much adapted to *Myristica* swamps in Southern Kerala with only a few occurrence of *S. travancoricum* recorded from non–swampy areas. According to Sasidharan (1997) this species, endemic to southern Western Ghats of Kerala, is associated with the *Myristica* swamp forests The *Myristica* swamps' distribution is specific to the following precise physical and climatic factors.

Elevation: The elevation of the *Myristica* swamps above sea level seems to be a critical as all the mapped *Myristica* swamps were found between 100-200 m from sea level. In Southern Western Ghats areas between 100-200 m, which are found near rivers have the ability to retain its ground water level above 6 m even in summer season and retain moisture throughout the year. Previous workers point out that this retention of moisture is crucial in the development of *Myristica* swamps and also in deciding the vegetation composition at various elevations.

SRTM (Shuttle Radar Topo Mission) data set of NASA distributed by USGS (United States Geological Survey) (*http://srtm.csi.cgiar.org*) was used as material for elevation. The SRTM 90 m DEMS have a resolution of 90 m at the equator, and are provided in mosaiced 5 degree

x 5 degree tiles, in geographic coordinate system-WGS-84 Datum (World Geodetic System-84). The vertical error of the DEMs is reported to be less than 16 m.

Hydrology: Most of the swamps are in the first order streams and in most cases the swamps are the origination point of the streamlets. To obtain data on streams, base layers from (scale 1: 1,000,000) Resource Atlas of Kerala, prepared and published by Centre for Earth Science Studies, were digitized and used.

Soil: All *Myristica* swamps mapped were found in specific soil type which indicates the influence of soils in the development of a particular plant community. According to soil maps of Kerala (scale 1: 500,000) published by National Bureau of Soil Survey and Land Use Planning (ICAR), the soil in which the mapped *Myristica* swamps were found can be classified into two categories.

1) Mapping Unit-31 Very deep well drained, gravelly loam soils on steeply sloping medium hills with thick vegetation, with moderate erosion: associated with very deep, well drained soils on moderate slopes.

2) Mapping Unit-32 Deep well drained, loamy soils on gently sloping low hills with isolated hillocks, with moderate erosion: associated with deep, well drained, loamy soils with coherent material at 100 to 150 cm on moderate slopes, severely eroded.

Monsoons: According to the rainfall map over a period of 1902-1979 published by Centre for Earth Science Studies (CESS) and the location of mapped swamps, *Myristica* swamps come under the rainfall range of 50 cm to 150 cm in South West monsoon, 60 cm to 80 cm in North East monsoon and 30 cm to 50 cm in rainfall other than monsoon.

Land use: *Myristica* swamps are located only in the forested area in the southern part of the Kerala. Some swamps of the past are now settlements or plantations. Hence, these areas lie outside the natural forest boundary as shown in Survey of India Topo sheets. Therefore, an updated forest map of Kerala prepared by Kerala Forest Research Institute (KFRI) was used for obtaining forest layers and protected area coverage of the forest.

These different parameters were combined to produce a model, which could simulate the areas that have the potential to be *Myristica* swamp. The process is depicted in the flowchart below (Fig. 5).

Results and Discussion

Importance value index of (IVI) *S. travancoricum*

We counted 153 trees in and around the sixty swamps but of the 17 *Myristica* swamps in Kulathupuzha Forest Range sampled using transect (17000 m^2) only six swamps have

S.travancoricum and only twenty trees were present in the transect. Going by the IVI values *S. travancoricum* is in sixth position when compared to other tree species in the 17 *Myristica* swamps sampled in Kulathupuzha (Table 1).

Table 1: Summary of the selected tree characteristics of *Myristica* swamps: (values interpolated to hectare).

Species	N	D	AB	RD	F	RF	RBA	IVI
Gymnacranthera farquhariana	760	447.0588	5	0.3384	0.8941	0.2013	0.3324	0.8721
Myristica fatua var. magnifica	691	406.4706	5.0809	0.3077	0.8000	0.1801	0.2505	0.7383
Lophopetalum wightianum	197	115.8824	2.3452	0.0877	0.4941	0.1113	0.1145	0.3135
Vateria indica	144	84.7059	3.3488	0.0641	0.2529	0.0570	0.0548	0.1758
Holigarna arnottiana	079	46.4706	1.6458	0.0352	0.2824	0.0636	0.0476	0.1463
Syzygium travancoricum	020	11.7647	1.2500	0.0089	0.0941	0.0212	0.0897	0.1198
Others species	355	208.8229	57.1082	0.157	1.6239	0.3647	0.1102	0.6341
Total	**2246**	**1321.176**	**75.7789**	**1.0000**	**4.4415**	**1.0000**	**1.0000**	**3.0000**

If the values for *S .travancoricum* from only those six swamps (where it is actually present) are considered (Table 2) then the importance of *S. travancoricum* in the swamps increases.

Table 2: Position of ***Syzygium travancoricum*** in selected *Myristica* swamps in Southern Kerala (values interpolated to hectare).

Site	N	D	AB	RD	F	RF	RBA	IVI
Emponge	5	50	1.25	0.0472	0.4	0.0816	0.296	0.425
Karinkurinji	2	20	1.00	0.0112	0.2	0.0392	0.256	0.306
Marappalam Major	4	40	1.33	0.0296	0.3	0.0857	0.210	0.325
Perum Padappy	5	50	1.67	0.0342	0.3	0.0469	0.272	0.353
Plavu Chal	3	30	1.00	0.0201	0.3	0.0526	0.269	0.3406
Pullu Mala	1	10	1.00	0.0109	0.1	0.0222	0.010	0.0431

In Uttara Kannada, where another sub-population of *S. travancoricum* has been reported (Chandran et al. 2010, Chandran et al. 2008) the position of *S. travancoricum* in terms of IVI is 17th. The IVI values range from 0.1065 to 0.5483 (Chandran et al. 2010). The mean IVI of 0.3044 is slightly higher than 0.2988, the mean of the IVI s recorded from the transects in six swamps of Southern Kerala (Table 2).

Girth class distribution

The girth class distribution for *S. travancoricum* is shown in the graph Fig. 6. The graph shows reduced number of individuals in the lower girth classes and the graph plotted is an almost perfect J instead of the expected inverted J. While phenological studies indicate normal fruiting and seed germination patterns for this species, regeneration enumeration shows that the problem may be in seedling recruitment. This indicates the there is a recent threat in the survival of the species. Whereas, in the Uttara Kannada sub-population of *S. travancoricum* graphical representations of girth class distribution return an almost perfect inverted J (Chandran et al. 2010) indicating a healthy regeneration pattern especially when compared with the *Myristica* swamps of Southern Kerala.

The data further indicates a steady future decline of the *S. travancoricum* population with immature trees contributing only 25% to the population in the transects. Trees in the lower girth class comprising the immature trees show a decline of upto 90% (Table 3).

Table 3: Population decline in *S. travancoricum* indicated by % of various girth classes

Girth class	No. of trees	% of total	% of mature and immature trees	% of decline of immature trees
120-180	10	50	75	mature
90-120	3	15		mature
60-90	2	10		mature
30- 60	3	15	25	85
10- 30	2	10		90
Total	20	100	100	-

Response to environmental parameters

S. travancoricum showed maximum tolerance to inundation when compared to the other three *Syzigium* species found in the swamp (Fig. 7). Soil texture especially the percent of gravel and sand seemed to elicit a positive response from the tree. *S. travancoricum* did not respond negatively to low pH of the soil (which is characteristic of the swamps) At the same

time the PCA map shows that humidity (a characteristic of the swamps) was placed quite far from *S. travancoricum* and undergrowth (not a characteristic of the swamps) is placed quite close to *S. travancoricum*. In the swamps, profuse undergrowth is rare due minimal penetration of sunlight to the forest floor. However, as *S. travancoricum* has a distinct leaf fall stage, the forest floor around this tree can support at least seasonal undergrowth. Better sunlight penetration around the tree also reduces humidity when compared to other areas in the swamp. So on one hand while *S. travancoricum* seems well adjusted to the salient environmental feature of the swamp, namely inundation, closely associated parameter humidity, and seems to deter the presence the tree. *S. travancoricum* may thus not qualify to be a true swamp species like *Myristica magnifica* but seems better adapted to the swamps than many other non swampy species.

Density and abundance of saplings inside the swamps

Of a total of 6402 saplings (GBH below 10cm) recorded from the 17000 m^2 area of *Myristica* swamps sampled *S. travancoricum* contributed 0.48% (30 individuals) and occurred in 10 plots out of 17 plots sampled.

Phenology

Leaf fall of this tree begins in January followed by flushing by mid February. Leaves begin to mature at the end of April. Flowering starts at the end of March. Flowers mature up to the month of July. Fruiting begins at end of April and extends up to September. At the end of September most of the fruits fall Germination of the seeds follow within one month. Numerous seeds germinated below the trees but almost all the seedlings dry up in the seedling stage.

Regeneration

We observed *S. travancoricum* produce thousands of seeds per tree (Fig. 4) every year. Most of these seeds germinated within one or two weeks but the seedlings do not survive after the two-leaf seedling stage. Usually the swamps are inundated at the time of fruit fall and seed germination. It was presumed that fungal attack in the intense humid nature of the swamp conditions is the problem.

Nursery trials

Of the 510 seedlings of *S. travancoricum* at 'two leaf stage' collected from *Myristica* swamp and transported in root trainer 500 survived and were planted in the nursery and treated with Bavistin fungicide to prevent fungal attack. 300 seedlings (Fig. 8) survived after one year. Field observations showed that no seedlings survived in the wild.

In field trials

The seven transplanted seedlings of *S. travancoricum* (randomly selected) showed 100 percent survival. They reached an average height of 193.14 cm in six years with the height ranging between 66-250 cm. The average diameter was 2.87 cm with values ranging between 0.9 - 4.7 cm.

The trees planted within one-metre radius from the stream showed a mean height of 331.167 m and trees planted beyond the one-metre radius showed a mean height of 186.556 m. There was a significant difference between the heights of the two sets of trees over six years of observation (p-value (Two-tailed) = 0.042; alpha = 0.05; DF; 5). The mean girth of the trees planted within one-metre radius from the stream had a mean girth of 10.050 cm and for the trees planted beyond the one-metre radius, the mean girth was 4.802 cm. There was no significant difference between the girths of the two sets of trees over six years of observation (p-value (Two-tailed) = 0.119; alpha = 0.05; DF; 5).

Distribution of *Syzygium travancoricum* in Myristica swamps in Kulathupuzha region

Out of 60 *Myristica* swamps studied, 29 swamps had *S. travancoricum.* The swamps in Shendureny WLS sanctuary had maximum number of trees. The distribution of *S. travancoricum* is depicted in the kernel density map is (Fig.9).

Identification of potential areas by using GIS

Based on GIS studies, it was predicted that *S. travncoricum* are mostly found in *Myristica* swamps, other swampy areas and river banks of Southern Kerala. The geographical distribution of surviving *Myristica* swamps were studied and mapped. Trivandrum and Punalur Forest Division show maximum potential area of *Myristica* swamps (Table 4 and Fig. 10). This area includes Anchal and Kulathupuzha Forest ranges.

Other forest areas also showed potential as a habitat for *S. travancoricum*, but in much lower degrees (less than 1%).

Ground truthing in Non *Myristica* Forests

Surveys in forest areas of Kerala from 2007 March onwards in both high altitude and low altitude areas have not led to the discovery of a sizeable sub population of *S. travancoricum* outside the *Myristica* swamps. Chalakudy Forest Division including (Athirapally, Vazhachal and Charpa Forest Ranges) has a small population of *S. travancoricum* with 20 mature trees recorded by us.

IUCN Status and Criteria

Following the various published reports of *S. travancoricum* we can estimate at the least a total of 287 trees (all are not mature) in Kerala (South of Palakad Gap) by adding up four trees from Aickad sacred grove, 20 from Guddrikal, 110 from Kalassamala grove (Sudhi, 2012) and 153 from our own observations in the *Myristica* swamps of Southern Kerala. In Uttara Kannada published reports establish the presence of 35 individual trees from the *Myristica* swamps of Siddapur taluk (14.4° N) and a single tree from Ankola (Chandran et al, 2008, 2010).

Table 4: Areas with potential for *Myristica* swamps in Kerala forests

S. No.	Forest Division	Potential area in km^2	Total forest area in km^2	% -potential area
1	Ranni	5.067	1059.07	0.478439
2	Konni	20.12	0331.66	6.066454
3	Achankovil	02.21	0269.00	0.821561
4	Punalur	40.29	0280.22	14.37799
5	Thenmala	04.27	0206.17	2.071106
6	Trivandrum	46.20	0369.88	12.49054
7	Shendurney WLS	04.23	0100.32	4.216507
8	Peppara WLS	14.82	0053.00	27.96226
9	Agasthyavanam BP	11.36	0031.12	36.50386
	Total	148.57	2700.44	5.501585

Since *S. travancoricum* has been seen closely associated with *Myristica* swamps, if we extrapolate with our data on *S. travancoricum* and *Myristica* swamps of Kerala we find that 11.76 trees/ 0.01km^2 or 1176.47 trees per km^2 is possible in terms of density. Given our prediction of about 148km^2 area with a potential for *Myristica* swamps in Kerala, we could theoretically have had 174788.15 trees for this entire area. This would be in terms of individual trees.

While our data indicates that there may be more than 250 mature individuals our data also shows that there has been a continuing decline over the generations and that pole sized individuals of the species are almost 90% less than the mature individuals.

Population reduction is clearly proved from our data and there is a continuing threat to the seedlings in the wild in the form of pathogens (IUCN criteria A1 e). Therefore, we suggest

that while *S. travancoricum* must remain in the critically endangered category till more data is unearthed the criteria should be changed to A1 e from C2a.

Conclusion

We agree with Chandran *et al.,* 2008, who express hope that more such relic patches with their valuable biota might be in existence in between Travancore and Uttara Kannada. Rigourous groundwork along with GIS and RS studies is necessary to validate the presence of more subpopulations of S. *travancoricum.* This is especially necessary because we have no record of extensive logging or habitat destruction of this tree during the inception of modern forestry in India by the British because of zero timber value.

Dasa *et al.* (2006) have considered Kulathupuzha Reserve Forests as a totally irreplaceable gird for the endangered species *Canthium pergracilis* and the Kulathupuzha-Palode forests as high conservation priority in the Western Ghats. Kulathupuzha area is one of the few regions having *Myristica* swamps. Inspite of the high biodiversity value of Western Ghats it is most threatened among the hotspots as this region has the highest population density per sq km (340km^2) and a positive growth rate (Cincotta *et al.*, 2000).

We conclude that while steps should be taken to ascertain the true population of S. *travancoricum* and all efforts in-situ and ex- situ be taken to ensure the continuity of this species, conserving the habitat in its pristine form should also be prioritized.

Conservation of *Myristica* swamps has many benefits which includes preservation of one of the smallest and most fragmented ecosystems found almost nowhere else in the world. It would also ensure protection to many endemic and red-listed populations of plants and animals.

References

[1] Bourdillon TF (1908) The Forest Trees of Travancore. The Travancore Government Press, Trivandrum. pp. 238-239.

[2] Chandran, M.D.S., D.K. Mesta, M.B. Naik. 1999. *Myristica* swamps of Uttara Kannada District. *My Forest*, 35(3): 217-222.

[3] Chandran, M.D.S and V.V. Sivan.1999. Myristicaceae. Classroom Lifescape Series, Part II. *Resonance* 72: 10-12.

[4] Chandran, M.D. S, D.K. Mesta, G.R. Rao, Sameer Ali, K.V. Gururaja and T.V. Ramachandra. 2008. Discovery of Two Critically Endangered Tree Species and Issues

Related to Relic Forests of the Western Ghats. *The Open Conservation Biology Journal*. 2, 1-8.

[5] Chandran, M.D.S., Rao, G.R., Gururaja, K.V. and Ramachandra, T.V. 2010: Ecology of the swampy relic forests of Kathalekan from Central Western Ghats, India. *Bioremediation, Biodiversity and Bioavailablity*, 4(Special issue 1), 54-68.

[6] Champion, H.G. and S.K. Seth. 1968. *A revised survey of the forest types of India*. Government of India. xxiii+404 pp.

[7] Cincotta R.P., J. Wisnewski and R. Engleman. 2000. Human population in the biodiversity hotspots. *Nature*. 404: 990-992.

[8] Dasappa, Swaminath MH (2000) A new species of *Semecarpus* (Anacardiaceae) from the *Myristica* swamps of Western Ghats of North Kanara, Karnataka, India. Indian Forester 126: 78-82.

[9] Dasa, A., J. Krishnaswamya, K.S. Bawaa, M.C. Kirana, V. Srinivas, N. Samba Kumar, K. U. Karanth. 2006. Prioritisation of conservation areas in the Western Ghats, India. *Biol. Conserv.*, 133: 16-31.

[10] Gamble JS (1935) Flora of the Presidency of Madras, Adlard and Son, Ltd., London, Vol. 1. 477, 480.

[11] Joyce J., K.K. Ramachandran and P.V. Nair. 2007a. A rare and little known lizard, *Otocryptis beddomi* from the *Myristica* swamps of Southern Kerala, India. *Herpetological Bulletin*. 101:27-31.

[12] Joyce J., K.K. Ramachandran and P.V Nair. 2007b. A preliminary overview and checklist of the spider fauna of *Myristica* swamp forests of Southern Kerala, India. *Newsl. Br. arachnol. Soc.*109: 12-14.

[13] Joyce J., K.K. Ramachandran, and P. V. Nair. 2007c. Animal diversity of the *Myristica* swamp forests of, Southern Kerala with special reference to herpetofauna. In: *The Proceedings of the 19th Kerala Science Congress*, 29th -31st January 2007. 724-726.

[14] Krishnamoorthy, K. 1960. *Myristica* swamps in the evergreen forests of Travancore. *Indian For.*, 86(5): 314-315.

[15] Mueller, D., and H.E. Dombois. 1974. *Aims and methods of vegetation ecology*. John Wiley and Sons. London. xix+547.

[16] Nair, P.V., K.K. Ramachandran, K. Swarupanandan and T. P. Thomas. 2007. *Mapping biodiversity of the Myristica swamps in Southern Kerala*. Report submitted to MoEF. 255 pp.

[17] Pascal, J.P., 1988. *Wet evergreen forests of the Western Ghats of India*. French Insititute, Pondichery. 345 pp.

[18] Ramesh, B.R. and J.P. Pascal. 1997. *Atlas of the Endemics of the Western Ghats (India). Distribution of tree species in the evergreen and semi evergreen forests*. French Institute, Pondicherry. 403 pp.

[19] Radha, R., Mohan, M.S.S.; A. Anand. 2000. Anti-fungal properties of crude leaf extracts of *Syzygium travancoricum*. *Journal of Medicinal and Aromatic Plant Sciences*. Vol. 22 No. 1B. 721-722.

[20] Ravikanth, G., R. Vasudeva, K.N. Ganeshaiah and R. Uma Shaanker. 2004. Molecular analysis of Semecarpus kathalekanensis (Anacardiaceae) - a newly described species from the Myristica swamps of Western Ghats, India. The Indian Forester 130 (1): 101-104.

[21] Roby, T.J. and P.V. Nair. 2006. *Myristica* swamps – an endangered ecosystem in the Western Ghats. In: *The Proceedings of the XVIII Kerala Science Congress*, 386–388.

[22] Roby T. J.2011. Floristic structure and diversity of *Myristica* Swamps at Kulathupuzha in a GIS perspective. (Ph.D. Thesis). FRIU, Dehradun.

[23] Rodgers, W.A. and H.S. Panwar. 1988a. *Planning wildlife protected area network in India*. Vol I. The Report. A report prepared for the Department of Environment, Forests and Wildlife, Government of India at Wildlife Institute of India. 341 pp.

[24] Rodgers, W.A. and H.S. Panwar. 1988b. *Planning wildlife protected area network in India*. Vol II. State Summaries. A report prepared for the Department of Environment, Forests and Wildlife, Government of India at Wildlife Institute of India. 267 pp.

[25] Santhakumaran, L.N., A. Singh and V.T. Thomas. 1995. Description of a sacred grove in Goa (India), with notes on the unusual aerial roots produced by its vegetation. *Wood.* Oct-Dec: 24-28.

[26] Sasidharan, N. 1997. *Studies on the flora of Shendurney Wildlife Sanctuary with emphasis on endemic species*. KFRI Research Report No 128. KFRI. Peechi. xvi+401 pp.

[27] Sasidharan, N. 2006. *Illustrated manual on tree flora of Kerala supplemented with computer aided identification*. KFRI Research Report No 282. 502 pp.

[28] Sivaram, M, N. Sasidharan, S. Ravi and P. Sujanapal. 2006. Computer aided inventory analysis for sustainable management of non-timber forest product resources. *Journal of Non Timber Forest Products*. 13(4): 237-244.

[29] Sudhi, K.S. 2012. *Kalassamala grove glows green*. Report in The Hindu dated 26-03-2012.

[30] URL: http://www.iucnredlist.org/apps/redlist/static/categories_criteria_2_3. accessed on 14/04/2011, 09/09/2012

[31] URL:http;//www.iucnredlist.org/serach-IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. accessed on 04-11-2013

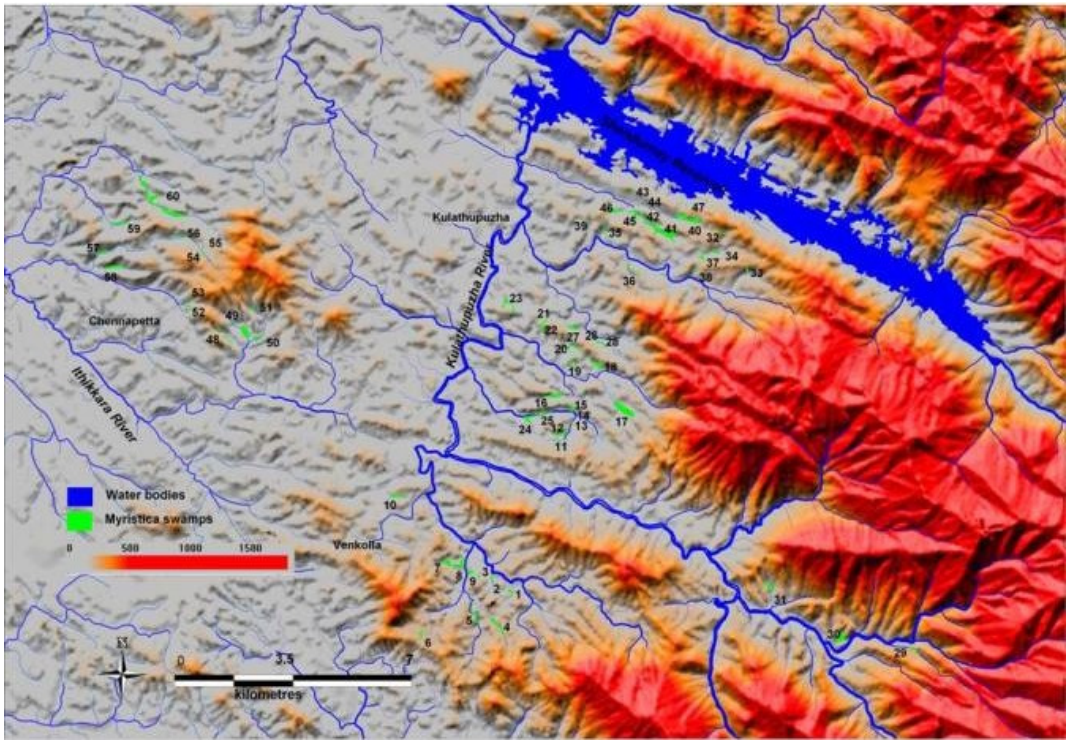
[32] URL: http://srtm.csi.cgiar.org/ accessed on 05/01/2008.

[33] Varghese, V. 1992. *Vegetation structure, floristic diversity and edaphic attributes of the fresh water swamps forests in Southern Kerala*. Dissertation submitted to College of Forestry, Kerala Agricultural University for award of B.Sc. 113+iv.

Acknowledgements

The work is part of a project was funded by the Ministry of Environment and Forests, Govt' of India. We are grateful to Dr. J. K. Sharma, Dr. R. Gnanaharan Dr K. V. Sankaran (former Directors) and Director KFRI for encouragement and support. We acknowledge Mr. Shinoj T.M. and our trackers for assistance in field and the Kerala State Forest Department for co-operation. We thank everyone at KFRI especially those at the KFRI Library and KFRI Nursery.

FIGURES



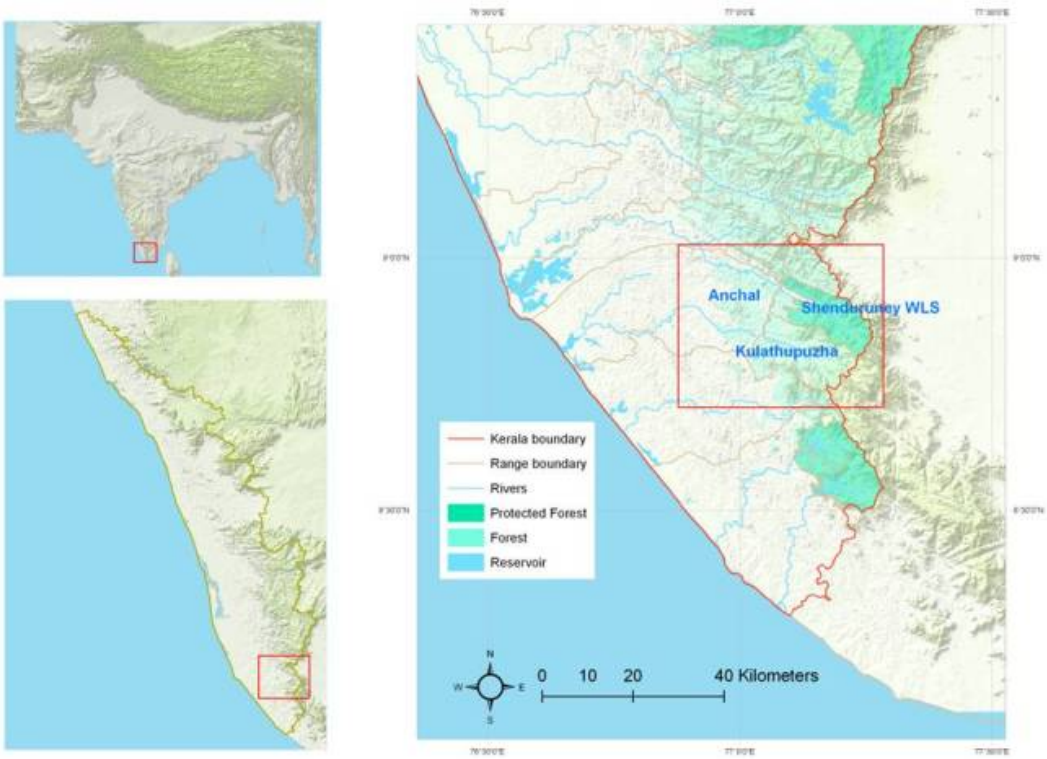


Figure 1a and b. Study Area

Fig 2: Bark Surface

Fig 3: Leaves and Fruits

Fig4: Seedlings in natural habitat

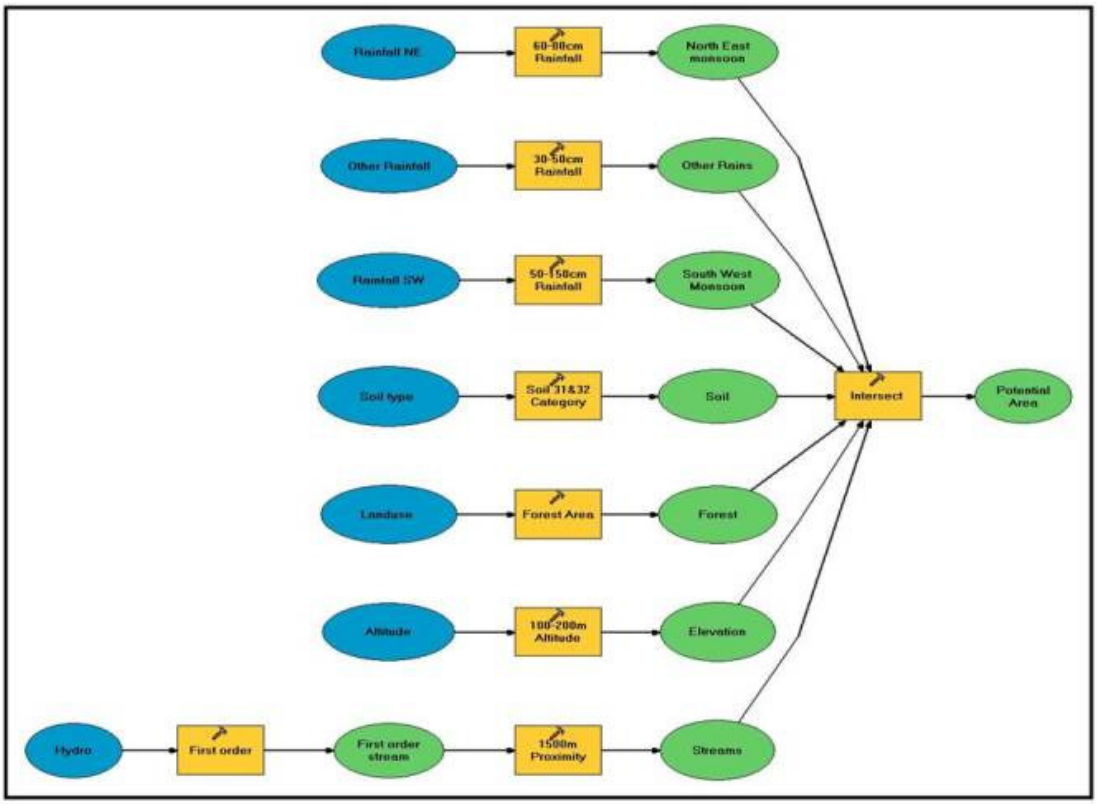


Fig 5: Various steps for the prediction of prime habitat for *Syzygium travancoricum*

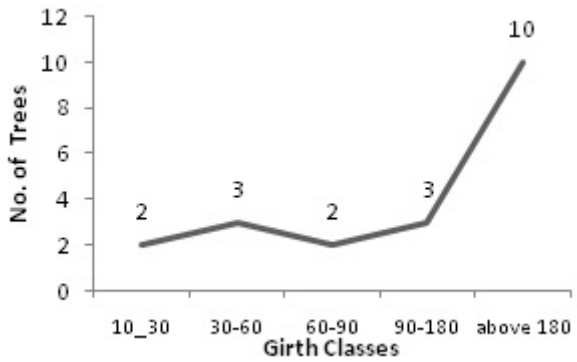


Fig 6. Girth class distribution of *Syzygium travancoricum*

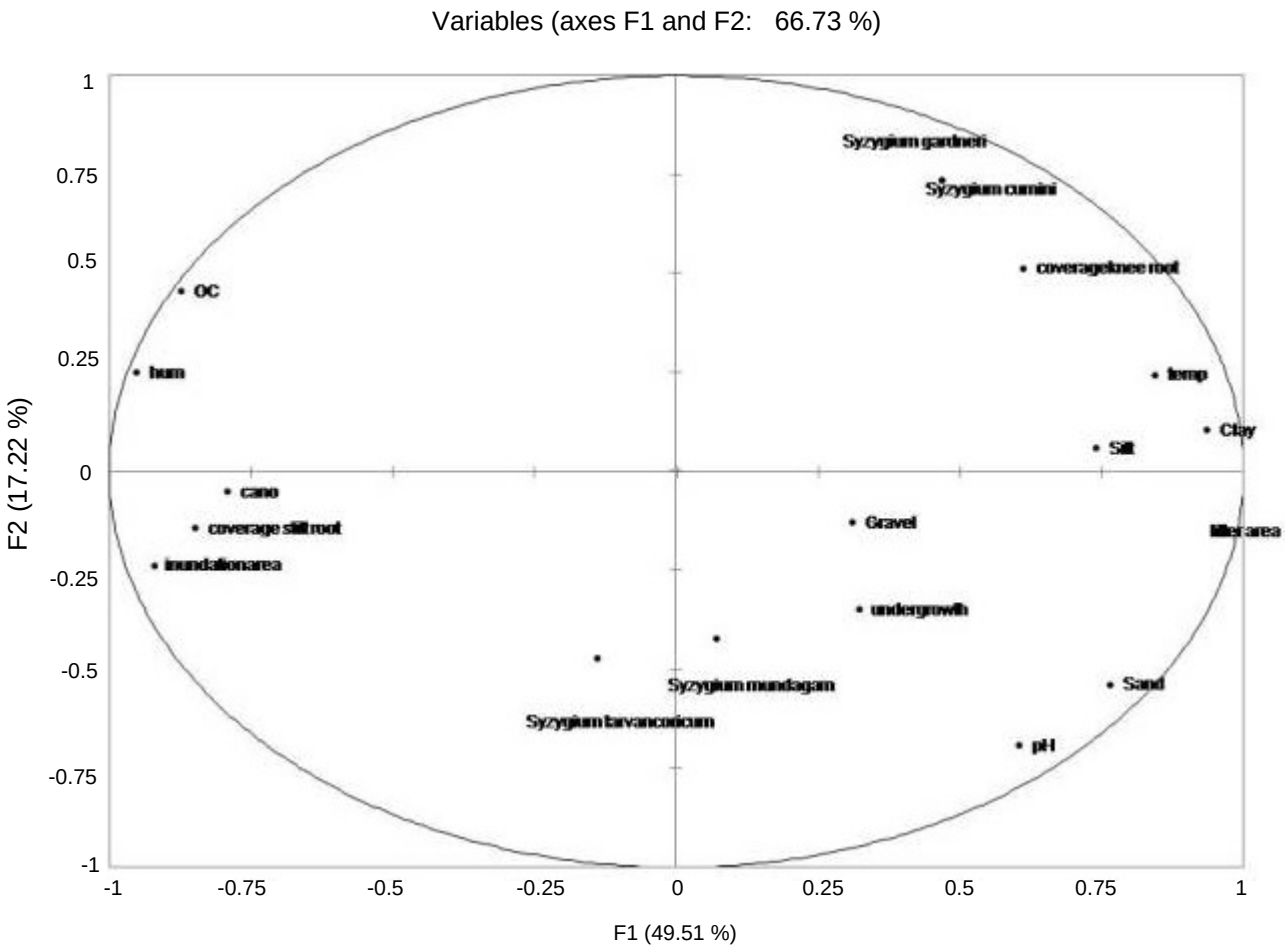


Fig 7. PCA map showing *S. travancoricum*'s response to environmental gradients in the swamp

Fig 8. *Syzygium travancoricum* in KFRI nursery

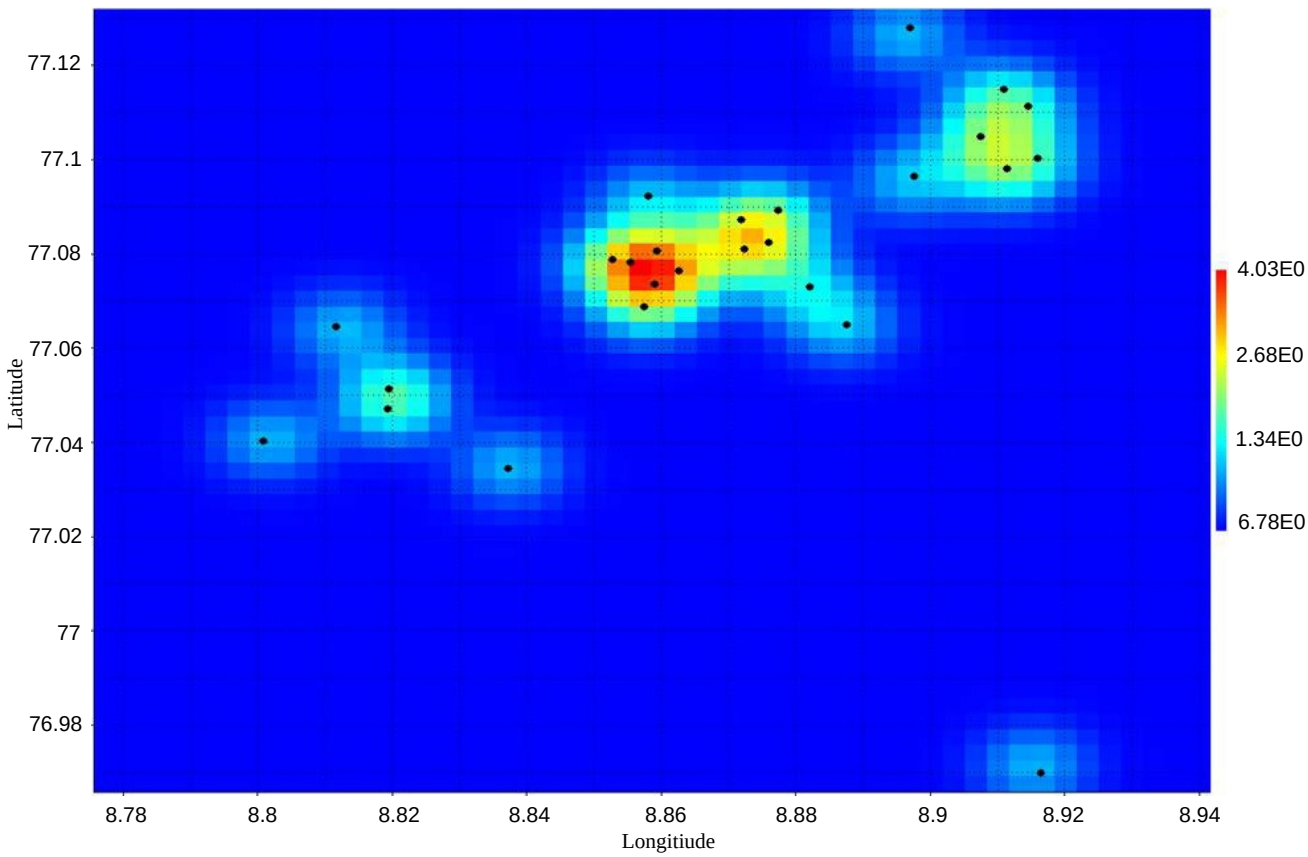


Fig 9. Kernel density map of *Syzygium travancoricum*

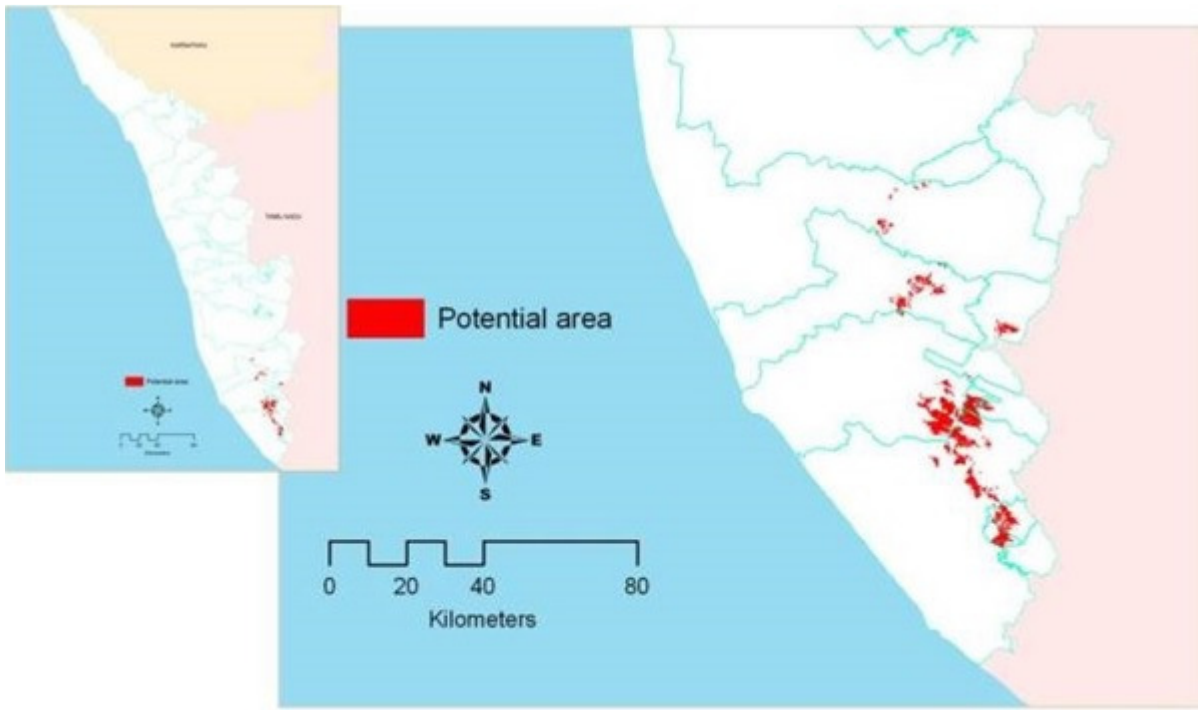


Fig 10. Area with a potential for *Myristica* swamp restoration- a prime habiat for *Syzigium travancoricum* (Kollam and Trivandrum districts are most favorable for *Myristica* swamps. As per the analysis the forest in the southern parts have more area coming under the required elevation, hydrology and rainfall and soil type for sustaining *Myristica* swamps)