NON-TIMBER FOREST PRODUCTS IN THE WESTERN GHATS OF INDIA: FLORISTIC ATTRIBUTES, EXTRACTION AND REGENERATION

P. K. Muraleedharan*, N. Sasidharan,

Kerala Forest Research Institute, Peechi, Kerala – 680 653, India

B. M. Kumar,

College of Forestry, Kerala Agricultural University, KAU P.O. Thrissur – 680 656, India

M. A. Sreenivasan & K. K. Seethalakshmi

Kerala Forest Research Institute, Peechi, Kerala – 680 653, India

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MURALEEDHARAN, P. K., SASIDHARAN, N., KUMAR, B. M., SREENIVASAN, M. A. & SEETHALAKSHMI, K. K. 2005. Non-timber forest products in the Western Ghats of India: floristic attributes, extraction and regeneration. An attempt was made to examine the occurrence, regeneration and extraction patterns of non-timber forest products (NTFPs) at three locations in the Western Ghats of Peninsular India. NTFP-yielding plants in the Western Ghats constituted about 40% of the flora. However, only less than 50% of the 229 NTFP species were commercially exploited. The rest were used by local people. Species richness was variable between sites but reflected disturbance regimes and/or the magnitude of NTFP extraction. During NTFP collection, often branches are lopped for harvesting fruits, fires are lit at the base of trees to stimulate resin flow and the bark is collected in a destructive manner. High extraction rates of some NTFPs resulted in poor density, sparse distribution of species and depletion of biodiversity. Yet herbaceous NTFP species, capable of regenerating through vegetative means, registered adequate regeneration, even when 95% of the plants were harvested. An understanding of the vital attributes of the NTFP species is, therefore, critical for sustainable NTFP management.

Key words: Biodiversity – indigenous knowledge – regeneration – species loss

MURALEEDHARAN, P. K., SASIDHARAN, N., KUMAR, B. M., SREENIVASAN, M. A. & SEETHALAKSHMI, K. K. 2005. Hasil hutan bukan kayu di Ghat Barat, India: flora, pengeluaran dan penjanaan semula. Satu kajian dijalankan untuk meneliti taburan, penjanaan semula dan pengeluaran hasil hutan bukan kayu (NTFP) di tiga tapak di Ghat Barat, Semenanjung India. Tumbuhan NTFP di Ghat Barat membentuk 40% daripada flora di sana. Namun, kurang daripada 50% daripada 229 spesies NTFP digunakan secara komersial. Yang selebihnya digunakan oleh penduduk tempatan. Kekayaan spesies berbeza di antara tapak kajian. Kekayaan spesies mencerminkan gangguan dan/atau kadar NTFP dikeluarkan. Semasa pengutipan NTFP, kerap kali dahan dicantas untuk mendapatkan buah, api dinyalakan di pangkal pokok untuk merangsang pengaliran resin dan kulit kayu dikutip dengan cara yang membinasakan.

**E-mail: pkmurali@kfri.org*

Kadar pengeluaran NTFP yang tinggi mengakibatkan bilangan pokok berkurang, pokok tumbuh jarang dan biodiversiti menurun. Spesies NTFP berherba yang berkebolehan menjana semula melalui pembiakan vegetatif merekodkan penjanaan semula yang memuaskan walaupun 95% daripadanya dituai. Pemahaman ciri-ciri utama spesies NTFP penting dalam pengurusan NTFP secara mapan.

Introduction

Exploitation of non-timber forest products (NTFPs) has been a primary mode of subsistence in many ethnic groups and cultures of indigenous people around the globe. With the advent of newer uses and products, however, NTFPs began to play a proactive role in commercial income generation and employment (Runk 1998). As NTFPs become commercially valuable, their levels of extraction are driven by market forces (Neumann & Hirsch 2000), leading to over-exploitation of such resources in the wild. Coincidentally, forest degradation continues unabated in most parts of the tropics. As a result, many NTFP-yielding plants have moved closer to extinction.

In the Western Ghats, one of the 18 biodiversity hot spots of the world (Myers 1988), forest dwelling tribal people have continuously harvested NTFPs, presumably at low-impact levels. Increased demand, however, has transformed the traditional low-impact patterns and techniques of resource extraction into more intensive forms. Extraction pattern of certain NTFPs such as honey, soap nut (*Sapindus emarginatus*) and Indian gooseberry (*Phyllanthus* spp.) have, thus, changed from the subsistence mode to large-scale commercial removals in the recent past (Muraleedharan *et al.* 1997).

While commercial exploitation prognosticates changes in species composition, density, abundance, regeneration capacity and/or loss of biodiversity, the diminishing stocks of NTFPs that follow it are likely to affect the livelihood of the indigenous people. Although sustainability related concerns and issues are assuming an increasingly prominent place in policy discussions throughout the world today, NTFP harvesting practices in the Western Ghats have seldom considered this (Kumar *et al.* 2001). Given that a significant portion (> 50%) of the revenue of forest departments comes from NTFPs and 75–80% of the forest export income comes from NTFP exports (Tewari 1998), it is crucial to evolve sustainable management regimes for these products.

Although the forests are subjected to a variety of disturbances during extraction of NTFP, a comprehensive account on disturbance related changes in NTFP availability, which will help in biodiversity conservation, is lacking. Therefore, an attempt was made to elucidate the floristic richness and diversity of NTFP bearing forests subjected to differing disturbance regimes in the Western Ghats and to evaluate the impact of various harvest intensities on the regeneration potential of selected NTFPs, so as to provide insights into sustainable management of these resources. The following specific questions were addressed: (1) What is the spectrum of NTFP resources along a broad range of disturbance intensities? (2) What is the impact of differing harvest intensities on resource availability? (3) What constitutes a desirable level of harvesting for some of the major herbaceous NTFPs in the Western Ghats, where the below ground parts are often completely removed? Of particular importance are the processes by which forest people collect NTFPs. NTFP extraction pattern by tribes and how it affects the NTFP management were ascertained.

Materials and methods

Sites

The study was carried out in three moist forest areas, namely Wayanad (Wa), Nilambur (Ni) and Attappady (At) in the Kerala part of the Western Ghats (Figure 1). These sites revealed an increasing magnitude of anthropogenic disturbances, with Wa having low, Ni moderate and At high disturbance intensities. All sites were located within a radial distance of about 70 km and showed a high degree of NTFP diversity.

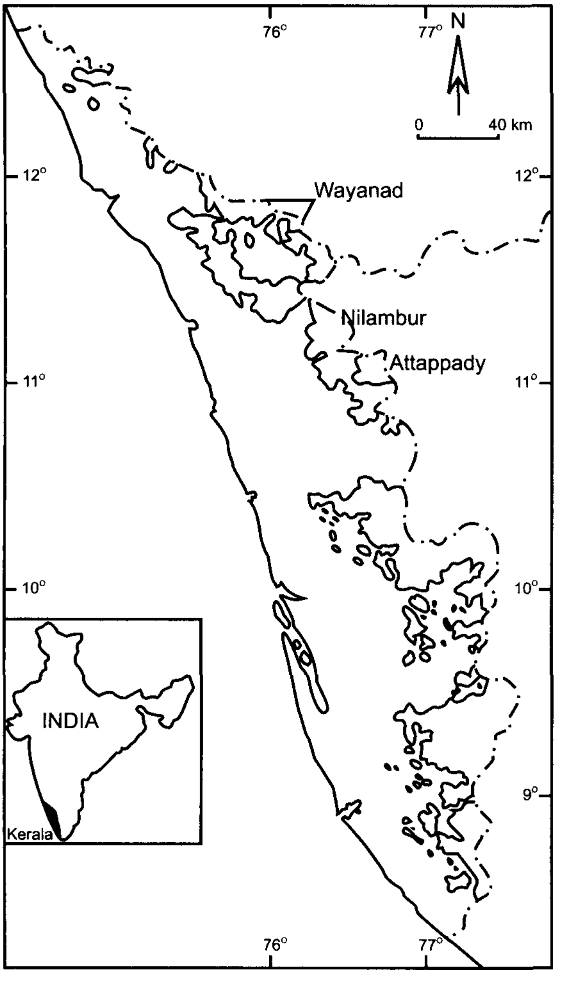

Figure 1 Location of the study areas in the Western Ghats of Kerala, India

NTFP spectrum

The moist forests of the three study areas were surveyed during the pre- and post-monsoon seasons to prepare an inventory of the NTFPs. Three transects (1 km × 10 m) were laid out, after a reconnaissance survey. The transects were positioned considering the terrain and vegetation type to cover a range of species associations and degradation levels. All potential NTFP producing plants (herbs, shrubs, climbers and trees) excluding seedlings at cotyledon stage and shorter herbs encountered along the transects were sampled to document the NTFP resources. The study was carried out with the assistance of tribal people engaged in NTFP collection. A total of 15 to 20 gatherers, randomly selected from the tribal hamlets at each site, constituted the survey team. All NTFP specimens along the transect were collected and identified after comparing with the collections at the Kerala Forest Research Institute.

Phytosociological analysis

For a detailed vegetation analysis of the NTFP bearing forests, 35 quadrats were laid out. This was done by marking 2 × 2 m grids on vegetation maps of scale 1:125 000 (representing 6.3 km^2 area). Sampling intensity was decided considering the species–area curves prepared using the enumeration data. There were 15 quadrats of 20 × 20 m at Wa site, 10 of 15 × 15 m at Ni site and 10 of 10 × 10 m at At site, laid out in the centre of the grids. Herbaceous NTFP yielding plants were regularly uprooted during the pre- and post-monsoon seasons of 1996 and 1997. The diameter of trees and shrubs was measured at 1.4 m above the ground, and for herbs, 2 cm above the ground.

Vegetation data of NTFP population were quantitatively analysed for abundance, density, frequency and abundance-to-frequency ratio (A/F ratio; Curtis & McIntosh 1951). Simpson's dominance index (Simpson 1949) and importance value index (IVI; as the sum of relative frequency, relative density and relative dominance; Phillips 1980) were computed. The abundance-to-frequency ratio was used to interpret the distribution pattern of the species (Curtis & Cottam 1956). Species diversity of each study site was calculated using Shannon's diversity index (Magurran 1988)

$$H' = \Sigma\, pi \ln pi$$

where

$$Pi = \frac{ni}{N}$$

For comparing the diversity of the different study sites, *t*-test (Hutchenson 1970) was employed. Similarity of any two given study sites in terms of number of NTFP plant species was quantitatively estimated using Sorenson's similarity index (Sorenson 1948):

$$CN = \frac{2Nj}{(Na + Nb)}$$

where

CN = Sorenson's quantitative index
Nj = Number of species common to both sites
Na = Number of species found in site 1
Nb = Number of species found in site 2

NTFP regeneration as affected by harvest intensity

The regeneration of nine commercially important annual and biennial NTFP species as influenced by differing harvest intensities were examined. The nine focal species were: At site (3): *Asparagus racemosus* (Liliaceae), *Hemidesmus indicus* (Asclepiadaceae), *Sida rhombifolia* (Malvaceae); Wa site (5): *Cyclea peltata* (Menispermaceae), *Pseudarthria viscida* (Fabaceae), *Strobilanthes ciliatus* (Acanthaceae), *Desmodium velutinum* (Fabaceae), *Curcuma aromatica* (Zingiberaceae) and Ni site (1): *Rauvolfia serpentina* (Apocynaceae).

Treatments included five harvest intensities, i.e. removing 25, 50, 75, 85 and 95% of the individuals present, as is customarily done by tribal collectors. For each harvest intensity, three replicate plots (total 15 plots) were randomly laid out within a study area during the monsoon season (June till September 1996). All plants of the focal species in these 10 × 10 m plots were enumerated and each species harvested to the percentage intensity specified by carefully pulling out. Harvesting was done before the monsoon season (April till May 1997). The number of plants of a given species regenerated was enumerated after the peak monsoon season (August till September 1997). Species-wise regeneration index was calculated as follows:

$$\text{Regeneration index (\%)} = \frac{\text{Number of plants regenerated}}{\text{Number of plants harvested}} \times 100$$

The relationship between regeneration rate and harvest intensity of the nine species was worked out with a linear regression model. The highest harvest intensity corresponding to the maximum value of regeneration index was considered as the desirable harvest rate.

Pattern of NTFP extraction by local collectors

To ascertain the pattern of NTFP extraction, an experiment was designed in which 10 plots (10 × 10 m) were established randomly at Wa site and five each at At and Ni sites. NTFPs present in each plot were enumerated. A group of carefully selected local gatherers (15 to 20 tribal people), experienced in identifying and collecting NTFPs, were deployed to collect the exploitable NTFPs from the selected plots 'as they normally do it'. The extraction methods were closely monitored through participant observation method. The number and quantity of each species harvested were then estimated to arrive at actual harvesting levels.

Results and discussion

Floristic spectrum of NTFPs

A total of 229 NTFP species, representing 73 plant families, were recorded (Table 1). Of the total 194 genera, 173 were represented by single species and 38 species were common to all sites. Forty-one plant families were represented with more than one genus. The most species-rich families were Fabaceae (27 species), Asteraceae (12), Rubiaceae (12), Euphorbiaceae (9) and Verbenaceae (9). There were 68 trees, 35 shrubs, 85 herbs, 35 climbers and 6 epiphytes (including two parasites) and 3 bamboos. The total number of species presently reported was comparable to what Godbole (1996) had reported for the northern parts of Western Ghats (219). Some of these species were traded through the co-operative societies (e.g. 32 at Wa, 27 at Ni and 38 at At), and the rest either through private traders or consumed locally (Muraleedharan *et al.* 1997).

The moist forests of Wa site (151 species) were most NTFP species-rich, followed by At (111 species) and Ni sites (91 species). The Shannon's diversity index for NTFP species also followed a similar trend, ranging from 3.4 to 3.9 ($p < 0.01$). Conversely, Simpson's dominance index and the number of species exploited were highest for Ni site, signifying the predominance of fewer NTFP species at this site.

It is hypothesized that the NTFP spectrum reflects the general floristic richness of a locality, which in turn, is dependent on the magnitude of disturbance that a site experiences. Although strong associations between the local environment and plant community composition have been reported (Pregitzer *et al.* 1983) in areas

Table 1 Density, species diversity and dominance of NTFP species

Parameter	Location			
	Wayanad	Nilambur	Attappady	All sites
Number of species present	151	91	111	229
Number of families	61	48	44	
Number of families with > 1 genus	32	17	26	
Number of genera	133	86	103	194
Number of species exploited	37	43	40	
Density of the tree species (individuals ha^{-1})	10	11	10	
Density of the non-tree species (individuals ha^{-1})	240	343	242	
Shannon diversity index (H')	3.914	3.434	3.883	
Simpson's index (cd)	0.033	0.052	0.035	

subjected to considerable anthropogenic influence, these relationships are probably obscured. That is, disturbance may sometimes override the site influences, especially where differences in these factors are relatively small, resulting in weaker association between the vegetation and site conditions (Foster 1988). Presumably, locations such as Ni, from where a higher number of species was extracted (Table 1) may suffer far greater disturbances than other sites, particularly Wa. Thus, floristic richness of a forest may be strongly impacted by the magnitude of NTFP extraction.

Concomitantly, differences in the number of species extracted also mirror the level of protection from human disturbances a site enjoys. For instance, the Wa site, which falls within the Wayanad Wildlife Sanctuary, is characterized by a higher level of protection contrived by the forest department than the two other sites. Implicit in this is the probability of increased local extinction of some potential NTFP yielding plants at Ni and At sites, which, however, did not occur *pro rata* at the Wa site. It was found that distant stands (less disturbed) showed far greater species richness and density than proximal stands (more disturbed) (Uma Shankar *et al.* 1998). The present study, therefore, suggests that NTFP extraction, as other forms of human-induced disturbances, is related to decline in species richness and the greater the magnitude of such disturbances, the greater is the potential for species loss. This study was devoted primarily to NTFP diversity as measured by species richness and H' along a disturbance gradient. Local environmental and edaphic factors also determine in part, the composition of the plant community.

Means for Sorenson's similarity indexes (calculated based on species number) were found to be reasonable: Wa–At sites (0.41), Ni–At sites (0.40) and Wa–Ni sites (0.31). This meant that 31–41% of the current suite of species at any of these sites were common. Being moist forest types experiencing largely similar climatic regimes, this was expected. Notably, At site contained the most (111) unique species, and only 11 non-native (exotic) species were found among all sampled locations. The Hutchenson's *t*-test for similarity in species diversity between pairs of study sites was significant ($p < 0.01$) and followed the order: Wa–Ni (19.92) > Ni–At (14.91) > Wa–At (1.26). It corroborated the trend outlined by the Sorenson's index.

Structural attributes and importance value index

Table 2 shows pronounced geographical variations in species composition along the transects. Stand basal area and density of NTFP species among the sites were significantly different and followed the general sequence: At > Ni > Wa sites. The total basal area at Wa site was 3.59 $m^2 ha^{-1}$, of which 2.89 $m^2 ha^{-1}$ were contributed by overstorey trees and the rest by understorey plants. *Sterculia villosa, Strobilanthes ciliatus, Phyllanthus emblica* and *Sida rhombifolia* exhibited the top four IVI. At the Ni site, the basal area of NTFP species was 12.38 $m^2 ha^{-1}$, of which 9.98 $m^2 ha^{-1}$ were accounted by trees. *Vateria indica, Stereospermum colais* and *Curculigo orchioides* were the dominant species. Total basal areas of all NTFP species and trees at the At site, however, were 29 $m^2 ha^{-1}$ and 25 $m^2 ha^{-1}$ respectively, which seem rather inflated. A few relatively large *Terminalia bellirica* trees at this site probably explains the high stand basal area (Table 2). *Sida rhombifolia* and *C. orchioides* formed other dominant species.

Table 2 Density, basal area, percentage frequency, A/F ratio and importance value index of commercially important NTFP species

Species	Family	Density (ha^{-1})	Basal area (cm^2 ha^{-1})	% Freq.	A/F ratio	IVI
WAYANAD						
Trees						
Sterculia villosa	Sterculiaceac	3	11465	13	0.12	34
Phyllanthus emblica	Euphorbiaceac	29	3399	63	0.02	18
Vateria indica	Dipterocarpaceae	2	4602	10	0.13	14
Terminalia belliria	Combretaceace	2	3538	7	0.13	11
Others		21	5799			
Total		57	28804			
Shrubs						
Strobilanthes ciliatus	Acanthaceae	527	1802	33	1.13	26
Helicteres isora	Sterculiaceae	88	1352	53	0.12	13
Others		69	1032			
Total		684	4186			
Herbs, climbers & bamboos						
Sida rhombifolia	Malvaceae	332	99	53	0.13	18
Curculigo orchioides	Hypoxidaceae	362	88	43	0.77	17
Desmodium velutinum	Fabaceae	134	76	50	0.33	13
Biophytum sensitivum	Oxalidaceae	250	186	37	0.75	13
Elephantopus scaber	Asteraceae	225	83	33	0.81	12
Pseudarthria viscida	Fabaceae	193	61	33	0.70	10
Rhynchosia rufescence	Fabaceae	225	76	40	0.13	12
Others		621	2096			
Total		2342	2774			
NILAMBUR						
Trees						
Stereospermum colais	Bignoniaceae	13	26325	20	0.05	23
Strychnos nux-vomica	Loganiaceae	13	20531	30	0.03	19
Vateria indica	Dipterocarpaceae	22	29225	40	0.03	26
Others		155	23750			
Total		204	99831			
Shrubs						
Helecteres isora	Sterculiaceae	182	4289	80	0.06	10
Others		129	397			
Total		311	4686			
Herbs, climbers & bamboos						
Baliospermum montanum	Euphorbiaceae	897	1597	80	0.32	14
Biophytum sensitivum	Oxalidaceae	1128	69	100	0.25	16
Curculigo orchioides	Hypoxidaceae	1856	450	100	0.42	22
Cylea peltata	Menispermaceae	519	25	100	0.12	11
Pseudarthria viscida	Fabaceae	635	214	80	0.23	10
Sida rhombifolia	Malvaceae	1354	380	100	0.36	20
Hemidesmus indicus	Asclepiadaceae	959	49	80	0.34	13
Piper longum	Piperaceae	1789	826	80	0.63	21
Bambusa bambos	Poaceae	317	11683	40	0.45	15
Others		2109	4006			
Total		10851	19299			

(continued)

(Table 2 - continued)

Species	Family	Density (ha^{-1})	Basal area (cm^2 ha^{-1})	% Freq.	A/F ratio	IVI
ATTAPPADY						
Trees						
Tamarindus indica	Combretaceae	20	42033	20	0.05	16
Terminalia bellirica	Combretaceae	20	135847	20	0.05	48
Vateria indica	Dipterocarpaceae	20	27414	20	0.05	11
Others		250	39653			
Total		310	244947			
Shrubs[a]		1110	8530			
Herbs, climbers & bamboos						
Curculigo orchioides	Hypoxidaceae	1810	445	60	0.05	18
Desmodium velutinum	Fabaceae	1300	492	80	0.20	16
Pseudarthria viscida	Fabaceae	780	256	60	0.22	10
Sida rhombifolia	Malvaceae	3000	801	100	0.30	30
Asparagus racemosa	Liliaceae	1040	74	80	0.16	14
Cyclea peltata	Menispermaceae	660	20	80	0.10	11
Hemidesmus indicus	Asclepiadaceae	870	30	80	0.14	12
Bambusa bambos	Poaceae	610	21078	30	0.68	14
Others		2580	15876			
Total		12650	39072			

A/F ratio = abundance-to-frequency ratio, IVI = importance value index
[a]None of the shrub species at At had IVI more than 10.

An increase in the basal area of the overstorey trees also did not seem to affect the basal area of the understorey community (understorey basal area for Wa, Ni and At being 0.7, 2.39 and 4.76 m^2 ha^{-1} respectively).

Regarding spatial distribution patterns of NTFP species, contiguous distribution for 79, 68 and 97% of the species was seen at Wa, Ni and At sites respectively (Table 3). Of the remaining species at the Ni site, about 7% showed regular distribution and about 25% showed random distribution, while none of the species showed regular distribution pattern at Wa and At sites. The shift in spatial pattern from contiguous to regular and to random may imply changes in species mortality and/ or regeneration strategies. Highest proportion of continuously distributed species at At site signifies that environmental and edaphic changes following human-induced disturbance may favour contiguous/regular distribution of more individuals. Differences in species diversity, species composition and species distribution pattern can, thus, be explained by variations in the environment, vegetation type and the level of management.

Table 3 Distribution pattern of NTFP species at the three experimental sites

Distribution pattern	Location		
	Wayanad	Nilambur	Attappady
Regular	0	6	0
Random	32	23	3
Contiguous	119	62	108

Based on A/F ratio the distribution pattern of species was interpreted, i.e. regular distribution if the ratio is below 0.025, random distribution if it is between 0.025 and 0.05 and contiguous distribution if more than 0.05 (Curtis & Cottom 1956).

Regeneration pattern

In general, a negative linear relationship existed between regeneration rate and harvest intensity (Figure 2). Threshold-level of harvesting that did not adversely affect regeneration was, however, species-dependent. For instance, regeneration was 100% for species such as *Asparagus racemosus, Curcuma aromatica* and *Hemidesmus indicus* even though 95% of the individuals in the plots were extracted (high regeneration). However, 100% regeneration was observed for *Desmodium velutinum, S. rhombifolia, Cyclea peltata* and *Pseudarthria viscida* only if the removal rate was below 75% (medium regeneration). *Rauvolfia serpentina* and *S. ciliatus* showed lower regeneration, even if the harvest rate was as low as 30 to 50%.

This variation in regeneration rates can be explained based on the vital attributes of the species involved. In general, method of persistence (dispersed seed, vegetative propagation, seeds stored in the soil), conditions for establishment (tolerance to shade, resistance to disturbance) and life history characteristics (age of production of propagules, age of maturity, senescence) are key determinants of regeneration. Abundant seed production together with vegetative means of regeneration can secure high regeneration. However, those species, which depend on seed propagation alone, may show poor regeneration potential, especially if their seed production potential is low. Of the 42 commercially important NTFP species at our study sites, 23 regenerate through seeds, 17 both by vegetative means and seeds and two only vegetatively.

Extraction pattern of the NTFP species constitutes the second major determinant of regeneration. Perhaps during the harvest process, complete removal of the long and tuberous roots of *A. racemosus, H. indicus* and *Plumbago zeylanica* are improbable and such species are, therefore, capable of regenerating from the left out roots/ rhizomes. In addition, while collecting roots of *S. rhombifolia, P. viscida, Rhynchosia rufescens* and *D. velutinum,* typically the robust plants are collected, leaving the smaller and less vigorous ones to act as parent populations, despite being genetically inferior.

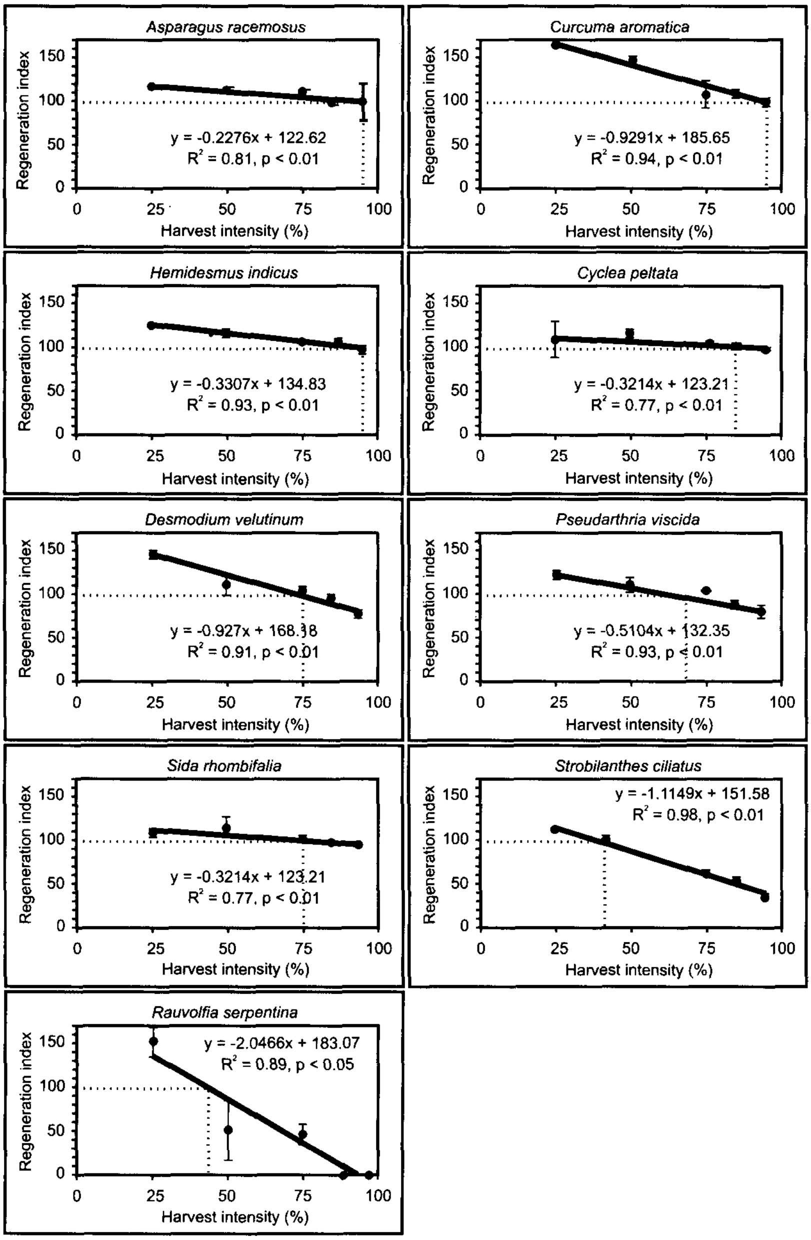

Figure 2 Relationships between regeneration rate and harvest intensity of selected NTFP species in the Western Ghats of Kerala, India

General pattern of NTFP extraction by tribal people

Our examination of NTFP harvesting in the Western Ghats suggests that the prime consideration of the gatherers is to maximise returns in the shortest time possible, regardless of whether sustainable or not. Percentages of actual and desirable levels of harvest (based on regeneration index) for nine selected commercially important species in the study areas are shown in Table 4. A comparison of this data showed that actual harvesting was significantly higher than the desirable levels, except for the difficult to harvest ones. As a result, the traditional, non-destructive methods of extraction of NTFPs gave way to methods that are less time consuming and labour intensive.

Most notably, the way in which the people extract NTFPs is dependent on their density and frequency of occurrence at a particular site. Although 229 NTFP species occurred at the sites, only 42 NTFP species were being commercially exploited (pers. comm., Tribal Service Co-operative Societies of Attappady, Nilambur and Wayanad and Kerala State Scheduled Tribe Development Co-operative Federation, Ltd.). For instance, *Adhatoda zeylanica, Aegle marmelos, Eclipta alba, Holostemma adakodien* and *Malaxis rheedii,* although present at the study sites (sparsely distributed), were not commercially extracted. This is presumably because the opportunity cost for common species is less than those of uncommon species.

Tribal people also selectively harvest fruits from trees that produce bumper yields, thereby ensuring relatively high economic returns per unit effort. Furthermore, in pursuit of such an exploitive strategy, often branches of *P. emblica, Myristica dactyloides, Mangifera indica* and *Hydnocarpus pentandra* are lopped. For extracting resins, cuts are made in the bark and the hardened resin is collected later; occasionally fire is also lit at the base of the trees to stimulate resin flow. However, a more destructive way of collecting fruit is observed in the case of *Acacia sinuata,* whereby the base of the woody climber is cut off to avoid the effort of climbing (Muraleedharan *et al.* 1997). A few days later the fallen fruits are gathered from the ground.

Table 4 Percentages of proposed and actual harvesting of NTFPs

Species	Desirable harvesting level	Actual harvesting level	Reason for excessive harvesting
Curcuma aromatica	95	100	Ease of collection
Asparagus racemosa	95	100	Ease of collection
Hemidesmus indicus	95	59	Difficult to collect & low price
Cyclea peltata	85	75	Difficult to collect & low price
Desmodium velutinum	75	99	Ease of collection
Pseudarthria viscida	75	93	Ease of collection & high price
Sida rhombifolia	75	93	Ease of collection & high price
Strobilanthus ciliatus	50	90	Ease of collection & high price
Rauvolfia serpentina	25	80	High price

Desirable level of harvesting is based on regeneration index (Figure 2) and actual harvesting is observed from the collection by the selected tribes.

Collection of bark, though not legal, is attempted, if there is demand for it. Bark is mostly collected in a destructive manner by removing as much quantity as possible. In the case of *Persea macrantha* where it is difficult to remove the bark completely from the wood, it is often cut into small pieces and collected. For trees with easily peeling bark e.g. *Cassia fistula, Stereospermum colais* and *Butea monosperma,* however, the potential for damage is even greater. Conversely, species with brittle and easily non-separable bark such as *Persea macrantha, Knema attenuata, Alstonia scholaris* and *Holarrhena antidysenterica* are found to withstand removal of a fair amount of bark, if not girdled. Empirical observations on the percentage of bark removed by the gatherers indicate that the removal of 15 to 20% of the bark in linear strips may not be lethal for many trees.

Although indigenous knowledge on NTFP extraction is often extolled as eco-friendly, our observations in the Western Ghats suggest that contemporary practices of the local people are exploitive and may harm the NTFP resources. Consequent to destructive extraction techniques outlined above and/or over-exploitation, many NTFP species have been depleted. For example *Rauvolfia serpentina, Coscinium fenestratum* and *Saraca asoca* have become severely depleted in the Western Ghats. There are many instances from elsewhere too where intensive harvesting techniques have affected the extracted species and ultimately led to their depletion (Clay 1997, Runk 1998). Thus, contrary to the general perception, many of the practices outlined above are unsustainable.

Implications for sustainable extraction and conservation of NTFPs in the Western Ghats

For a wide spectrum of NTFP yielding species encountered at the study sites, harmful harvesting methods have been a major threat. For sustainable resource use, the replenishment (regeneration) rate of the resources, however, should be considered (Peters 1996). The present study demonstrated that in the case of plants propagated vegetatively, regeneration index had been between 100 and 30 at 95% harvest rate (e.g. *A. racemosus, C. aromatica* and *H. indicus*).

Unsustainable extraction has long-standing adverse effects on the population structure, which will be detected only in the long run (Uma Shankar *et al.* 1998). In addition, at the individual tree level, harvesting of NTFPs such as fruits may also lead to changes in flowering and fruiting patterns and lowered yields. Resolution of such ecological hassles, however, may be possible by providing encouragement to the gatherers for conservation and better management of NTFP resources. Likewise, the economic uplift of the tribal people and providing institutional and public policy support are important. Value addition of the NTFPs through improved post-harvest processing may guarantee higher profits to the collectors. Management interventions proposed include adopting collection techniques that minimise the ecological impacts through participatory resource monitoring involving tribal people, non-governmental agencies and forest personnel, besides domestication of the more promising NTFPs in integrated land-use systems such as agroforestry.

Conclusions

Obvious linkages seemed to subsist between species richness and disturbance regimes. However, these interactions could have been probabilistic due to a lack of straight species–habitat relationships associated with disturbances. High rates of extraction (60 to 100%) of NTFPs driven by market forces resulted in poor density and sparse distribution of NTFP species. Density, frequency of distribution of given species and fruit crop size are also limiting factors for NTFP collection. A strongly negative relationship between regeneration and harvest intensity and harvesting choices and techniques have affected several target species and ultimately led to their depletion.

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References

CLAY, J. W. 1997. The impact of palm heart harvesting in the Amazon estuary. Pp. 283–314 in Freese, C. H. (Ed.) *Harvesting Wild Species: Implication for Biodiversity Conservation.* Johns Hopkins University Press, Baltimore.

CURTIS, J. T. & COTTAM, C. 1956. The use of distance measures in phytosociological sampling. *Ecology* 37: 451–460.

CURTIS, J. T. & MCINTOSH, R. P. 1951. The upland forest continuum in the prairie forest border region of Wisconsin. *Ecology* 32: 476–496.

FOSTER, D. R. 1988. Disturbance history, community organization and vegetation dynamics of the old-growth Pisgah Forest, south-western New Hampshire, USA. *Journal of Ecology* 76: 105–134.

GODBOLE, A. 1996. A note on survival of some NTFP plants from north-western Ghats. Pp. 554–559 in Shiva, M. P. & Mathur, R. B. (Eds) *Management of Minor Forest Produce for Sustainability.* Oxford & IBH Publishing, New Delhi.

HUTCHENSON, K. 1970. A textbook for comparing diversities based on the Shannon formula. *Journal of Theoretical Biology* 29: 151–154.

KUMAR, B. M., MURALEEDHARAN, P. K. & MAHAJAN, M. 2001. Linkages between ecology and economics: an analysis of the non-wood forest production scenario in India. Pp. 251–260 in *Proceedings of the International Symposium Tropical Forestry Research: Challenges in the New Millennium.* 2–4 August 2000. Kerala Forest Research Institute, Peechi.

MAGURRAN, A. E. 1988. *Ecological Diversity and its Measurement.* Croom Helm, London.

MURALEEDHARAN, P. K., SASIDHARAN, N. & SEETHALAKSHMI, K. K. 1997. *Biodiversity in Tropical Moist Forests: a Study of Sustainable Use of Non-Wood Forest Products in the Western Ghats, Kerala.* KFRI Research Report No. 133. Kerala Forest Research Institute, Peechi.

MYERS, N. 1988. Threatened biotas: 'hot spots' in tropical forests. *The Environmentalist* 8: 187–208.

NEUMANN, R. P. & HIRSCH, E. 2000. Commercialisation of non-timber forest products: review and analysis of research. Centre for International Forestry Research, Bogor.

PETERS, C. M. 1996. Observations on the sustainable exploitation of non-timber tropical forest products. Pp. 19–40 in Ruiz Perez, M. & Arnold, J. E. M. (Eds.) *Current Issues in Non-Timber Forest Products Research.* CIFOR, Bogor.

PHILLIPS, D. J. H. 1980. *Quantitative Aquatic Biological Indicators.* Applied Science Publisher, Essex.

PREGITZER, K. S., BARNES, B. V. & LEEME, G. D. 1983. Relationship of topography to soils and vegetation in an upper Michigan ecosystem. *Soil Science Society of America Journal* 47: 117–123.

RUNK, J. V. 1998. Productivity and sustainability of a vegetable ivory palm (*Phytelphas aequatorialis*, Arecaceae) under three management regimes in north-western Ecuador. *Economic Botany* 52: 168–182.

SIMPSON, E. H. 1949. Measurement of diversity. *Nature* 163: 688.

SORENSON, T. 1948. A method of establishing groups of equal amplitude on similarity of species content. *Biologiske Skrifter K. Danske Videnskbernes Selskab* 5(4): 1–34.

TEWARI, D. D. 1998. *Economics and Management of Non-timber Forest Products: a Case Study of Gujarat, India.* Oxford and IBH Publishing, New Delhi.

UMA SHANKAR, MURALI, K. S., UMA SHAANKER, R., GANESHAIAH, K. N. & BAWA, K. S. 1998. Extraction of non-timber forest products in the forests of Biligiri Rangan Hills, India. 4. Impact on floristic diversity and population structure in a thorn scrub forest. *Economic Botany* 52(3): 302–315.