EXTRACTION OF NON-TIMBER FOREST PRODUCTS IN THE FORESTS OF BILIGIRI RANGAN HILLS, INDIA. 2. IMPACT OF NTFP EXTRACTION ON REGENERATION, POPULATION STRUCTURE, AND SPECIES COMPOSITION[1]

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Extração de Produtos Não Madereiros Nas Florestas de Biligiri Rangan Hills, India. 2. Impacto da Extração de Produtos Não Madereiros Na Regeneração, Estrutura de População e Composição de Espécies. *A exploração sustentavél de produtos forestais não madereiros tem ganho recentemente considarável atenção como um meio de aumentar a renda rural e conservar florestas tropicais. No entanto, existem poucas informações sobre a relação entre quantidade de produtos coletados e impacto da extração na estrutura e composição da floresta. Duas áreas de pesquisa, distal (DS) e proximal (PS), foram selecionadas de acordo com suas proximidades com uma tribo de Soligas. A frequência de diferentes classes de tamanho de planta indica que a regeneração de uma forma geral é baixa. Ambas as áreas mostraram diferenças em riqueza de espécies, área basal e mortalidade de árvores. Além disso, espécies cuja madeira é explorada possuem um menor déficit no estágio de plântula do que espécies cujos frutos e sementes são explorados. Isto sugere que a exploração de sementes e frutos afeta a regeneração. No entanto, a regeneração pode também ser afetada por pressão antropogênica, tais como: fogo, pastagem e competição com ervas daninhas.*

Key Words: non-timber forest products (NTFPs); human usage; forest regeneration; Soligas.

Extraction of non-timber forest products (NTFPs) offers considerable potential in the conservation of tropical forests. Judicious harvesting and processing of NTFPs can enhance rural incomes and can contribute to gross na-

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Economic Botany 50(3) pp. 252–269. 1996

tional product without degrading forests. Moreover, local communities can be involved in conservation because of the economic stake they are likely to have in preserving the resource base. At the same time a substantial amount of biodiversity can be conserved in extractive forests. Thus, conservation biologists and resource managers have recently shown considerable interest in management of tropical forests for non-timber forest products (Peters et al. 1989; Panayotou and Ashton 1992; Hladik et al. 1993).

However, overharvesting of NTFPs can have a negative impact on conservation of biodiversity. There are many examples of depletion of populations as a result of overexploitation in the tropics (Browder 1992; Homma 1992; Nepstad et al. 1992). As a result, several authors have questioned the conservation potenial of extractive reserves. In general, however, the impact of extraction of NTFPs on forest structure and composition is unknown for most extractive reserves. There is little information on the amounts extracted per unit area, nor is there much data on the relative abundance and distribution of NTFP species. Here we examine the effect of extraction of a wide range of NTFPs on the structure and composition of a dry deciduous forest. We also compare the population structure of selected timber and NTFP species. Specifically, our objectives were: 1) to ascertain the amounts of major NTFPs gathered per unit area, 2) to determine the relative abundance of NTFP species and 3) to examine the impact of extraction on the population structure of extracted species.

Methodology

Study Site

The terrain of the Biligiri Rangaswamy Temple (BRT) Wildlife Sanctuary, located between 11–13°N and 77–78°E in the southeast corner of Mysore district in the State of Karnataka, India, is a series of highly undulating hills with altitude ranging from 600 m to 1800 m above sea level. The hills are largely composed of metamorphic charnokite rocks of granulite facies and quartz magnetite rocks belonging to the Archaen Complex. The laterite soil cover on the bedrock is shallow and gravelly with a preponderance of quartz pebbles and iron concretions. The soil in valleys is alluvial and loamy with a good humus layer. The water holding capacity is low to moderate and leaching is high. Although the site straddles the eastern and western Ghats, the forests are floristically more similar to those of the western Ghats, particularly the dry deciduous forests, the subject of the present study.

The climate of the area is tropical monsoonal with the rainy season extending from June to November, winter from December to February, and summer from March to May. April is the hottest month and December the coldest. The BR Hills straddle the western and eastern Ghats of peninsular India and receive both southwest monsoon from the west coast (about 160 km away) and retreating northeast monsoon from the east coast nearly 210 km away. The rainfall is highly sporadic and varies greatly among locations, presumably because of the highly undulating terrain. Rainfall is generally greater at higher elevation than at low altitude. Honnamatti, the highest peak in this range (1800 m msl), receives 1850 mm of rain per annum (data available from 1926 to 1991, CV = 15.8%) as compared to Bedguli (1484 mm), the site just below the Honnamatti peak at 1200 m msl (data available from 1911 to 1991, CV = 19.4%). The daily fluctuations in the temperature and relative humidity recorded at BR Betta site from May 1981 to August 1992 indicate that the temperature may fall as low as 18.0°C in July, and may go as high as 32.2°C in April. Relative humidity varies from 53% in December to 95% in September.

The Soligas, one of indigenous tribes of south India, have lived in the sanctuary for hundreds of years, practicing hunting-gathering and shifting agriculture. The shifting agriculture was completely banned when the area was incorporated into a wildlife sanctuary in 1972. The Soligas, however, continued to extract non-timber forest products, which are now marketed through cooperative societies known as LAMPS (Large Scale Adivasi [Tribal] Multipurpose Societies). The operations of LAMPS are regulated and supervised by government officials.

Ramesh (1989) has classified the natural vegetation of the BRT santuary into five types: dry deciduous forest, scrub, grasslands, wet evergreen, and, high altitude, stunted, montane forest. The deciduous forest, the subject of this paper, is found generally at an altitude between 1100 to 1400 m.

The study was conducted around a hamlet called Kanneri Colony in a dry deciduous forest.

The hamlet has 92 households and 478 people. In this forest, we identified distant sites (DS) and proximal sites (PS), assuming that the human impact on the forest decreases with the increasing distance from the settlement. The inverse relation between distance from the settlement and the magnitude of impact is based on the assumption of greater opportunity costs in collecting products from distant sites as compared to nearby sites. The proximal site was within 3 km radius of the settlement and the distant site between 5 and 7 km radius. Both sites were in the natural forests of similar type.

Sampling and Analysis of Data

To determine the relative abundance of NTFPs, five one-hectare areas were sampled in each of the sites, in the form of 1 km long and 10 m wide linear transects laid in different directions. Each transect was divided into 10 plots of 100 m length and 10 m width (total 50 plots in each disturbance regime). All individuals of ≥10 cm dbh (diameter at breast height, or 1.30 m) were enumerated in all the plots. Simultaneously, one quadrat of 10 × 10 m was laid in the beginning of every 100 × 10 m plot (total 50 quadrats covering 0.5 ha area) and all the individuals between ≥1 and <10 cm dbh size were recorded. Further, one quadrat of 1 × 1 m size was randomly laid in each 10 × 10 m quadrat in first three transects at each site (total 30 quadrats constituting 0.03 ha area per regime) to count all the seedlings of trees (<1 cm dbh or those smaller than breast height) and other plants in the herb layer.

Disturbance index (DI) was calculated as the proportion of number of cut stems to the total standing number of stems in the transect, expressed as a percent. The importance value index (IVI) was calculated for each disturbance regime and pooled over all the regimes as per the formula given by Curtis and McIntosh (1951). Shannon-Weiner's diversity index (H) for both disturbance regimes was calculated.

The population structure was analyzed at the community level and for selected species that yield timber and non-timber forest products. The size class selected for community-wide analyses ranged from 10 cm dbh to 100 cm dbh, but for individual species the size-class category varied based on the maximum girth attained.

Similarity index was calculated between transects and the index of dispersion for each species was calculated by the techniques given by Ludwig and Reynolds (1986). However, the maximum number of classes was limited to ten. All the analyses of vegetation were done separately for the two disturbance regimes and also for pooled data across the disturbance regimes.

Results

NTFP Species

The most commonly collected NTFP species, their uses, and plant parts are shown in Table 1. Some species are traded through the cooperative societies, LAMPS. Other harvested species are marketed directly by the Soligas, bypassing LAMPS. There is yet a third class composed of a diverse range of products that are extracted for Soligas' own use. A complete list of such species that includes medicinal plants is not yet compiled. Data in Table 1 are based on information from records of LAMPS and, for products not marketed through LAMPS, on the basis of interviews with several Soliga groups.

As shown in Table 2, the amounts of fruit collected are highly correlated with the density of these species. Only the first three species in Table 2 are typically found in the dry deciduous forest. *Acacia sinuata* is generally found in scrub forests and *Sapindus emarginatus* in the moist evergreen forests of the BRT sanctuary.

The floristic composition at the two sites is given in Table 3. Vegetation at each site was sampled in three distinct strata viz., tree layer (individuals ≥10 cm dbh), understorey (individuals <10 and ≥1 cm dbh) and herb layer (individuals <1 cm dbh). Mosses and orchids were few, both in abundance and number of species. Vines and/or lianas were common. A few loranthaceous semiparasites were found frequently on individuals of many species, but two such parasites, *Taxillus tomentosus* (Roth.) Var. Tiegh and *Dendrophthoe falcata* (L.f.) Etting., were especially common on *Phyllanthus emblica* Linn.

Forest Structure and Composition

Trees

Species richness and diversity. The number of species in individual transects ranged from 23 to 36 (mean = 28.4, sd = 4.9) at the proximal sites and from 28 to 40 (mean = 31.8, sd = 5.2) at the distant sites. The most species rich transect was T9 at DS and the poorest was T1 at the

TABLE 1. NON-TIMBER FOREST PRODUCTS (NTFPS) COMMONLY EXTRACTED BY THE SOLIGA TRIBES IN THE BRT SANCTUARY.

Species	Habit	Marketing channel[1]	Plant part harvested	Use
Acacia sinuata	liana	CU	fruit	soapnut powder
Aristida setacea	herb	C	culm	broomstick
Bauhinia purpurea	medium-sized tree	U	leaf	plate
Boswellia serrata	small tree	U	resin	aromatic powder
Butea monosperma	medium-sized tree	U	leaf	plate
Cinnamomum zeylanicum	large tree	U	bark, leaf	spice, medicine
Curcuma domestica	herb	U	rhizome	spice, medicine
Diospyros melanoxylon	medium-sized tree	U	leaf	bidi wrapping
Phyllanthus emblica	small tree	C	fruit	pickling, medicine, tanning, dyeing
Feronia elephantum	medium- sized tree	U	fruit	food
Ficus bengalensis	large tree	U	leaf	plate
Hemidesmus indicus	herb	CU	rhizome	pickling, medicine
Piper sp.	climber	U	seed	spice, medicine
Ricinus communis	shrub	U	seed	oil, medicine
Sapindus emarginatus	meduim-sized tree	CU	fruit	soapnut powder
Shorea taluma	large tree	U	resin	aromatic powder
Strychnos potatorum	small tree	C	fruit	medicine
Tamarindus indica	large tree	CU	fruit	spice
Terminalia bellirica	large tree	C	seed	medicine
Terminalia chebula	medium tree	C	seed	medicine
Zingiber officinale	herb	U	rhizome	pickling, spice
Gum (mixed)		C		paste
Honey		CU		medicine, food
Lichens		C		paint, medicine, food

[1] C—extracted commercially and marketed through LAMPs. U—extracted, but not marketed through LAMPs.

proximal site. The similarity index between any two transects at proximal sites varied from 0.604 to 0.840 (mean = 0.635, sd = 0.049) and at the distant sites from 0.576 to 0.842 (mean = 0.747, sd = 0.043), indicating that there was appreciable homogeneity (overlap of species) among the transects at both the sites, and the overlap was more at the distant sites than at the proximal sites. The mean of similarity indices among cross-transects of two sites was 0.713 with sd 0.067 (CV = 9.4%).

TABLE 2. RANKINGS IN DENSITIES AND AMOUNTS COLLECTED FOR NTFPS THAT YEILD SEEDS AND FRUITS AND ARE MARKETED THROUGH LAMPS.

Species	Density per ha	Amounts in tons
Phyllanthus emblica (Gooseberry)	28.3	496.6
Terminalia chebula (Arale)	8.1	8.3
Terminalia bellirica (Tare)	3.2	2.6
Acacia sinuata (Soapnut)	2.3	2.2
Sapindus emarginatus (Soapberry)	0.5	2.2

Trees ≥10 cm dbh in a ten hectare area of the pooled forest included 3101 individuals in 62 species under 51 genera of 30 families (excluding those genera and families which could not be identified) (Table 3). The total number of species was more at the distant sites (52) than at the proximal sites (47). While only 15 species were exclusive to DS and 10 to PS, 37 species were shared by both sites. Eleven families were represented by more than one genus: Rubiaceae, Fabaceae, Sterculiaceae, and Euphorbiaceae with 4 four genera each, Anacardiaceae (three genera), and Combretaceae, Salicaceae, Myrtaceae, Bignoniaceae, Lauraceae and Mimosoideae with two genera each. Only three genera exhibited more than one species: *Terminalia* (four species), *Dalbergia* (two species), and *Glochidion* (two species). The most species rich families were Combretaceae, Euphorbiaceae, and Fabaceae with five species each, and Sterculiaceae and Rubiaceae with four species each.

Shannon-Weiner's index of species diversity was greater for distant sites (2.86) than proximal

TABLE 3. FLORISTIC COMPOSITION OF TREE LAYER AT PROXIMATE AND DISTANT SITES IN DRY DECIDUOUS FOREST WITH DENSITY, FREQUENCY, COVER, IMPORTANCE VALUE AND VARIANCE/MEAN RATIO OF EACH SPECIES. THE SPECIES ARE ARRANGED IN DESCENDING ORDER ACCORDING TO IMPORTANCE VALUE CALCULATED AFTER POOLING OF DATA ACROSS THE DISTURBANCE REGIMES.

			Distant sites					Proximal sites					Pooled	
	Soliga name	Family name	Den.[1]	Freq[2]	Cov[3]	IVI	V/M	Den.[1]	Freq[2]	Cov[3]	IVI	V/M	IVI	V/M
Terminalia crenulata Heyne.	Matti	Combretaceae	239	48	406 368	50.0	0.55^{U}	228	48	346 482	52.9	0.60^{U}	51.32	0.57^{U}
Anogeissus latifolia Wall.	Bejja	Combretaceae	295	43	169 250	36.7	0.87^{U}	483	44	261 451	63.6	1.12^{R}	48.91	1.11^{R}
Grewia tiliaefolia Vahl.	Dadsalu	Tiliaceae	112	39	83 305	19.1	1.02^{R}	85	39	86 641	20.9	0.96^{U}	19.94	1.01^{R}
Kydia calycina Roxb.	Bende	Malvaceae	136	40	72 964	20.1	1.00^{R}	68	26	36 795	13.1	1.53	16.85	1.23^{R}
Phyllanthus emblica L.	Nelli	Euphorbiaceae	109	41	26 473	15.5	0.85^{U}	96	37	39 161	17.6	1.17^{R}	16.45	1.00^{R}
Eriolaena lushingtonii DC.	Katale	Sterculiaceae	91	39	22 488	13.8	0.94^{U}	63	29	20 430	12.1	1.06^{R}	13.03	1.01^{R}
Pterocarpus marsupium Roxb.	Honne	Fabaceae	68	20	126 002	16.0	2.88^{C}	14	11	44 100	6.7	2.05^{C}	11.73	3.46^{C}
Glochidion zeylanicum (Gaertn.) A. Juss	Hanase	Euphorbiaceae	112	35	18 899	14.1	1.3^{C}	25	18	5190	6.0	1.53^{C}	10.37	1.74^{C}
Catunaregam rugulosa (Thw.) Tiruv.	Kare	Rubiaceae	109	22	28 545	12.3	2.72^{C}	37	13	22 563	7.1	2.28^{C}	9.90	2.80^{C}
Terminalia bellirica Roxb.	Tare	Combretaceae	20	17	75 977	9.3	1.49^{C}	17	13	82 899	10.4	1.84^{C}	9.78	1.65^{C}
Terminalia chebula Retz.	Arale	Combretaceae	33	19	39 695	8.0	1.67^{C}	24	17	24 910	7.2	1.64^{C}	7.61	1.68^{C}
Radermachera xylocarpa Roxb.	K. Schum. Udi	Bignoniaceae	32	19	8894	5.8	1.69^{C}	45	25	14 236	9.6	1.27^{C}	7.53	1.45^{C}
Terminalia paniculata Roth.	Ulube	Combretaceae	24	5	10 854	3.1	3.40^{C}	58	18	55 504	12.2	1.80^{C}	7.23	2.31^{C}
Syzygium cuminii (L.) Skeels.	Nerele	Myrtaceae	15	10	51 218	6.1	2.26^{C}	10	7	72 559	7.8	2.86^{C}	6.88	2.50^{C}
Careya arborea Roxb.	Dolli	Lecythidaceae	38	22	28 273	8.0	1.52^{C}	18	12	9381	4.5	1.93^{C}	6.42	1.73^{C}
Gmelina arborea Roxb.	Kule	Verbenaceae	13	9	12 890	3.2	2.31^{C}	13	10	32 990	5.6	2.31^{C}	4.31	2.30^{C}

TABLE 3. CONTINUED.

			Distant sites					Proximal sites					Pooled	
	Soliga name	Family name	Den.[1]	Freq[2]	Cov[3]	IVI	V/M	Den.[1]	Freq[2]	Cov[3]	IVI	V/M	IVI	V/M
Sterculia villosa Roxb. ex DC.	Chowve	Sterculiaceae	26	17	33497	6.8	1.61[C]	3	3	4518	1.2	4.00[C]	4.22	2.26[C]
Schrebera swietenioides Roxb.	Gante	Oleaceae	20	8	16619	3.7	2.72[C]	27	8	15853	4.8	3.27[C]	4.22	3.11[C]
Ficus sp.	Itchi	Moraceae	5	5	84979	6.9	3.03[C]	2	2	6010	1.0	4.95[C]	4.17	3.66[C]
Cordia obliqua Willd.	Selle	Boraginaceae	15	12	4549	3.3	1.93[C]	14	10	12675	4.1	2.29[C]	3.66	2.10[C]
Bridelia retusa Spreng.	Sirrone	Euphorbiaceae	14	10	13575	3.5	2.29[C]	11	8	5609	2.9	2.65[C]	3.22	2.44[C]
Dalbergia latifolia Roxb.	Bite	Fabaceae	10	8	23933	3.6	2.68[C]	3	3	3894	1.2	4.00[C]	2.47	3.22[C]
Alseodaphnae semecarpifolia Nees.	Karvadi	Lauraceae	12	8	14956	3.1	2.60[C]	2	2	5472	1.0	4.95[C]	2.14	3.37[C]
Stereospermum personatum (Hassk.) Chatterje	Padure	Bignoniaceae	7	5	6564	1.7	3.23[C]	7	5	11743	2.5	3.23[C]	2.07	3.21[C]
Canthium parviflorum Lam.	Doddakare	Rubiaceae	8	6	2906	1.7	2.93[C]	8	7	2976	2.3	2.64[C]	1.97	2.77[C]
Garuga pinnata Roxb.	Arnelli	Burseraceae	9	4	23028	2.8	4.30[C]	2	2	5020	1.0	4.95[C]	1.94	5.16[C]
Cassia fistula L.	Kakke	Caesalpiniaceae	6	5	682	1.3	3.21[C]	13	8	1700	2.7	2.60[C]	1.94	2.89[C]
Zizyphus xylopyrus (Retz.) Willd.	Gotti	Rhamnaceae	6	6	788	1.5	2.73[C]	9	8	1022	2.4	2.43[C]	1.89	2.57[C]
Viburnum punctatum Ham.	Thonde	Caprifoliaceae	13	4	13236	2.4	4.59[C]	1	1	8862	1.0	7.05[C]	1.73	6.09[C]
Albizia odoratissima (L.f.) Benth.	Sele	Mimosaceae	7	7	14861	2.6	2.51[C]	1	1	2694	0.5	7.05[C]	1.66	3.41[C]
Lagerstroemia parviflora Roxb.	Chanangi	Lythraceae						18	8	5538	3.4	2.96[C]	1.55	4.28[C]
Buchanania lanzan Spreng.	Murki	Anacardiaceae	7	5	3716	1.5	3.23[C]	2	2	1396	0.7	4.95[C]	1.15	3.90[C]
Mallotus philippensis Muell.-Arg.	Kesilu	Euphorbiaceae	5	3	4329	1.1	4.63[C]	4	2	3849	1.0	5.55[C]	1.06	5.02[C]
Butea monosperma (Lamk.) Tanb.	Muttuga	Fabaceae	2	2	8445	1.0	4.95[C]	2	2	1480	0.7	4.95[C]	0.87	4.93[C]

TABLE 3. CONTINUED.

	Soliga name	Family name	Distant sites Den.[1]	Freq[2]	Cov[3]	IVI	V/M	Proximal sites Den.[1]	Freq[2]	Cov[3]	IVI	V/M	Pooled IVI	V/M
Glochidion sp.	Mustaka	Euphorbiaceae	5	4	4908	1.3	3.64^C						0.72	5.22^C
Bauhinia purpurea L.	Kanchale	Caesalpiniaceae						6	3	5600	1.5	4.95^C	0.68	7.03^C
Bombax ceiba L.	Buruga	Bombacaceae	2	2	4083	0.7	4.95^C	1	1	3475	0.6	7.05^C	0.66	5.70^C
Litsea deccanensis Gamble.	More	Lauraceae	4	4	3797	1.2	3.43^C						0.65	4.93^C
Eucalyptus sp.	Nilgiri	Myrtaceae						3	1	10249	1.2	7.07^C	0.56	10.00^C
Pavetta tomentosa Roxb. ex Sm.	Papete	Rubiaceae	4	4	686	1.0	3.43^C						0.54	4.93^C
Acacia sinuata (Lour.) Merr.	Sige	Mimosaceae	1	1	350	0.3	7.05^C	3	3	404	0.9	4.00^C	0.54	4.93^C
Diospyros montana Roxb.	Jagalganti	Ebenaceae	2	1	4662	0.6	7.05^C	1	1	299	0.3	7.05^C	0.47	7.05^C
	Avarehambu							4	2	2611	0.9	5.5^C	0.41	7.88
Canthium dicoccum (Gaertn.) Teijsm & Binnd	Ambe	Rubiaceae	2	2	3994	0.7	4.95^C						0.40	7.05^C
Dalbergia lanceolaria L.	Buduga	Fabaceae						3	2	3218	0.9	5.23^C	0.40	7.43^C
Ougeinia oojeinensis (Roxb.) Hochr.	Kallumuttuga	Fabaceae						5	1	2644	0.8	7.07^C	0.35	10.00^C
Nothapodytes nimmoniana (Grah.) Mabberly	Moragadi	Icacinaceae	1	1	750	0.3	7.05^C	1	1	1165	0.4	7.05^C	0.33	7.05^C
	Gojjali	Meliaceae	2	2	1496	0.6	4.95^C						0.31	7.05^C
Schleichera oleosa (Lour.) Oken.	Sagade	Sapindaceae						2	2	1621	0.7	4.95^C	0.31	7.05^C
Spondias pinnata (Linn.) Kurtz.	Ambatte	Anacardiaceae	1	1	4744	0.6	7.05^C						0.30	10.00^C
Salix sp.	Neeranchi	Salicaceae	3	1	2789	0.5	7.07^C						0.29	10.00^C
Bischofia javanica	Neelelu	Bischofiaceae	1	1	3475	0.5	7.05^C						0.25	10.00^C
	Neremara		1	1	2680	0.4	7.05^C						0.22	10.00^C
Salix tetrasperma Roxb.	Byese	Salicaceae						2	1	1308	0.5	7.08^C	0.21	10.00^C

TABLE 3. CONTINUED.

	Soliga name	Family name	Distant sites					Proximal sites					Pooled	
			Den.[1]	Freq[2]	Cov[3]	IVI	V/M	Den.[1]	Freq[2]	Cov[3]	IVI	V/M	IVI	V/M
Clematis gouriana Roxb. ex DC.	Aragehambu	Ranunculaceae	3	1	381	0.4	7.07^{C}						0.21	10.00^{C}
Anacardium occidentale L.	Gerumara	Anacardiaceae	1	1	1308	0.3	7.05^{C}						0.18	10.00^{C}
Wedlandia thyrsoidea (R. & S.) Steud.	Koli	Rubiaceae						1	1	856	0.4	7.05^{C}	0.16	10.00^{C}
	Peekehambu		1	1	232	0.3	7.05^{C}						0.14	10.00^{C}
Helicteres isora Linn.	Kaori	Sterculiaceae	1	1	80	0.2	7.05^{C}						0.13	10.00^{C}
Ardisia solanacea Roxb.	Kattugudi	Myrsinaceae	1	1	97	0.2	7.05^{C}						0.13	10.00^{C}
Aphanamyxis polystachya	Naigantu		1	1	92	0.2	7.05^{C}						0.13	10.00^{C}
	Huliavare							1	1	137	0.3	7.05^{C}	0.13	10.00^{C}
Total	62 Species		1655	574	1 493 362	300		1446	469	1 289 187	300		300	
Shannon's diversity index						2.86					2.56		2.81	

[1] Density denotes total number of individuals ≥10 cm dbh in 5 ha area; [2] frequency denotes number of plots (100 × 10 m) in which species occurred out of total 50 plots in each regime; [3] cover is measured in cm^2 per 5 ha area; U—uniform dispersion; R—random dispersion; C—clumped dispersion.

TABLE 4. DENSITY, DISTURBANCE INDEX AND MORTALITY AT SITES PROXIMATE TO AND DISTANT FROM SETTLEMENTS IN DRY DECIDUOUS FOREST IN BRT SANCTUARY.

	Distant sites	Proximal sites
Standing trees	308.2 ± 70.51	301.2 ± 43.62
Cut trees	0.8 ± 1.17	16.0 ± 9.82
Broken trees	0.4 ± 0.49	3.8 ± 7.11
Naturally dead trees	7.0 ± 3.50	35.4 ± 8.01
Total trees	334.6 ± 79.24	357.8 ± 64.97
Disturbance index	0.3 ± 0.43	5.0 ± 2.44
Mortality	8.6 ± 1.41	9.8 ± 0.66

sites (2.56). When these two indices were treated statistically according to Zar (1984), the difference was found to be highly significant ($t = 7.28$, $df = 2790$, $P < 0.0001$). The evenness or homogeneity index, the measure of observed diversity as a proportion of the maximum possible diversity (Zar 1984), was more for distant sites (73.5%) than for proximal sites (66.6%).

Density. There was no significant difference between two sites with respect to the density of trees per hectare (Table 4). The density of trees ≥10 cm dbh was 308.2 for distant sites and 301.2 for proximal sites. The most common species were *Anogeissus latifolia* (295 at DS, 483 at PS), *Terminalia crenulata* (239 at DS, 228 at PS), *Grewia tiliaefolia* (112 at DS, 85 at PS) and *Kydia calycina* (136 at DS, 68 at PS). When put together, these four species, comprising only 7.7% of all the species at DS and 8.5% at PS, account for 47% of individuals at the distant and 60% at the proximal sites. Ten species at distant sites and seven species at proximal sites have representation by only a single individual. These species could be classified as "rare." The family Combretaceae alone comprised 37% individuals at distant and 56% at proximal sites.

Frequency. Besides the first six species listed in Table 3, all other species had clumped dispersion in both distant and proximal, even when pooled across the two sites. Of the remaining six species, four species at distant and two species at proximal sites showed uniform dispersion with one species, *T. crenulata,* common to both the sites. The other two species at distant sites and three out of the other four species at proximal sites showed random dispersion; the fourth

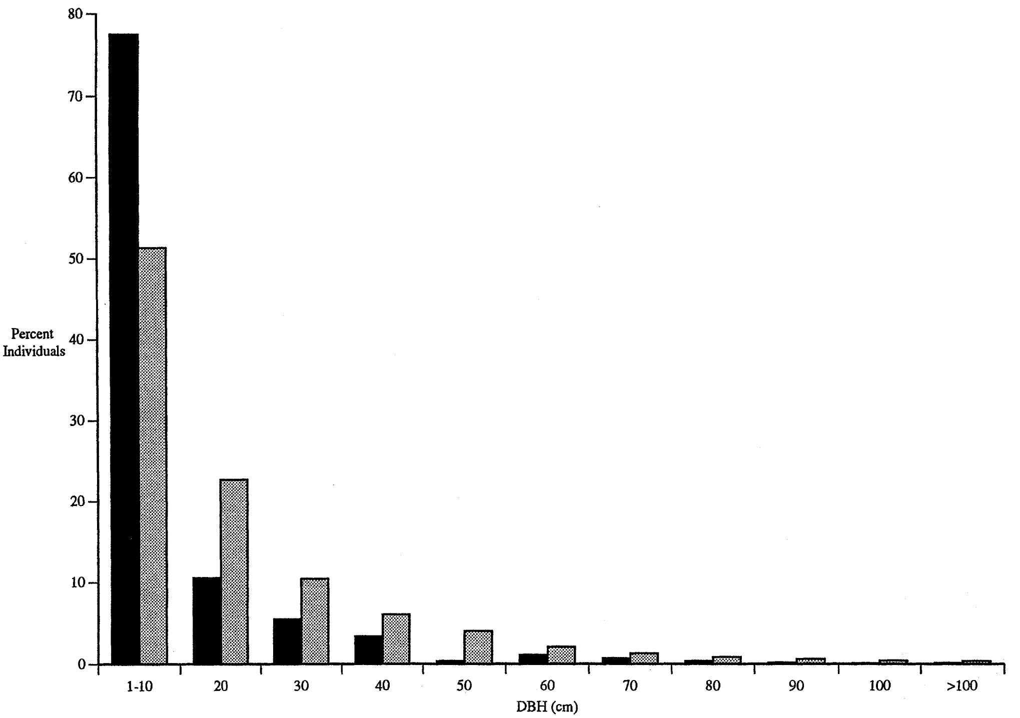

Fig. 1. Size class distribution of all stems above 10 cm dbh at distant (solid) and proximal sites (hatched).

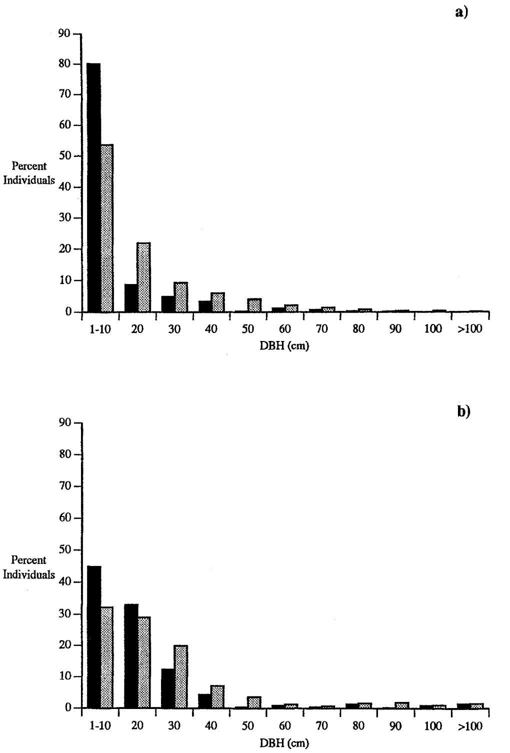

Fig. 2. a.) Size-class distribution of TFP species of all stems above 10 cm dbh at distant (solid) and proximal (hatched) sites. b.) Size-class distribution of NTFP species of all stems above 10 cm dbh at distant (solid) and proximal (hatched) sites.

species at proximal sites had clumped distribution. While the most important species at distant sites, *T. crenulata,* had uniform distribution, the most important species at proximal sites, *A. latifolia,* had random distribution.

Basal area. The basal area of trees ≥10 cm dbh was higher at distant (149.3 m^2) than at proximal sites (128.9 m^2). But when this total basal area was translated into an average basal area/tree (by dividing the total basal area by total density), it did not considerably differ between distant (902 cm^2) and proximal (891 cm^2) sites. While *T. crenulata* occupied almost similar basal area in both the disturbance regimes (27.2% at DS and 26.9% at PS), *A. latifolia* occupied more basal area at the proximal (20.3%) than at the distant (11.3%). However, basal area per individual for *T. crenulata* was more at distant (1700 cm^2) than at proximal (1520 cm^2), and for *A. latifolia,* it did not vary significantly between the two sites (574 cm^2 at DS and 541 cm^2 at PS). The four most common species make up 49% of the basal area at distant sites and 57% at proximal sites. The most dominant family, Combretaceae, accounts for 47% basal area at distant sites and 60% at proximal sites.

Importance value. T. crenulata was the dominant species with an importance value of 51.3 in the pooled forest. It was closely followed by *A. latifolia* with IVI 48.9. Thus, it is a case where two species dominate, rather than one, as has been observed in several other tropical forests. The dominance of these two species, however, differed greatly between the two sites. While *A. latifolia* had greater IVI value at PS (63.6) than at DS (36.7), *T. crenulata* had comparable IVI between both sites. There were 16 species with <1 IVI at distant, compared to 14 such species at proximal sites. This number was 29 for the pooled forest.

Population structure. The size distribution of individuals of all species, though reverse J-shaped or positively skewed at both the distant and the proximal sites, differs significantly between the two sites ($D = 0.16$, $P < 0.01$, Fig. 1). This difference is accounted for by the lower frequency of individuals in the 1–10 cm dbh class at proximal than at distant sites. This is evident from further analysis, in which we truncated 1–10 cm dbh class and compared the distributions again. The distribution of individuals in the remaining dbh classes does not differ significantly between the two sites ($D = 0.056$, $n1 = 1201$, $n2 = 1191$, $P > 0.05$).

The distribution of individuals of only NTFP species (*P. emblica, T. chebula, T. bellirica*) put together was different between the two sites ($D = 0.17$, $P < 0.01$, Fig. 2b); the distant site exhibited a significantly greater proportion of individuals in 1–10 cm dbh class than the proximal site, and clearly reflects poorer recruitment of young NTFP individuals at the proximal site. This trend was even more pronounced for timber forest product species which are not directly influenced by extraction activity ($D = 0.18$, $P < 0.01$, Fig. 2a).

The proportion of NTFP individuals in the 1–10 cm dbh class was significantly lower than that of TFP at both sites ($D = 0.21$, $P < 0.01$, Fig. 2a,b). This comparison may not be strictly valid, because it suffers from the heterogeneity caused by the pooling of species with different intrinsic growth strategies and attainable maximum vigour. To circumvent this difficulty, the

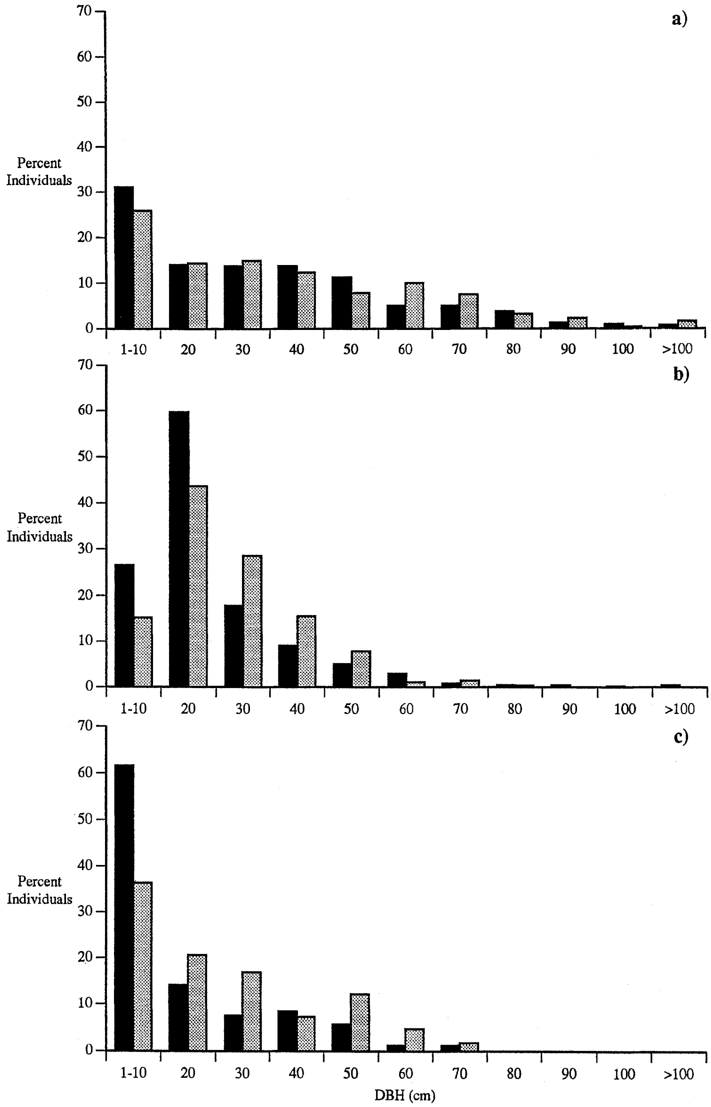

Fig. 3. Size-class distribution of three major TFP species at distant sites (solid) and proximal (hatched) sites. a.) *Terminalia crenulata*; b.) *Anogeissus latifolia*; c.) *Grevia tiliefolia.*

size class distribution of individual species was attempted. However, we had insufficient individuals of all NTFP species to plot a dbh distribution (Table 3). Therefore, the forest was revisited and the trees of three major NTFP species were sampled randomly in close proximity to previously laid transects. We also made sure that no individual was resampled. Finally, the number of individuals was increased from 20 to 45 at DS and 17 to 100 at PS for *T. bellirica,* from 33 to 59 at DS and from 24 to 99 at PS for *T. chebula,* and from 109 to 218 at DS and from 96 to 163 at PS for *P. emblica.*

One species, *A. latifolia,* has fewer individuals in the 1–10 cm dbh class than in 10 to 20 dbh category. However, two TFP species, *T. crenulata* and *G. tiliaefolia,* show a reverse J shaped curve, with the largest number of individuals in the smallest size class (1–10 cm) DBH) at both the proximal and distant sites (Fig. 3a–c). In contrast, all three NTFP species *P. emblica, T. bellirica,* and *T. chebula,* show a deficit of in-

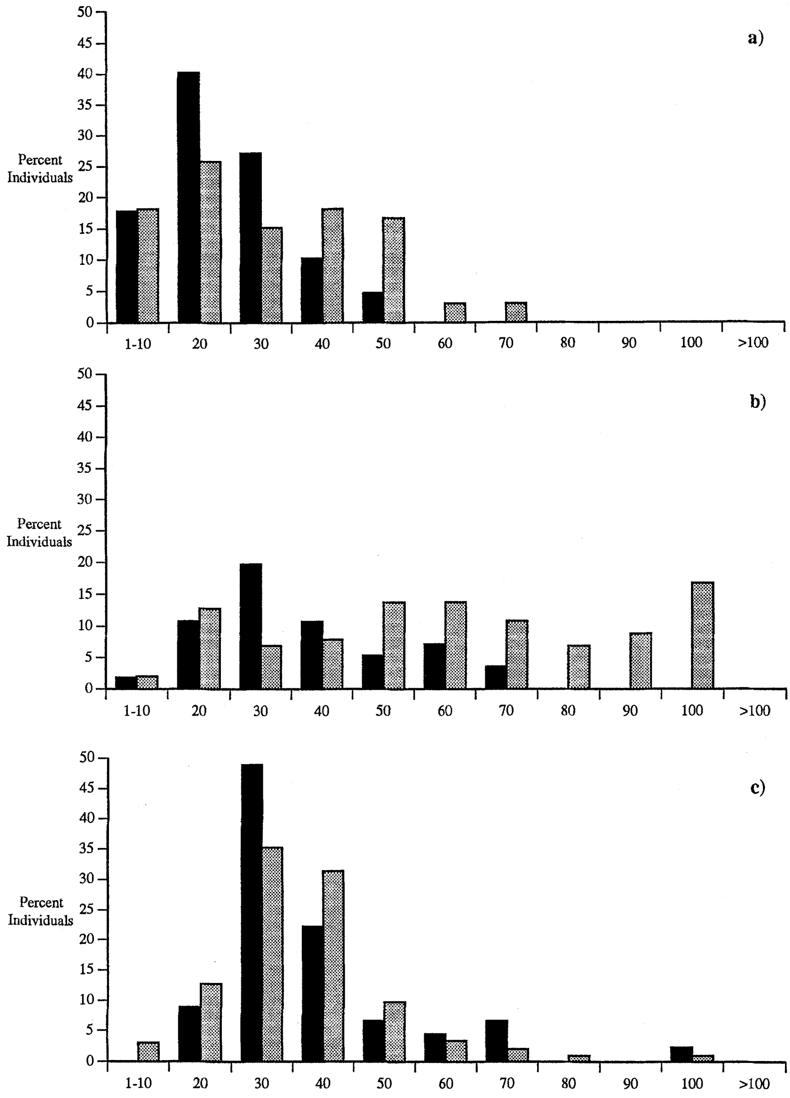

Fig. 4. Size-class distribution of three major NTFP species at distant (solid) and proximal (hatched) sites. a.) *Phyllanthus emblica*; b.) *Terminalia bellirica*; c.) *T. chebula.*

dividuals in the smallest size class (1–10 cm DBH) at both the sites (Fig. 4a–c), and there seems to be no difference in regeneration potential between the two disturbance regimes.

Understory Layer

In the understory the dominant species found was *Catunaregam rugulosa,* an understory tree (Table 5). The saplings (stems of 1–10 cm dbh) of these trees were also found in large numbers. The saplings of *P. emblica,* the major NTFP species, were found to take 5th place in dominance in the understorey layer. The other major NTFP species, which takes 25th place in its dominance, was *Terminalia bellirica.* The diversity index for the shrub layer at the proximal sites was 1.9, compared to an index for the distant sites of 2.5, indicating increased richness in distant sites.

Herb Layer

Grasses and sedges dominate the herb layer vegetation and are followed by tree seedlings (Table 6). The tree seedlings were dominated by

TABLE 5. FLORISTIC COMPOSITION OF UNDERSTORY LAYER IN DISTANT AND PROXIMAL SITES IN DRY DECIDUOUS FOREST WITH DENSITY, FREQUENCY, COVER AND IMPORTANCE VALUE OF EACH SPECIES. THE SPECIES ARE ARRANGED IN DESCENDING ORDER ACCORDING TO IMPORTANCE VALUE CALCULATED AFTER POOLING OF DATA ACROSS THE DISTURBANCE REGIMES.

			Distant sites				Proximal sites				Pooled
Species	Soliga name	Family Name	Den	Freq	Cov	IVI	Den	Freq	Cov	IVI	IVI
Catunaregam rugulosa (Thw.) Tiruv.	Kare	Rubiaceae	253	37	3083	115.5	21	8	105	27.4	90.90
Pavetta tomentosa Roxb. ex Sm.	Papete	Rubiaceae	88	22	1335	49.8	3	3	81	8.2	37.87
Helicteres isora Linn.	Kaori	Sterculiaceae	20	1	326	8.9	43	7	361	48.6	19.44
Anogeissus latifolia Wall.	Bejja	Combretaceae	5	4	236	6.8	17	7	777	43.6	17.39
Emblica officinalis Gaertn.	Nelli	Euphorbiaceae	16	10	409	15.3	7	4	276	18.1	15.93
Terminalia crenulata Heyne.	Matti	Combretaceae	15	8	350	13.0	7	6	290	21.0	15.37
Kydia calycina Roxb.	Bende	Malvaceae	11	4	311	8.9	10	9	229	25.0	13.87
Grewia tiliaefolia Vahl.	Dadsalu	Tiliaceae	14	4	261	8.9	6	5	210	16.7	11.32
Alseodaphne semecarpifolia Nees.	Karvadi	Lauraceae	26	11	159	14.8	1	1	1	2.0	10.94
Cassia fistula L.	Kakke	Caesalpiniaceae	6	5	98	5.9	8	6	176	18.3	9.51
Radermachera xylocarpa (Roxb.) K. Schum.	Udi	Bignoniaceae	7	6	228	8.4	4	4	114	11.2	9.22
Glochidion sp.	Hanese	Euphorbiaceae	6	4	363	8.6	2	2	110	7.2	8.15
Zizyphus xylopyrus Willd.	Gotti	Rhamnaceae	8	7	135	8.1	3	3	78	8.2	8.06
Eriolaena lushingtonii DC.	Katale	Sterculiaceae	3	3	184	5.0	3	3	189	11.5	6.95
Pterocarpus marsupium Roxb.	Honne	Fabaceae	1	1	3	0.9	2	2	65	5.8	2.40
Cordia obliqua Willd.	Selle	Boraginaceae					3	2	102	7.6	2.27
Sterculia villosa Roxb. ex DC.	Chowve	Sterculiaceae	3	3	12	2.8					1.90
Canthium parviflorum Lam.	Doddakare	Rubiaceae	2	1	122	2.7					1.85
Syzygium cumini (L.) Skeels.	Nerele	Myrtaceae	1	1	2	0.9	1	1	39	3.1	1.56
	Kumuli		1	1	1	0.9	2	1	4	2.7	1.40
Acacia sinuata (Lour.)	Sige	Mimosaceae	2	2	17	2.0					1.35
Diospyros montana Roxb.	Jagalganti	Ebenaceae	2	2	12	1.9					1.31
Caryea arborea Roxb.	Dolli	Lecythidaceae					1	1	62	3.8	1.16
Dalbergia lanceolaria L.	Buduga	Fabaceae					1	1	55	3.6	1.10
Terminalia bellerica Roxb.	Tare	Combretaceae	1	1	44	1.5					1.00
Albizia amara Boiv.	Sele	Mimosoideae	1	1	30	1.3					0.87
Bridelia retusa Spreng.	Sirrone	Euphorbiaceae	1	1	28	1.3					0.85
Lantana camara L.	Lantana	Verbenaceae	2	1	9	1.2					0.83
	Togotte		1	1	22	1.2					0.80
Terminalia paniculata Roth.	Ulube	Combretaceae					2	1	2	2.7	0.77
Viburnum punctatum Ham.	Thonde	Caprifoliaceae	1	1	4	0.9					0.63
Dalbergia latifolia Roxb.	Bite	Fabaceae	1	1	1	0.9					0.61

TABLE 5. CONTINUED.

Species	Soliga name	Family Name	Distant sites Den	Freq	Cov	IVI	Proximal sites Den	Freq	Cov	IVI	Pooled IVI
Lagerstroemia parviflora Roxb.	Chanangi	Lythraceae					1	1	1	2.0	0.61
Cinnamomum sp.	Kumavo	Lauraceae	1	1	1	0.9					0.61
	Tanike		1	1	2	0.9					0.61
Gmelina arborea Roxb.	Kule	Verbenaceae					1	1	2	2.0	0.61
Total			500	146	7787	300	149	79	3328	300	300
Shannon's diversity index			1.90				2.48				2.21

the understory tree *Catunaregam regulosa.* The seedlings of *P. emblica* were 18th among the dominant seedling species in the herb layer and that of *Terminalia bellirica* was 24th. In fact, the seedlings of the dominant species such as *Anogeissus latifolia* and *Terminalia crenulata* were less common.

DISCUSSION

The Soligas, as described earlier, extract a wide variety of NTFPs from the BRT forests. It is important to note that this paper pertains to the impact of extraction of products that are harvested in quantities large enough to be traded through LAMPS. Furthermore, the discussion is restricted to species extracted from dry deciduous forests.

SPECIES EXTRACTED AND EXTRACTION LEVELS

The opportunity cost for collection of common species should be less than those of uncommon species (Godoy and Bawa 1993). Thus, the most common species is expected to be harvested more intensely than the less abundant species. In the BRT Sancturary, the seeds and fruits are harvested from abundant species, though not necessarily from the most common species. *Phyllanthus emblica* ranks fifth, *Terminalia bellirica* ninth, and *T. chebula* eleventh in terms of importance value. Our data on density and frequency for the remaining two species in Table 2 are not appropriate to determine ranking because, as mentioned earlier, *Acacia sinuata* typically occurs in scrub forests, and *Sapindus emarginatus* in moist evergreen patches. However, the opportunity cost is also dependent upon the price of the product gathered. If the unit price is very high, even rare species can be harvested. If all the species from which seed and fruits are collected are grouped together, one notes that the amounts extracted are positively correlated with the abundance of species. There is no a priori reason to expect such a relationship unless one assumes that most of the fruits produced are captured by the harvesters or there is a strong demand for all the products. Unfortunately, estimates of total productivity are not available, making it difficult to determine the proportion of output that is harvested. However, for one of the species, *Phyllanthus emblica,* our observations indicate that 60–80% of all the fruits are extracted at the level of populations,

TABLE 6. FLORISTIC COMPOSITION OF HERB LAYER IN DISTANT AND PROXIMAL SITES IN DRY DECIDUOUS FOREST WITH DENSITY, FREQUENCY, COVER AND IMPORTANCE VALUE OF EACH SPECIES. THE SPECIES ARE ARRANGED IN DESCENDING ORDER ACCORDING TO IMPORTANCE VALUE CALCULATED AFTER POOLING OF DATA ACROSS THE DISTANCE REGIMES.

Species	Soliga name	Family name	Distant sites			Proximal sites			Pooled
			Den	Freq	IVI	Den	Freq	IVI	IVI
Tree seedlings			187		64.2	201		61.0	62.6
Catunaregam rugulosa (Thw.) Tiruv.	Kare	Rubiaceae	54	23	14.7	105	23	20.1	17.1
Zizyphus xylopyrus Willd.	Gotti	Rhamnaceae	12	12	7.0	8	7	4.8	6.0
Acacia sinuata (Lour.) Merr.	Sige	Mimosaceae	9	5	3.1	18	12	8.5	5.6
Sterculia villosa Roxb. ex DC.	Chowve	Sterculiaceae	13	8	4.9	8	5	3.6	4.3
Syzygium cumini (L.) skeels.	Nerele	Myrtaceae	31	10	6.7	9	1	1.1	4.1
Pavetta tomentosa Roxb. ex Sm.	Papete	Rubiaceae	25	7	1	1		0.7	4.1
Grewia tilaefolia Vahl.	Dadsalu	Tiliaceae	10	7	4.2	6	5	3.5	3.9
Terminalia crenulata Heyne.	Matti	Combretaceae	3	2	1.2	5	3	2.1	1.6
Anogeissus latifolia Wall.	Bejja	Combretaceae	3	3	1.8	2	2	1.4	1.6
Mellotus philippensis Muell.-Arg.	Kesilu	Euphorbiaceae	5	5	2.9				1.6
Helictres isora L.	Kaori	Sterculiaceae	12	4	3.2				1.4
Dalbergia latifolia Roxb.	Bite	Fabaceae	1	1	0.6	3	3	2.0	1.3
Eriolaena lushingtonii DC.	Katale	Sterculiaceae	1	1	0.6	5	3	2.1	1.3
Kydia calycina Roxb.	Bende	Malvaceae	6	3	2.2				1.0
Glochidion sp.	Hanese	Euphorbiaceae	4	2	1.3	1	1	0.7	1.0
Pterocarpus marsupium Roxb.	Honne	Fabaceae	2	2	1.2	1	1	0.7	0.9
Albizzia amara Boiv.	Sele	Mimosaceae	2	2	1.2	1	1	0.7	0.9
Phyllanthus emblica L.	Nelli	Euphorbiaceae	3	2	1.4				0.7
Canthium parviflorum Lam.	Doddakare	Rubiaceae	4	2	1.3				0.7
	Kakkilu		2	2	1.2				0.6
	Udupe		2	2	1.2				0.6

but not all populations are harvested, and not more than 20% of the fruits produced in the whole area of the sanctuary are extracted (Uma Shankar et al. 1996). Whether such a level of extraction interferes with regeneration is discussed in the companion paper (Uma Shankar et al. 1996).

FOREST STRUCTURE AND COMPOSITION

India's forest vegetation largely consists of tropical dry deciduous forests. Approximately 60% of the country's forests are classified under this category (World Resources Institute 1994). In the Western Ghats, dry deciduous forests constitute a large area on the eastern slopes. In the BRT Hills, deciduous forests account for approximately 61% of the total area (Ramesh 1989). Yet, despite their prevalence, little is known about the structure and composition of dry deciduous forests, nor is there much information about the dynamics of these forests.

Most of our results on the composition of the forest are comparable to those obtained by Sukumar et al. (1992) in their analysis of the structure and dynamics of the tropical dry deciduous forest in a 50 ha plot at Mudumalai, 100 km away from our site. The study by Sukumar et al. represents the only published report on the structure of tropical deciduous forests from south India. The number of species with stems ≥1 cm dbh in our 10 hectare sampled area was 63, compared to 63 species at Mudumalai over a sampling area of 50 ha. The stand density was 306 stems per ha as compared to a density of 308 stems per ha in Mudumlai. Mortality of trees was 6% in BRT sanctuary, while in Mudumalai it was 3%. However, in their mortality estimates Sukumar et al. (1992) consider only stems ≥10 cm dbh.

In terms of vegetation composition, the forests of Mudumalai are different from those of BR Hills. At Mudumalai the three dominant species, in the order of abundance, are: *Kydia calycina, Lagerstroemia microcarpa,* and *Tectona grandis.* In the sampled areas in BR Hills, the three dominant species are: *Terminalia crenu-*

lata, *Anogeissus latifolia* and *Grewia tiliaefolia.* The absence of *Tectona grandis* and *Lagerstroemia microcarpa* could be due to differences in soil, terrain or factors associated with dispersal of propagules including dispersal by humans. Both species occur at other sites in the area.

HUMAN IMPACT

The forests of the BRT Sanctuary have been impacted by humans for a very long time. The Soligas have lived there for centuries, practicing shifting agriculture, gathering forest products and hunting wildlife. Although shifting agriculture has been discontinued in recent decades, the collection of non-timber forest products continues. For some products, (*Phyllanthus emblica,* for example), there is evidence that the extraction levels have increased over time (Uma Shankar et al. 1996).

Timber has also been commercially extracted from the BRT forests in the past. The state forest department has mostly used selective felling to remove timber trees. Although there has been no commercial logging since the mid 1980s, the forests have not yet recovered. The canopy at many places is sparse and the weeds, particularly *Lantana camara* are abundant by roadsides, near settlements, and in large openings.

Thus, the differences in forest structure, composition and regeneration at the two sites could also be due to differences in history as well as current usage patterns. Differences in soils, microclimate, frequency of fires and grazing could also influence the outcome. Therefore, the differences in species diversity between the two sites could be due to factors outlined above. However, a greater number of cut stems and dead trees at the proximal sites as compared to distant sites is apparently due to the present usage patterns.

Comparison of the size-class distribution of species, such as *Phyllanthus emblica, Terminalia chebula,* and *T. bellirica* and dominant species that are not being harvested for any of their parts also shows the impact of recent and current anthropogenic pressures on populations of extracted species. First, the pooled data for all species indicates that the frequency of individuals in the smallest size class in NTFP species is significantly less than that for TFP species. Furthermore, in each of the NTFP species, the percentage of individuals in the 1–10 cm dbh class is less than the next size class. Only one out of three TFP species shows this pattern, indicative of poor recruitment. Episodic recruitment could also account for poor regeneration, but the consistency of differences in population strucures between the two classes of species, TFP and NTFP, suggests that differences are due to harvest of seeds and fruits.

It is interesting that the regeneration potential of NTFP species is poor at both the proximal and distant sites. However, the frequency of smaller size classes is lower in proximal than in the distant sites. This is true for TFP species also.

Poor recruitment could also result from fire, grazing, and compaction of soil from large mammals, such as elephants, gaur, and deer, all of which are abundant in the area. Fires occur with high frequency in the area, but grazing by domesticated cattle, though common elsewhere in India, may not be a major factor in the BRT sanctuary because less than 33% of the estimated 978 households in the sanctuary own livestock. The wild mammals have been a part of the ecosystem for thousands of years and should not normally curtail regeneration, but because of extensive deforestation in the surrounding areas, the number of large mammals may be unusually high relative to the area of the sanctuary. Although fire, grazing and soil compaction may be interfering with regeneration, these factors do not explain the differences in the frequency of small size classes between TFP and NTFP species.

Seeds of all the three NTFP species are dispersed by large mammals. The mechanism of seed dispersal for the three TFP species are not known, though the fruit morphology of two species, *Terminalia crenulata* and *Grewia tiliaefolia* suggests that the former is dispersed by mammals and the latter by birds. To the extent that seed dispersers may also act as seed predators, combined 'predation' by mammals and humans could have a negative effect on recruitment of tree populations.

Clearly, many factors may be responsible for poor regeneration of NTFP species. Although extraction by humans appears to have an effect on regeneration of the harvested species, the relative contributions of the harvesting by humans to low frequency of small size classes is not known. Research on the various factors that influence regeneration, and on demographic models based on the current population structures that may predict population trends are currently underway. It should also be mentioned that regeneration in general is poor in most of India's forests, perhaps due to intense anthropogenic pressures. Sukumar et al. (1992) noted poor regeneration for the dominant species in Mudumalai. In addition, a recent forest inventory on a large scale, involving the entire district of Mysore, in which the BRT sanctuary is located, indicates the lack of saplings at many sites (Forest Survey of India 1995). Thus, the extraction of non-timber forest products, without adequate controls and management, can further limit the already inadequate regeneration.

Conclusions

Millions of people in India derive a subsistance level livelihood by extracting forest products. The well being of these people depends upon the maintenance of regenerating forests. Yet the extraction itself may be contributing to the demise of the forests. The forest managers in India have neglected the management of non-timber forest products, which annually contribute heavily to the rural economies at the expense of timber trees (Chambers et al. 1989). However, with the ban on logging of timber trees from natural forests in most states, particularly in protected areas, NTFPs constitute the primary forest resources. These resources, when adequately managed, have the potential to enhance rural income without jeopardizing the existance of forests. Adequate management requires information about the quantities of natural stocks, the amounts collected per unit area, and the impact of collection on forest structure and composition. Furthermore, as discussed in the companion paper, value addition by extractors can increase the economic returns for the extractors and, with adequate controls, decrease the amounts collected, thereby conserving natural stocks.

Acknowledgments

This paper represents contribution number 32 of a research program in Conservation of Biodiversity and the Environment jointly coordinated by the Tata Energy Research Institute and the University of Massachusetts at Boston. The program is supported in part by the MacArthur Foundation. Work on this manuscript has also been supported, in part, by a grant from the Biodiversity Conservation Network of the Biodiversity Support Program of the World Wildlife Fund. We thank Madhav Gadgil, Utkarsh Ghate, Pamela Hall and Joseph Rose for their comments on the manuscript. Joseph Rose also assisted in the compilation of figures and tables. Our collaboration with the Vivekananda Girijana Kalyana Kendra, BR Hills, greatly facilitated the field work. Many officials of the State Forest Department of Karnataka, especially A. N. Yellappa Reddy, S. N. Rai, S. M. Puttabuddhi, and Sanjay Mohan not only provided access to the old forest records, but also shared their views from time to time. The guidance rendered by the two Soliga youths, Basava and Kumbha, during field surveys made this work possible. We also thank numerous forest people for interacting and appraising us of their invaluable knowledge about the forest.

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Book Review

The Farming Game Now. J. P. Makeham and L. R. Malcolm. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211. 1993. xi + 399 pp. (hardcover), $79.95. ISBN 0-521-40452-5. (paperback). $34.95. ISBN-0-521-42679-0.

This is a textbook of farm management covering the basic principles of microeconomics as they apply to agriculture. *The Farming Game Now* has much material of interest for those readers of *Economic Botany* who are concerned with the development of new crops, or for those you might be contemplating a venture into commercial farming. The book covers in an accessible style all economic aspects of the individual farm business, including chapters on financial management, animal farm management, crop farm management, machinery, buying and leasing farmland, risk, and analysis and planning.

Most economic botanists are concerned with questions such as: what natural products are found in a particular plant?; have these products been used in the past?; are they currently used?; or, are there markets for these products? We might answer all these questions in the affirmative and still not have the slightest idea why our plant is not more widely grown. Why, for instance, are such apparently valuable crops as grain amaranths, quinoa, or tepary beans not grown by more farmers? This book provides some of the answers from the grower's point of view. In deciding whether or not to include a new crop on his or her farm, the grower evaluates not only the financial risk, but how the crop fits into the current farm enterprise. Is the new crop compatible with the present crop rotation? What machinery is required? How much labor is required, and, equally importantly, when is it required? The principles of discounting, which apply particularly to perennial crops such as jojoba, guayule, palms, or fruit trees, are often not well understood by economic botanists.

The authors are from Australia. Examples the book uses are all from Australian agriculture, which differs substantially from agriculture as practiced in much of the United States and western Europe today. The difference is in Australia's greater use of integrated crop-livestock operations and lack of reliance on agricultural subsidies. I suspect that United States agriculture is more likely to move in the direction of Australian practices than vice-versa.

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