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Ecological problems of tree species in protected ecosystems of Orissa, India

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Abstract

The tree layer vegetation of two protected ecosystems *i.e.* Similipal Biosphere Reserve (SBR) and Bhitarkanika National Park (BNP) of eastern ghat was analysed for structure, composition and diversity. With respect to the tree species composition the two protected ecosystems were differed from each other at the family, genera and species level. About 117 tree species representing 85 genera and 42 families were recorded in SBR. The average number of species per hectare was 32.5. However, a total of 29 tree species representing 22 genera and 16 families were recorded in BNP with an average number of species per hectare of 24.17. Species dominancy of the two protected areas was also different due to their difference in habitat condition. In SBR *Shorea robusta* was the most dominant species while in BNP *Excoecaria agallocha* was the most dominant species. Shannon-Wiener species diversity was 3.15 for Similipal and 2.314 for Bhitarkanika indicating that Similipal was highly diverse than Bhitarkanika. In general both the protected ecosystems of Orissa are highly rich in biodiversity and are characteristics of good ecological wealth of eastern ghat. Thus conservation and management practices are essential for the sustainability of their biodiversity.

Key words

Protected area, Eastern ghats, Species composition, Species diversity, Vegetation dynamics

Introduction

Forest ecosystems are the major natural resources in Orissa covering about 37.34% of the State's geographical area and about 7.66% of country's forests. Eighteen percent of forests in Orissa have more than 40% crown cover known as good forest, which includes both reserve and protected forests (SPCB, 2006). Large population of the state utilizes various components of the forests for both commercial and subsistence purposes. In the past few decades, heavy human pressures have reduced the forested area in the country resulting in degradation and fragmentation of historically contiguous landscapes posing threats to biodiversity and local livelihoods. Between 1980 and 2004, in Orissa 28,800.73 ha of forest area has been diverted for different non-forestry purposes (SPCB, 2006). In today's human dominated environment it is necessary to have baseline ecological information on both reserved and protected forests for their ecological management in the future. The Man and Biosphere Programme launched by UNESCO (1971) aims at conserving the floral wealth in protected areas established by the Govt. of India in different states. Under the protected area network twenty numbers of protected areas have already been established in the state covering about 8019.12 sq.km. which is 13.79% of the State's forested area (SPCB, 2006). Orissa supports a wide range of terrestrial vegetation owing to its varied eco-climatic conditions. Since vegetation is the most obvious physical representation of ecosystems, state of vegetation in any area also indicates the health of ecosystem. Large protected areas free from heavy anthropogenic pressures safeguard ecosystem functioning and allow evolutionary processes. Long-term ecological services provided by the protected areas are often disturbed by the short term demands for the natural resources which lead to conflicts between conservation and development. Such conflicts have raised serious questions regarding the ways and means of managing the protected areas (Rawat, 2005; Sapkota *et al*., 2009 ; Dharani *et al*., 2009).The protected areas are important not only because these are storehouses of different life forms but also the naturally sound ecological areas containing soil, air and water, provide basic life

support systems for living organisms. The vegetation structure and function of protected areas has been studied by several workers in India such as Ilorkar and Totey (1999) in Navegaon National Park (Maharastra), Kothamasi *et al.* (1998) in Great Nicobar Biosphere Reserve (Andaman and Nicobar), Dattaraja *et al.* (1998) in Nilgiri Biosphere Reserve (Karnatak, Kerala and Tamilnadu), Tripathi (2000) in Nokrek Biosphere Reserve, Baruah (2000) in Manas Biosphere Reserve and Babu (2000) in Great Nicobar Biosphere Reserve. However, only a few studies on the vegetation dynamics of protected areas of Orissa were carried out by Mishra *et al.* (2003 and 2006). This paper deals with the vegetation dynamics of two different forest ecosystems (protected areas) of Orissa and highlights the significance of vegetation types and differences in structural ecological parameters.

Materials and Methods

To study the vegetation dynamics, 18 study sites were selected inside Similipal Biosphere Reserve (SBR) and 4 study sites inside Bhitarkanika National Park (BNP). Tree layer vegetation was analysed by sampling 20 quadrats of 10 × 10 m size at each site in SBR and 30 quadrats of the same size in BNP. The collected vegetation data were quantitatively analysed for density, frequency, abundance (Curtis and Mc Intosh, 1950) and Importance Value Index (Curtis, 1959). Trees were considered to be individuals $\geq$ 30 cm cbh (circumference at breast height) measured at 1.37 m from the ground for SBR and $\geq$10 cm cbh for BNP. The diversity index was computed by using Shannon-Wienner's information index (Shannon and Wiener, 1963) and concentration of dominance by Simpson's index (Simpson, 1949). Basal area was calculated as πr^2 where "r" is the radius of the stem.

Results and Discussion

Tree layer composition: A total of 117 tree species representing 85 genera and 42 families were recorded in SBR. The average number of species per hectare was 32.5. The number of species per genus was 1.38 and that per family was 2.79 (Table 1).

Species richness in some genera was quite high; *Ficus* had 8 species; *Albizia* and *Diospyros* both had 5 species each followed by *Bauhinia* and *Terminalia* (4 species each); *Wendlandia* (3); *Anthocephalus*, *Casearia*, *Dalbergia*, *Phoebe*, *Syzygium* and *Ziziphus* had 2 species each (Table 2). In tropical rain forests the range of tree species count per hectare is about 20 to a maximum of 223. The number of tree species $\geq$30 cm GBH in Similipal biosphere reserve was 33 ha^{-1} and this number is at the lower side of the range given in tropical rain forests. In the study of tree species richness of the Western ghat, South India Sunderpandian and Swamy (2000) stated that pronounced dry season and relatively low annual precipitation factors may correlate with low species richness. The lower tree species diversity (number of species) in the present study could also be partly attributed to enumerations restricted to only adult tree ($\geq$30 cm GBH) species. In the process juveniles (especially pioneer species) which come up in the canopy gaps were ignored off.

Table - 1: General characteristics of the tree layer vegetation of two protected areas of Orissa

Parameters	Protected areas	
	SBR	BNP
Total number of species	117	29
Total area sampled (in ha.)	3.6	1.2
Total number of family	42	16
Total number of genera	85	22
Species richness ha^{-1}	32.5	24.17
Species/Genus ratio	1.38	1.32
Species/Family ratio	2.79	1.81

SBR = Similipal Biosphere Reserve, BNP = Bhitarkanika National Park

During ecological sampling at BNP we found a total of 29 species in the tree layer representing 22 genera and 16 families within 1.2 ha area. The average number of species ha^{-1} was 24.17. The number of species per genus was 1.32 and that per family was 1.81 (Table 1). In Bhitarkanika the genera like *Avicennia* and *Xylocarpus* had 3 species each followed by *Heriteria*, *Rhizophora* and *Sonnertia* with 2 species each. Rest of the genera had one species each (Table 3).

Occurrence, density, frequency and basal area: *Shorea robusta* was the most frequent species of the reserve followed by *Terminalia alata*, *Protium serratum*, *Syzygium cumini, Dillenia pentagyna, Adina cordifolia, Buchanania lanzan* and *Terminalia chebula*. Several species which showed the minimum value of occurrence or site specific distribution were *Xantolish tomentosa, Wendlandia exerta, Trichilia connaroides, Trewia nudiflora, Tectona grandis, Symplocos chinensis, Suregada angustifolia, Sterculia urens, Saraca indica, Prunus ceylanica, Phoebe lanceolata, Phoebe wightii, etc.* (Table 2). Species wise density of individuals having $\geq$30 cm girth of the reserve ranged from less than one plant ha^{-1} to 284 plants ha^{-1} and the total density of the reserve was 794 plants ha^{-1}. Maximum density (per hectare of individuals of $\geq$30 cm girth) was recorded for *Shorea robusta* (284) followed by *Terminalia alata* (50), *Anogeissus latifolia* (45), *Protium serratum* (32) and *Dillenia pentagyna* (29). Density was observed less than or equal to one for many species like *Antidesma acidum, Artocarpus lacuccha, Butea monosperma, Casearia elliptica, Chionanthus intermedicus, Cochlospermum religiosum, Euonymus glaber, etc*. All other species showed intermediate range of density per hectare. Total basal area of trees of the reserve was 71.05 m^2 ha^{-1} in which maximum was experienced by *Shorea robusta*. *Shorea robusta* contributed maximum of 39% to the basal area followed by *Terminalia alata* (6.15%), *Anogeissus latifolia* (4.73%) and *Dillenia pentagyna* (3.57%). The total contribution that resulted from this associated combination of *Shorea-Terminalia-Anogeissus-Dillenia* was 53.45%. The density of 794 plants ha^{-1} and basal area of 71.05 m^2 ha^{-1} of the biosphere reserve is well within the reported range of various Indian tropical forests (Visalakshi, 1995; Sapkota *et al*., 2009).

Table - 2: Species composition, frequency (%), density (Plants ha^{-1}), basal area (m^2 ha^{-1}), Importance Value Index (IVI), Species diversity ($H^{/}$) and concentration of dominance (Cd) of tree layer in Similipal Biosphere Reserve (SBR)

Name of the family	Name of the plant species	Frequency (%)	Density (plants ha^{-1})	Basal area (m^2 ha^{-1})	IVI	$H^{/}$	Cd
Anacardiaceae	*Buchanania lanzan*	67	19.44	0.81	6.16	0.09	0.000602
	Lannea corromandelica	28	4.722	0.84	2.85	0.03	0.000036
	Mangifera indica	39	3.611	1.08	3.48	0.03	0.000021
	Semecarpus anacardium	11	1.94	0.08	0.78	0.02	0.000006
Annonaceae	*Miliusa velutina*	17	0.83	0.02	0.77	0.01	0.000001
Apocynaceae	*Holarrhena antidysentrica*	22	2.78	0.07	1.31	0.02	0.000012
Barringtoniaceae	*Baringtonia acutangula*	11	1.11	0.04	0.63	0.01	0.000002
Bignoniaceae	*Oroxylon indicum*	6	0.28	0.03	0.29	0	0.0000001
	Sterospermum suaveolens	39	1.94	0.33	1.82	0.02	0.000006
Bombacaceae	*Bombax ceiba*	56	10.83	1.53	5.64	0.06	0.000187
Burseraceae	*Garuga pinata*	28	2.78	0.16	1.65	0.02	0.000012
	Protium serratum	83	32.22	1.99	10.1	0.13	0.001654
Caesalpinaceae	*Bahunia malabarica*	6	1.11	0.01	0.48	0.01	0.000002
	Bauhinia purpurea	6	0.56	0.06	0.3	0.01	0.000001
	Bahunia variegata	11	1.11	0.28	0.96	0.01	0.000002
	Bauhinia roxburghiana	6	1.11	0.09	0.36	0.01	0.000002
	Cassia fistula	44	6.67	0.12	3.06	0.04	0.000071
	Saraca indica	11	1.11	0.04	0.63	0.01	0.000002
Celastraceae	*Elaeodendron glaucum*	6	0.56	0.02	0.32	0.01	0.000001
	Euonymus glaber	6	0.56	0.1	0.31	0.01	0.000001
Cochlospermaceae	*Cochlospermum religiosum*	6	0.28	0.01	0.26	0	0.0000001
Clusiaceae	*Mesua ferea*	11	0.83	0.03	0.55	0.01	0.000001
Combretaceae	*Anogeissus latifolia*	78	45.28	3.36	13.4	0.16	0.003267
	Terminalia alata	94	50.28	4.37	16.1	0.18	0.004028
	Terminalia arjuna	11	1.39	0.38	0.61	0.01	0.000003
	Terminalia bellirica	44	6.67	0.44	3.49	0.04	0.000071
	Terminalia chebula	61	5.56	0.78	4.3	0.04	0.000049
Dilleniaceae	*Dillenia pentagyna*	78	29.17	2.53	10.2	0.12	0.001355
Dipterocarpaceae	*Shorea robusta*	100	284.17	27.73	77.7	0.37	0.128663
Ebenaceae	*Diospyros malabarica*	6	0.83	0.01	0.33	0.01	0.000001
	Diospyros melanoxylon	44	8.61	0.66	3.73	0.05	0.000118
	Diospyros montana	22	2.78	0.07	1.34	0.02	0.000012
	Diospyros sylvatica	11	0.83	0.34	0.59	0.01	0.000001
	Diospyros embryopteris	22	2.78	0.17	1.44	0.02	0.000012
Euphorbiaceae	*Antidesma acidum*	6	0.28	0.05	0.32	0	0.0000001
	Bridelia retusa	39	4.72	0.45	2.73	0.03	0.000036
	Cleistanthus collinus	11	3.33	0.06	0.94	0.02	0.000018
	Croton roxburghii	22	6.11	0.21	1.93	0.04	0.000059
	Glochidion lanceolarium	11	1.11	0.06	1.43	0.01	0.000002
	Glochidion velutinum	6	1.11	0.03	0.39	0.01	0.000002
	Macaranga peltata	6	0.556	0.023	0.32	0.01	0.000001
	Mallotus phillipensis	17	1.944	0.054	0.97	0.02	0.000006
	Phyllanthus emblica	28	4.17	0.2	1.88	0.03	0.000028
	Securinega virosa	33	11.11	1.02	4.13	0.06	0.000197
	Suregada angustifolia	6	1.39	0.1	0.54	0.01	0.000003
	Trewia nudiflora	11	0.56	0.19	0.77	0.01	0.000001
Fabaceae	*Butea monosperma*	6	0.56	0.01	0.3	0.01	0.000001
	Desmodium oojeinensis	28	5	0.58	2.53	0.03	0.00004
	Pterocarpus marsupium	56	12.22	1.24	5.43	0.06	0.000238
Flacourtiaceae	*Casearia graveolens*	56	5.28	0.12	2.98	0.03	0.000044
	Homalium nepalens	11	1.667	0.04	0.68	0.01	0.000004
	Casearia elliptica	6	0.28	0.01	0.27	0	0.0000001
Lauraceae	*Phoebe lanceolata*	6	0.56	0.02	0.32	0.01	0.000001
	Phobe wightii	6	0.28	0.11	0.41	0	0.0000001
Lecythidaceae	*Careya arborea*	44	6.67	0.36	3.07	0.04	0.000071
Lythraceae	*Lagerstroemia parviflora*	33	6.389	0.39	2.65	0.04	0.000065
Magnoliaceae	*Michelia champaca*	11	7.778	0.98	2.78	0.05	0.000096

Malvaceae	*Kydia calycina*	39	5.556	0.22	2.51	0.04	0.000049
Melastomataceae	*Memecylon umbelatum*	6	0.833	0.03	0.36	0.01	0.000001
Meliaceae	*Melia dubia*	6	0.278	0.1	0.39	0	0.0000001
	Trichilia connaroides	6	0.56	0.21	0.59	0.01	0.0000005
Mimosaceae	*Accacia leucophloea*	11	1.11	0.03	0.61	0.01	0.000002
	Albizia chinensis	6	1.94	0.06	0.55	0.02	0.000006
	Albizia lebbeck	11	1.94	0.14	0.87	0.02	0.000006
	Albizia marginata	22	3.33	0.37	1.8	0.02	0.000018
	Albizia odoratissima	6	0.56	0.06	0.36	0.01	0.000001
	Albizia procera	28	2.5	0.19	1.5	0.02	0.00001
	Dalbergia latifolia	22	2.78	0.21	1.41	0.02	0.000012
	Dalbergia sisoo	6	0.56	0.14	0.31	0.01	0.000001
	Samanea saman	3	2.78	0.13	1.4	0.02	0.000012
	Xylia xylocarpa	17	2.78	0.2	1.27	0.02	0.000012
Moraceae	*Ficus benghalensis*	33	1.67	1.61	3.76	0.01	0.000004
	Ficus benjamina	6	0.28	0.09	0.38	0	0.0000001
	Ficus glomerulata	17	2.22	0.05	0.99	0.02	0.000008
	Ficus microcarpa	6	0.28	0.12	0.42	0	0.0000001
	Ficus religiosa	11	0.83	0.35	1.03	0.01	0.000001
	Ficus semicordata	6	1.11	0.24	0.49	0.01	0.000002
	Ficus sp.	28	2.5	0.18	1.65	0.02	0.00001
	Ficus virens	6	1.94	0.18	0.71	0.02	0.000006
	Artocarpus lacuccha	6	0.83	0.11	0.48	0.01	0.000001
Myrsinaceae	*Embelia tsjeriam*	6	0.56	0.01	0.3	0.01	0.000001
Myrtaceae	*Syzygium cerasoides*	67	18.06	1.27	6.64	0.09	0.000519
	Syzygium cumini	83	23.06	2.03	10.2	0.1	0.000847
Ochnaceae	*Ochna obtusata*	17	5.83	0.35	1.87	0.04	0.000054
Oleaceae	*Schrebera swetinoides*	6	0.56	0.01	0.29	0.01	0.000001
	Chionanthus intermedicus	6	0.56	0.03	0.32	0.01	0.000001
	Ligustrum gamblei	6	0.833	0.04	0.38	0.01	0.000001
	Nyctanthes arber-tristis	28	3.89	0.15	1.79	0.03	0.000024
Rhamnaceae	*Ziziphus mauritiana*	6	0.28	0.04	0.31	0	0.0000001
	Ziziphus rugosa	28	2.78	0.05	1.48	0.02	0.000012
Rosaceae	*Prunus ceylanica*	6	0.83	0.06	0.4	0.01	0.000001
Rubiaceae	*Morinda pubescens*	6	0.56	0.01	0.3	0.01	0.0000005
	Wendlandia exerta	11	1.39	0.03	0.65	0.01	0.000003
	Wendlandia sp.	6	0.28	0.003	0.25	0	0.0000001
	Wendlandia tinctoria	28	3.61	0.21	1.82	0.03	0.000021
	Adina cordifolia	78	11.94	1.44	6.54	0.06	0.000227
	Anthocephalus cadamba	6	0.56	0.11	0.43	0.01	0.000001
	Anthocephalus chinensis	6	1.11	0.08	0.47	0.01	0.000002
	Gardenia latifolia	11	1.94	0.16	0.89	0.02	0.000006
	Hymenodictyon excelsum	11	1.389	0.24	0.95	0.01	0.000003
	Ixora sp.	11	0.556	0.012	0.52	0.01	0.0000005
	Mitragyna parviflora	22	2.222	0.94	2.46	0.02	0.000008
Rutaceae	*Aegle marmelos*	44.44	4.722	0.353	2.81	0.03	0.000036
	Murraya koengi	28	2.5	0.01	0.54	0.01	0.000002
	Micromelum minutum	6	1.39	0.085	0.51	0.01	0.000003
Salicaceae	*Salix tetrasperma*	6	1.11	0.04	0.42	0.01	0.000002
Sapindaceae	*Schleichera oleosa*	33	13.33	1.48	5.05	0.07	0.000283
Sapotaceae	*Madhuca latifolia*	44	12.778	1.074	4.84	0.07	0.00026
	Xantolish tomentosa	6	0.28	0.02	0.28	0	0.0000001
Simaroubaceae	*Ailanthus excelsa*	11	1.94	0.02	0.84	0.02	0.000006
	Gmelina arborea	50	5.28	0.44	3.21	0.03	0.000044
Sterculiaceae	*Sterculia urens*	6	1.11	0.004	0.36	0.01	0.000002
	Firmiana colorata	6	1.94	0.01	0.62	0.02	0.000006
Symplocaceae	*Symplocos chinensis*	6	0.56	0.03	0.32	0.01	0.000001
	Symplocos racemosa	6	0.556	0.025	0.3	0.01	0.0000005
Verbenaceae	*Tectona grandis*	6	0.83	0.06	0.4	0.01	0.000001
	Vitex leucoxylon	39	5.56	0.21	2.5	0.04	0.000049
Total			**793.66**	**71.043**	**300**	**3.15**	**0.1437071**

Table - 3: Species composition, frequency (%), density (Plants ha^{-1}), basal area (m^2 ha^{-1}), Importance Value Index (IVI), Species diversity ($H^/$) and Concentration of dominance (Cd) of tree layer in Bhitarkanika National Park (BNP)

Name of the family	Name of the plant species	Frequency (%)	Density (Plants ha^{-1})	Basal area (m^2 ha^{-1})	IVI	$H^/$	Cd
Apocynaceae	*Cerbera manghas*	50	30	0.28	3.683	0.014	0.0000055
Arecaceae	*Phoenix paludosa*	75	84.33	0.11	4.851	0.033	0.0000432
Avicinniaceae	*Avicennia alba*	75	568.33	1.23	12.164	0.138	0.0019637
	Avicennia marina	25	246	0.89	6.012	0.076	0.0003679
	Avicennia officinalis	100	384.5	3.17	18.142	0.105	0.0008988
Caesalpinaceae	*Cynometra ramiflora*	50	979	1.15	13.831	0.196	0.0058268
	Intsia bijuga	25	27	0.3	2.440	0.013	0.0000044
Combretaceae	*Lumnitzera racemosa*	50	1012.5	2.26	17.599	0.200	0.0062324
Euphorbiaceae	*Excoecaria agallocha*	100	3585.5	6.54	53.748	0.356	0.0781562
Malvaceae	*Hibiscus tiliaceous*	75	124.33	0.21	5.479	0.045	0.0000940
	Thespesia populnea	75	13.33	0.03	4.045	0.007	0.0000011
	Xylocarpus granatum	100	33.25	0.25	6.177	0.015	0.0000067
	Xylocarpus mekongensis	50	21.5	0.1	3.048	0.011	0.0000028
	Xylocarpus molluccensis	50	21.5	0.18	3.3	0.011	0.0000028
Meliaceae	*Amoora cucullata*	50	81.5	0.66	5.285	0.032	0.0000404
Myrsinaceae	*Aegiceras corniculatum*	100	639.25	0.52	11.755	0.149	0.0024843
Papilionaceae	*Pongamia pinnata*	50	123.5	1.05	6.845	0.045	0.0000927
Plumbaginaceae	*Aegialities rotundifolia*	50	155	0.41	5.068	0.053	0.0001461
Rhizophoraceae	*Bruguiera gymnorrhiza*	75	45.66	0.14	4.645	0.02	0.0000127
	Ceriops decandra	100	2026.25	1.48	25.603	0.292	0.0249603
	Kandelia candel	75	30	0.08	4.333	0.014	0.0000055
	Rhizophora apiculata	50	15	0.11	3.029	0.008	0.0000014
	Rhizophora mucronata	100	43.25	0.28	6.35	0.019	0.0000114
Sonneratiaceae	*Sonnertia apelata*	100	79	1.16	9.409	0.031	0.0000379
	Sonnertia caseseolaris	100	367.33	1.23	11.879	0.102	0.0008203
Sterculiaceae	*Heritiera fomes*	100	2011.5	7.55	44.667	0.291	0.0245983
	Henitiera littoralis	25	47	0.23	2.375	0.021	0.0000134
Tamaricaceae	*Tamarix troupii*	25	20	0.03	1.533	0.01	0.0000024
Tiliaceae	*Brownlowia tersa*	50	10	0.02	2.705	0.006	0.0000006
Total			**12825.31**	**31.65**	**300**	**2.313**	**0.146834**

Table - 4: Distribution of tree species under various frequency classes in two protected ecosystems of Eastern ghat

Frequency class (%)	SBR	BNP
A (0-20)	71	00
B (21-40)	27	04
C (41-60)	10	10
D (61-80)	05	06
E (81-100)	04	09

As far as the distribution of species concerned in BNP *Aegiceras corniculatum, Avicennia officinalis, Ceriops decandra, Excoecaria agallocha, Hereteria fomes, Rhizophora mucronata, Sonnertia apelata* and *Sonnertia caeseolaris* were frequently distributed all over the national park while *Avicennia marina, Hereteria littoralis, Intsia bijuga* and *Tamarix troupii* were restricted in their distribution. The stand density of BNP was 12825 individuals ha^{-1} and basal area was 31.65 m^2 ha^{-1} for individuals with ≥10 cm girth (Table 3). Species wise density ranged from 10 to 3586 individuals per hectare with maximum was experienced by *Ceriops decandra* and minimum for *Brownlowia tersa*. However, the basal area of the National Park ranged from 0.02 to 7.65 $m^2 ha^{-1}$. Species wise maximum basal area was exhibited by *Heritiera fomes* and minimum by *Brownlowia tersa*. The tree (≥10 cm girth) density and basal area of mangrove species in the BNP recorded in the present study is comparable to the report of Satyanarayana *et al.* (2002), where basal area of 0.1 to 10.9 $m^2 ha^{-1}$ for the entire stand of Coringa mangroves have been reported.

Frequency class: Species wise frequency percentage in SBR ranged from 6 to 100% in which maximum was experienced by *Shorea robusta* and minimum by many species. Comparison of the percentage frequency in five different frequency classes (A=0-20%, B=21-40%, C=41-60%, D=61-80% and E=81-100%) of the reserve taking all the tree species into account indicates a decrease in number of species in successive 20% frequency class intervals up to 100% frequency class. This has been widely interpreted as being a fundamental community characteristic indicating homogeneity. However, in BNP there was a deviation in frequency class from the normal frequency class of Raunkiaer indicating the heterogeneity nature of the vegetation (Kershaw, 1973).

Importance Value Index (IVI): Importance Value Index (IVI) is the measurement of the ecological amplitude of the species (Ludwig

and Reynolds, 1988) which is the ability of a species to establish over an array of habitats. However, there is no single perfect way of assessing the ecological amplitude of a species. The abundance of a species can be represented by several measures such as relative density, relative frequency and Importance Value Index (IVI). Though frequency and density values are suitable for herbs and shrubs (Airi *et al.*, 2000), IVI is an important information for tree species. On the basis of IVI *Shorea robusta* was found as the dominant species in the SBR having IVI of 76.33 followed by *Terminalia alata* (15.57) and *Anogeissus latifolia* (13.16). *Wendlandia* sp. had IVI of 0.41 and is considered as the rare species of the reserve. All other tree species showed intermediate range of IVI (Table 2). But in BNP where the habitat condition is completely different from SBR, maximum value of IVI was recorded for *Excoecaria agallocha* (54) followed by *Heritiera fomes* (45), *Ceriops decandra* (26), *Avicennia officinalis* (18), *Avicennia alba* (12) and *Aegiceras corniculatum* (11.76) (Table 3).

Species diversity and concentration of dominance: Species diversity depends upon adaptation of species and increases with stability of community (Sagar and Singh, 2006). Shannon Wiener species diversity was 3.15 for SBR and 2.313 for BNP indicating that SBR was highly diverse and BNP was the least. The species diversity is generally higher for tropical forests, which is reported as 5.06 and 5.40 for young and old stand, respectively (Knight, 1975). For Indian forests the diversity index ranges between 0.83- 4.1 (Singh *et al.*, 1984; Visalakshi, 1995). The diversity index of tree species both in SBR and BNP are well within the reported range for the forests of Indian sub-continent (Table 2 and 3). Higher species diversity index in tropical forests as reported by Knight (1975) in comparison to the present investigation may be due to differences in the area sampled and lack of uniform plot dimensions. On the other hand the value obtained for the concentration of dominance for the tree layer both in SBR (0.144) and BNP (0.147) was greater than those recorded in Nelliampathy (0.085) (Chandrashekara and Ramakrishnan, 1994) and Silent valley (0.06-0.14) (Singh *et al.*, 1981). The high dominance value in the present study indicates single species dominance by *Shorea robusta* (around 25% of IVI value) in SBR and by *Excoecaria agallocha* (around 18% of IVI value) in BNP (Table 2, 3). Both these protected ecosystems of Orissa are highly rich in biodiversity and are characteristics of good ecological wealth of eastern ghat. The ecological value obtained on structural characteristics is comparable to other forests of the country.

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References

Airi, S., R.S. Rawal, U. Dhar and A.N. Purohit: Assessment of availability and habitat preference of Jatamasi - A critically endangered medicinal plant of West Himalayas. *Curr. Sci.*, **79**, 1467-1470 (2000).

Babu, C.R.: Inventorisation, utilization and conservation of biodiversity in the Great Nicobar biosphere reserve. *In*: Biosphere reserves in India and their management (*Eds.*: J.K. Sharma, P.S. Easa, C. Mohanan, N. Sasidharan and R.K. Rai). Kerala Forest Research Institute, Peechi, Kerala. pp. 151-153 (2000).

Baruah, C.K.: Biodiversity status in Manas biosphere reserve. *In*: Biosphere reserves in India and their management (*Eds.*: J.K. Sharma, P.S. Easa, C. Mohanan, N. Sasidharan and R.K. Rai). Kerala Forest Research Institute, Peechi, Kerala. pp. 151-153 (2000).

Chandrashekara, U.M. and P.S. Ramakrishnan: Vegetation and gap dynamics of a tropical wet evergreen forest in the western ghats of Kerala, India. *J. Trop. Ecol.*, **10**, 337-354 (1994).

Curtis, J. and R. Mc Intosh: An upland forest continuum in the prairie forest border region of Wisconsin. *Ecology*, **32**, 476-496 (1950).

Curtis, J.T.: The vegetation of Wisconsin. Wisconsin Press, Madison (1959).

Dattaraja, H.S., H.S. Suresh, J. Robert and R. Sukumar: Ecological research in Nilgiri biosphere reserve. *In*: Biosphere reserves and management in India (*Eds*.: R.K. Maikhuri, K.S. Rao and R.K. Rai). Himavikas Occassional Publication No. 12, Almora. pp. 163-170 (1998).

Dharani, N., J.I. Kinyamario, P.W. Wagacha and A.J. Rodrigues: Browsing impact of large herbivores on *Acacia xanthophloea* Benth. in lake Nakuru national park, Kenya. *Afr. J. Ecol.,* **47**, 184-191 (2009).

Ilorkar, V.M. and N.G. Totey: Regeneration status of Navegaon national park, Maharastra. *Ind. J. For.*, **22**, 203-209 (1999).

Kershaw, K.A.: Quantitative and dynamic plant ecology. Edward Arnold, London (1973).

Knight, D.H.: A phytosociological analysis of species rich tropical forest on Barro Colorado Island, Panama. *Ecol. Monograph*, **45**, 259-284 (1975).

Kothamasi, D.M., A. Bhattacharya and C.R. Babu: Ecosystem diversity in the Great Nicobar biosphere reserve. *In*: Biosphere reserves and management in India (*Eds.*: R.K. Maikhuri, K.S. Rao and R.K. Rai). Himavikas Occassional Publication No. 12, Almora. pp. 97-100 (1998).

Ludwig, J.A. and J.F. Reynolds: Statistical ecology: A primer on methods and computing. Wiley-Interscience, New York (1988).

Mishra, R.K., V.P. Upadhyay and R.C. Mohanty: Vegetation diversity of Similipal biosphere reserve. *E-Planet*, **1**, 4-9 (2003).

Mishra, R.K., V.P. Upadhyay, P.K. Mohapatra, S. Bal and R.C. Mohanty: Phenology of species of moist deciduous forest sites of Similipal biosphere reserve. *Lyonia,* **11**, 5-17 (2006).

Rawat, G.S.: Terrestrial vegetation and ecosystem coverage within Indian protected areas. *Nat. Acad. Sci. Lett.*, **28**, 241-250 (2005).

Sagar, R. and J.S. Singh: Tree density, basal area and species diversity in a disturbed dry Tropical forest of northern India: Implications for conservation. *Environ. Conser.,* **33**, 256-262 (2006).

Sapkota, I.P., M. Tigabu and P.C. Oden: Species diversity and regeneration of old-growth seasonally dry *Shorea robusta* forests following gap formation. *J. For. Res*., **20**, 7-14 (2009).

Satyanarayana, B., A.V. Raman, F. Dehairs, C. Kalavati and P. Chandramohan: Mangrove floristic and zonation patterns of Coringa, Kakinada Bay, East Coast of India. *Wetland Ecology and Management*, **10**, 25-39 (2002).

Shannon, C.E. and W. Wiener: The mathematical theory of communication. University of Illinois Press, Urbana (1963).

Simpson, E.H.: Measurement of diversity. *Nature*, **163**, 688 (1949).

Singh, J.S., S.P. Singh, A.K. Saxena and Y.S. Rawat: The Silent valley forest ecosystem and possible impact of proposed hydroelectric project.Reports on the Silent valley study. Ecology Research Circile, Kumaun University, Nainital (1981).

SPCB, Orissa: State of environment Orissa. Member Secretary, State Pollution Control Board, Orissa (2006).

Sunderpandian, S.M. and P.S. Swamy: Forest ecosystem structure and composition along an altitudinal gradient in the western ghats, south India. *J. Trop. For. Sci.*, **12**, 104-123 (2000).

Tripathi, R.S.: Studies on impact of human activities in buffer zone ecosystems of Nokrek biosphere reserve. *In*: Biosphere reserves in India and their management (*Eds*.: J.K. Sharma, P.S. Easa, C. Mohanan, N. Sasidharan and R.K. Rai). Kerala Forest Research Institute, Peechi, Kerala. pp. 151-153 (2000).

UNESCO: Final report. First session, International coordinating council of the programme on Man and the Biosphere (MAB), Paris. pp. 9-19 November (1971).

Visalakshi, N.: Vegetation analysis of two tropical dry evergreen forests in Southern India. *Tropical Ecol.*, **36**, 117-127 (1995).