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Population structure of dominant tree species in tropical deciduous forest covers of Chandaka Dampara wildlife sanctuary, Odisha, India

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ABSTRACT

Population structure based on girth at breast height (gbh) measurements of individuals of nine dominant tree species viz. *Careya arborea* Roxb., *Shorea robusta* Gaertn. f., *Strychnos nux-vomica* L., *Tectona grandis* L. f., *Pterocarpus marsupium* Roxb., *Limonia acidissima* L., *Azadirachta indica* A. Juss., *Cassia fistula* L. and *Aegle marmelos* (L.) Corr. was studied in disturbed and undisturbed forest stands of Chandaka Wildlife Sanctuary (CWS), Odisha. All the dominant species except *Careya arborea*, *Shorea robusta* and *Limonia acidissima* in undisturbed stand and, *Tectona grandis* and *Pterocarpus marsupium* in disturbed stand showed rotated sigmoid type of gbh-density curve. Concave type of gbh-density curve of *Shorea robusta* only in undisturbed forest stand and of *Careya arborea* was recorded both in disturbed and undisturbed forest stands of the sanctuary indicating their strong dominance. However, formation of plateaus and depressions in gbh-density curve of *Shorea robusta, Tectona grandis* and *Pterocarpus marsupium* at the disturbed stand reflect the gap phase type of regeneration with a resultant reduction in survival of individuals during respective stages. A low percentage of established seedlings compared to saplings of *Limonia acidissima* was observed in the undisturbed stand of the sanctuary. Cut stumps frequently occurred in the disturbed stands giving rise to more number of sprouters. However, due to frequent lopping of the coppices there was no substantial regeneration and establishment of trees in the disturbed stand of the sanctuary. With continuance of such activities in the sanctuary, future populations of dominant tree species in the forest covers may be threatened, thus requiring conservation measures to protect these species.

1. Introduction

The forest covers of eastern India are exposed to various kinds of disturbances including logging and clear felling, which are commonly practised in this region. However, a few forest patches are still protected and undisturbed. The increase in population pressure in recent years has caused accelerated tree felling and reduction in forest area. The forest cover in the state of Odisha, a constituent unit of eastern India has been depleted by 9.01% from 1981 and 2005 (FSI, 1987 and 2005) and the regeneration of native trees on disturbed stand is becoming exceedingly difficult. The prevailing disturbance may strongly influence the population structure of trees in these forests. In most of the forest covers of North East India and some forest covers of Odisha strategies of forest regeneration through analysis of the age and gbh / cbh structure of constituent tree species have been studied by several workers (Uma Shankar, 2001; Mohanty *et al.*, 2005; Khumbongmayum *et al.*, 2006; Vipin and Madhur, 2014). However, such type of study is completely lacking in Chandaka wildlife sanctuary. Thus the present study on the species composition and gbh structure of nine dominant tree species in the disturbed and undisturbed forest stands of Chandaka was undertaken to analyse the effect of disturbance on the population structure of tree species.

1.1 Study sites and climate

Chandaka Wildlife Sanctuary (CWS), Odisha (location co-ordinates: 20º 12’ 30" and 20º 26’ 03" N latitudes and 85^0 49’ 35" and 85^0 34’ 42" E longitudes covering an area of 193.39 sq. km) represents the north-eastern limits of Eastern Ghats. It forms the uppermost part of ‘North Eastern Ghats sub-division becoming a part of ‘Tropical deciduous forest biome’. This is now an isolated forest, though once formed a part of vast Eastern Ghats forest and Central Indian Elephant range (Tiwari *et al.*, 1997). The sanctuary was once covered with dense forest covers harbouring a rich biodiversity, but with the establishment of state capital at Bhubaneswar in 1957, this forest came under enormous pressure for grazing, firewood collection and illegal removal of timber for various constructional activities of local inhabitants causing thinning of forest cover and threatening its sustainability (Tiwari, 2000). However, the year 1982 the Govt. declared this forest as a wildlife sanctuary for overall protection of the gasping forest ecosystem, more particularly, to provide a safe habitat for resident elephants.

The CWS altitude varies from 35 m to 219 m above the sea level and in all there are 32 small hillocks and hills of the sanctuary (Mishra and Sarangi, 1984). The sanctuary experiences a wet tropical monsoon type of climate. Average annual rainfall is about 1498 mm experiences in two parts of the year i.e. from June to September (76 %) and from October to December (14 %). The mean maximum temperature ranges from 31^0 C to 34^0 C during summer (March-June) and the mean minimum from 12^0 C to 24^0 C during winter (December –February). The mean maximum humidity ranges from 71 % to 83 % is recorded during the south-west monsoon and the mean minimum from 41% to 78% during March-June. The atmosphere is more humid than the inland regions of Odisha (Tiwari, 2000).

2. Materials and methods

Dominant tree species of the sanctuary were selected on the basis of Importance Value Index (IVI). IVI of tree species of the sanctuary was determined as: IVI = relative frequency + relative density + relative basal area (Kershaw, 1973). The degree of disturbance of the study sites was analysed through study of disturbance index (Pandey and Shukla, 1999). Population structure of dominant woody perennials of the sanctuary was studied during 2011-2012 using quadrat method. Quadrats of 20 m x 20 m for trees, 5 m x 5 m for saplings and 1 m x 1 m for seedlings were laid randomly in each site. The gbh structure of dominant woody perennials of the sanctuary were grouped into five different gbh classes viz., < 10cm (seedlings), 10 – 30 cm (saplings/Juvenile), 30 - 90 cm (young), 90 - 180 cm (elder) and > 180 cm (mature) (Uma Shankar, 2001). Number of individuals belonging to each of the above girth class was recorded. Basal area (m^2/ha) and the density (plants/ha) of individuals of each girth class was calculated as per Kershaw (1973).

3. Results and discussion

Human activity had induced various modifications on the structure and function of forest ecosystems which can be determined through study of the age structure of woody perennials on the basis of different age classes. The five different age classes of dominant tree species determined on the basis of their gbh classes were subjected to analysis and interpretation. Basal area (m^2/ha) of adult trees (>30cm gbh) of living and damaged plants were calculated to find the disturbance index (D.I.). Stands were classified as disturbed (disturbance index : >50%) and undisturbed (disturbance index: <30%) (Table 1)

3.1 Tree species composition

The disturbed (Jahalara, Ambilo, Deras and Minchipatana) and undisturbed (Salapada, Godibari, Kumarkhunti and Chhatiani) sites of CWS have 41 and 37 tree species, respectively. Out of these *Morinda pubescens, Terminalia arjuna, Terminalia alata, Terminalia bellirica, Buchanania lanzan, Ziziphus mauritiana, Limonia acidissima, Aegle marmelos, Alstonia scholaris, Diospyros sylvatica, Xylia xylocarpa, Cassia fistula, Cleistanthus collinus, Holarrhena pubescens, Diospyros melanoxylon, Casearia elliptica, Strychnos nux-vomica, Careya arborea, Lannea coromandelica, Azadirachta indica, Mitragyna parvifolia, Atalantia monophylla, Butea monosperma, Pterocarpus marsupium, Peltophorum pterocarpum, Tectona grandis, Shorea robusta, Lagerstroemia parviflora, Bombax ceiba, Phyllanthus emblica* and *Simarouba glauca* are common to both the stands (Table 2). *Alangium salvifolium, Anthocephalus chinensis, Syzygium cumini, Tamarindus indica, Pongamia pinnata, Madhuca indica, Mangifera indica, Benkara malabarica, Borassus flabellifer* and *Streblus asper* occur only in the disturbed stand, whereas *Dalbergia paniculata, Anogeissus latifolia, Grewia tiliifolia, Albizia lebbeck, Chloroxylon swietiana* and *Bridelia retusa* are exclusive to the undisturbed stand (Table 2). The increase in species richness in the disturbed stand of the sanctuary may be primarily due to colonization by fast growing secondary species like *Anthocephalus chinensis, Pongamia pinnata, Syzygium cumini* and *Tamarindus indica* in the open gaps created due to selective cutting of economically valuable tree species. Secondly disturbance favours both the competitive species and those others that tolerate disturbance to co-exist (Quigley and Platt, 2003; Upadhaya

Table 1
Basal area (m^2/ha) and Disturbance Index (%) of study sites.

Sites	Basal area			Disturbance Index (%)
	Normal plants	Damaged plants	All plants	
Jhalara	19.69	21.59	41.28	52.30
Amibilo	11.77	17.69	29.46	60.05
Deras	15.89	24.34	40.23	60.50
Minchipatana	13.56	20.17	33.73	59.79
Salapada	37.99	9.46	47.45	19.94
Godibari	57.42	11.23	68.65	16.36
Kumarkhunti	26.49	10.41	36.30	28.21
Chhatiani	20.81	8.68	29.49	29.43

et al., 2006). Some studies also demonstrated that in tropical conditions maximal species richness occurs under different disturbance regime (Paine and Levin, 1981; Hobbie *et al.*, 1994).

3.2 Comparative phytosociological attributes

Average density (plants/ha) and basal area (m^2/ha) of tree species (>30 cm gbh), among disturbed and undisturbed forest stands of the sanctuary were significantly different (Table 3). As expected maximum tree density and basal area was recorded in undisturbed stand and minimum in disturbed stand (Table 3). However, a significant reverse condition was marked in case of the density of seedlings and density and basal area of saplings in the disturbed and undisturbed stands of the sanctuary. Significant negative relationship between tree density ($r = -0.86$) and basal area ($r = -0.85$) with that of disturbance index was observed, whereas the correlation between density of seedlings, saplings and basal area of saplings with that of disturbance index were significantly positive ($r = 0.70$ and 0.78, $P \leq 0.05$ for density of seedling and sapling, respectively and $r = 0.71$, $P \leq 0.05$ for sapling basal area). The forest stands were considerably dense, like other Sal dominated forests of India. Individuals of trees of >30cm gbh is comparable to the tree density of Sal dominated forest covers of Gorakhpur division (Pandey and Shukla, 2003) and Kumaun Central Himalaya (Arya,1991). However, the range of basal area (15.23 ± 3.42 to 35.68 ± 16.16) among the forest stands of the sanctuary may be due to differences in species composition, age of trees and degree of disturbance as observed in other Sal dominated forests of India (Pandey and Shukla, 2003).

3.3 Girth class wise Species richness, density and basal area:

Distribution of tree species in five age classes in the disturbed and undisturbed forest stands of the sanctuary showed a nearly linear decline from seedling to mature age class through juvenile, young and elder age classes (Fig. 1 'a' and 'b'). Primarily reduction in number of species with increase in age class may arise due to lower colonization rate of tree species in higher age classes in comparison to lower age classes (Dodd and Silvertown, 2000) and secondly due to selective felling of older trees for timber and other purposes (Rahman and Roy, 2014). Number of species in seedling and juvenile class in the disturbed forest stand of the sanctuary was more than undisturbed stand but with the increase in girth class the reverse condition was true. Low canopy cover in the disturbed forest stand might have favoured germination and seedling establishment through increased solar radiation on the forest floor and reduced competition from trees of upper canopy (Khan *et al.*, 1987; Oliver, 1981). Basal area (m^2/ha) of trees in four different age classes (juvenile, young, elder, mature) both in disturbed and undisturbed stands of the sanctuary showed a progressive increase and decrease from juvenile to young age class and elder to mature age class, respectively. But the density of trees in the said four different age classes both in the disturbed and undisturbed areas of the sanctuary showed a linear decline from juvenile to mature through young and elder age classes signifying that the density of few young individuals in comparison to juvenile resulted into greater percentage of basal area (Fig. 2 'a' and 'b'). The same trend was true in case of basal area and density of all woody species of the sanctuary as a whole (Fig. 3 'a' and 'b').

There are 5 mature, 22 elder, 28 young ,35 juvenile and 41 seedling species and in each class 3 to 4 species are dominant in terms of individuals and basal area, which gives rise to a mixed dominant pattern. For instance *Terminalia arjuna*, *Tamarindus indica*, *Shorea robusta*, and *Mangifera indica* in mature, *Limonia acidissima, Shorea robusta, Careya arborea*, *Cassia fistula* in elder, *Strychnos nux-vomica, Aegle marmelos, Careya arborea and Shorea*

Table 2
Importance Value Index (IVI) of tree species at different study sites of Chandaka Wildlife Sanctuary (CWS).

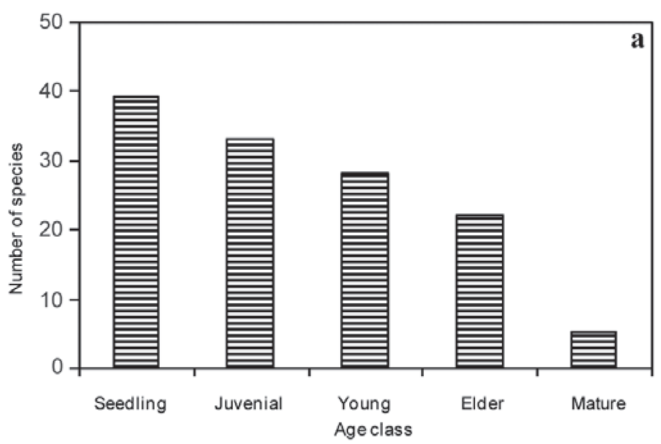
Name of Tree Species	Godibari	Salapada	Chhatiani	Kumarkhunti	Deras	Jhalara	Ambilo	Minchipatana
Aegle marmelos(L.) Corr.	10.52	3.17	10.52	4.09	16.24	15.32	5.58	19.60
Alangium salvifolium (L.F.) Wang.	-	-	-	-	-	11.93	-	1.36
Albizia lebbck (L.)Benth	6.92	1.136	-	0.83	-	-	-	-
Alstonia scholaris (L.)R.Br	-	-	16.77	12.54	9.17	-	11.48	-
Anogeissus latifolia (Roxb.ex DC.) Wall. ex Guill.& Perr.	19.85	8.86	-	-	-	-	-	-
Anthocephalus chinensis (Lam.) A.Rich. ex Walp.	-	-	-	-	-	-	-	1.25
Atalantia monophylla (L.)Corr.	12.06	8.01	6.63	3.16	10.64	16.41	16.61	-
Azadirachta indica A.Juss.	8.75	1.55	5.76	10.77	21.75	16.75	4.55	41.72
Bombax ceiba L.	4.88	2.78	1.49	5.26	-	-	1.85	-
Borassus flabellifer L.	-	-	-	-	1.26	-	-	6.99
Bridelia retusa (L.) Spreng.	21.12	16.58	7.82	9.71	-	-	-	-
Buchanania lanzan Spreng.	-	2.90	-	-	-	-	-	1.23
Butea monosperma (Lam.) Taub.	4.88	-	15.77	13.55	-	-	-	9.02
Benkara malabarica (Lam.) Tirveng	-	-	-	-	-	-	4.43	-
Careya arborea Roxb.	12.26	27.16	19.1	32.11	40.63	36.35	37.67	27.34
Casearia elliptica Willd.	-	1.762	2.871	3.996	6.75	13.36	21.856	-
Cassia fistula L.	-	1.649	21.6	12.76	17.06	22.47	20.84	-
Chloroxylon swietiana DC.	5.91	-	3.28	-	-	-	-	-
Cleistanthus collinus (Roxb) Benth. ex Hook.f.	-	7.22	12.73	27.50	-	-	10.56	-
Dalbergia paniculata Roxb.	10.73	2.46	2.89	2.05	-	-	-	-
Diospyros melanoxylon Roxb.	8.05	1.31	11.09	7.03	8.93	8.87	8.07	-
Diospyros sylvatica Roxb.	3.56	-	1.31	-	-	-	-	-
Grewia tiliifolia Vahl.	-	15.71	3.21	-	-	-	-	-
Holarrhena pubescens (Buch.-Ham). Wall.ex G.Don	-	-	2.46	-	-	8.86	-	-
Lagerstroemia parviflora Roxb.	-	3.79	6.99	-	9.22	17.11	15.46	-
Limonia acidissima L.	3.41	-	8.98	10.70	15.31	23.88	24.89	36.93
Lannea coromandelica (Houtt.)Merr.	-	-	3.51	-	10.09	22.14	10.78	-
Madhuca indica Gmel.	-	-	-	-	3.32	3.58	-	-
Mangifera indica L.	-	-	-	-	-	-	-	10.20
Mitragyna parvifolia (Roxb.)Korth.	-	-	1.34	-	-	14.07	7.61	-
Morinda pubescens Sm.	-	2.54	1.43	12.34	8.39	-	-	-
Peltophorum pterocarpum (DC.) Back.ex K.Heyne	5.22	-	-	-	-	-	-	33.21
Petrocarpus marsupium Roxb.	20.03	53.09	5.01	5.83	20.93	-	14.70	9.72
Phyllanthus emblica L.	10.29	-	-	-	-	-	3.45	-
Pongamia pinnata (L.) Pierre	-	-	-	-	3.28	-	-	23.91

Shorea robusta Gaertn. f.	108.32	93.26	1.46	12.17	-	-	-	7.25
Simarouba glauca DC.	8.25	-	-	10.11	13.93	-	18.36	-
Streblus asper Lour.	-	-	-	-	-	-	-	7.70
Strychnos nux-vomica L.	1.78	12.54	28.16	46.38	32.48	19.55	20.95	33.04
Syzygium cumini (L.)Skeels	-	-	-	-	5.35	8.87	-	-
Tamarindus indica L.	-	-	-	-	-	-	-	7.16
Tectona grandis L.f.	-	-	86.68	41.57	-	-	8.02	7.29
Terminalia alata Heyne ex Roth.	-	13.44	4.71	-	-	-	-	9.16
Terminalia arjuna (Roxb. ex DC.) Wight. & Arn.	-	-	-	-	6.09	13.09	10.96	-
Terminalia bellirica (Gaertn.)Roxb.	12.80	-	3.61	9.81	5.09	-	6.10	-
Xylia xylocarpa (Roxb.)Taub.	-	15.81	2.48	-	23.86	19.63	5.98	-
Ziziphus mauritiana Lam.	-	1.33	-	4.37	9.50	7.16	8.55	5.06

Table 3
Average disturbance index (%), tree density (Plants/ha), basal area (m^2/ha), sapling density (plants/ha), basal area (m^2/ha) and seedling density (individuals/m^2), light intensity (µ mol/m^2/S) and canopy area (m^2/ha) of Chandaka Wildlife Sanctuary.

Parameter	Undisturbed	Disturbed	t value
Disturbance index	23.41 ± 6.35	58.16 ± 3.92	11.41**
Tree density	615 ± 111.49	455 ± 72.18	2.36*
Tree basal area	35.68 ± 16.16	15.23 ± 3.42	2.84*
Sapling density	4675 ± 971.55	5240 ± 981.19	6.68**
Sapling basal area	3.06 ± 0.041	4.14 ± 0.019	5.14**
Seedling density	28 ± 4.31	34.12 ± 5.39	4.56*
Light Intensity	409.75 ± 29.71	845.75 ± 38.76	5.35**
Canopy area	22674 ± 403.89	11480 ± 301.29	11.46**

Note: significant at * P = 0.05 or **P = 0.01



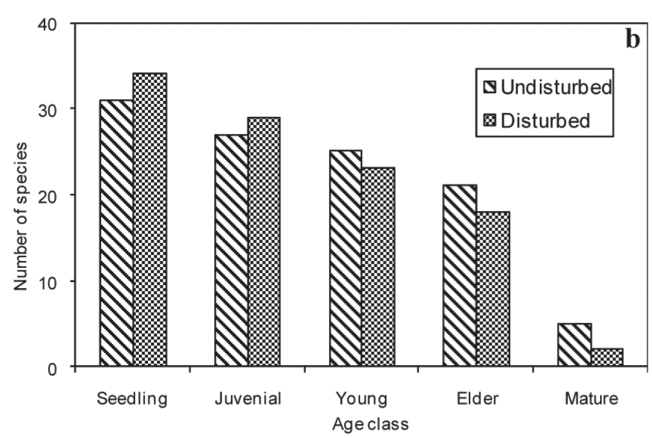


Fig.1. Population structure of tree species based on the number of species of the sanctuary as a whole (a) and in the disturbed and undisturbed stands (b).

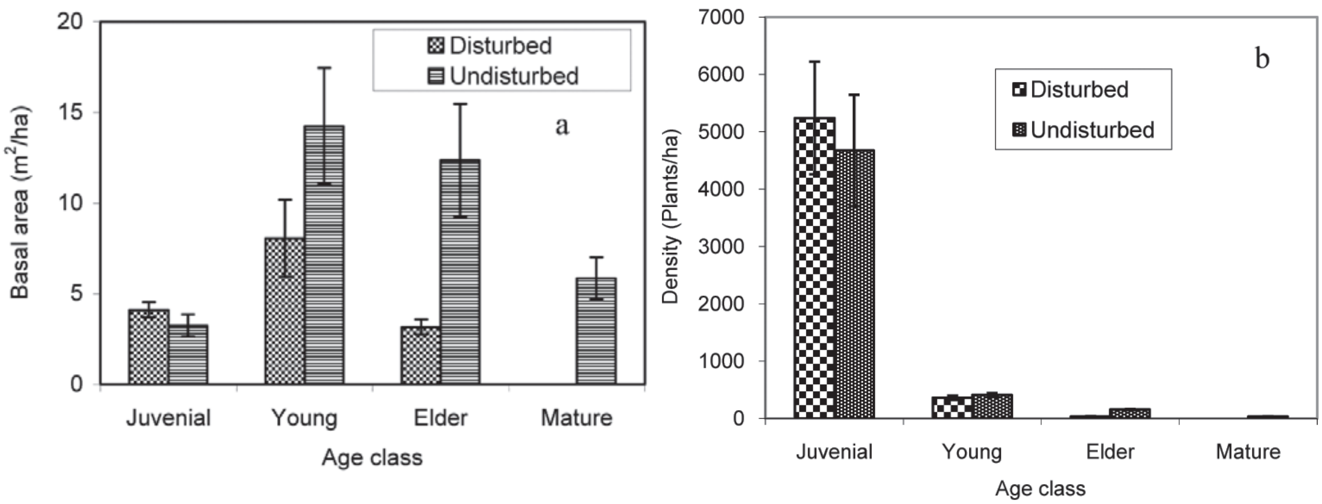


Fig.2. Population structure of tree species in disturbed and undisturbed stands of the sanctuary based on basal area (a) and density (b).

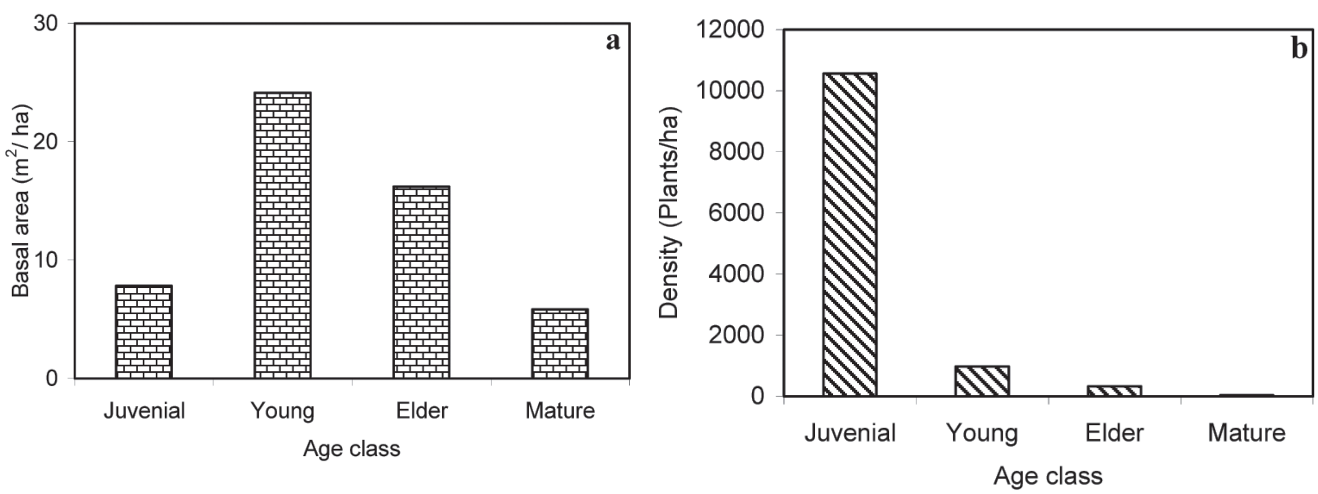


Fig.3. Population structure of tree species of the sanctuary as a whole based on basal area (a) and density (b).

robusta in young *Shorea robusta, Xylia xylocarpa* and *Terminalia alata* in juvenile classes were the dominant species.

3.4 Girth class wise density and basal area of dominant tree species

Distribution of stems of dominant tree species in most of the five gbh classes showed significant difference among the two stands of the sanctuary (Table-4). Density of seedlings and saplings/juveniles of dominant tree species in the disturbed stands was greater than that of the undisturbed stands. However, the density of higher age classes of dominant tree species i.e. in young, elder and mature age groups were higher in the undisturbed sites than the disturbed sites (Table-4).

The density of dominant tree species in the five different age groups both in disturbed and undisturbed stands of the sanctuary was in order of: seedlings >saplings / juveniles > young > elders >matures (Table-4). This clearly indicates that the regeneration status of dominant tree species is not poor in all the stands of the sanctuary. But transformation of individuals from lower gbh classes to higher gbh classes in the disturbed stand is very poor than in undisturbed stand. The pattern of relative proportion of individuals of the said age classes indicates a gradual decrease in number of individuals from the lower age groups to the higher age groups of the dominant tree species indicating a good regeneration pattern of dominant tree species (Sunderpandian and Swamy, 2000). However, absence of individuals in the mature gbh class in the disturbed stand indicates anthropogenic pressure imposed on it (Table 4). The cumulative proportion of individuals of the dominant tree species in the seedling and juvenile category in the undisturbed stand is much less compared to the disturbed

Table 4
Average density (plants/ha ± SD) and basal area (BA) (m^2 /ha ± SD) of dominant tree species in different age groups at disturbed (DS) and undisturbed (UDS) stands of Chandaka Wildlife Sanctuary

Age group	Density (Plants/ha)		t-value	LS	Basal area (m^2/ha)		t-value	LS
	DS	UDS			DS	UDS		
Seedling	24125±5039	18000±2857	4.74	P ≤ 0.01	-	-	-	-
Sapling/Juvenile	3375 ± 771	3040 ± 781	1.44	NS	2.304±0.241	2.102±0.219	0.447	NS
Young	293± 35	330 ±34.37	0.39	NS	5.293±1.108	12.482±2.25	3.117	P ≤ 0.05
Elder	26.37±6.12	120 ±8.02	7.21	P ≤ 0.001	2.72 ± 0.351	10.71±2.106	5.944	P ≤ 0.01
Mature	0	10.0 ±0.18	4.03	P ≤ 0.01	0	4.039±0.218	3.926	P ≤ 0.01

LS: Level of Significance; NS: Not Significant

stand of the sanctuary .However, cumulative percentage of stems in higher age classes such as young elder and mature was in the reverse trend in the disturbed stand of the sanctuary (Table-4). This may be attributed to the harvesting of higher girth class individuals for fire wood and other purposes by the local people (Tiwari, 2000).

3.5 *IVI of dominant tree species*

In any highly heterogeneous plant community, data on density and dominance of species do not yield a total picture of ecological importance independently. Although each has its own importance, density gives the numerical strength but does not provide sufficient information regarding its spread or cover. On the other hand, dominance tells about the cover but not the number. IVI represents the importance of species holistically more so than any single parameter determinants. Thus only on the basis of IVI the dominant tree species of the sanctuary could be marked. IVI of *Shorea robusta*, *Careya arborea* and the seven common tree species growing as its associates is given in Fig.4. *Strychnos nux-vomica, Azadirachta indica* and *Aegle marmelos* had grater IVI in the disturbed stand while *Cassia fistula*, *Limonia acidissima, Pterocarpus marsupium* and *Tectona grandis* had low IVI in the disturbed stand and high IVI in the undisturbed stand. Out of these the two most dominant tree species of the sanctuary are *Shorea robusta* and *Careya arborea.* Among these two species one of the species viz. *Shorea robusta* had considerably high IVI in the undisturbed stand and very low or negligible IVI in the disturbed stand. However, the variation in IVI of *Careya arborea* was not significant between the disturbed and undisturbed stands of the sanctuary (Fig.4).

3.6 *Number of cut stumps*

The number of cut stumps in the undisturbed stand is much less than in the disturbed stand. It varied greatly among the two and ranged from 37 ± 6.31 to 96 ± 17.21 stumps/ ha (Fig. 5). The variation in number of cut stumps between disturbed and undisturbed stands of the sanctuary was significantly different (t= 5.96, P ≤ 0.001). This may be due to various types of disturbances imposed on the disturbed forest stand of the sanctuary by the local inhabitants. Moreover, as far as the percentage of sprouting stems is concerned, the proportion of stumps sprouting in two different disturbance regimes showed no significant difference (t=1.884, P ≤ 0.05). Similarly sprouting of cut stumps was common and number of sprouting / stump in the two stands differ from each other but the difference was not differ significantly (t= 0.415, P ≤ 0.05). Percentage of sprouting of cut stumps/ha ranged from 53 ± 7.64 (undisturbed stand) to 70 ± 12.45 (disturbed stand) (Fig.5), indicating that the dominant tree species are the good coppicers. However, survival of sprouts is poor in the disturbed stand of the sanctuary and is frequently lopped for fuel wood. Hence they do not able to contribute much towards the regeneration of species (Khurana and Singh, 2001).

3.7 *GBH – Density Curve*

The gbh-density curve of dominant tree species showed marked difference between the disturbed and undisturbed stands of the sanctuary (Fig. 6). In the former the distribution of individuals of *Careya arborea, Strychnos nux-vomica, Cassia fistula, Aegle marmelos, Limonia acidissima* and *Azadirachta indica*, and in the latter all the dominant tree species except *Limonia acidissima* in different gbh classes yielded a gradual decrease in number of individuals from seedling to mature through juvenile and elder age classes, indicating good regeneration potential of these species (Khan *et al.*, 1987; Mishra *et al.*, 2013; Vipin and Madhur, 2014). Among the populations of nine tree species, seedlings constituted about 95% of the total density at disturbed stand and 89% at undisturbed stand. In the disturbed stand the seedling population of *Strychnos nux-vomica* was maximum

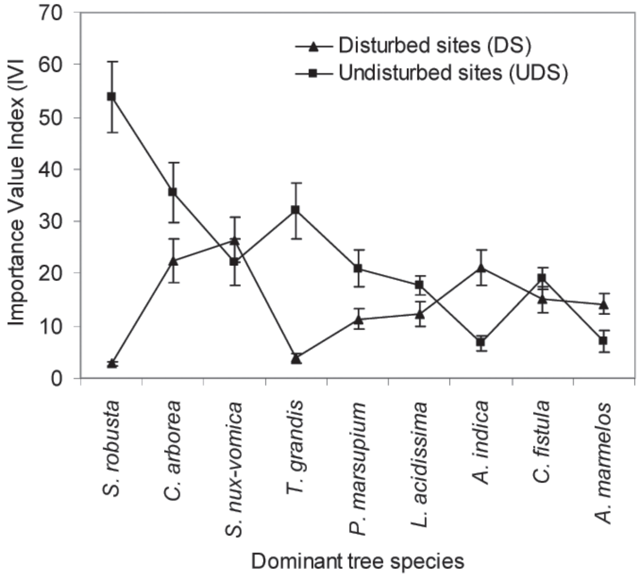


Fig.4: Mean Importance Value Index (IVI) of dominant tree species at disturbed and undisturbed sites of Chandaka Wildlife Sanctuary.

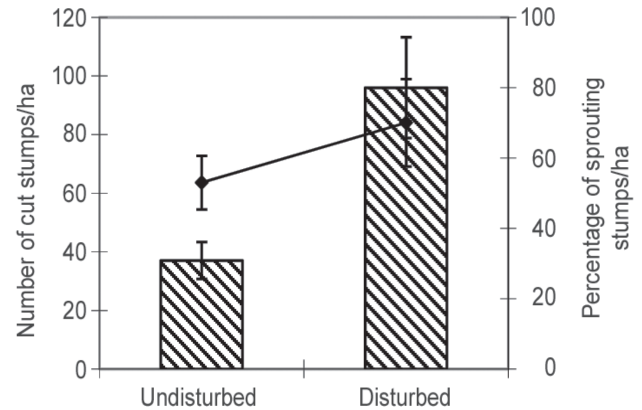


Fig. 5. Number of cut stumps and percentage of sprouting stumps per hectare in disturbed and undisturbed stands of Chandaka Wildlife Sanctuary.

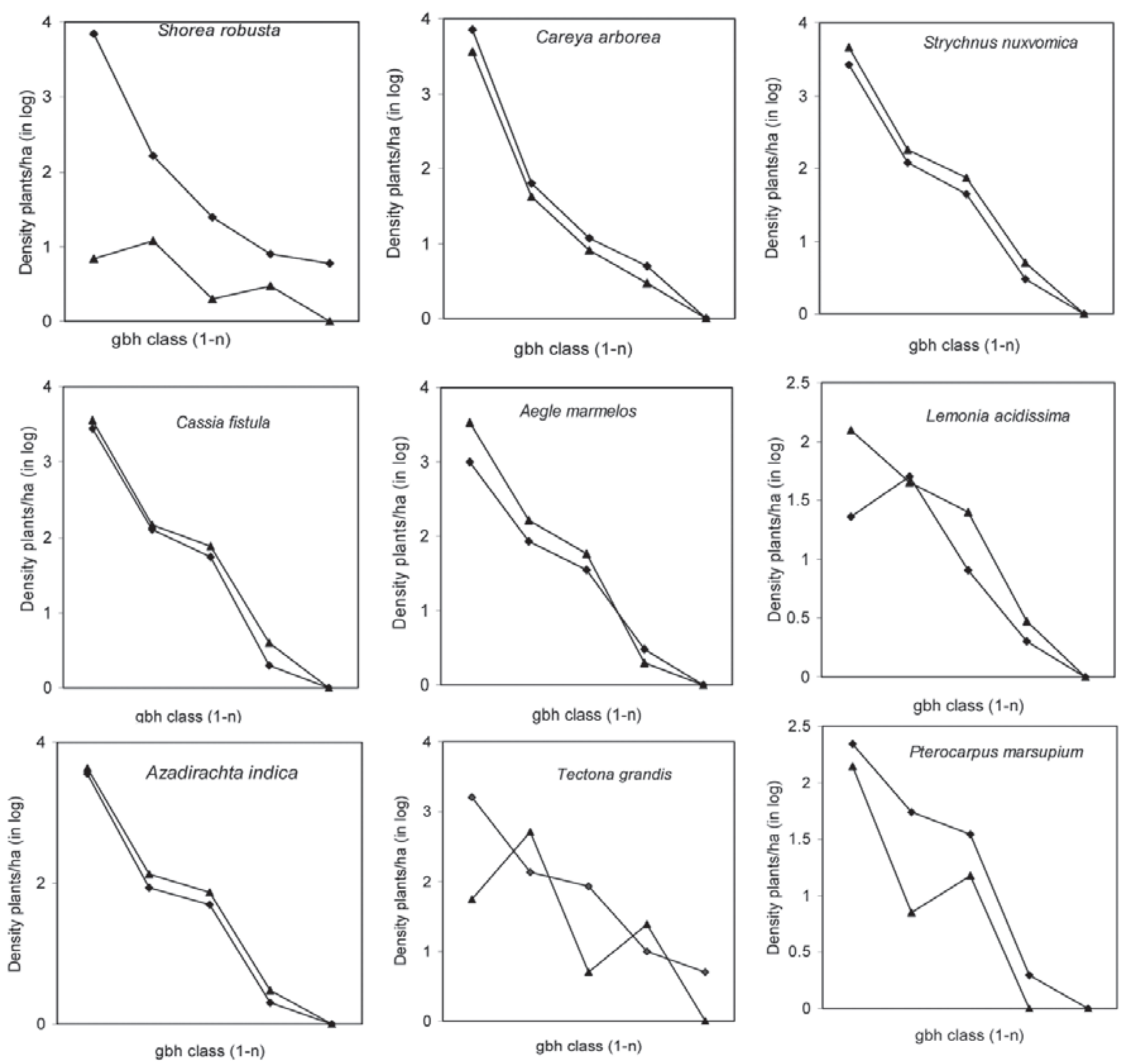


Fig. 6: Population structure of nine dominant tree species both in disturbed (▲) and undisturbed (◆) forest stands of Chandaka Wildlife Sanctuary.

and *Shorea robusta was* minimum, whereas in the undisturbed forest stand the maximum and minimum values were observed by *Careya arborea* and *Limonia acidissima*, respectively. Higher seedling population recorded in disturbed stand than undisturbed stand was not transferred to higher age classes as against undisturbed stand may be the disturbance caused by grazing and fire (Tiwari, 2000). A lower percentage of established seedlings compared to saplings (juvenile) of *Shorea robusta* in the disturbed stand and *Lemonia acidissima* in the undisturbed stand can be termed as fair reproducers as they reproduced well in the immediate past and continued to do so though at a lower rate (Khumbongmayum *et al.*, 2006). The shape of the gbh –density curve for *Shorea robusta* in undisturbed and *Careya arborea* both in disturbed and undisturbed stands was basically alike indicating strong dominance of *Shorea robusta* in the undisturbed stand and *Careya arborea* at all levels of disturbance (Tripathi *et al.*, 1989). The concave or L- shaped size-class distribution curve exhibited by the two most dominant tree species of the sanctuary is typical of all types of forests (Sunderpandian and Swamy, 2000). Species like *Strychnos nux-vomica, Cassia fistula, Aegle marmelos, Azadirachta indica* both in disturbed and undisturbed stands, *Limonia acidissima* in disturbed stand, and *Tectona grandis* and *Pterocarpus marsupium* in undisturbed stands of the sanctuary showed rotated sigmoid type of gbh-density curve (Fig.6). In one hand rotated sigmoid type of distribution curve of such species in different disturbance levels indicates that small gbh classes produce a steep negative slope on the left end of the curve. The curve again attains a steep negative slope in the large gbh classes at the far right side. Much lower mortality and/or much faster growth rates in intermediate gbh classes of such dominant tree species emerging from the under-storey in the forest canopy causes a leveling influence in the middle of the distribution curve (Rikhari *et al.*, 1989). However, on the other hand the conversion of seedlings into juveniles and young ones into elder stage and elder ones into mature stage were inadequate to support the entire population (Rikhari *et al.*, 1989). The plateaus and depressions in gbh-density curve formed by *Shorea robusta*, *Tectona grandis* and *Pterocarpus marsupium* at the disturbed stand reflect the gap phase type of regeneration with a resultant reduction in survival of individuals during that stage (Pande, 1999).

4. Conclusion

Overall population structure of the sanctuary reveals that most of the hard wood species may not be available for extraction in future, unless specifically augmented for regeneration. Yet controlled quantities of fuel wood can be taken from shrubs. In any case the two dominant species of the sanctuary need special attention so as to be conserved. Seedlings and saplings of *Shorea robusta* were found very low in the disturbed areas of the sanctuary, due to continuous anthropogenic pressure. If the present situation continues it will certainly retrogress the succession leading to a degraded community. In this process the less valuable woody trees might pose dominance substituting the age old Sal species.

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