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Population Structure of dominant tree species in different Disturbance Gradients of Similipal Biosphere Reserve, Orissa

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Population structure based on circumference at breast height (cbh) measurements of individuals of ten dominant and economically important tree species viz. Shorea robusta, Anogeissus latifolia, Dillenia pentagyna, Protium serratum, Syzygium cumini, Syzygium cerasoides, Schleichera oleosa, Buchanania lanzan, Terminalia alata and Adina cordifolia was studied in different disturbance gradients of Similipal Biosphere Reserve (SBR), Orissa. Concave type of cbh –density curve for Shorea robusta in different disturbance gradients of the reserve indicating about its strong dominance. Except Shorea robusta the cbh-density curves of all other dominant tree species viz. Anogeissus latifolia, Dillenia pentagyna, Protium serratum, Syzygium cumini, Schleichera oleosa, Buchanania lanzan , Terminalia alata, Adina cordifolia and Syzygium cerasoides were semi-log type. However formation of plateaus and depressions in cbh-density curve of Schleichera oleosa at the disturbed stand and Adina cordifolia in moderately disturbed and undisturbed stands reflecting the gap phase type of regeneration with a resultant reduction in survival of individuals during respective stages. From the present investigation it was also marked that cut stumps are frequently occur in the disturbed stands of the reserve and more number of sprouters are arise from the cut stumps. This indicates that the dominant tree species are the good coppicers. But due to frequent lopping of the coppicers for fuel wood and other purposes they are not able to contribute much towards their further regeneration and establishment in the disturbed and moderately disturbed areas of the reserve. If such activities are continued both in the disturbed and moderately disturbed areas of the reserve, future populations of dominant tree species in the forest covers of the reserve may be threatened. Hence proper conservation measures have to be formulated to protect these species.

Introduction:

Population structure is an important characteristic feature of forests which determines both mortality and natality (Singh et al., 1986). The ratio of various age groups in a population determines the reproductive status of the population and indicates the future course (Odum, 1971). Population dynamics of plant species, especially those of long-lived species, could be considered as an indicator of vegetation succession as well as climate changes on tree line eco-tone (Brubaker, 1980; Camarero and Gutierrez, 2004). As it is generally infeasible to trace the whole life history, from birth to death, of a long-lived species, a static investigation on age structure of population is often accepted on population dynamic estimations over time (Harper, 1977; Stewart, 1986; Johnson and Fryer, 1989; Svenson and Jaglum, 2001). Quantitative reconstruction of age structure conditions (the distribution and range of tree ages), could also serve as a basic point of reference central to restoration and management of forest ecosystems (Covington, 1981; Fule et al., 1997; Mast et al., 1999). Assessing and analyzing age structures are therefore prerequisites for understanding ecological processes and restoration of natural forests. Plant could generally grow and survive in certain range of environmental gradients, e.g. temperature, precipitation, etc. (Block and Treter, 2001). Optimum environmental conditions could enable a well-developed population and limiting factors would result in poor growth of individuals as well as create problems in the regeneration process of the local population. Age structures of plant populations, especially those of long-lived species could therefore act as an indicator of environmental changes. Although in India strategies of population structure of tree species have been studied by several workers (Uma Shankar, 2001; Saxena et al., 1984; Khan et al., 1987), there is a conspicuous lack of such studies for the forest covers of Orissa including the forest covers of Similipal biosphere reserve. Therefore the present study was undertaken to analyze the age structure of dominant tree species at different sites of Similipal biosphere reserve receiving different levels of biotic disturbance.

Study area:

Similipal Biosphere Reserve (SBR) 21° 28' to 22° 08 'N latitude and 86° 04' to 86° 37' E longitude is situated in the Mayurbhanj district of Orissa stretch over an area of 4374 sq. km. The vast patch of forest covers of Similipal is one of the mega –bio diversity zones of the country with a rich population of flora and fauna. The elevation of valleys peaks ranges from 80m to 1166m M.S.L. rolling with pockets of grassy meadows in between and traversed by a number of streams and water falls.

Climate:

Climate of all the study sites is monsoonal. Maximum rainfall occurs from mid June to October accounting for 75-80% of annual rainfall. In spite of high annual rainfall summer and winter are relatively dry generally with <10cm monthly rainfall (Mishra et al., 2006). The amount of average annual rainfall is uncorrelated with elevation and generally ranges between 28.11 to 395.96 cm. Summer is not unbearable, as the maximum temperature rarely goes above 40 °C. Winter is severe and the temperature comes down to 4 °C in parts with frost in valleys (Mishra et al., 2006). Spring is very pleasant. Because of good vegetation and a network of perennial streams Similipal is relatively moist throughout the year. Humidity of Similipal at 0600 hrs is around 74% and at 1800 hrs is around 81% to 93% (Srivastava and Singh, 1997).

Materials and Methods:

Dominant tree species of the reserve was selected on the basis of Importance Value Index (IVI). Those species having maximum IVI were considered as the dominant species. Importance Value Index (IVI) of the tree species of the reserve were determined as: IVI = relative frequency + relative density + relative basal area, where the relative values of frequency, density and basal area were derived as the value for a species expressed as percentage of the sum of these values for all the species of a community (Kershaw, 1973). Population structure of the dominant woody perennials of the reserve was studied during 2005-2006 using quadrat method. For this purpose 20 quadrats of 10 m x 10 m for trees, 5m x 5 m for saplings and 1m x 1m for seedlings were laid randomly in each site. The gbh structure of populations of the dominant woody perennials of the reserve were grouped into five different age classes such as < 10cm gbh, 10 cm to < 31cm gbh, > 31 cm to 90 cm gbh, > 90 cm to < 180 cm gbh and > 180 gbh. From the data on density (plants / ha) basal area (m^2 / ha) and numbers of species of the trees belonging to five different age groups viz seedlings (< 10cm gbh), juvenile (10cm to = 30 cm gbh), young (> 30cm to 90cm gbh) elder (> 90 cm to < 180cm gbh) and mature (> 180cm gbh) were recorded in 20 (10x10m^2) randomly laid quadrats following Uma Shankar (2001). Number of individuals belonging to each of the above girth class was estimated and percent density of individuals of each girth class was calculated as follows:

$$\text{Percent Density} = \frac{\{Number\ of\ individuals\ in\ each\ girth\ class\}}{Total\ number\ of\ individuals\ in\ each\ girth\ class} X100$$

Results and Discussion:

Human activity had induced various modifications on the structure and function of forest ecosystems which can be determined through the study of the age structure on the basis of different age classes. Five different age classes of dominant trees species such as seedling, juvenile, young, elder and mature were considered on the basis of their gbh classes for better analysis and interpretation. Basal area (m^2/ha) of adult trees (>30cm gbh) of living and damaged plants were calculated for analysis of disturbance index (D.I).Stands were classified as disturbed (disturbance index : >30%), moderately disturbed (disturbance index: 17 to 22%) and undisturbed (disturbance index: <7%) (Table-1)

Basal area of adult tree species (>30 cm gbh), saplings (10cm to = 30 cm gbh), and seedlings (< 10cm gbh) at different disturbance gradients is represented in Table-2. Maximum density of adult trees were recorded in undisturbed stand (931.83 ± 54 plants/ha) and minimum (704 ± 33 plants/ha) in disturbed stand (Table-2).Similarly basal area of adult trees was maximum (89 ± 6.25 m^2/ha) in the undisturbed stand and minimum (53 ± 5.26 m^2/ha) in the

Table-1: Characteristic feature of study sites.

Sites	Basal area (m^2/ha) of living plants	Basal area (m^2/ha) of damaged plants	Basal area (m^2/ha) of living and damaged plants	Disturbance Index (%)
Podadiha	52.37	24.31	76.68	31.70
Bangirposi	59.94	27.13	86.67	31.30
Handipuhan	48.71	29.33	78.04	37.58
Ghodabindha	49.13	28.47	77.60	36.69
Gurguria	63.46	16.94	80.40	21.07
Kalikaprasad	78.61	17.66	96.27	18.34
Nawna	68.99	14.78	83.77	17.64
Chahala	88.59	4.23	90.82	4.56
UBK	85.07	5.51	90.58	6.08
Nigirdha	84.86	4.73	89.59	5.28
Jenabil	91.43	3.13	94.56	3.31

disturbed stand, showing significant difference among the stands. However in case of the density of seedlings and saplings reverse condition was marked (Table-2).

Distribution of stems of dominant tree species in various diameter classes i.e. seedling (<10 cm gbh), juvenile (>10 to <30cm gbh), young (> 30cm to 90cm gbh) elder (> 90 cm

Table-2: Disturbance index (%), stand density (Plants/ha), Basal area (m^2/ha), sapling density (Plants/ha) and seedling density (Plants/ha) of Similipal biosphere reserve.

Parameter	Undisturbed Stand	Disturbed Stand	Moderately Disturbed stand
Disterbance index (%)	4.75 ± 1.26	34.5 ± 3.51	19.25 ± 1.5
Tree density (plants /ha)	931.83 ± 54	704 ± 33	768± 53
Tree basal area (m^2 /ha)	89 ± 6.25	53 ± 5.2	68 ± 8.1
Sapling density (plants /ha)	1610 ± 141	2054 ± 520	1805 ± 271
Seedling density (Individuals/m^2)	12 ± 1.3	38 ± 5.3	17 ± 2.6

to < 180cm gbh) and mature (> 180cm gbh) in the total population of the species showed significant difference among the stands. However, the density of seedlings and saplings/ juvenile was highest in the disturbed stand and lowest in the undisturbed stand of the reverse (Table-3).

The density of dominant tree species in different age groups follows the trend seedlings >saplings /juveniles > young > elders >matures in all the stands (Table-3). This clearly indicates

Table-3: Average density (plants/ha) ± SD of dominant tree species in different age groups at three different stands of Similipal biosphere reserve.

Age group	Disturbed	Moderately disturbed	Undisturbed
Seedling	3764 ± 152	3364 ± 183	2664 ± 146
Sapling/Juvenile	88 ± 6.53	79 ± 7.81	73 ± 10.42
Young	15 ± 2.43	29 ± 3.18	27 ± 2.19
Elder	08 ± 2.08	19 ± 2.13	22 ± 2.19
Mature	02 ± 0.31	06 ± 0.73	11 ± 1.21

that the regeneration status of dominant tree species is not poor in all the stands of the reserve. But transformation of individuals from lower cbh classes to higher cbh classes in the disturbed stand is very poor in comparison to moderately disturbed and undisturbed stands. The pattern of relative proportion of individuals of different age classes i.e. seedlings, saplings/ juveniles, young ones, elders and matures in the total population of species in all the three stands of the reserve 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 appearance of vêry few individuals in the mature cbh class at disturb stand indicates about the rate of anthropogenic pressure imposed on it in comparison to the moderately disturbed and the undisturbed stands of the reserve (Table-3). The cumulative proportion of individuals of the dominant tree species in the seedling and juvenile category in undisturbed stand is much less compare to moderately disturbed and disturbed stand of the reserve .However, cumulative percentage of stems in higher age classes such as young elder and mature was in the reverse trend in comparison to the moderately disturbed and undisturbed stands of the reserve (Table-3). This may be attributed to the harvesting of higher girth class individuals for fire wood and other purposes by the local people (Khumbongmayum et al., 2006). 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 gives no information regarding its spread cover;

dominance gives the cover but not the spread and number. Importance value index represents the importance of species holistically more so than any other single stand determinants. Thus on the basis of IVI the dominant tree species of the reserve was marked on the different disturbance gradients of the reserve. Importance Value Index of *Shorea robusta* and the nine common tree species growing as its associates is given in Table-4. *Adina cordifolia* and *Anogeissus latifolia* had grater IVI in the disturbed sites while *Protium serratum* and *Syzygium cerasoides* had low IVI. However the importance value index of *Shorea robusta* was considerably high only at sites facing comparatively moderate disturbance. The IVI of the rest five common associates of sal like *Terminalia alata*, *Dillenia pentagyna*, *Syzigyum cumini*, *Buchanania lanzan* and *Schleichera oleosa* were in the following order:

Terminalia alata: DS > UDS > MDS

Dillenia pentagyna: UDS > DS > MDS

Syzygium cumini: UDS > DS > MDS

Buchanania lanzan: DS > UDS > MDS and

Schleichera oleosa: DS > UDS > MDS.

Cut stumps were marked in all the stands but the number of cut stumps in the undisturbed stands is much less compared to the disturbed and moderately disturbed stands. The number

Table-4: Mean importance value index (IVI) of dominant tree species at different states of disturbance in Similipal biosphere reserve.

Name of dominant species	Disturbed sites (DS)	Moderately disturbed sites (MDS)	Undisturbed sites (UDS)
Shorea robusta	67.18 ± 27.88	116.25 ± 31.70	95.01 ± 30.6
Terminalia alata	22.06 ± 17.31	14.65 ± 9.0	21.09 ± 13.92
Anogeissus latifolia	22.33 ± 9.08	20.73 ± 9.5	11.45 ± 9.92
Dillenia pentagyna	14 ± 6.9	6.97 ± 1.09	20.53 ± 6.03
Protium serratum	10.17 ± 3.58	11.04 ± 9.34	11.84 ± 8.77
Syzygium cumini	10.31 ± 5.42	7.24 ± 5.38	15.56 ± 7.19
Buchanania lanzan	14.27 ± 11.73	7.82 ± 3.39	10.14 ± 5.34
Syzygium cerasoides	5.52 ± 1.43	8.13 ± 3.64	13.41 ± 6.14
Schleichera oleosa	10.17 ± 4.89	3.77 ± 1.27	7.31 ± 4.75
Adina cordifolia	11.75 ± 6.83	9.33 ± 3.25	8.16 ± 5.10

vary greatly among the three ranged stands, from 37 ± 6.31 to 136 ± 17.21 stumps/ha (Fig-1) This may be due to extraction of trees for household uses by people inhabiting near the forest. Moreover as far as the percentage of sprouting stems per hectare concerned, the proportion of stumps sprouting in different disturbance regimes showed insignificant difference.

Similarly sprouting of cut stumps was common and number of sproutings / stump in the three stands experiencing different degrees of disturbance did not differ significantly. Sproutings / stump in the stands experiencing different degrees of disturbance did not differ significantly. Sprouting of cut stumps/ha ranged from 53 ± 7.64 (undisturbed stand) to 70 ± 12.45 (disturbed stand) (Fig.1), indicating that the dominant tree species are the good coppicers. However, survival of sprouts is poor both in the disturbed and moderately disturbed stands of the reserve and is frequently loped for fuel wood. Hence they are not able to contribute much towards the regeneration of species (Khurana and Singh, 2001).

The distribution of species and individuals in different age classes showed a linear decline from juvenile to mature classes (Fig.2). The distribution of basal

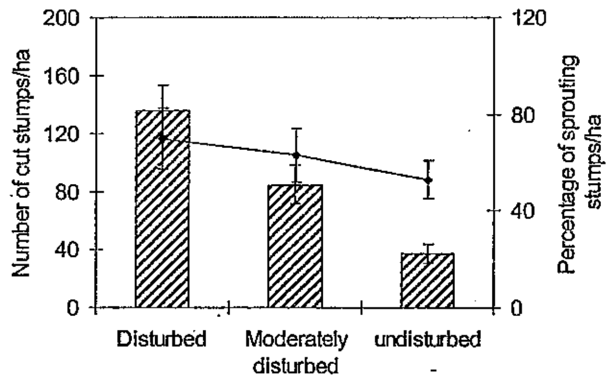

Fig. 1. Number of cut stumps and percentage of stumps sprouting per hectare in three different stands of Similipal biosphere reserve.

area showed a progressive increase from juvenile to mature age class signifying that the small number of mature individuals accounted for a better percentage of basal area (Fig.2).

The cbh –density curve for dominant tree species of the reserve is given in (Fig. 3). From the cbh-density curve the following patterns of age structures are recognized. All of the dominant tree species except *Schleichera oleosa* in the disturbed stand and *Adina cordifolia* in the undisturbed and moderately disturbed stands of the reserve showed a gradual decrease in number of individuals from seedling to mature classes through juvenile and elder age classes, indicating good regeneration potential of these species (Khan et al., 1987; Saxena and Singh, 1984).

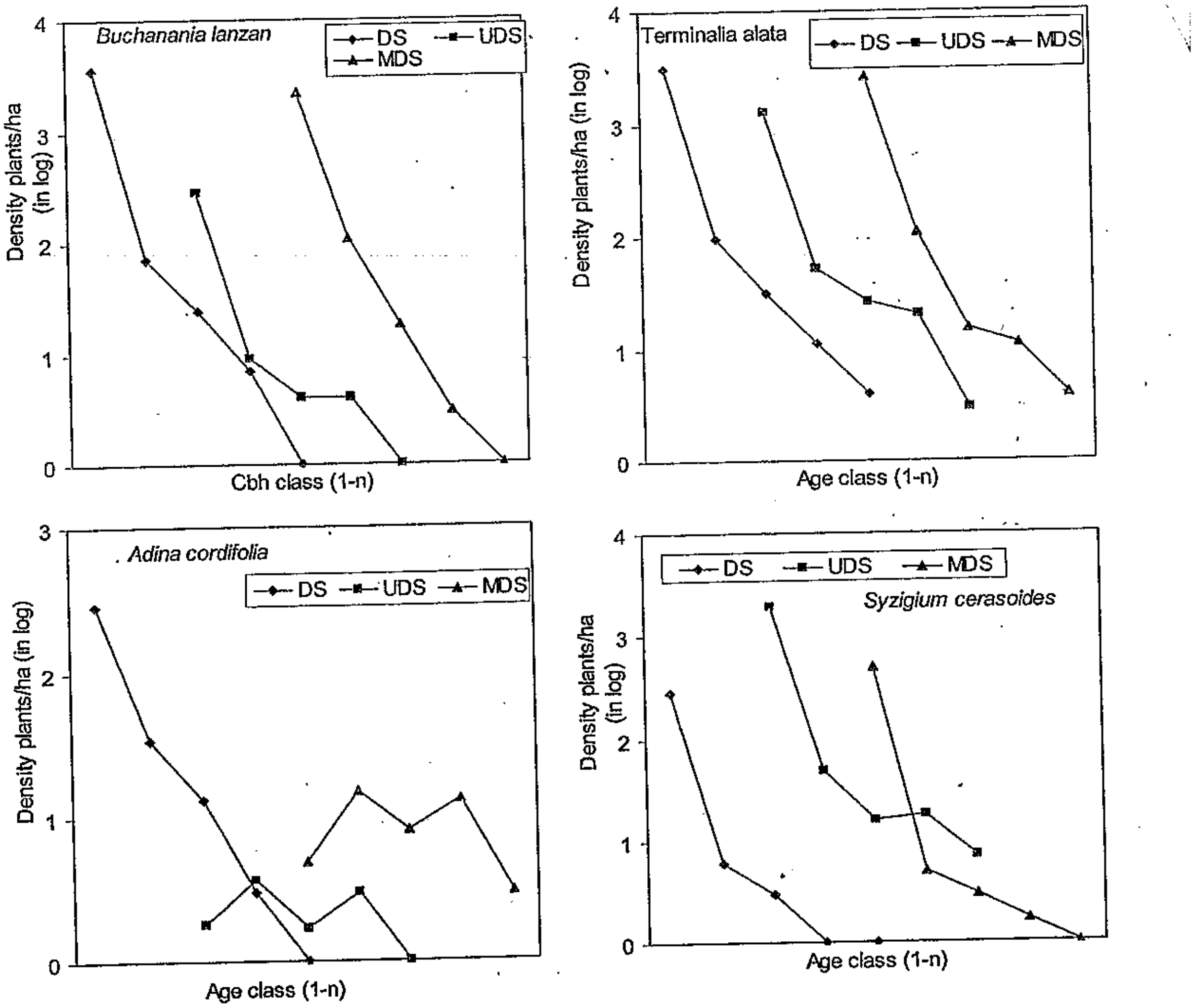

Fig. 3. Population structure of dominant tree species of Similipal biosphere reserve.

The plateaus and depressions in cbh-density curve formed by *Schleichera oleosa* in the disturbed stand and *Adina cordifolia* in the moderately disturbed and undisturbed stands reflecting the gap phase type of regeneration with a resultant reduction in survival of individuals during that stage (Pande, 1999).

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A lower percentage of established seedlings compare to saplings (juvenile) of Schleichera *oleosa* in the disturbed stand and *Adina cordifolia* in disturbed and moderately disturbed stands of the reserve, refer to as the poor regenerators (Khumbongmayum et al., 2006). The shape of the cbh–density curve for *Shorea robusta* was basically concave in comparison to the other dominant tree species indicating strong dominance of sal at all different level of disturbance (Tripathi et al., 1989). Except *Shorea robusta* all other dominant species viz. *Anogeissus latifolia, Dillenia pentagyna, Protium seratum, Syzygium cumini, Schleichera oleosa, Buchanania lanzan , Terminalia alata, Adina cordifoli*a and *Syzygium cerasoides*, the cbh-density curves were semi-log type. However *Schleichera oleosa* at the disturbed stand and *Adina cordifolia* in moderately disturbed and undisturbed stands were not shown the same type of cbh-density curve (Fig. 3).

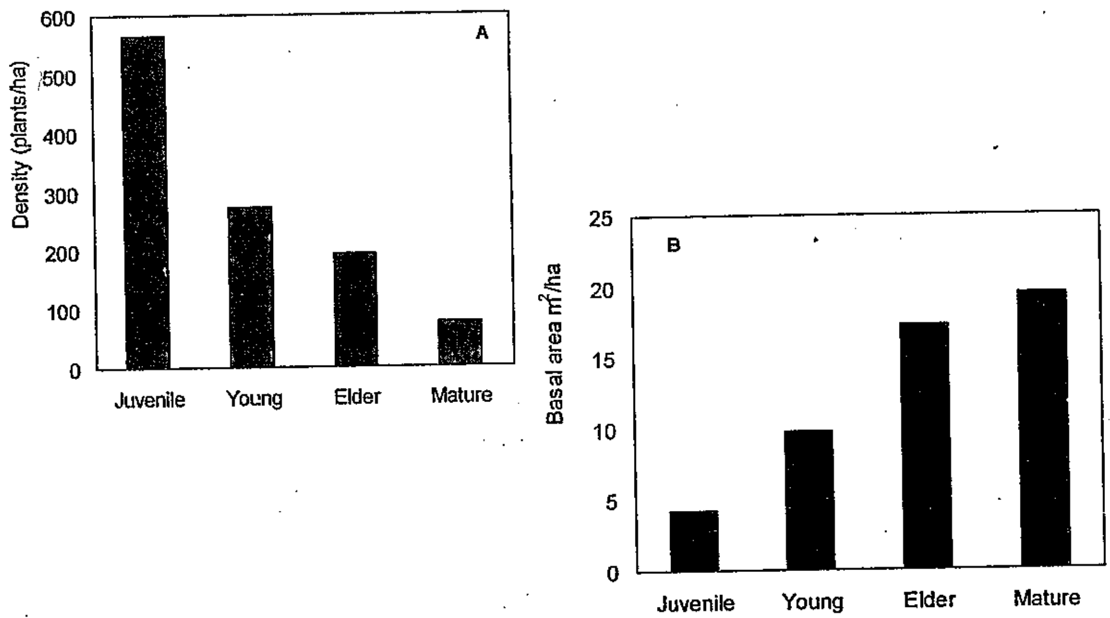
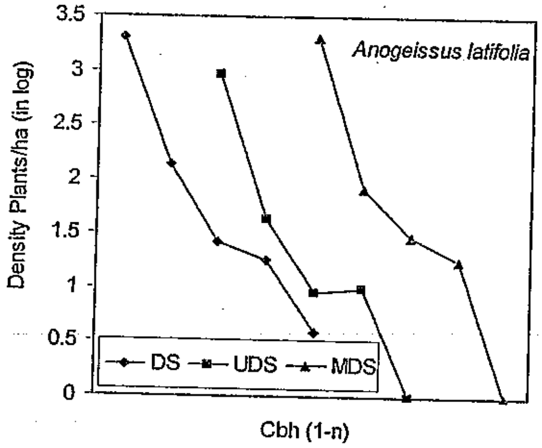
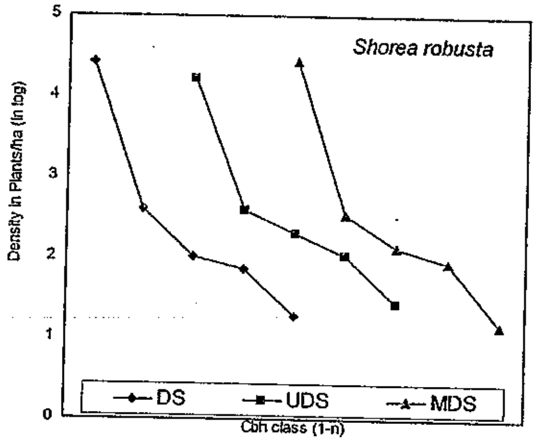
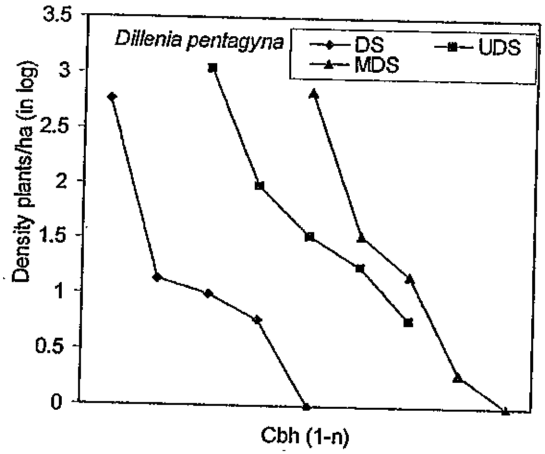
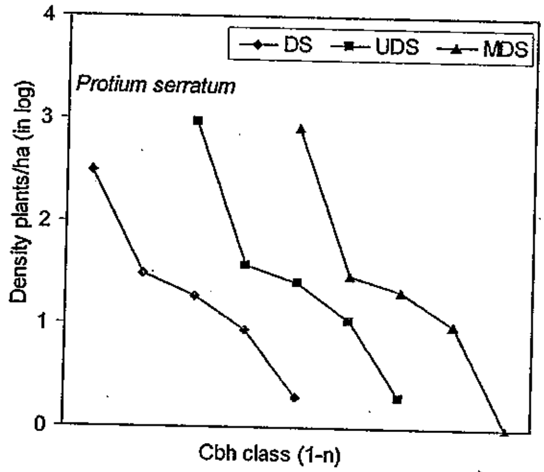


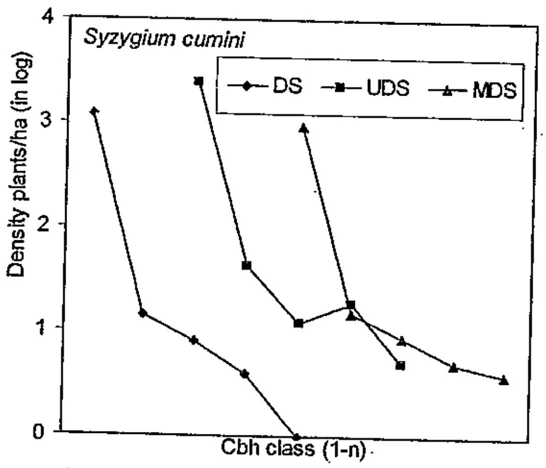
Fig. 2. Population structure of dominant species based on density (A) and basal area (B) of Similipal biosphere reserve.

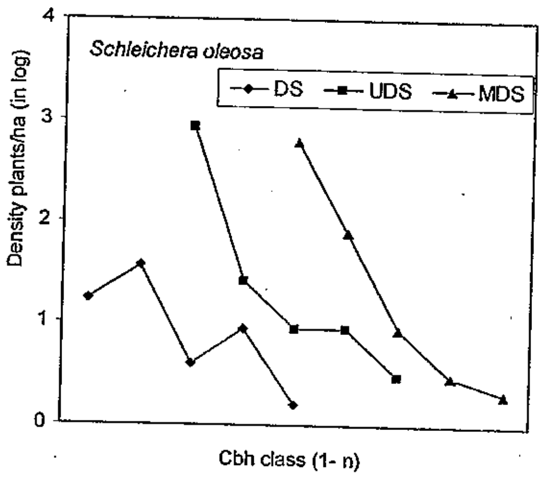

Anogeissus latifolia
Density Plants/ha (in log)
3.5
3
2.5
2
1.5
1
0.5
0
DS
UDS
MDS
Cbh (1-n)


Shorea robusta
Density in Plants/ha (in log)
5
4
3
2
1
0
DS
UDS
MDS
Cbh class (1-n)


Dillenia pentagyna
Density plants/ha (in log)
3.5
3
2.5
2
1.5
1
0.5
0
DS
UDS
MDS
Cbh (1-n)


Protium serratum
Density plants/ha (in log)
4
3
2
1
0
DS
UDS
MDS
Cbh class (1-n)


Syzygium cumini
Density plants/ha (in log)
4
3
2
1
0
DS
UDS
MDS
Cbh class (1-n)


Schleichera oleosa
Density plants/ha (in log)
4
3
2
1
0
DS
UDS
MDS
Cbh class (1- n)

References:

Block, J. and Treter, U. (2001).The limiting factors at the upper and lower forest limits in the mountain-woodland steppe of Northwest Mongolia, In: Kaennel Dobbertin M., Braker O.U. (eds.), International Conference, Tree Rings and People. Abstracts, Birmensdorf, Swiss Federal Research Institute, WSL. 250-251.

Brubaker, L.B. (1980). Spatial patterns of tree growth anomalies in the Pacific northwest. Ecology, 61:798-807.

Camarero, J.J. and Gutierrez, E. (2004). Pace and pattern of recent tree-line dynamics: response of eco-tones to climatic variability in the Spanish Pyrenees. Climate Change, 63: 181-200.

Covington, W.W. (1981). Changes in the forest floor organic matter and nutrient content following clear cutting in northern hardwoods. Ecology, 62:41-58.

Fule, P. Z., Covington, W. W., Moore, M. M. (1997). Determining reference conditions for ecosystem management of southwestern Ponderosa pine forests. Ecological Applications, 7(3):895-908.

Harper, J.L. (1977). Population Biology of Plants. Academic Press. London, U.K.

Johnson, E.A. and Fryer, G.I. (1989). Population dynamics in Iodgepole pine and englemann spruce forests. Ecology, 70: 1335-1345.

Kershaw, K.A. (1973). Quantitative and Dynamic Plant Ecology. Edward Arnold Ltd. (Second Edition), London, U.K.

Khan, M.L., Rai, J.P.N.and Tripati, R.S. (1987). Population structure of some tree species in disturbed and protected sub-tropical forests of north east India, Acta Ecologica, 8: 247-255.

Khumbongmayum, A. D., Khan, M. L. and Tripathy, R. S. (2006). Biodiversity conservation in sacred grooves of Manipur, northeast India: population structure and regeneration status of woody species. Biodiversity and Conservation, 15: 2439-2456.

Khurana, E. and Singh, J. S. (2001). Ecology of tree seed and seedlings: Implications for tropical forest conservation and restoration. Current Science, 80(6), 748-752.

Mast, J. N., Fuel, P. Z., Moore, M. M., Covington, W. W. and Waltz., A. E. M. (1999). Restoration of pre-settlement age structure of an Arizona ponderosa pine forest. Ecology and Application, 9: 228-239.

Mishra, R. K. Upadhaya, V. P. Mohapatra, P. K., Bal, S. and Mohanty, R. C. (2006). Phenology of species of moist deciduous forest sites of Similipal biosphere reserve. Lyonia, 11(1): 5-17.

Odum, E. P. (1971). Fundamentals of Ecology. W.B Saunders Company (Third Edition), London.

Pande, P.K. (1999). Comparative vegetation analysis and sal (*Shorea robusta*) regeneration in relation to their disturbance magnitude in some sal forest. Tropical Ecology, 40(1): 51-61.

Saxena, A. K. and Singh, J. S. (1984). Tree population structre of certain Himalayan forest association and implication concerning their future composition. Vegitatio, 58: 61-69.

Saxena, A. K., Singh, S. P. and Singh, J. S. (1984). Population structure of forests of Kumaun Himalaya: implication for management. Environmental Management, 19: 307-324.

Singh, S. P. Tewari, J. C. Yadav, S. and Ralhan, P. K. (1986). Population structure of tree species in forest as an indicator of regeneration and future stability. Proceeding Indian Academy of Sciences, 96(6): 443-445.

Srivastava, S. S and Singh, L. A. K. (1997). Monitoring of precipitation and temperature of Similipal tiger reserve, pp. 30-40. In : Tripathy, P. C. and Patro, S. N. (eds.) Similipal : A National Habitat of Unique Biodiversity, Orissa Enviornmental Society, Bhubaneswar,

Stewart, G.H. (1986). Population dynamics of montane conifer forest, western Cascade range, Oregon, USA. Ecology, 67: 534-544.

Sunderpandian, S.M. and Swamy, P.S., (2000). Forest ecosystem structure and composition along an altitudinal gradient in the Western Ghats, south India. Journal of Tropical Forest Science, 12(1): 104-123.

Svenson, J. S. and Jaglum, J. K. (2001). Structure and dynamics of an undisturbed old-growth Norway spruce forest on the rising Bothnian coastline. Forest Ecology, 151: 67-79.

Tripathi, S.K., Singh, R. S., Upadhyaya, V. P. and Singh, R. P. (1989). Population structure of *Pinus ruxiburghi* and *Quercus leucotrichphora* forests of Allmora hills in Kumaun Himalaya. Journal of Tree Science, 8(2): 78-80.

Uma Shankar (2001). A case of high tree diversity in a sal (*Shorea robusta*) dominated lowland forest of eastern Himalaya: floristic composition, regeneration and conservation. Current Science, 81:776-786.

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