

High Dominance of *Shorea robusta* Gaertn. in Alluvial Plain Kamrup Sal Forest of Assam, N. E. India

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Abstract The study emphasizes on the community characteristics of naturally regenerated sal forest of Kamrup district, Assam, India. Sal is one of the most important timber yielding plants and also good source of aromatic gum and non-timber forest product. These forests are exposed to over-exploitation, deforestation, encroachment and alteration in land use and land cover and in return being replaced by secondary regenerated sal forest. Altogether, 71 plant species were recorded from the selected sal forest. Herbaceous layer of the forest was most species rich (30 species) layer followed by tree and shrub species. Leguminosae and Asteraceae were among the most dominant families in the forest while large number of families was monospecific. *Shorea robusta* has contributed about 90% of the total stand density (2559 individual ha⁻¹) of the forest, while species like *Erythrina suberosa*, *Delonix regia* and *Pterospermum acerifolium* were represented by single stem. Similar to that of stand density, sal have contributed to the maximum basal area of the forest. The girth class distribution confirmed a reverse J-shaped distribution, with higher density in lower girth classes and sharp decline thereafter. Total density of shrubs and herbs was recorded 2 individuals m⁻² and 63 individuals m⁻², respectively. Based on the dominance, *Shorea robusta* showed highest dominance followed by *Zizyphus rugosus*. Diversity index for tree, shrub and herb species was recorded 1.43, 2.30 and 3.28, respectively. Dominance index showed reverse trend to that of diversity index. About 84% of the plant species showed contagious distribution, however none of the species exhibited regular distribution. The forest is heterogenous in composition with high dominance of *Shorea* and is under regenerating stage. Therefore, for sustainability of the forest it requires effective conservation measures for sal and its associate plant species.

Keywords Basal area, Dispersion pattern, Dominance, *Shorea robusta*, Species diversity, Stand density

1. Introduction

Forest communities of northeast India have been studied by several workers and considerable information is available on species composition, biodiversity, regeneration potential etc.[1-7]. Disturbance changes the overall forest community structure[8,9]. Tree species diversity in a community declines with increasing disturbance, hence disturbed stands show low equitability or high dominance and undisturbed stands shows high equitability or low dominance which may result in contagious distribution of the tree species with increasing intensity of disturbance[2]. Regeneration of any species is considered as a key process for its existence in the community as it maintains desired species composition and stocking after biotic and abiotic disturbances[10]. Presence of ample number of seedlings, saplings and young trees in a given population indicate a successful regeneration[11]. Meanwhile, several authors have predicted regeneration status of tree species based on

the age and diameter structure of their population[1,12]. However, interaction of biotic and abiotic factors of the environment also had a significant impact on the regeneration potential of any species[13].

The sal (*Shorea robusta*) forests are mainly distributed in South and South-east Asia. In India it occupies two main regions, the northern and central regions separated by the Gangetic Plain. In the northern region, there is almost a continuous belt of sal stretching along the sub-Himalayan tract from Punjab to Assam and at some places it extends some distance into the Plains of the terai region[14]. In India sal is spread over an estimated area of 13 million hectares. Sal forests are typically categorized as 'Tropical Moist Deciduous Forest' which in this part of the country can be further divided into 'Khasi hill Sal forest' (3C/C1 1a (ii)) and 'Kamrup Sal forest' (3C/C2 2d (iv))[15]. Jacob[16] considered 'Kamrup Sal' forest type to be secondary invasive and it extended from the foothills down to the alluvial grassland. In Assam, Kamrup Sal forests occupy a considerable area in the Central and Lower parts of the State in the districts of Kamrup, Nagaon, Morigaon, parts of Nalbari and Barpeta, Darrang, Dhubri, Kokrajhar and Goalpara[15]. Sal is one of the most important timber yielding plants and are also a good source of 'aromatic gum' which is also

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known to have medicinal properties. The leaves of Sal tree also acts as an important source of non- timber forest product. But due to over-exploitation, deforestation, encroachment and alteration in land use and land cover, basically in the low-lying areas of the Assam valley, the mother Sal forest was slowly replaced by secondary regenerated Sal forest (Figure 1). Till date no documentation has been done on composition and regeneration of sal forest of Kamrup district, hence the present study was carried out in this secondary regenerated sal forest of Chaygaon, Palasbari and Boko circle of Kamrup district in Assam. Present study aims to provide quantitative information on the community structure and regeneration status of tree species in this secondary Sal forest.



Figure 1. Kamrup sal forest in its natural habitat in the study area

2. Materials and Methods

2.1. Study Site

The study site is located in Chaygaon, Palasbari and Boko circle of Kamrup district in Assam, northeast India. The district lies between 25.43° and 26.51° N latitude and between 90.36° and 92.12° E longitude. The district is spread over 4345 sq. km and contributes 5.53% of the total geographic area of the state. Total forest cover of the district is 1432 sq. km (32.96% of the total geographic area)[17]. The district is bounded in the North by foot hills of Bhutan and Nalbari district, South by the State of Meghalaya, East by Nagaon and Darrang districts and in the West by Goalpara and Nalbari districts. Kamrup district falls under the Lower Brahmaputra Valley zone. Soil structure of the district is mainly alluvial in nature. About 80% of total population of the district lives in rural areas and are mainly engaged in settled agriculture, allied, non-farm and service related activities which is predominantly subsistence in nature.

2.2. Methods

2.2.1. Plant Species Composition

Plant species composition was studied by collecting and preparing herbarium. Herbarium specimens were prepared following the protocol of Jain and Rao[18]. Each species was

identified by consulting available flora reference; including ‘Flora of Assam’[19].

2.2.2. Community Structure

Thirty quadrats were laid randomly in sal forest stand for sampling trees, shrubs and herbs. Quadrat size of 20m X 20m was used for trees, 5m X 5m for shrub/saplings and 1m X 1m for seedlings/ground growths. Plants species were categorized into trees, shrubs and herbs based on the habitat characteristics and literatures.

The GBH of all the tree species was measured at 1.37 m from the base during the sampling. Frequency, density, basal area, abundance and importance value index (IVI) of plant species were calculated following Misra[20] and Mueller-Dombois and Ellenberg[21]. Basal area of each individual tree species was calculated following $g^2/4\pi$ where g = Girth (cm). Importance value index (IVI) for trees was calculated by summing its relative frequency, relative density and relative dominance. For shrubs and herbs, IVI were calculated from the values of relative frequency and relative density. Species diversity index was calculated following Shannon-Wiener index[23], as: $H' = -\sum (ni/N) \ln ni/N$ where H' = Shannon- Wiener index of general diversity, ni = importance value index of i^{th} species, N =sum of importance value index of all the species. Species dominance index was calculated by the formula given by Simpson[24]. $Cd = \sum(ni/N)^2$, ni = importance value index of i^{th} species, N =sum of importance value index of all the species. Spatial distribution of plant species was determined following Whitford index[25], as: $WI = Abundance/Frequency (A/F Ratio)$. If value is <0.025 = regular distribution, value lies between $0.025-0.05$ = random distribution and value >0.05 = clumped distribution.

3. Results

A total of 71 plant species belonging to 68 genera under 38 families were recorded from the present study (total area of 1.2 hectares). This was represented by 25 trees, 16 shrubs and 30 herbs. Leguminosae was the dominant family having 8 species followed by Asteraceae, Malvaceae, Euphorbiaceae and Vebenaceae with 6, 5, 4 and 4 species, respectively. Families like Dipterocarpaceae, Anacardiaceae, Apocynaceae, Dilleniaceae, Lauraceae, Lythraceae, Magnoliaceae, Moraceae, Myrtaceae Rhamnaceae, Theaceae were represented by 1 species each. For shrubs species, both Leguminosae and Malvaceae were the dominant families with 3 species followed by Apocynaceae, Verbenaceae and Vitaceae with 2 species each. Among herb species, Asteraceae was the most dominant family with 5 different genus followed by Poaceae with 3 species. Based on the density, *Ageratum conyzoides* was recorded as the most dominant herb species followed by *Xanthium strumarium*, *Commelina benghalensis*, *Borreria articularis* etc. (Table 1 and 2).

Total stem density in the present study was found to be

Table 1. Phytosociological analysis of trees in Kamrup sal forest stands

Name of Species	Family	Density ha-1	Basal area (m ² ha-1)	IVI	A/F ratio
<i>Shorea robusta</i> Gaertn.	Dipterocarpaceae	2431	26.087	212.67	0.972
<i>Zizyphus rugosa</i> Lam.	Rhamnaceae	29	0.18	13.33	0.047
<i>Schima walichii</i> (DC.) Korth.	Theaceae	22	0.172	8.39	0.096
<i>Stereospermum personatum</i> (Hassk.) Chatt.	Bignoniaceae	13	0.135	7.94	0.059
<i>Lagerstroemia speciosa</i> (L.) Pers	Lythraceae	8	0.08	7.51	0.033
<i>Streblus aspera</i> Lour.	Moraceae	5	0.119	5.24	0.05
<i>Trewia nudiflora</i> L.	Euphorbiaceae	5	0.071	5.07	0.05
<i>Tectona grandis</i> L.	Verbenaceae	12	0.256	4.46	0.263
<i>Alstonia scholaris</i> L. R.Br.	Apocynaceae	4	0.064	4.24	0.06
<i>Dillenia indica</i> L.	Dilleniaceae	3	0.053	3.4	0.075
<i>Actinodaphne obovata</i> (Nees) Blume	Lauraceae	3	0.015	3.26	0.075
<i>Spondias mangifera</i> Willd.	Anacardiaceae	3	0.059	2.62	0.1
<i>Talauma hodgsonii</i> Hooker f. & T. Thomas	Magnoliaceae	3	0.045	2.57	0.1
<i>Bauhinia purpurea</i> L.	Leguminosae	3	0.029	2.51	0.1
<i>Bischofia javanica</i> Blume.	Euphorbiaceae	3	0.019	2.48	0.1
<i>Syzygium cumini</i> Linn.	Myrtaceae	2	0.033	1.72	0.15
<i>Mallotus philippensis</i> (Lam.) Muell.	Euphorbiaceae	2	0.026	1.7	0.15
<i>Oroxylum indicum</i> Vent.	Bignoniaceae	2	0.019	1.67	0.15
<i>Callicarpa arborea</i> Roxb.	Verbenaceae	2	0.018	1.67	0.15
<i>Sterculia villosa</i> Roxb.	Malvaceae	2	0.015	1.66	0.15
<i>Cassia fistula</i> L.	Leguminosae	2	0.015	1.66	0.15
<i>Sapium baccatum</i> Roxb.	Euphorbiaceae	2	0.01	1.64	0.15
<i>Delonix regia</i> (Boj.ex Hook.) Raf.	Leguminosae	1	0.045	0.97	0.3
<i>Erythrina variegata</i> L.	Leguminosae	1	0.007	0.83	0.3
<i>Pterospermum acerifolium</i> Willd.	Malvaceae	1	0.005	0.82	0.3

Table 2. Phytosociological analysis of shrubs and herbs in Kamrup sal forest stands

Scientific Name	Family	Density ha-1	IVI	A/F Ratio
Shrub layer				
<i>Chromolaena odorata</i> (L.) King & Robinson	Asteraceae	5147	37.45	1.033
<i>Cledodendron viscosum</i> Vent.	Verbenaceae	4627	36.1	0.805
<i>Urena lobata</i> L.	Malvaceae	4160	33.44	0.776
<i>Flemingia strobilifera</i> (L.) Aiton f.	Leguminosae	3573	29.21	0.836
<i>Desmodium latifolium</i> DC.	Leguminosae	1453	16.92	0.531
<i>Lantana camara</i> L.	Verbenaceae	280	5.9	0.506
<i>Solanum torvum</i> L.	Solanaceae	333	5.63	0.762
<i>Rauvolfia tetraphylla</i> L.	Apocynaceae	373	5.3	1.114
<i>Rauvolfia serpentina</i> Benth.	Apocynaceae	347	5.18	1.035
<i>Cassia sophera</i> L.	Leguminosae	387	4.85	1.571
<i>Cannabis sativa</i> Linn.	Cannabaceae	480	4.25	4.388
<i>Leea indica</i> (Burm.f.) Merr.	Vitaceae	120	3.63	0.488
<i>Abutilon indicum</i> L.(Sweet)	Malvaceae	213	3.54	1.248
<i>Sida cordifolia</i> L.	Malvaceae	160	3.3	0.936
<i>Caesaria vereca</i> Roxb.	Flacourtiaceae	93	2.99	0.546
<i>Leea crispa</i> L.	Vitaceae	53	2.3	0.488
Herbaceous layer				
<i>Ageratum conyzoides</i> L.	Asteraceae	52000	16.13	0.937
<i>Xanthium strumarium</i> Linn.	Asteraceae	32667	12.32	0.719
<i>Commelina benghalensis</i> Linn.	Commelinaceae	39000	11.43	1.582
<i>Borreria articularis</i> Linn.f.	Rubiaceae	37333	11.17	1.514
<i>Cyperus brevifolius</i> (Rottb.) Hassk	Cyperaceae	45333	10.92	3.604
<i>Cynodon dactylon</i> Pers.	Poaceae	42667	9.37	6.922
<i>Mikania macrantha</i> Kunth ex H.B.K.	Asteraceae	24667	8.42	1.362
<i>Dryopteris</i> spp.	Dryopteridaceae	24000	8.31	1.325
<i>Centella asiatica</i> Linn.	Apiaceae	24000	7.56	1.908
<i>Spilanthes peniculata</i> Wall. ex DC.	Asteraceae	24000	7.56	1.908
<i>Oplismenus</i> spp.	Poaceae	22000	7.24	1.749
<i>Melastoma malabathricum</i> L.	Melastomataceae	18667	7.1	1.226
<i>Chrysopogon aciculatus</i> (Retz.) Trin.	Poaceae	28000	7.06	4.543
<i>Borreria hispida</i> (Linn.) K. Schum.	Rubiaceae	21333	6.76	2.094
<i>Costus speciosus</i> (J. König) Smith	Costaceae	11333	6.32	0.626
<i>Cleome viscosa</i> L.	Capparidaceae	18667	5.96	2.319
<i>Drymeria cordata</i> (L.) Roem. & Schult.	Caryophyllaceae	16000	5.92	1.57
<i>Achyranthes aspera</i> L.	Amaranthaceae	18000	5.86	2.236
<i>Oxalis corniculata</i> L.	Oxalidaceae	21667	4.93	10.766
<i>Crotalaria</i> spp.	Leguminosae	6333	4.77	0.503
<i>Polygonum hydropiper</i> Linn.	Polygonaceae	18667	4.45	9.275
<i>Justicia simplex</i> D. Don	Acanthaceae	15333	4.31	4.876
<i>Pollia japonica</i> Thunb.	Commelinaceae	15333	4.31	4.876
<i>Amorphophallus campanulatus</i> Roxb.	Araceae	5333	4.24	0.523
<i>Leucas aspera</i> (Willd.) Linn.	Lamiaceae	9667	4.17	1.568
<i>Brunella vulgaris</i> L.	Lamiaceae	9333	3.36	2.968
<i>Polygonum chinense</i> Linn.	Polygonaceae	12000	3.02	10.6
<i>Crassocephalum crepidiodes</i> (Benth.) S.Moore	Asteraceae	6000	2.46	2.981
<i>Cyperus rotundas</i> Linn.	Cyperaceae	5333	2.35	2.65
<i>Scoparia dulcis</i> Linn.	Scrophulariaceae	9333	2.23	18.55

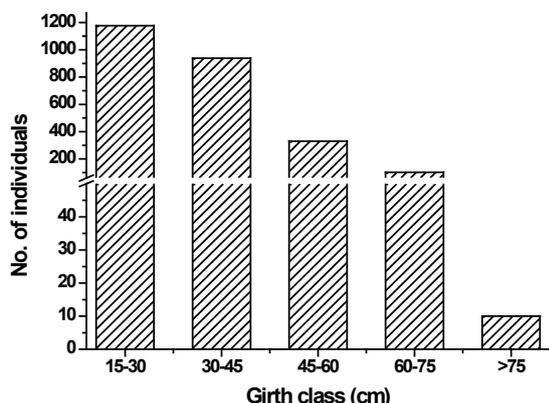


Figure 2. Girth class distribution of the tree species

2559 individual ha⁻¹. Tree species density varies from species to species to ca. 1-2431 individual ha⁻¹ (GBH > 15 cm). Density-girth distribution of the tree species confirmed reverse J-shaped distribution with decreasing density class with increase in girth (Figure 2). The present study exhibited that lower girth class contributed highest number of individuals which proportionally decrease with the increase in girth size.

Stem density was found to be maximum (1177 ha⁻¹) in the girth class 15-30 cm, which accounts for 46.01 % of the total stem density, followed by girth class 30-45 cm (938 ha⁻¹, 36.67 %), 45-60 cm (331 ha⁻¹, 12.93 %), 60-75 cm (103 ha⁻¹, 4.01%) and > 75 cm (10 ha⁻¹, 0.40 %), respectively. Among the trees, *Shorea robusta* exhibited highest stem density of ca. 2431 stems ha⁻¹, while *Erythrina suberosa*, *Delonix regia*, *Pterospermum acerifolium* showed the lowest stem density of ca. 1 stem ha⁻¹. Further, it has been observed that maximum number of individuals of *Shorea robusta* was recorded between girth classes 15-45 cm and lowest in girth classes > 60 cm. (Figure 3).

Basal area varies from 0.005 - 26.08 m²ha⁻¹ for different species (Table 1). Total basal area of the stand was found to be 27.57 m²ha⁻¹ of which *Shorea robusta* comprises the highest basal area of 26.08 m²ha⁻¹. Among the total basal area of *Shorea robusta*, highest basal area (10.44 m²ha⁻¹) was recorded in 30-45 cm girth class followed by 45-60 cm (6.63 m²ha⁻¹) and 15-30 cm (3.98 m²ha⁻¹) girth class (Figure 3).

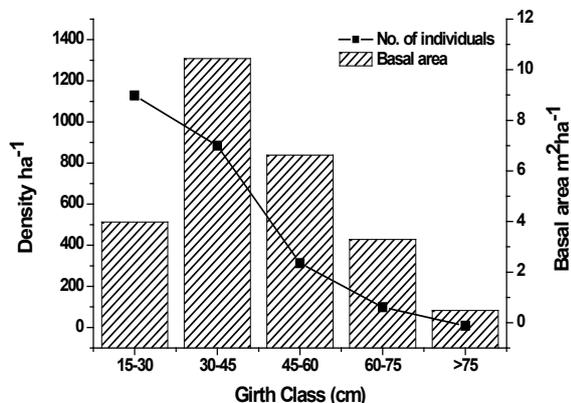


Figure 3. Density and basal area of *Shorea robusta* in different girth class

Among the tree species *Shorea robusta* exhibited the

highest IVI (212.67) followed by *Zigyphus rugosa* (13.33) and *Schema wallichi* (8.39), which indicates that the forest is dominated by *Shorea robusta* trees. The least dominant species of the stand includes *Erythrina suberosa* (IVI- 0.8) and *Pterospermum acerifolium* (IVI- 0.8) (Table 1).

Stand density of shrubs and herbs species was 2.18 individuals' m⁻² and 63.4 individuals m⁻², respectively (Table 2). Among shrubs, *Chromolaena odorata* was the dominant species with highest IVI (36.48) having density (5560 individuals ha⁻¹) followed by *Cledodendron viscosum* with IVI (33.22) with density of 4506 individuals ha⁻¹ and *Flemingia strobilifera* with IVI (32.47) and density 4826 individuals ha⁻¹. The least dominant species like *Leea crispa* and *Cassia verecca* having the density of 53 and 93 individuals ha⁻¹, respectively. Among the herb species, *Ageratum conyzoides* was dominant with IVI (16.13) and density of 5.2000 individuals m⁻² whereas *Scoparia dulcis* was found to be least dominant with IVI (2.23) and density 1 individuals m⁻² (Table 2). Dominance-diversity curve for tree, shrub and herb species (Figure 4) showed that the forest stand had higher dominance or low evenness among trees and shrubs, while comparatively low dominance or higher evenness among herbs.

Shannon-Wiener's index was 1.43 for the tree species, 2.30 for shrub species and 3.28 for herbaceous species. Simpson's dominance index for tree species was recorded 0.51 while for shrub species it was 0.12 and for the herbs it was found to be 0.04. About 84% of the species exhibited clumped distribution, however, only 16% species showed random distribution. None of the species exhibited regular distribution.

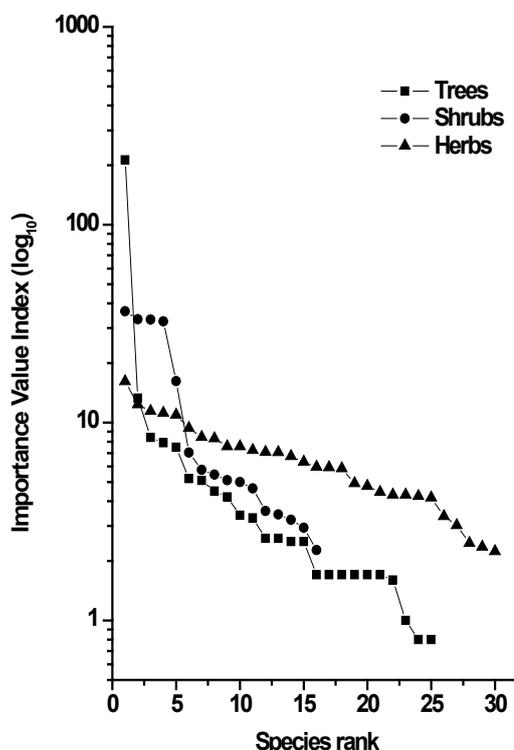


Figure 4. Dominance-diversity curve of trees, shrubs and herbs in Kamrup sal forest

3. Discussion

The plant species richness in the present study was recorded quite high (71 species in 1.2 ha). Uma Shankar[3] also reported high species richness from Sal forests in Eastern Himalaya and reported 87 species in 2 ha plot. The present species richness was found higher as compared to those reported from Central Himalayas and Central India[25,26]. However, it was found to be lower than the sal forest in Gorakhpur division of eastern *terai* region (208 species in 24 ha)[14] and Madhupur sal forest of Bangladesh (94 in 3 ha)[27], which may be due to much lesser sampled area in the present study. Leguminosae was found to be the largest family among plant species and is represented by 8 species. Several authors have also reported Leguminosae as the prominent family for Indian deciduous forests[28-30]. Among trees, both Leguminosae and Euphorbiaceae were found to be the dominant families with 4 species each followed by Moraceae, Verbenaceae and Bignoniaceae. Uma Shankar[3] reported Euphorbiaceae as the most dominant group in the Eastern Himalayan lowland forests. Gentry[31] reported Bignoniaceae as the second most specious family from neo-tropical deciduous forests. In shrub layer, both Leguminosae and Malvaceae were recorded as most dominant families. In herbaceous community Asteraceae was the dominant groups while the co-dominant being the Poaceae. Nath et al.[5] also reported Asteraceae as the dominant family followed by Poaceae among the herbaceous communities in tropical forest of north-east India. The stem density of tree species decreases with increase of girth size observed in the present study was in agreement with the findings of other workers[32-34]. The stem density of 1303 stems ha⁻¹ (>30 cm GBH) obtained in the present study was quite high than the reported value (180-860) from tropical forests of different parts of India[14,26,35]. However, Swamy et al.[36] reported that the tree density (> 30 cm GBH) varies from 245-859 individuals ha⁻¹ in the tropical forest of Tamil Nadu, India. Further, the present study confirms to the findings of Singh et al.[37] who reported 1233 individuals ha⁻¹ from the tropical moist deciduous sal forest of Achanakmar Wildlife Sanctuary. Total basal area in the present study was recorded 27.57m² ha⁻¹. Shukla and Pandey[38] also reported similar basal area (22.23 m² ha⁻¹) from Sal forest of Gorakhpur division. While, Jha and Singh[35] reported basal area between 7-29 m² ha⁻¹ from Sal forest in Central India. On the other hand, Uma Shankar[3] reported basal area 26.3 m² ha⁻¹ from Sal forest of Eastern Himalaya. Similarly, Tiwari et al.[39] also reported a basal area (26.1 m² ha⁻¹) from Sal Forest in Subtropical Submontane Zone of Garhwal Himalaya. Presence of large number of individuals in the lower girth classes contributed the maximum basal area compared to the other sal forests of India. The tree species *Shorea robusta* shared the maximum IVI (212.67) then the other plant species, which was much higher than the reported values[3,38,39]. However, Kushwaha and Nandy[40] reported an higher IVI value of 221.78 for *Shorea robusta* from Chotanagpur Plateau in West Bengal.

The diversity index of trees in the present study was recorded 1.43 was within the range of earlier reported values[14,37,41,42]. Nath et al.[5] also reported a diversity value of 1.46 for tropical forest of north-east India. Generally, Shannon-Weiner diversity for tropical forests, ranged from 0.81 to 4.1 for the Indian sub-continent[12,36]. Further, diversity index for shrubs and herbs was recorded 2.30 and 3.28 respectively. Sobuj and Rahman[43] also reported diversity index of 2.56 and 3.27 for shrubs and herbs respectively from tropical moist deciduous forest of Khadimnagar national park in Bangladesh. The Simpson's dominance index in the present study ranges between 0.04 and 0.51 which is less than the reported value (0.047- 2.11) from 24 different sal communities in Gorakhpur Division[40]. Higher fluctuation of Shannon index (H) value (1.43-3.27) indicates that this tropical moist deciduous sal forests are also species diverse systems.

The density girth distribution of tree species in the present study confirmed the reverse J-shaped distribution. Similar distribution pattern for sal forest was also reported by Tiwari et al.[39] and Kushwaha and Nandy[40]. Rao et al.[2] reported that, predominance of lower diameter classes attributed to the reverse J-shaped distribution. Abundance/frequency ratio exhibited that most of the species have contagious distribution, while only two species showed random distribution. Similar distribution pattern was also reported by Tripathi and Singh[44] for sal forest from Katerniaghat Wildlife Sanctuary. Odum[45] reported that contagious distribution is the commonest pattern in nature.

Thus, from the present study it can be established that the forest is heterogenous in composition with high dominance of *Shorea*. Girth class distribution structure of the population also confirms that the forest is under regenerating stage. Girth class distribution decreases exponentially with increasing GBH are characteristic for species with continuous regeneration[46].

4. Conclusions

From the present study, it can be concluded that Kamrup sal forest has high species diversity. Presence of large number of individuals in the lower girth class in the forest gives a good indication of better regeneration potential in the prevailing climatic condition. Climatic conditions of Kamrup region have also preferred sal and its associates to form a diverse sal forest. It can also be concluded that the present study stand has faced a huge destruction in the past, which at present is regenerating once again into its natural habitat. Therefore this type of forest can also be classified as "Regenerated Sal forests". Thus, effective conservation and management initiatives are most important for sal and its associate plant species in order to conserve this sal forest.

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