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Research article

Species composition and structure of Sal (*Shorea robusta* Gaertn. f.) forests along disturbance gradients of Western Assam, Northeast India

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Abstract: The present paper deals with the structure and species composition of undisturbed and disturbed secondary Sal forests of Goalpara district, Western Assam, Northeast India. Species richness was recorded very low with only 3 species in undisturbed Sal forests compare to the 18 species in disturbed Sal forests. The density and basal area were recorded high in undisturbed forests than the disturbed one. *Shorea robusta* is the single dominant species and constitute the bulk of the stocks in both forests types. Girth class distribution of density revealed the dominance of middle girth classes in undisturbed forests whereas in disturbed forests 45 % of the total density recorded in lowermost girth class. Anthropogenic disturbances influence the forests structure, functions as well as services in both forests types in the present study.
Keywords: Species diversity - Density - Disturbance index - Sal forests.

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INTRODUCTION

Sal (*Shorea robusta* Gaertn. f.) is one of the dominant tree species in the tropical moist as well as dry deciduous forests in India (Champion & Seth 1968) and frequently forms a mono-specific canopy (Rautiainen & Suoheimo 1997). Sal is well known for its high timber value and government always attempted to manage Sal forests for commercial timber production in order to increase revenue (Gautam & Devoe 2006). Sal tree grows gregariously and tends to form dense vegetation in its natural habitat. Natural Sal forests have high resilience capacity and survive through regeneration (Soni 1961, Qureshi *et al.* 1968). In India, Sal forests are found to occur gregariously in the northern and central regions and cover approximately 13.30% of the total forest area of the country (Upreti & Nayaka 2005). There is almost a continuous belt of Sal stretching along the sub-Himalayan tract from Punjab to Assam (Pandey & Shukla 2003) in the northern Indian region.

In Assam, Sal is a semi-deciduous species and found in the form of high forest and coppice forest confined specially to the Western part of Assam (Sarma & Das 2012). Champion & Seth (1968) categorized Assam's Sal forests as "Tropical Moist Deciduous Forest" further divided into 'Khasi hill Sal forest' (3C/C1 1a (ii)) and 'Kamrup Sal forest' (3C/C2 2d (iv)). Kamrup Sal forests are more prominent and confined in Western part of the state.

Disturbances not only influence diversity but also regeneration and dominance of tree species (Lawes *et al.* 2007). Recurrent anthropogenic disturbances treated as a major threat of natural Sal forests which can change its structure as well as function (Lalfakawma *et al.* 2009). Due to the ongoing over-exploitation, deforestation, encroachment and alteration in land use and land cover the mother Sal forests gradually replace by secondary regenerated Sal forest of the low lying areas of Assam (Deka *et al.* 2012). Again regeneration was very poor where soil moisture is inadequate and which experienced higher degree of disturbances such as fire and different human activities (Padey & Shukla 2001, Chauhan *et al.* 2008). Chitale & Behera (2012) stated that moisture is one of the key factors that influence the distribution to shift the Sal forests towards northern and eastern India due to changing climate. Ahmed & Medhi (2005) estimated that there was shrinkage of 1050.46 hectares reserve forests and proposed reserve forest areas of Goalpara District during the period 1981–2002 due to encroachment for human habitation, pasture and agricultural uses. These are causing loss of Sal forest trees at a very fast rate, thereby encouraging the spread of mix forest communities (Sarma & Das 2012). Timely, accurate assessment

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and understanding of the dynamics of plant resources is important for their sustainable management, utilization and biodiversity conservation (Sarkar & Devi 2014). Comparatively a good number of quantitative studies of community attributes are available for tropical Sal forest of northeast India (Uma Shankar 2001, Ahmed & Medhi 2005, Lalfakawma *et al*. 2009, Deka *et al*. 2012, Sarma & Das 2012, Dutta & Devi 2013) but in Western part of Assam which constitute the major partion of 'Kamrup Sal forest' (Champion & Seth 1968) have not received much attention, except few similar studies (Deka *et al*. 2012, Sarma & Das 2012). Therefore the present study deals with the species composition and other community attributes of undisturbed and disturbed Sal forest of Goalpara District, Western Assam, Northeast India.

MATERIAL AND METHODS

The study was conducted in undisturbed and disturbed Secondary Sal forest located in Goalpara District, Western Assam, Northeast India (Fig. 1). The geographical location of Goalpara District is between latitude 25° 53'–26° 30' N and longitude 90° 07'–91° 05' E. The vegetation was analysed by delimiting a total of five 0.1

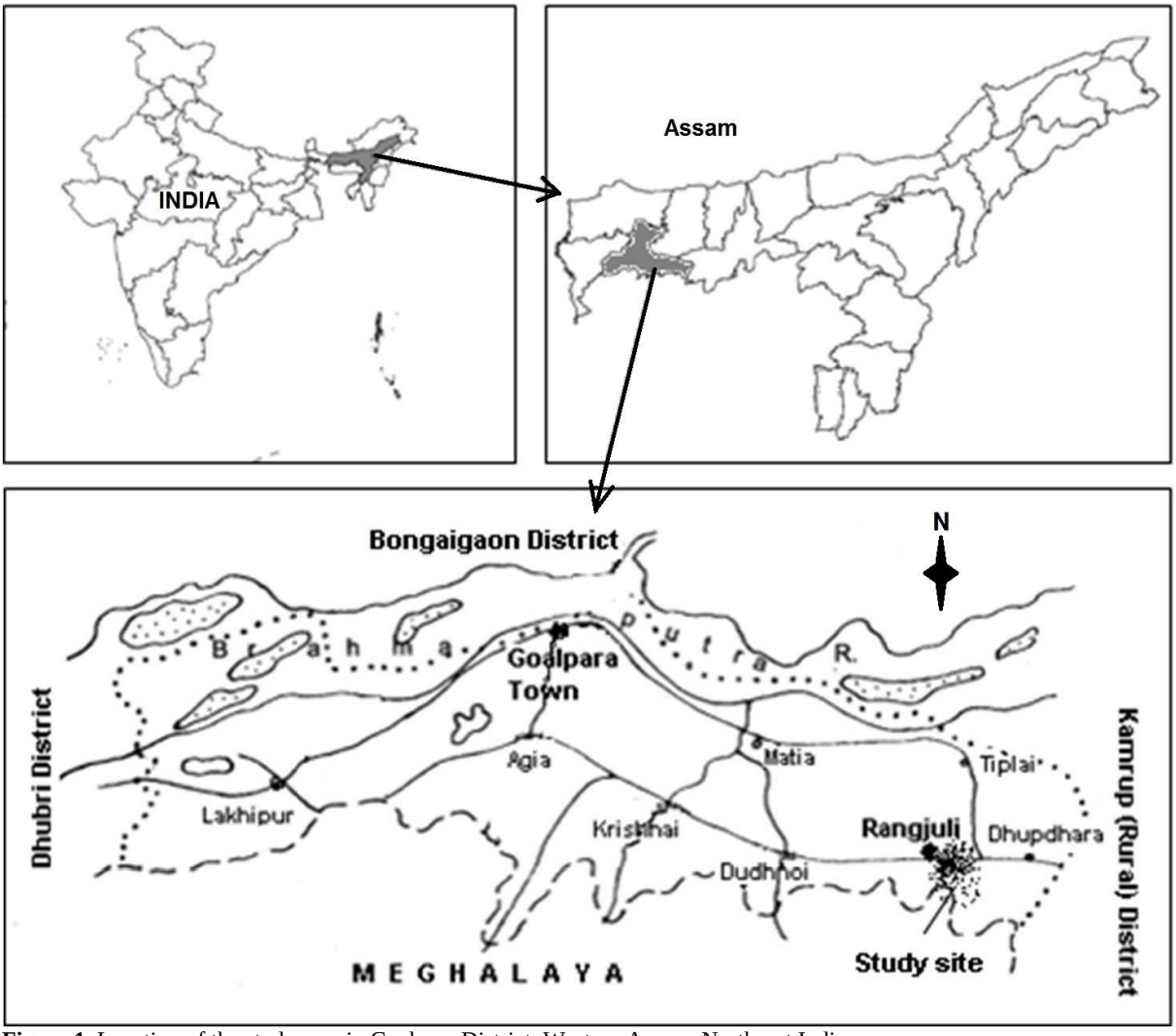

Figure 1. Location of the study area in Goalpara District, Western Assam, Northeast India.

hectare quadrats randomly in each undisturbed and disturbed Sal forests. The girth of all the trees (≥ 10 cm GBH) within the sampling area were measured at breast height (*i.e.* 1.37 m above the ground) and identified. The climate is damp and warm humid and average annual rainfall of last five-year period (2008–2012) was 2173.02 mm yr^{-1} (Hydromet Division 2013).

Quantitative analysis of tree vegetation for Density and Basal area were done by following Misra (1968). The importance value index (IVI) is the sum of relative density, relative frequency and relative dominance. Shannon-Wiener diversity index (Shannon & Wiener 1963) was calculated from the IVI values using the formula -

$$H = -\sum_{i=1}^{s} P_i \ ln \ P_i$$

Where, P_i is the proportion of individuals of i^{th}species and total number of individuals all the species (n_i/N).

Concentration of dominance (cd.) was measured by Simpson index (Simpson 1949).

$$\text{Cd.} = \sum_{i=1}^{s} (P_i)^2$$

Where, P_i is same as Shannon-Wiener diversity index.

A disturbance index for each forest site was calculated following Kanzaki & Kyoji (1986), Pandey & Shukla (2001) and Borah *et al*. (2014). The disturbance index (DI) was calculated as the basal area of cut trees measured at the ground level expressed as fraction of total basal area of all trees:

$$\text{DI \%} = \frac{\text{Basal area of cut stumps}}{\text{Total basal area (cut stumps basal area + Standing tree basal area)}} \times 100$$

RESULTS

Species richness of pure Sal forests is generally very poor. In the present study only 3 species belonging to three families was recorded in undisturbed forests whereas 18 species representing 14 families in disturbed Sal forests (Table 1). Disturbances might be responsible for arrival and establishment of new species in disturbed

Table 1. Cumulative results of the undisturbed and disturbed Sal forest of Western Assam, Northeast India.

Parameter	Undisturbed	Disturbed
Species number	3	18
Family number	3	14
Density (tree ha^{-1})	410	306
Basal area (m^2 ha^{-1})	26.40	12.90
Shannon index	0.73	2.05
Simpson index	0.60	0.25
Disturbance index (DI %)	7	51

Sal forests besides its high resilience capacity. The density and basal area of the tree species were significantly lower in the disturbed forests than the undisturbed forests. The encountered density as well as basal area was 410 tree ha^{-1} and 26.40 m^2 ha^{-1} in undisturbed and 306 tree ha^{-1} and 12.90 m^2 ha^{-1} in disturbed forests respectively (Table 1). Disturbance index indicated the degree of disturbance and found high (51%) in disturbed forests and less (7%) in undisturbed forests (Table 1). *Shorea robusta* was found dominant in both undisturbed and disturbed forests based on IVI score (Table 2). IVI score of each species in both forest types are shown in Table 2.

In each forest type distribution of density and basal area in different GBH classes was shown in figure 2. In undisturbed forests maximum density (30%) was recorded in 70–90 cm GBH class and overall 78% density in middle girth classes (50 cm to 130 cm GBH class) evidenced the post mass regeneration of that particular forest. In disturbed forests maximum density (45%) was recorded in lowermost *i.e.* 10–30 cm girth class and it drastically decrease in successive girth classes hints its past disturbance history and the resilience capacity. Density of other species was found high in disturbed Sal forests especially in lower girth class (Table 3). Diversity index was comparatively more in disturbed forests than undisturbed forests (Table 1).

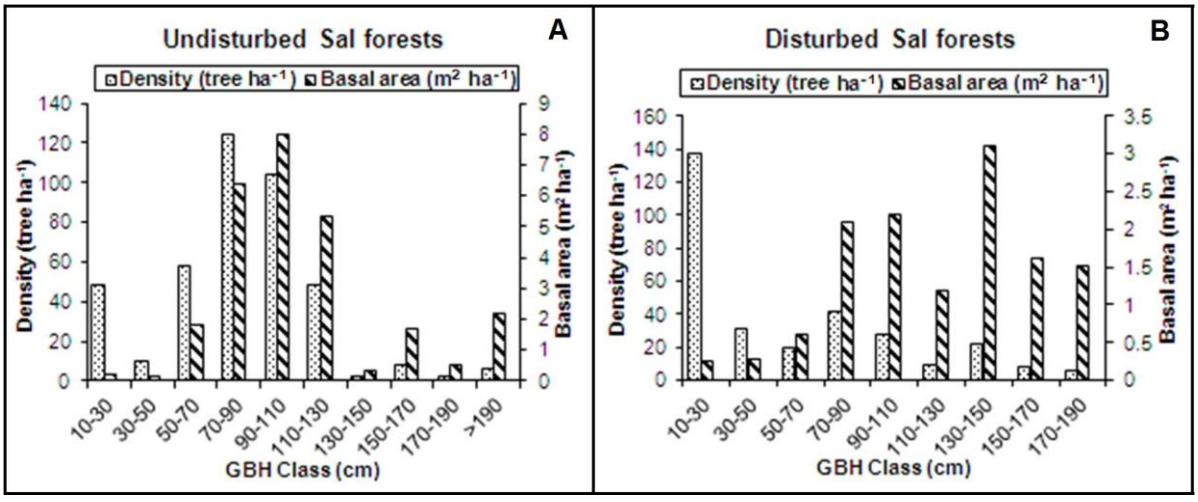

Figure 2. Girth class distribution of tree species in Sal forest: **A,** undisturbed; **B,** disturbed.

Table 2. IVI score of each species in undisturbed and disturbed Sal forests of Western Assam, Northeast India.

S.No.	Species name	Undisturbed				Disturbed			
		R.De	R.Fr.	R.Do.	IVI	R.De	R.Fr.	R.Do.	IVI
1	*Aegle marmelos* (L.) Corr.	1.31	4.44	0.47	6.22	-	-	-	-
2	*Alstonia scholaris* (L.) R.Br.	1.31	4.44	0.09	5.84	-	-	-	-
3	*Artocarpus chama* Buch.-Ham.	0.65	2.22	0.14	3.02	-	-	-	-
4	*Callicarpa arborea* Roxb.	2.61	6.67	7.75	17.03	-	-	-	-
5	*Dillenia indica* L.	0.65	2.22	0.21	3.08	-	-	-	-
6	*Dillenia pentagyna* L.	3.92	8.89	2.17	14.98	-	-	-	-
7	*Ficus religiosa* L.	0.65	2.22	3.73	6.61	-	-	-	-
8	*Holarrhena pubescens* (Buch.-Ham.) Wall. ex G.Don	0.65	2.22	0.02	2.90	-	-	-	-
9	*Litsea monopetala* (Roxb.) Pers.	3.92	8.89	1.26	14.07	-	-	-	-
10	*Mallotus ferrugineus* (Roxb.) Muell. Arg	3.27	8.89	1.09	13.24	-	-	-	-
11	*Mitragyna rotundifolia* (Roxb) O. Kuntze	1.96	4.44	0.31	6.72	-	-	-	-
12	*Shorea robusta* Gaertn.	62.09	11.11	71.25	144.45	94.14	41.66	90.22	226.04
13	*Schima wallichii* (DC) Kuntze	7.19	11.11	8.22	26.52	3.41	33.33	5.53	42.27
14	*Spondius pinnata*	1.96	4.44	0.31	6.72	-	-	-	-
15	*Streblus asper* Lour.	1.31	2.22	0.03	3.56	-	-	-	-
16	*Sterculia villosa* Roxb.	2.61	4.44	0.62	7.68	-	-	-	-
17	*Terminalia bellirica* (Gatertn.) Roxb.	2.61	6.67	2.17	11.45	2.43	25.00	4.24	31.68
18	*Toona ciliata* M. Roem.	1.31	4.44	0.17	5.92	-	-	-	-
	Total	100	100	100	300.00	100	100	100	300.00

*R.De.= Relative density; R.Fr.= Relative frequency; R.Do.= Relative dominance; IVI= Importance Value Index.

Table 3. Density of Sal and other species in different girth class in undisturbed and disturbed Sal forest of Western Assam, Northeast India.

GBH Class (cm)	Species	Density (tree ha^{-1})	
		Undisturbed	Disturbed
10-30	Sal	40	72
	Other species	8	66
30-50	Sal	8	18
	Other species	2	14
50-130	Sal	322	76
	Other species	12	24
>130	Sal	16	30
	Other species	2	6

DISCUSSIONS AND CONCLUSION

In present study only 3 species was found in undisturbed Sal forests agreement with the study carried out by Stainton (1972) in Pure Sal forests of Nepal. More species number (18 species) in disturbed Sal forests might be due to the anthropogenic disturbances which favour arrival and establishment of new species. In the present study overall species number is quite low compare to the other studies reported from different part of Northeast India (Uma Shankar 2001, Lalfakawma *et al*. 2009, Deka *et al*. 2012, Sarma & Das 2012, Dutta & Devi 2013). The density of undisturbed forests was found 410 tree ha^{-1} and it is comparable to other studies done in different Sal forests of the country such as 294–559 tree ha^{-1} in Central India (Jha & Singh 1990), 484 tree ha^{-1} in Eastern Himalaya, Meghalaya (Uma Shankar 2001), 408 trees ha^{-1} in Gorakhpur, India (Padey & Shukla 2003), 438 tree ha^{-1} in moist Sal forests of West Bengal, India (Kushwaha & Nandy 2012), 422 tree ha^{-1} in Doboka reserve forest, Assam, NE India (Dutta & Devi 2013). Comparatively less density in disturbed forests especially >50 cm GBH class trees (136 tree ha^{-1} in disturbed against 340 tree ha^{-1} in undisturbed forests) might be due to the various anthropogenic disturbances (Table 2). In the present study the basal area was recorded 26.40 m^2 ha^{-1} in undisturbed and 12.90 m^2 ha^{-1} in disturbed Sal forests. Similar basal area (7–29 m^2 ha^{-1}) was reported from Sal forest of Central India (Jha & Singh 1990). High density of other species in disturbed forests might be due to the canopy gaps resulted from the disturbances. Disturbances enabled increased light intensity and ultimately change the environmental condition make favourable for other lights demanding successional species (such as

Schima wallichii, *Callicarpa arborea* etc.) leading towards mix forest communities. Species richness of disturbed forest is a cumulative outcome of differential responses of species to disturbances (Sagar *et al*. 2003). Kushwaha & Nandy (2012) reported that climatic conditions-mainly the rainfall, disturbance regimes and the management practices influenced the species composition and community structure of Sal forests while in the present study differences occur mainly because of the disturbance regimes.

Sal is a very important tree species and usually harvested for its timber. The Sal forests of Goalpara district of Assam were exposed to different intensities of fire and anthropogenic disturbances in the past. Sarma & Das (2012) stated that Sal forests of Western Assam has been facing great biotic pressures such as illegal felling, firewood collection, encroachment of peripheral areas leading to pure Sal forests to mix forests which was also reflected in the present study. Weeds and creeper also greatly influenced the regeneration of Sal forests. The major threats such as illegal tree felling, firewood collection, encroachment of peripheral areas might be due to the inadequate conservation strategy, negligence of concerned forest departments. The ongoing disturbances, if not control then these undisturbed pure Sal forests may degrade and convert to the mix forests in the very near future.

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