ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 12, Issue, 07, pp.12770-12776, July, 2020

DOI: https://doi.org/10.24941/ijcr.39095.07.2020

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

TREE DIVERSITY, STAND STRUCTURE, AND COMMUNITY COMPOSITION OF TROPICAL FORESTS IN DALMA WILDLIFE SANCTUARY OF JHARKHAND, INDIA

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ARTICLE INFO

Article History:
Received 07th April, 2020
Received in revised form
25th May, 2020
Accepted 27th June, 2020
Published online 30th July, 2020

Key Words:
Species diversity, Beta diversity, Basal area, Girth class, Canopy height and Species composition.

ABSTRACT

Species diversity and density of trees were assessed in forests of Dalma Wildlife Sanctuary of Jharkhand comprising mostly of tropical deciduous forests. We compared tree community characteristics like stem density, basal area, diversity index, Beta(β diversity), Girth class, Canopy height class and species composition of tree species in all three zones (Altitude between 199 -603m) in the study area. A total of 41 tree species of 25 families, 71 genera, and 95 species were recorded. Gramineae (10) family is most represented followed by Euphorbiaceae (6). It was noticed that the tree density varied from 30.64 to 62.51. The maximum basal area contributed by *Terminalia belerica* (1.323 m^2ha^{-1}) followed by *Albezzia stipulate* (1.145 m^2ha^{-1}). Shan none Weiner index (H') ranged from 3.073 to 3.997 and species richness index ranged from 1.05 to 1.20. Beta diversity of tree species varied from 2.32 to 3.80. The highest number of tree species was occurred in girth class of 61 – 80 cm in all three zones. At present the biodiversity of these forests are under threat due to the anthropogenic and illegal interference of outside people for cutting of furniture tree species. The present study will help us to understand the patterns of tree species composition and diversity in the Dalma Wildlife Sanctuary, of India.

Citation: ***Narendra Prasad, Sah R. B. and Sahoo, U.K.*, 2020.** "Tree diversity, stand structure, and community composition of tropical Forests in Dalma Wildlife Sanctuary of Jharkhand, India". *International Journal of Current Research*, 12, (07), 12770-12776.

INTRODUCTION

Few balancing factors of this Universe like Sun, Earth, Air, Water & Vegetation are playing together a greater role in existence of life on this planet. Forest is one of the constituents of the vegetation considered as important natural resources. It is balancing the relation between the life and environment. Deforestation from long past has drawn attention at global level. vegetation is a need to balance the ecosystem of the earth for well being of human life. Land use practices is leading as a driver of land cover loss which may be resolved by proper conservation adopting community based forest management to save bio-resources for future generation, otherwise the loss of biodiversity will respond very bad impact over the issue of predominately in a particular area. Forest is providing direct or indirect benefit to human being by various produce and indirectly serves for balance the ecology. It also protects our life, relation among the society, and gives a healthy life to all.
In a study it was found that in past one or two century, the extinction rate of plant species has increased by more than hundred times so the population of fauna is decreasing on this planet. The clever lives at this earth are rightfully and cruelly misusing the natural resources of earth surface which are changing unbelievable. Ecologically forest cover has a vital role in protection and conservation of fertile soil, climate as well as aquatic and micronutrient for the vegetation on the earth. It also give habitat to flora and fauna species. Woodland having a mature or over mature tree is the most valuable for repository of the world's flora for genetic heritage. In India, National Forest Policy (1952) and recent policy (1988) has also recommended that one third of the geographical area to be reserved for forest cover (Govt. of India, 1980). However, In India according to State Forest Report, 2017 forest cover is 24.39 percent of the geographical area of the country, which has been regularly, monitored and published in the form of "States of Forest" every alternate year by Forest Survey of India. Due to forest dependent developmental activities monitoring of day to day status of forest cover is required as entire ecosystems on earth is dependent on forests, which are also direct cause of change of environmental condition in the country. Therefore, information is needed and the progressive change in land cover over periods of decades is of interest. Remotely sensed data may provide a better source for derivations of land cover due to internal consistency,

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reproducibility and coverage in locations where ground based knowledge is sparse (Roy and Joshi, 2002). Thus, remote sensing is one of the potential tools to carry out vegetation mapping. Jharkhand with a geographical area of 79,714km² constitutes 2.42% of the country's area. The total recorded forest area of the state is 23,605 km² which is 29.61 % of the geographical area of the state. India State of Forest Report, 2017 published by Forest Survey of India, forest cover in the state is 23,553 km² which is 29.54% of the state's geographical area. The total forest and tree cover put together, it constitutes about 33.21% of the geographical area of the state. In proper conservation and management of ecosystem of wildlife sanctuaries, it is essential to know the details of existing vegetation by classifying and mapping of the protected area. Change of status and distribution of vegetation with time is now possible to study, using the technology of remote sensing, which provides information in quantitative aspects of floral composition of the target area (Muller-Dombois and Ellenberg, 1974).

MATERIALS AND METHODS

Study area: The study was conducted during the period of 2016 to 2018 in partial fulfilment of the requirement of the degree of Doctor of Philosophy in forestry of Mizoram University, Aizawl.

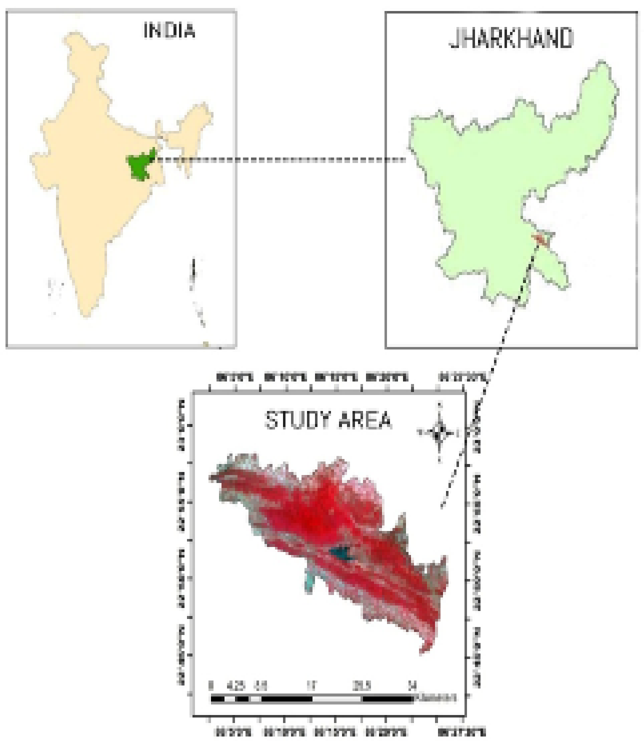

Figure 1. Study Area

The data were collected from Dalma wildlife sanctuary which is situated on the Chhotanagpur plateau of Jharkhand near the steel city of Jamshedpur and extends into portions of the East Singhbhum and Saraikela-Kharshanwa districts of Jharkhand it lies between Latitudes 22^0 46' 30" N and 22^0 57'N and Longitudes 86^0 3' 15" E and 86^0 26'30"E. Its eastern limit extends up to the border of Purulia district of West Bengal on the eastern side. The entire Forest of Dalma Sanctuary fall in the catchment *area* of Subarnarekha River and Dimna Lake of Jamshedpur.

The Sanctuary is 193.22 sq. kms (R.F. 45.56 sq. km, and P.F.—147.44 sq.km out of which 157.71 sq. kms were transferred by Dhalbhum Forest Division and the remaining 35.51 Sq.kms by Chaibasa North presently Saraikela Forest Division. Out of this, 193.22 sq. kms, the core area consists of 59.27 sq. kms. Soil of the sanctuary area is generally sandy-loam and clayey-loam. The depth of soil greatly varies. Soil depth is moderate in the plain areas and minimum in the hillocks. Often at places, pure laterite and moorum exist. The area has three distinct seasons- Summer, Rainy and Winter Seasons. An unpleasant hot and dry weather prevails from March to June and hot westerly winds blow during the period The maximum day temperature reaches 48°C and more. Due to extreme variations of temperature are different parts of the sanctuary, considerable variation in flora and fauna is observed. In extreme summers one experiences complete microclimate in the core area. The rainy season extends from middle of June to middle of October and moderate temperature prevails in the area. The average rainfall in this area is 57 inches (1400 mm) and (lie average number of rainy days observed in a year are 85. The core area of the sanctuary experiences a bit more rainfall than the other parts of the sanctuary.

Methodology

Species distribution: Distribution of Species is an important component to study the ecology of a place, which has alarmed a special attention to the ecologists. It is calculated by Abundance/frequency ratio to know the present status of distribution of species. There is a correlation between species distribution, richness and altitudinal variation which provide a basis of biodiversity conservation which is is governed by various ecological factors. According to study report by (Bajpai *et al.* 2012), Bliss (1963), Douglas & Bliss (1977) and Billings (1973) " the vegetation of any place is the interaction on result of many factors like topographic gradients, the elevation, soil, species composition and biotic interferences. It has been also said that the patterns of species richness are result of local factors, such as plant species productivity, competition among tree species, geographical configuration of the area, plant species dynamics, regional, variation of environment condition and human interference (Woodward 1988, Palmer 1991, Eriksson 1996, Zobel 1997, Criddle *et al*. 2003).

Basal area: Basal area is regarded as an index of dominance of a species. Higher the basal area, greater the dominance. The average basal area and the relative basal are calculated out of the average diameter of the stem at the breast height using the following formula.

Basal area (BA) = $(GBH)^2/4$

Relative basal area

$$\text{Relative basal area (RBA)} = \frac{\text{Basal area of the species}}{\text{Total basal area of all species}} \times 100$$

Alpha diversity (£): It is measured as the number of species occurring within an area of a given size (Huston1994). It helps to measure potentially interactive assemblage of species.

Beta diversity (β) diversity: it is expressed as degree of species change in a given habitat. It indicate the rate of proportion, normally it is termed as Similarity Index or species turnover rate.

$\beta = Sc / S$

Where Sc = Total number of species encountered in all community

S = Average number of species for community.

RESULTS

Plant Composition Summary: The summery of plant composition of study area of Dalma Wildlife Sanctuary (Table- 1). It included No. of trees, shrubs, herbs and climbers for upper, middle and lower zones.

Table 1. Summary of plant composition in study area of Dalma Wildlife Sanctuary

Sl. No	Particulars	Upper altitude	Middle Altitude	Lower Altitude
1	Trees	41	30	25
2	Shrubs	20	15	19
3	Herbs	21	16	21
4	Climber	13	11	9
5	Family	47	40	25
6	Genera	71	59	63
7	Species	95	72	74
8	Tree density	62.51	33.6	30.64

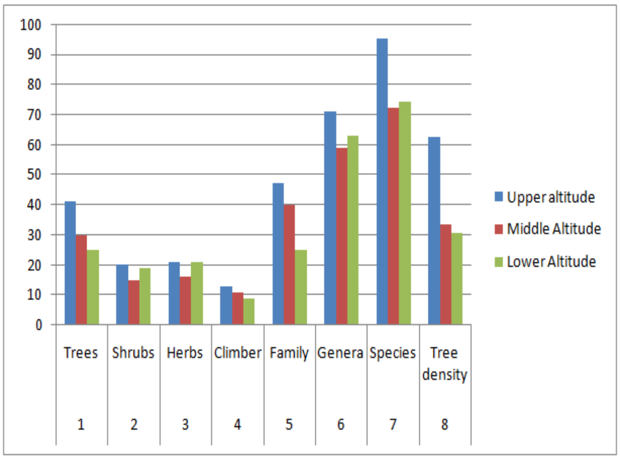

Fig. 1. Summary of plant composition in study area of Dalma Wildlife Sanctuary

The plant distribution is found to belong 47 families in upper zone, 40 families in middle zone and 25 families in lower zone. The total number of genera identified at upper, middle and lower zone were 71, 59 and 63 respectively, while total number of species found distributed in upper, middle and lower zones were 95, 72 and 74 respectively. The density of tree species as calculated for upper, middle and lower zones were found as 62.51, 33.60 and 30.64 respectively. This indicates higher density of tree species at upper zone. The species richness Index was also calculated for Dalma Wildlife Sanctuary at three three related sites ie upper zone, middle zone and lower zones. Its value was for upper (8.77) and less for lower zone (8.34). The comparative summary of plant composition for upper, middle and lower zones is also depicted (figure 1) with bar diagram for Dalma Wildlife Sanctuary.

Diversity pattern: The highest value of Shannon Wiener index (3.997) was found for middle zones followed by upper zone (3.33) and lower zone (3.073). In the lower zone maximum and minimum species diversity was recorded for *Shorea robusta* (H= 0.518) and *Odina wodier (H=0.015)* respectively. In the middle zone maximum and minimum species diversity was recorded for Shorea robusta H = 0.798) and *Cleistanthus collinus (D =0.010)* respectively while the maximum and minimum value for upper zone was recorded for *Shorea robusta (D =0.257)* and *Pterospermum pteragonum* (D = 0.006) respectively.

Table 2. Species richness and diversity pattern of tree species

Study zone	Species Richness (SR)	Shannon Diversity Index (H)
Upper Zone(454m – 603 m)	41	3.333
Middle Zone(250m – 452m)	29	3.997
Lower Zone(199m – 250m)	25	3.073

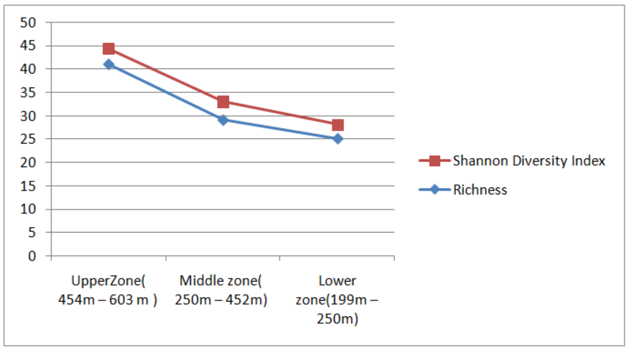

Figure 2. Species richness and diversity pattern of tree species in upper, middle and lower zones

Basal Area (m^2ha^{-1}): The Basal area of tree species spreading over the upper zone, middle zone and lower zone of Dalma Wildlife Sanctuary. Maximum basal area contributed by *Terminalia belerica* (1.323 m^2ha^{-1}) followed by *Albizzia stipulate* (1.145). The basal area contributed by *Cedrela toona* was found minimum (0.040 m^2ha^{-1}). In case of middle zone out of 30 tree species, maximum basal area contribution was observed for *Terminalia belerica* (1.44 m^2 ha^{-1}) followed by *Adina cordifolia* (1.00 m^2 ha^{-1}) similar to upper zone contribution to basal area by *Cedrela toona* remained minimum(0.063 m^2ha^{-1}) in middle zone. In case of lower zone of Dalma Wildlife Sanctuary, out of 25 tree species basal area contribution of *Terminalia belerica* was found maximum (1.44 m^2 ha^{-1}), followed by *Bauhinia racemosa (* 0.93 m^2 ha^{-1}). Twenty common tree species observed in upper, middle and lower zone indicated highest value for *Terminalia belerica* as 1.32, 1.44 and 1.44 m^2ha^{-1} for upper, middle and lower zone respectively. A comperative view of total Basal Area of all the species existing in all the three zone of Dalma Wildlife Sanctuary and also for common species occurring on all the three sites is shown (figure 3) . It indicated wide difference in total basal area of upper zone with respect to other zone (middle and upper). Whereas, for common tree species there is not much difference in total basal at the three studied zone.

Canopy Height Class: The tree species observed in upper, middle and lower zone of Dalma Wildlife Sanctuary has been also classified in different canopy height classes as 1 to 10m, 11 to 20 m and 21 to 30m, respectively for lower canopy height, middle canopy height and top canopy height.

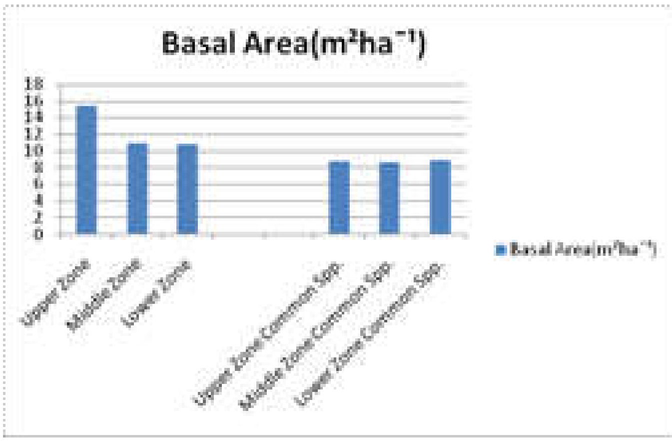

Figure 3. Basal Area of Dalma Wildlife Sanctuary for total species Upper, Middle and Lower Zones and for common tree species presence in all the three identified zones

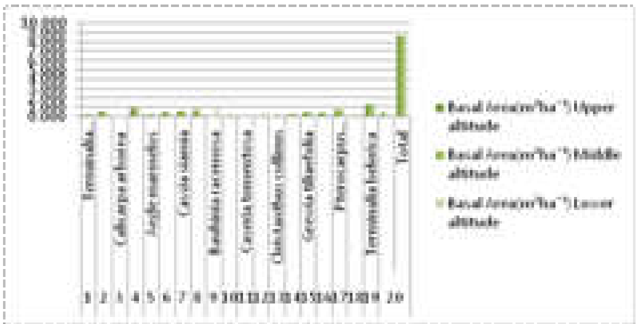

Figure 4. Graphical presentation of Basal area of common tree species found in all three study zones

The data representing canopy height for upper zone, middle and lower zone. Perusal of the data of indicated presence of 23 tree species in lower, 15 species in middle and 3 species in upper zone which occupied top canopy. In case of middle zone the canopy is represented by 18, middle by 9 and top canopy is by two species namely *Terminalia tomentosa* and *Shorea robusta* . At lower zone lower canopy height is represented by 13 tree species, middle zone by 11 and top canopy height by 1 species. It further observed that *Terminalia tomentosa* is a common species that occupies top canopy height at all the three zones (Upper, middle and lower). In middle and upper zone, *Shorea robusta* has also occupied as top canopy height, while one more species i.e. Lager *Stroema parviflora* has been also occupying top canopy height at upper zone . The canopy height has also been represented with bar diagram (Fig. 5), which indicated presence of maximum number of tree species at upper canopy height.

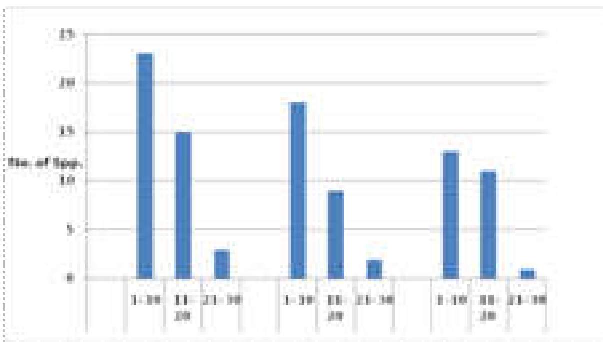

Figure 5. Numerical strength of plant species of vertical stratified classes based on canopy height found in upper, middle and lower zones of Dalama Wildlife Sanctuary

Table 3 Girth class (cm) of tree species for Upper, Middle and Lower zones

Tree Diameter Class (cm)	No. of tree species		
	Upper Zone	Middle Zone	Lower Zone
20 – 40	0	0	0
41 – 60	9	5	3
61– 80	8	9	6
81 – 100	7	4	5
101 – 120	5	2	0
121 – 140	1	1	5
141– 160	6	4	2
161 – 180	2	2	1
181 – 200	1	1	2
201 - above	2	1	1
Total	41	29	25

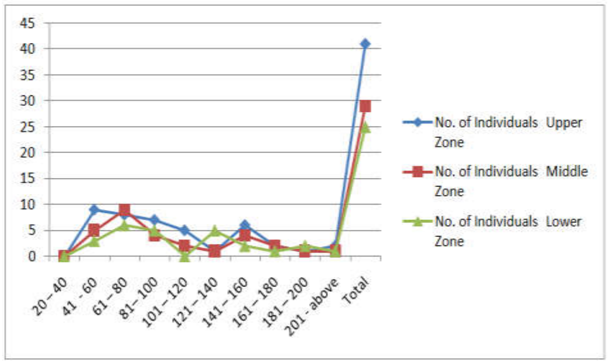

Figure 6. Girth class of total tree species found in all three zones

Table 4. Whittaker (β diversity)

Species	Upper zone	Middle zone	Lower zone
Tree	2.32	3.28	3.80
Shrub	2.70	3.60	2.84
Herb	2.48	3.25	3.47
Climber	2.54	3.00	3.67

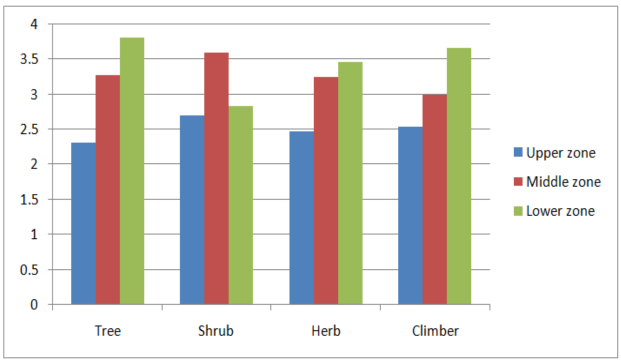

Fig. 7. Whittaker (β diversity) of existing vegetation in all three zones

Distribution of tree species as per Girth class: Contribution of tree stands according to Girth class distribution in Dalma Wildlife Sanctuary for analysis of individual GBH (Girth at breast height) class, all tree species found in all three zones were taken into consideration. The recorded girths of all individual trees were classed at a range of 20cm into ten classes. A comparison was made for the relative distribution of the total number of individuals in respect of Girth class. The highest number of tree species was occurred in girth class of 61-80cm in all three zones, which are quantified as 8 in upper zones, 9 in middle zone and 6 in lower zone followed by Girth class of 41-60cm with 9 species in upper zone, 5 in middle zone and 3 in lower zone as shown (Table 3), where as the tree species having highest Girth (> 200cm) are *Terminalia belerica (2.30)* and *Albizzia stipulae (2.10)* in upper zone and Terminalia belerica (2.30) with same value of GBH was found in both middle and lower zone respectively. It has been also shown in fig. 6.

Beta Diversity (β): The Beta diversity of different plant type (Tree, Shrub, herb, and Climber) is shown in Table 4. Perusal of the data indicated in upper zone value of β – diversity is found maximum for Shrubby species (2.70), while in middle zone similar situation observed i.e. for shrub beta diversity is found maximum. On the other hand, for lower maximum beta diversity was calculated for tree species(3.80). The comperative of β- diversity value of tree, shrub, herb and climber species found at Dalma Wildlife Sanctuary for upper, middle and lower zone is also shown with graph (Figure 7). In upper zone the value of beta diversity was observed low for tree, shrub, herb and climber.

DISCUSSION

Species composition: The species composition of entire Dalma Wildlife Sanctuary has been also studied with respect to the distribution among the three zones viz. Upper, middle and lower zones. In upper zone maximum number of genera(4) belonged to Combretaceae and Caesalpiniaceae, whereas in middle zone similar to upper zone maximum genera were found from Caesalpiniaceae and in lower zone again Caesalpiniaceae is reported by three (3) species. Bixaceae family showed maximum plant in under shrub groups, upper zone(3) and middle zone(2) respectively. While in lower zone Rubiaceae and Euphorbiaceae have found from 2 genera in each. Under the herbaceous category in all these zones, members of Gramineae dominated indicating 10, 7, and 6 for upper, middle and lower zone respectively. In upper zone for trees, maximum IVI was found for *Shorea robusta* (19.25) whereas in case of middle zone, the *Terminalia tomentosa* showed maximum IVI (15.52) and on the other hand in the lower zone again *Terminalia belerica* represented 18.81 IVI value.

The IVI value of shruby species for upper and middle zone was found for *Clerodendron infortunatum* as 30.40 and 37.32 and 42.88, respectively in upper, middle and lower zone. The seven common tree species observed in upper zone (core area) has shown maximum IVI value for *Cochlospermum gossipium* (7.73). The IVI distribution (d-d) curve showed that the highly distributed stand had higher dominance or low evenness while the moderately and least distributed stand had lower dominance or higher evenness among tree. Similar results were obtained by Lalfakawma *et al* (2009) while studying community composition and tree population structure in undisturbed and disturbed tropical semi-evergreen forest stands of north-east India. Similar patterns of diversity across altitudinal gradients have been observed in other studies in the Himalayan regions (Kharkwal *et al*. 2005; Tanner *et al*. 1998; Vazquez and Givnish, 1998), Diversity of life-forms usually decreases with increasing altitude and one or two lifeforms remain at extreme altitudes (Pavón *et al.* 2000). Altitude itself represents a complex combination of related climatic variables closely correlated with numerous other environmental properties (soil texture, nutrients, substrate stability, etc.; Ramsay and Oxley, 1997). Within one altitude the cofactors like topography, aspect, inclination of slope and soil type further effect the forest composition (Holland and Steyn, 1975).

In the present study, the species richness and Shannon Weinner diversity index varied from 25 to 41 and 3.07 to 3.997, respectively in study zones of Dalma Wildlife Sanctuary (Table 2) The highest value of Shannon Wiener index (3.997) was found for middle zones followed by upper zone(3.33) and lower zone(3.073). In the lower zone maximum and minimum species diversity was recorded for *Shorea robusta* (H= 0.518) and *Odina wodier (H=0.015)* respectively. In the middle zone maximum and minimum species diversity was recorded for *Shorea robusta* (H = 0.798) and *Cleistanthus collinus (D =0.010)* respectively while the maximum and minimum value for upper zone was recorded for *Shorea robust (D =0.257)* and *Pterospermum pteragonum* (D = 0.006) respectively. A similar pattern of tree species richness (deciduous) in timberline area was reported by Rawal et al. (1991). The low elevation appeared likely to be drier although precipitation varied inconsistently with elevation (Singh *et al.* 1994). At the highest elevation (2800-2700m asl) the maximum species diversity (0.52). They observed that overall maximum species diversity (Shannon-Wiener index) (2.37) was recorded at comparatively lower elevation (2600-2400m asl). The overall pattern of species richness, Margalef's index, Menheink's index, Shannon-Wiener index (species diversity) and Simpson's diversity index showed a sharp decline at the highest altitude (2800- 2700m asl). A similar pattern of tree species richness in timberline area was reported by Rawal *et al*. (1991). Tree species richness increases with increasing moisture in the Indian Central Himalaya (Rikhari *et al.* 1989). Total basal area is represented by 15.48 m^2ha^{-1} , whereas in Middle zone it is 11.02 m^2ha^{-1} and on the other hand Lower zone the minimum 10.78 m^2ha^{-1} basal area of the tree species is observed. In upper zone with respect to the basal area of individual tree species, maximum basal area is obtained for *Terminalia belerica* (1,32 m^2ha^{-1}) followed *by Albizziz stipulate*(1.15 m^2ha^{-1}. However contribution in basal area by *Cedrella toona* is found minimum (0.04 m^2ha^{-1}). In case of middle zone, like upper zone contribution in the basal area for *Terminalia belerica* was found maximum (1.44 m^2ha^{-1}) followed by 1.00 m^2ha^{-1} basal area of *Adina cordifolia* one of the important timber species. In case of lower zone, again contribution to the basal area observed maximum for *Terminalia belerica* (1.44 m^2ha^{-1}). A comprehensive basal area of twenty common tree species as indicated that *Terminalia belerica* has contributed maximum basal area in all three zones (upper, middle and lower zone). This is further substantiated in (fig. 3) showing comperatively high contributing tree species to total basal area. (*Terminalia belerica, Adina cordifolia, Pterocarpus marsupium).* Sagar and Singh 2006) observed basal area of tree in northern EG forests (mean 25.82 m^2 ha^{-1}, range 12.98 – 33.63)is much higher than the range (1.31 – 13.78 m^2 ha^{-1}). The reported basal area fro other studies include 7– 28 m^2 ha^{-1} from certain dry forest communities in India (Jha and Singh 1990). 10.79 – 20.44 m^2 ha^{-1} for tropical dry evengreen forests of Southern India (Parthasarathy and Sethi 1997) and 3.9 – 16.7 m^2 ha^{-1} for Moimbo woodlands, Tanzania (Backeus *et al.* 2006). The values are less comparable with those reported from New Caledonia (47 – 49.5 m^2 ha^{-1}, Jaffre and Veillon 1990) and fan – palm dominated forests of coast peninsular Malaysia (25.3 – 48.6 m^2 ha^{-1}, Nizam *et al.* 2013). The difference in the basal area of tree layerssss among the study plots may be due to difference in altitude, species composition, age of trees and extent of disturbances and successional strategies of the stands. Girth class frequency showed that the population structure of trees exhihibited in the study plots are in harmony with other forest stands (Bhadra *et al.* 2010; Sahu *et al.* 2010). Tree distribution across different girth classes revealed how well the growing forest is utilizing functional and structural resources. The diameter distribution of tree has been often used to represent the population structure of forests (Rao *et al*. 1990).

The stratification of different tree species existing in the three study zones have been categorised on the basis of three canopy height class (1-10m), (11 -20m) and (21-30m). In case of upper zone, only three species occupieng highest (21 – 30m) canopy height are *Terminalia tomentosa* (21m), *Shores robusta (23m) and Lagerstroemia parviflora* (21m*)*. Whereas in middle zone only two species of tree namely *Terminalia tomentosa* (21.50 m) and *Shorea robusta* (24m) dominated the upper canopy height (21–30m), while in case of lower zone only *Terminalia tomentosa* (24m) represented as top canopy height, 24 m (21–30). In lower canopy height group of upper, middle and lower zone, the numbers of trees were 23, 18, and 13, respectively. The middle canopy height for upper zone was representd by 15 tree species, in middle zone by 9 species in lower zone by 11 species. In contrast to this, some of the tallest and largest trees in the Himalaya were reported between 2500 and 3000 m by Singh and Singh (1987). They had also revealed that with further rise in elevation, in response to a sudden decline in the rainfall, and in severely cold and windy conditions, tree height of Himalayan forests were found to be reduced drastically. In this study, canopy height was also found to be slightly decreased with the elevation in Dalma Wildlife Sanctuary. In the mountains, gradual changes in vegetation structure and composition are expected as a consequence of changing environmental conditions along the increasing elevation. Also, anthropogenic activities cause changes in structural attributes (Gairola *et al*. 2009).

The highest number of tree species occurred in girth class of 61-80cm in all three zones, which are quantified as 8 in upper zones, 9 in middle zone and 6 in lower zone followed by Girth class of 41-60cm with 9 species in upper zone, 5 in middle zone and 3 in lower zone as shown in Table 3, The tree species having highest Girth(> 200cm) are *Terminalia belerica (2.30)*and *Albizzia stipulae (2.10)* in upper zone and *Terminalia belerica* (2.30) with same value of GBH was found in both middle and lower zone respectively as shown in (fig. 6). A similar study reported that Girth class frequency showed the population structure of trees exhibited in the study plots are in harmony with other forest stands (Bhadra *et al*. 2010; Sahu, 2010). Tree distribution across different girth classes revealed utilization of locality factor. The diameter distribution of trees has been often used to represent the population structure of forests (Rao *et al.* 1990).)

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