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Tree Diversity and Timber Resources Richness of Reserve Forests under Pasighat Forest Division, Arunachal Pradesh, India

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ABSTRACT

A combined study on the tree diversity and timber resources richness was carried out in five reserve forests of tropical moist and tropical semi evergreen forests under Pasighat forest division, Arunachal Pradesh. Total tree species richness was 92 and varied from 44 to 55. The total stem density ranged from 282.50 to 426.25 individuals per ha and basal area from 18.23 to 58.56 m^2 ha^{-1}. The Shannon Index of diversity was low in all reserves ranging from 1.24 to 1.46. *Terminalia myriocarpa* is a dominant species in three reserve forests while *Gmelina arborea* in the other two. Based on the Arunachal Pradesh Gazette notification number No. FOR.220/IND/2005/ Royalty/4391-4591 dated 8th March 2018 trees were categorised in one of the 7 royalty classes or designated unclassed. The highest number of species was found under B2 category in all reserves. Tree density of timber species ranged from 178.33 to 316.25 individuals ha^{-1} and basal area from 14.10 to 55.72 m^2 ha^{-1}. Among different timber classes, tree density and basal area per ha were the highest for A4 timber class in four reserves contributing 33% to 66.49% in terms of basal area. The species included in the A4 class are *Teminalia myriocarpa, Phoebe goalparensis, Gmelina arborea* and *Mesua ferrea.* The study exhibits that reserve forests of Pasighat division are rich in terms of tree composition and wealth of timber resources. The study is first of a kind to include both ecological information as well as economic wealth of forest communities that can be applied in forest management and conservation.

Key words *: Gmelina arborea, Terminlia myriocarpa, Timber class, Tropical forests*

Introduction

Forest community and trees supply an abundance of ecosystem goods and services that are crucial for human survival. The northeast region of India is renowned for its wealth of forest resources. It harbors 25% of India's forest cover (Anonymous, 2019) and listed as one of four biodiversity hotspots of the country. The diverse landscape has given birth to rich life forms making the region a haven for discov-

ery of new species (Thompson, 2009), exploration of crop relatives (Asati and Yadav, 2004) and prospecting of useful plants (Purkayastha, 2016). In an era where biodiversity issues have taken center stage, assessing forest community diversity, structure and composition is a routine exercise (Bhuiyan *et al.*, 2003; Nath *et al.*,2005; Kumar *et al.*, 2006; Majumdar and Datta, 2015; Saikia *et al.*, 2017; Linthoinggambi Devi *et al.*, 2018; Joshi, 2020). These studies showcase the rich and diverse vegetation of the region and serve as a constant reminder about the threats perceived from deforestation, biodiversity degradation and climate change, and therefore require constant monitoring, especially in protected areas that constitute the core units for *in situ* conservation of biological diversity.

In India, the practice of assigning protective status started with establishment of reserve forests which have been constituted under the Indian Forest Act of 1927 and are defined as "forests kept aside /protected or saved for future use or any national emergency". However, they are seldom given the importance of a protected area. For example, Rodger and Pawar (1988) did not include reserve forests under protected area network because they are not designed for wildlife and biodiversity conservation. As a result, there is limited knowledge on the composition and structure of reserve forests especially with the existence of the more high profile protected areas like wild life sanctuaries, national parks and biosphere reserve.

Quantification of tree species distribution and abundance is an important aspect as they contribute to the structural characteristics of the forest and provides resources and habitat for many species (Huang *et al.*, 2003). Among all the ecosystem goods and services that forests provide, timber is currently one of the most readily marketable benefits. However, rich timber resources are routinely overlooked especially post ban on green felling in 1996. While green felling is regulated in the country as per the direction of Hon'ble Supreme Court, the large stock of unharvested wood contributes to the total economic value of forests (Verma *et al.*, 2014).

In the present study, we assessed tree community diversity and composition in 5 reserve forests under Pasighat Forest division of Arunachal Pradesh, India. We feel that with forestlands being extensively diverted for development activities, it is essential that information on the economic value of forest be gathered, besides its ecological significance. Therefore we extended our study to include an inventory of timber species in these reserve forests and classified them into categories based on royalty class of timber.

Materials and Methods

The study was undertaken in five reserve forests under Pasighat Forest Division, East Siang District, Arunachal Pradesh during the year 2016-18 (Table 1; Fig. 1). The reserves broadly fall under North Indian Moist deciduous Forests and North India Tropical semi evergreen forests (Champion and Seth, 1968) The region experiences hot and humid pre-monsoon

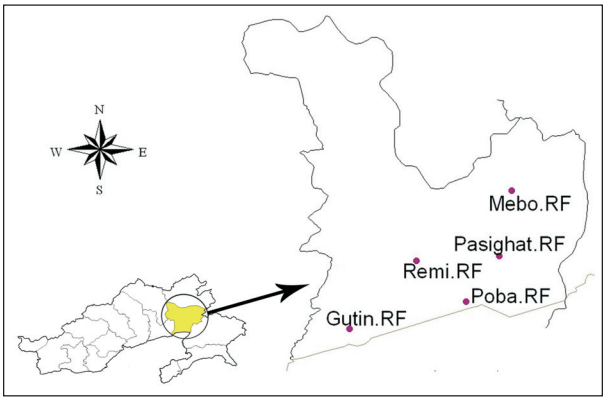

Fig. 1. Map showing the location of five reserve forests under Pasighat forest division

Table 1. Name of 5 reserve forests under Pasighat forest Division along with area and forest type.

ReserveForest	Area(ha)	Forest type
Mebo	1300	Himalayan light alluvial Semi- Evergreen forest - 2B/C1/$_1$S$_1$, Secondary moist bamboo brakes 2b/2S$_1$
Remi	1300	Himalayan light alluvial Semi- Evergreen forest - 2B/C1/$_1$S$_1$
Gutin	11218	Assam alluvial plans semi-evergreen forest - 2B/C1 (a), Himalayan light alluvial Semi- Evergreen forest - 2B/C1/$_1$S$_1$, Secondary moist bamboo brakes 2b/2S$_1$
Pasighat	4596	Eastern Hollock forest 3/lS$_2$(b)
Poba	10007	Eastern Hollock forest 3/lS$_2$(b)

from March to May, followed by wet season which lasts upto September with mild winter accompanied by strong winds from December to February. Monthly average maximum and minimum temperature ranges between 24.4 and 32.8°C, and between 12.1 and 24.6°C, respectively. The soil type ranges from loamy sand to sandy loam and devoid of any humus due to heavy rains.

Tree diversity assessment was carried out using quadrats of 20 m × 20 m plots. Except for Pasighat station reserve where 30 plots were laid, 40 plots were laid in the other four reserves. The distance between two neighboring plots was atleast 50 m. Under a sampling unit, trees of all species (>15 cm gbh) were enumerated and their girth measured. The field data was analyzed for number of species and quantitative analysis of frequency, density per ha and basal area per ha and their relative values were calculated and summed to get Importance Value Index (IVI) using Ellenberg (1974). General diversity was calculated using Shannon and Wiener Index (1963) and the index of dominance of the community was calculated by Simpsons Index (1949).

Based on the Arunachal Pradesh Gazette notification number No. FOR.220/IND/2005/Royalty/4391-4591 dated 8th March 2018, enumerated tree species were categorized under different timber classes and data was quantitatively analyzed for frequency, density and their relative values (Curtis and McIntosh, 1950).

Results and Discussion

The area sampled in five reserve forests under Pasighat division ranged between 1.2 to 1.6 ha, which depended on the terrain and accessibility of the reserve. A total of 92 tree species were recorded out of which 84 were identified. The 84 tree species belong to 46 families and 68 genera with Meliaceae and Euphorbiaceae family and genus ficus having highest representation (Appendix 1). Species richness ranged between 44 in Pasighat and 55 in Poba (Table 2). Tree species richness recorded in the present study is comparable to the species richness of some of the tropical forests in the region. Most recently, Saikia *et al.* (2017) reported tree species richness ranging between 0 and 64 in 234 transects laid in tropical forests of Arunachal Pradesh. More localized studies in the same state by Bhuyan *et al.* (2003) and Nath *et al.*(2005) listed 54 and 50 tree species, respectively. Pasighat reserve, which had the lowest species richness, is the closest to human habitation located 1km from the district capital. Hence, it is highly disturbed with large human settlements along the fringes of the reserve and huge cattle population inside the reserve. In addition the Pasighat reserve lies along the bank of the mighty Siang river and therefore vulnerable to the river dynamics. In the year 2000 floodwaters submerged major portion of the reserve (Dasgupta and Mukhopadhyay, 2014).

Analysis of Raunkier's frequency classes revealed that more than 70% of the tree species had low frequency (0-20%; Figure 2) as would be expected in

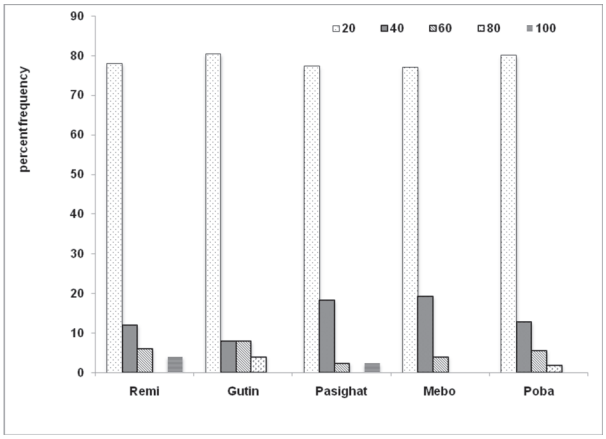

Fig. 2. Raunkier's frequency classes of trees in 5 reserve forests of Pasighat Division, Arunachal Pradesh.

Table 2. Species richness, number of tree species classified as timber, density, basal area and diversity indices of five reserve forests under Pasighat forest Division

Name of Reserve	Species richness	No. of classed species	Density (individuals ha^{-1})	Basal Area (m^2 ha^{-1})	Shannon diversity index	Simpson Index
Mebo	51	30 (58.82%)	282.50	22.77	1.46	0.05
Remi	49	26 (53.06%)	340.00	18.23	1.32	0.08
Gutin	50	30 (60.00%)	465.25	24.40	1.30	0.09
Pasighat	44	24 (54.54%)	288.33	41.47	1.24	0.13
Poba	55	26 (47.27%)	378.12	58.56	1.31	0.08

Appendix 1. List of tree species, families, timber class, density (individuals ha-[1]), basal area (m^2 ha-[1]) and importance value index (IVI) in 5 reserve forests of Pasighat Forest division, Arunachal Pradesh, India.

Scientific name	Family	CL/ UC	MEBO			REMI			GUTIN			PASIGHAT			POBA		
			D	BA	IVI	D	BA	IVI	D	BA	IVI	D	BA	IVI	D	BA	IVI
Aesculus assamica	Sapindaceae	UC	-	-	-	1.25	0.36	2.92	-	-	-	-	-	-	4.38	0.16	3.12
Ailanthus grandis	Simaroubaceae	B1	10.00	1.36	14.28	-	-	-	5.63	0.12	3.97	12.50	2.47	15.39	1.88	0.35	2.11
Albizzia lucida	Fabaceae	B2	0.63	0.02	0.68	2.50	0.02	2.02	-	-	-	6.67	0.14	5.26	0.63	0.00	0.51
Alstonia scholaris	Apocynaceae	D	18.13	3.47	26.77	5.63	1.48	12.10	4.38	1.25	7.70	10.83	2.44	13.23	25.63	8.83	27.61
Altingia excelsa	Altingiaceae	B2	-	-	-	21.88	1.36	19.69	0.63	0.07	0.75	0.83	0.32	1.56	-	-	-
Amora wallichii	Meliaceae	B1	-	-	-	-	-	-	-	-	-	-	-	-	0.63	0.61	1.55
Neolamarckia cadamba	Rubiaceae	C	-	-	-	2.50	0.34	3.46	3.13	1.22	6.35	3.33	0.63	4.19	3.13	0.22	1.55
Artocarpus chaplasa	Moraceae	B1	2.50	0.09	2.40	3.13	0.16	2.97	0.63	0.05	0.65	-	-	-	-	-	-
Artocarpus integrifolia	Moraceae	C	-	-	-	-	-	-	0.63	0.00	0.47	-	-	-	-	-	-
Baccaurea sapida	Phyllanthaceae	UC	-	-	-	-	-	-	2.50	0.03	1.63	-	-	-	3.75	0.15	2.94
Bahunia variegata	Fabaceae	UC	11.88	0.01	7.54	-	-	-	5.00	0.05	2.92	10.00	0.76	9.93	-	-	-
Barbi		UC	-	-	-	-	-	-	-	-	-	0.83	0.09	1.01	-	-	-
Bischofia javanica	Phyllanthaceae	B2	1.25	0.07	1.46	-	-	-	-	-	-	2.50	0.12	1.70	1.25	0.05	1.10
Bombax ceiba	Malvaceae	B2	-	-	-	-	-	-	0.63	0.05	0.65	-	-	-	-	-	-
Callicarpa arborea	Verbenaceae	UC	-	-	-	-	-	-	8.75	0.20	5.99	-	-	-	2.50	0.03	1.38
Canarium strictum	Burseraceae	B1	7.50	0.64	9.86	18.13	0.87	17.10	16.88	0.69	13.03	-	-	-	1.88	0.14	1.76
Caryota urens	Arecaceae	UC	-	-	-	-	-	-	-	-	-	2.50	0.09	2.60	0.63	0.07	0.63
Caesalpinia bonduc	Caesalpiniaceae	UC	-	-	-	-	-	-	1.25	0.01	0.64	1.67	0.05	1.22	-	-	-
Castanopsis hystrix	Fagaceae	UC	-	-	-	1.88	0.01	1.19	-	-	-	-	-	-	11.88	0.72	7.76
Castanopsis indica	Fagaceae	B2	22.50	0.63	18.43	11.88	0.80	11.93	11.25	0.12	7.48	0.83	0.00	0.81	-	-	-
Cinnamomum tamala	Lauraceae	UC	8.75	0.36	8.72	3.13	0.02	2.47	0.63	0.00	0.48	3.33	0.15	3.06	1.88	0.01	1.52
Cinnamomum zeylanicum	Lauraceae	UC	0.63	0.04	0.78	-	-	-	-	-	-	-	-	-	-	-	-
Cinnamonmum cecicodaphne	Lauraceae	B1	15.63	1.96	17.06	-	-	-	-	-	-	-	-	-	-	-	-
Dadkon		UC	-	-	-	-	-	-	-	-	-	-	-	-	0.63	0.01	0.52
Duabanga grandiflora	Lythraceae	B1	5.00	2.74	15.61	1.88	0.60	4.70	30.00	2.88	25.06	0.83	1.17	3.57	9.38	1.74	7.83
Dichapetalum gelanoides	Dichapetalaceae	UC	1.25	0.00	1.19	-	-	-	-	-	-	-	-	-	-	-	-
Dillenia indica	Dilleniaceae	C	-	-	-	2.50	0.29	3.50	5.63	2.18	11.49	1.67	0.07	1.77	10.00	1.16	9.03
Dysoxylum allarianum	Meliaceae	UC	-	-	-	2.50	0.09	2.40	1.25	0.01	0.94	-	-	-	0.63	0.10	0.67
Dysoxylum binectariferum	Meliaceae	B2	1.25	0.06	1.43	2.50	0.14	2.38	0.63	0.05	0.67	2.50	0.47	3.51	3.75	0.38	3.68
Dysoxylum procerum	Meliaceae	UC	-	-	-	16.88	0.50	13.54	5.00	0.07	3.31	-	-	-	1.25	0.07	1.13
Echinocarpus assamicus	Elaeocarpaceae	E	1.88	0.04	1.96	3.13	0.39	3.62	2.50	0.24	2.19	1.67	0.06	1.74	0.63	0.11	0.70
Edioa spp	Convolvulaceae	UC	-	-	-	-	-	-	0.63	0.00	0.47	-	-	-	3.75	0.05	2.10
Elaeocarpus ganitrus	Elaeocarpaceae	UC	-	-	-	-	-	-	-	-	-	-	-	-	1.25	0.03	1.06
Erythrina indica	Fabaceae	UC	1.25	0.06	1.43	1.25	0.01	1.03	2.50	0.04	1.99	16.67	0.82	12.54	1.88	0.02	1.21
Ficus auriculata	Moraceae	E	2.50	0.05	1.85	5.00	0.18	4.23	7.50	0.11	4.37	1.67	0.11	1.87	-	-	-
Ficus elastica	Moraceae	E	2.50	1.42	8.60	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1. *Continued ...*

Scientific name	Family	CL/ UC	MEBO			REMI			GUTIN			PASIGHAT			POBA		
			D	BA	IVI	D	BA	IVI	D	BA	IVI	D	BA	IVI	D	BA	IVI
Ficus hirta	Moraceae	E	0.63	0.02	0.68	3.75	0.02	2.97	5.63	0.07	3.46	2.50	0.31	3.14	1.25	0.18	1.32
Ficus semichordata	Moraceae	E	0.63	0.05	0.82	-	-	-	5.63	0.18	2.66	-	-	-	-	-	-
Gapo beleng		UC	1.25	0.09	1.22	-	-	-	-	-	-	-	-	-	-	-	-
Garcinia cowa	Clusiaceae	UC	3.75	0.15	3.09	-	-	-	-	-	-	-	-	-	1.25	0.02	1.04
Garcinia paniculata	Clusiaceae	UC	-	-	-	1.25	0.07	1.33	-	-	-	-	-	-	-	-	-
Gmelina arborea	Verbanaceae	A4	44.38	2.67	34.77	15.63	1.10	14.41	111.88	7.40	65.88	-	-	-	65.00	15.58	51.93
Gynocordia odorata	Flacourtiaceae	UC	2.50	0.11	2.85	3.13	0.10	2.63	-	-	-	6.67	0.41	6.38	5.00	0.18	4.01
Harpulia arborea	Sapindaceae	UC	-	-	-	-	-	-	-	-	-	0.83	0.00	0.81	1.25	0.02	0.70
Helicia nilagirica	Proteaceae	UC	-	-	-	61.88	2.29	40.65	-	-	-	-	-	-	-	-	-
Heretiria macrophylla	Sterculiaceae	E	6.88	0.18	6.17	8.75	0.07	6.15	8.13	0.25	6.65	8.33	0.88	9.11	3.75	0.02	3.07
Knema linifolia	Myristicaceae	UC	1.25	0.03	0.94	2.50	0.02	1.70	-	-	-	-	-	-	-	-	-
Lagerstroemia speciosa	Lythraceae	B1	5.00	0.15	4.27	-	-	-	-	-	-	-	-	-	26.25	3.31	17.68
Lea indica	Vitaceae	UC	2.50	0.02	2.07	6.88	0.04	5.45	25.63	0.32	14.82	16.67	0.10	13.30	16.88	0.38	9.51
Lannea coromandelica	Anacardiaceae	C	-	-	-	-	-	-	-	-	-	-	-	-	2.50	0.16	1.95
Lero		UC	-	-	-	-	-	-	-	-	-	-	-	-	0.63	0.00	0.51
Litsea panamonja	Lauraceae	E	7.50	0.25	7.41	10.00	0.05	6.70	26.88	0.20	15.55	10.83	0.21	9.42	11.25	0.11	8.24
Macaranga denticulata	Euphorbiaceae	UC	5.00	0.07	3.90	4.38	0.03	3.48	0.63	0.00	0.46	-	-	-	-	-	-
Mallotus phillipinensis	Euphorbiaceae	UC	-	-	-	-	-	-	1.88	0.00	1.08	-	-	-	-	-	-
Mangifera indica	Anacardiaceae	B1	2.50	0.34	3.46	4.38	0.04	3.24	-	-	-	-	-	-	-	-	-
Meliosma simplicifolia	Sabiaceae	UC	-	-	-	1.88	0.01	1.19	-	-	-	12.50	0.39	10.48	-	-	-
Mesua ferrea	Calophyllaceae	A4	-	-	-	-	-	-	1.25	0.01	0.95	-	-	-	-	-	-
Micromelum spp.	Rutaceae	UC	-	-	-	0.63	0.00	0.48	1.88	0.03	1.21	-	-	-	3.13	0.03	2.56
Morus laevigate	Moraceae	A4	9.38	0.88	10.49	5.00	0.44	6.22	10.00	0.48	6.80	0.83	0.00	0.81	2.50	0.84	3.46
Nephelium lappaceum	Sapindaceae	UC	1.25	0.06	1.43	1.88	0.04	1.62	-	-	-	2.50	0.04	2.50	-	-	-
Numbang		UC	3.75	0.31	4.17	-	-	-	-	-	-	-	-	-	-	-	-
Oroxylum indicum	Bignoniaceae	UC	-	-	-	-	-	-	-	-	-	0.83	0.01	0.82	-	-	-
Ostoides paniculata	Euphorbiaceae	UC	-	-	-	3.13	0.12	3.03	-	-	-	5.00	0.13	3.64	-	-	-
Otibari		UC	-	-	-	-	-	-	-	-	-	0.83	0.00	0.81	2.50	0.05	1.76
Panamus nepalensis	Pandanaceae.	UC	6.88	0.16	6.05	0.63	0.02	0.57	6.88	0.05	3.99	1.67	0.09	1.81	16.88	0.81	10.94
Pedupedak		UC	-	-	-	-	-	-	-	-	-	1.67	0.03	1.67	0.63	0.01	0.51
Phoebe goalparensis	Lauraceae	A4	-	-	-	0.63	0.00	0.49	28.75	1.62	17.12	-	-	-	10.63	4.63	12.75
Premma benghalensis	Lamiaceae	D	0.63	0.00	0.60	1.25	0.01	1.01	-	-	-	3.33	0.41	3.67	-	-	-
Randia spp	Rubiaceae	UC	-	-	-	-	-	-	-	-	-	-	-	-	0.63	0.01	0.52
Sapium baccatum	Euphorbiaceae	D	6.88	0.76	8.69	3.75	0.08	3.28	8.13	2.01	12.62	3.33	0.13	3.02	13.75	1.31	11.64
Sapium eugeniaefolium	Euphorbiaceae	UC	6.88	0.76	-	-	-	-	-	-	-	-	-	-	-	-	-
Saurauia napaulensis	Actinidiaceae	UC	-	-	-	1.88	0.06	1.74	5.63	0.16	4.17	-	-	-	3.13	0.12	2.39
Schefflera venulosa	Araliaceae	UC	10.00	0.11	8.43	0.63	0.00	0.48	1.25	0.00	0.62	16.67	0.14	11.92	8.75	0.26	6.15
Simang		UC	0.63	0.00	0.59	-	-	-	-	-	-	-	-	-	0.63	0.01	0.52
Spondias axillaris	Anacardiaceae	UC	-	-	-	0.63	0.08	0.90	-	-	-	-	-	-	1.25	0.03	0.72

Appendix 1. *Continued ...*

Scientific name	Family	CL/ UC	MEBO D	MEBO BA	MEBO IVI	REMI D	REMI BA	REMI IVI	GUTIN D	GUTIN BA	GUTIN IVI	PASIGHAT D	PASIGHAT BA	PASIGHAT IVI	POBA D	POBA BA	POBA IVI
Spondias pinnata	Anacardiaceae	D	5.00	0.69	6.64	-	-	-	1.88	0.51	3.46	1.67	0.17	1.51	-	-	-
Sterculia alata	Malvaceae	D	0.63	0.04	0.78	-	-	-	-	-	-	-	-	-	-	-	-
Sterculia roxburghii	Malvaceae	UC	0.63	0.00	0.60	-	-	-	1.25	0.00	0.62	-	-	-	0.63	0.00	0.51
Sterculia villosa	Malvaceae.	B2	0.63	0.01	0.64	0.63	0.01	0.51	4.38	0.07	2.54	1.67	0.01	1.63	0.63	0.05	0.59
Sterospermum chenoloides	Bignoniaceae	C	0.63	0.04	0.78	-	-	-	1.88	0.06	1.61	1.67	0.04	1.69	-	-	-
Syzygium cummini	Myrtaceae	C	-	-	-	5.63	0.16	4.58	2.50	0.04	1.67	1.67	0.03	1.17	3.75	0.33	2.57
Talauma hodgsonii	Magnoliaceae	UC	10.63	0.50	9.64	13.75	0.10	9.22	2.50	0.20	2.04	-	-	-	-	-	-
Tectona grandis	Verbenaceae	A1	-	-	-	-	-	-	1.88	0.07	1.04	-	-	-	0.63	0.31	1.04
Terminalia bellirica	Combretaceae	B2	-	-	-	1.25	0.08	1.38	-	-	-	-	-	-	0.63	0.00	0.51
Terminalia chebula	Combretaceae	B2	0.63	0.06	0.85	-	-	-	-	-	-	-	-	-	-	-	-
Terminalia myriocarpa	Combretaceae	A4	9.38	1.09	10.31	63.13	5.38	59.68	5.00	0.64	5.35	95.00	28.09	114.48	73.13	14.47	54.56
Tetremeles nudiflora	Tetramelaceae	B2	-	-	-	-	-	-	32.50	0.39	15.78	-	-	-	-	-	-
Toona ciliata	Meliaceae	B2	2.50	0.14	2.97	0.63	0.04	0.67	2.50	0.21	2.71	3.33	0.09	3.41	1.88	0.07	1.63
Vatica lancaefolia	Dipterocarpaceae	UC	-	-	-	-	-	-	-	-	-	-	-	-	1.25	0.10	1.18
Vitex glabrata	Lamiaceae	UC	6.88	0.50	7.92	0.63	0.06	0.80	-	-	-	4.17	0.36	4.36	3.13	0.13	2.07
Wrightia tomentosa	Apocynaceae	UC	3.13	0.11	3.08	-	-	-	1.88	0.02	1.47	2.50	0.03	2.48	-	-	-
Zanthoxylum rhetsa	Rutaceae	UC	-	-	-	1.25	0.01	1.02	-	-	-	-	-	-	-	-	-

1. * CL: Classed; UC: Unclassed; D: Density; BA: Basal Area

typical species-abundance distributions in tropical forest. The total stem density was the highest in Gutin reserve (426.25 individuals per ha) and the lowest in Mebo forest (282.50 individuals per ha). Saikia *et al*. (2017) recorded an average stem density of 325 individuals per ha for tropical forests in Arunachal Pradesh. However, higher values of stem density have been reported in tropical forests from other states in northeast India by Kumar *et al*. (2006) and Baishya *et al*. (2009) in Meghalaya, Mazumdar *et al.* (2012) in Tripura and Meitei *et al.* (2017) in Manipur. Highest basal area was recorded in Poba reserve (58.56 m^2 ha^{-1}) and the lowest in Remi (18.23 m^2 ha^{-1}). Basal area of a tree is an important attribute that determines its status in the community and to quantify the vegetation structure and site quality (Suthari, 2013). Although density of trees at Pasighat reserve was low, tree basal area was relatively high indicating to the presence of large sized trees within the reserve, which is the opposite for Gutin reserve (Table 2). The basal areas of the reserve forests were comparable to results from other protected areas in the region such as Balpakram National Park and Siju Wildlife Sanctuary of Meghalaya (Kumar *et al.*, 2006), reserve forests under 4 forest divisions of Tripura (Majumdar and Datta, 2015) and Dibru-Saikhowa Biosphere Reserve in Assam (Joshi, 2020). However, the reported values were lower than some community managed forests such as sacred groves in Meghalaya (Upadhaya *et al*., 2003) and community reserve forest in Mizoram (Linthoingambi Devi *et al*., 2018).

Tree diversity based on Shannon Index ranged from 1.24 in Pasighat to 1.46 in Mebo (Table 2). Our reported values are on the lower side when compared to studies on tropical forests in the Indian subcontinent (Panda *et al.*, 2013; Saikia *et al*., 2017; Maradana *et al*., 2018), but they tend to be similar to diversity values of disturbed sites of tropical wet evergreen forest at Deomali in Arunachal Pradesh (H= 0.7; Bhuyan *et al*., 2003) and tropical forests of Bhuban hills in south Assam (1.44 -1.52; Borah *et al*., 2014). The importance value indices (IVI) of the top five trees in all reserves along with other population parameters are shown in Table 3. *Terminalia myriocarpa* is a dominant species in three reserve forests (Pasighat, Poba and Remi) and *Gmelina arborea* in the other two (Mebo and Gutin). In

Pasighat reserve *T. myriocarpa* showed exceedingly high dominance evident from the sudden drop in the IVI ranking of subsequent species (Table 3) and the highest Simpson index value (0.14; Table 2). The parameter that accounts for their dominance is relative basal area contributing 66.49% of the total basal area. In other reserves no single species showed excessive dominance as Simpson index values were under 0.10 (Table 2) and differences among IVI values were not very large (Table 3).

The economic assessment of timber resource in 5 reserve forests was based on the Arunachal Pradesh Gazette notification number No. FOR.220/IND/2005/Royalty/4391-4591 dated 8th March 2018. Out of 9 royalty classes of timber that are listed in the notification, tree species recorded in all reserves were categorized under 7 royalty classes. The percentage of trees from 5 reserves included in these 7 royalty classes was 44.79%. The percentage of timber species under different categories were as follows; A1 =4.65%, A4 = 9.30%, B1 = 20.93%, B2 = 27.90%, C = 9.30%, D = 9.30% and E = 18.60%. Among the reserves, the highest percentage of classified species was found in Gutin reserves (60.00%) and the lowest in Poba reserve (47.27%; Table 1). So far, there is no study in India that has categorized tree species of a community based on timber classes, and therefore we are unable to make any comparative inferences. However, in 4 of 5 reserves, the values were more than 50%, which is considerable for a mixed tropical forest type. Further, relative density and relative basal area values of the timber species were highly impressive in all reserves (Table 4). The relative density ranged from 60.30% to 76.03% and

Table 3. Population parameters of five tree species with highest importance value indices (IVI) in 5 reserve forests under Pasighat Forest Division, Arunachal Pradesh

Scientific name	Density (individuals ha^{-1})	RF (%)	RD (%)	Basal Area (m^2 ha^{-1})	RBA (%)	IVI
Mebo Reserve Forest						
Gmelina arborea	44.38	7.33	15.71	2.67	11.73	34.77
Alstonia scholaris	18.13	5.13	6.42	3.47	15.23	26.77
Castanopsis indica	22.50	7.69	7.96	0.63	2.77	18.43
Cinnamonmum cecicodaphne.	15.63	2.93	5.53	1.96	8.59	17.06
Daubanga grandiflora	5.00	1.83	1.77	2.74	12.01	15.61
Remi Reserve Forest						
Terminalia myriocarpa	63.1	11.6	18.6	5.4	29.5	59.7
Helicia nelagirica	61.9	9.9	18.2	2.3	12.6	40.7
Altingia excelsa	21.9	5.8	6.4	1.4	7.4	19.7
Canarium strictum	18.1	7.0	5.3	0.9	4.8	17.1
Gmelina arborea	15.6	3.8	4.6	1.1	6.0	14.4
Gutin Reserve Forest						
Gmelina arborea	111.88	9.35	26.25	7.40	30.29	65.88
Duabanga grandiflora	30.00	6.23	7.04	2.88	11.79	25.06
Phoebe goalparensis	28.75	3.74	6.74	1.62	6.63	17.12
Tetrameles nudiflora	32.50	6.54	7.62	0.39	1.61	15.78
Litsea monptela	26.88	8.41	6.30	0.20	0.83	15.55
Pasighat Reserve Forest						
Terminalia myriocarpa	95.00	12.77	35.22	28.09	66.49	114.48
Ailanthus grandis	12.50	4.91	4.63	2.47	5.85	15.39
Lea indica	16.67	6.88	6.18	0.10	0.24	13.30
Alstonia scholaris	10.83	3.44	4.02	2.44	5.78	13.23
Erythrina indica	16.67	4.42	6.18	0.82	1.94	12.54
Poba Reserve Forest						
Terminlia myriocarpa	73.13	10.51	19.34	14.47	24.71	54.56
Gmelina arborea	65.00	8.14	17.19	15.58	26.60	51.93
Alstonia scholaris	25.63	5.76	6.78	8.83	15.07	27.61
Lagerstroemia speciosa	26.25	5.08	6.94	3.31	5.65	17.68
Phoebe goalparensis	10.63	2.03	2.81	4.63	7.91	12.75

RF: Relative Frequency; RD: Relative Density; RBA: Relative Basal Area

relative basal area from 77.40% to 95.13% suggesting that economically important timber species were more prominent in the reserves.

The highest number of species was found under B2 category in all reserves; it was 26.67% in Mebo and Gutin and 33.34% in Pasighat reserve (Fig 3).

Table 4. Density, Relative density (RD), Basal area (BA) and relative basal area (RBA) of classed and unclassed timber species in 5 reserve forests of Pasighat division

Reserve		Density (individuals ha-^{1})	RD (%)	BA (m^2 ha-^{1})	RBA (%)
Mebo	A1	9.37	3.37	0.88	3.87
	A4	53.75	19.63	3.76	16.53
	B1	50.62	17.92	7.41	32.58
	B2	26.87	9.51	0.84	3.72
	C	0.62	0.22	0.04	0.19
	D	31.25	11.06	4.96	21.79
	E	22.50	7.96	2.02	8.89
	TOTAL	195	69.03	19.94	87.58
	UNCLASSED	95	30.08	2.74	12.04
Remi	A1	5.00	1.47	0.44	2.42
	A4	79.40	23.33	6.50	35.50
	B1	24.38	7.16	1.71	9.39
	B2	50.00	14.75	2.56	14.06
	C	5.00	1.47	0.62	3.42
	D	13.75	4.04	1.95	10.73
	E	27.50	8.08	0.32	1.77
	TOTAL	205	60.03	14.10	77.40
	UNCLASSED	133.8	39.30	4.00	22.10
Gutin	A1	11.88	2.56	0.54	2.26
	A4	118.13	25.55	8.05	33.00
	B1	53.13	11.49	3.74	15.32
	B2	51.25	11.09	2.22	9.13
	C	9.37	2.02	3.40	13.95
	D	18.75	4.05	4.57	10.76
	E	53.75	11.62	0.79	3.26
	TOTAL	316.25	74.19	22.83	93.42
	UNCLASSED	109.38	25.66	1.61	6.57
Pasighat	A1	0.83	0.28	0.003	0.007
	A4	95.00	32.95	28.09	66.49
	B1	16.67	5.78	4.27	10.10
	B2	19.99	6.93	1.17	2.78
	C	3.33	1.15	0.11	0.26
	D	20.83	7.22	3.32	7.84
	E	23.33	8.09	1.51	3.59
	TOTAL	178.33	66.12	38.31	90.68
	UNCLASSED	110.00	40.78	3.94	9.32
Poba	A1	3.12	0.82	1.15	1.97
	A4	148.12	39.43	34.69	59.23
	B1	38.12	10.08	5.81	9.92
	B2	25.62	6.77	1.94	3.32
	C	15.62	4.13	1.54	2.63
	D	40.00	10.58	10.25	17.51
	E	16.25	4.29	0.31	0.53
	TOTAL	287.50	76.03	55.72	95.13
	UNCLASSED	90.62	23.96	2.85	4.86

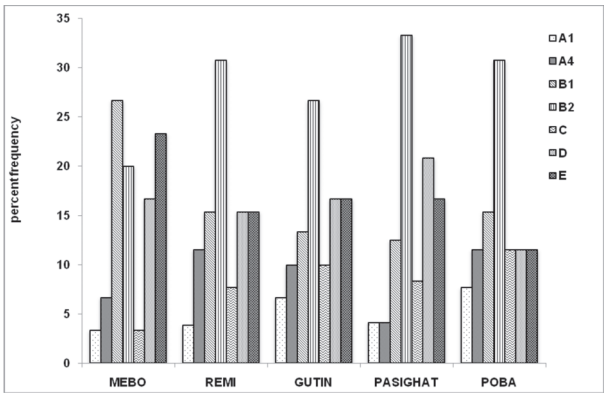

Fig. 3. Percent frequency of tree species under different timber classes in 5 reserve forests of Pasighat division

Species under this category include *Dysoxylum binectariferum, Terminalia chebula, Syzygium cumminii, Phoebe cooperiana, Castanopsis indica, Bombax ceiba* and *Sterculia villosa*. *Tectona grandis* and *Morus laevigata* are the only two species listed under A1 category of the Arunachal Pradesh Gazette notification Both species were recorded in Gutin and Poba reserve while only *M. laevigata* was recorded in the other reserves.

Tree density of timber species was the highest in Gutin (316.25 individuals ha^{-1}) and the lowest in Pasighat (178.33 individuals ha^{-1}). However differences in relative density was small, ranging between 60.30% in Remi and 76.03% in Poba. Basal area ranged from 14.10m^2 ha^{-1} in Remi to 55.72 m^2 ha^{-1} in Poba (Table 4), which accounted for 95.13% of the total basal area of the reserve with a major contribution from A4 class species (59.23%; Table 4). The relative basal areas of economic species in other reserves were also high (Table 4). Among different timber classes, tree density and basal area per ha were the highest for A4 timber class in all reserves except Mebo where it had the highest density but third in terms of basal area (Table 4). The contribution of A4 timber to total density ranged from 23.33% in Remi to 39.34% in Poba while basal area contribution ranged from 33% in Gutin to as high as 66.49% in Pasighat. The species included in the A4 class are *Teminalia myriocarpa, Phoebe goalparensis, Gmelina arborea* and *Mesua ferrea*.Two tree species, *Tectona grandis* and *Morus laevigata*, are listed under the A1 category and in all reserves there is a clear deficiency of these species. Therefore, in order to enhance the economic value of the reserves use of such species in enrichment and plantation programs should be encouraged.

The study exhibits that reserve forests of Pasighat division are rich in terms of tree composition although diversity values and density were poor matching those of disturbed sites, which indicates the vulnerability of reserves to human disturbances. *T. myriocarpa* and *G. arborea* are the two most dominant species in the division. In fact, Poba and Pasighat reserves fall under the Eastern Hollock forest $3/lS_2(b)$ type of India, which derives its name from the dominant hollock or *Terminalia myriocarpa* trees.*G. arborea* on the other hand is indigenous to the region and also planted by forest department for its fast growth, profuse regeneration potential, wide adaptability and marketability. The reserves display a wealth of timber resources among which the largest representation was from the B2 timber class. However in terms of density and basal area, A4 class timber was the highest enhancing the overall economic value of the reserves. The study is first of a kind that incorporates timber wealth in a tree diversity assessment study. By doing this we can obtain a broader overview of the tree resources in the forest community, both from the ecological as well as economic perspective and then use the information for planning forest management and conservation strategies or choosing species in a plantation program.

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