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Plant Community Structure in the Parshuram Kund Area of Kamlang Wildlife Sanctuary, Arunachal Pradesh

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ABSTRACT

Tropical and Subtropical forests in the Eastern Himalayan region records the highest estimates of plant species and act as a carbon sink with enhanced carbon sequestration potential. Parshuram Kund, in Lohit District of Arunachal Pradesh lies to the north of Kamlang Wildlife Sanctuary and is characterized by sub-tropical evergreen forest and steeply sloped landform. A total of 30 quadrats (10 m × 10 m) were laid out randomly to estimate the tree, shrubs and herb diversity in the Parshuram Kund area. The study recorded 48 tree species belonging to 40 genera and 34 families. *Dalbergia sissoo* was the most dominant tree species with highest important value index (18.69) and was followed by *Duabanga grandiflora* (18.42), *Pterospermum acerifolium* (18), whereas *Altingia excels* was the least dominant species. Dipterocarpaceae and Moraceae with 4 species each were the most dominant family. The Shannon-Wiener diversity index was estimated to be 3.47. The individuals with 20—40 cm girth class were higher in all the dominant species and less individuals were recorded with 80-100 cm girth class in *Dalbergia sissoo*, *Duabanga grandiflora*, *Pterospermum acerifolium* and *Terminalia myriocarpa*. Less number of trees were observed in 60–80cm and >100 girth classes. The regular visits and disturbance in the Parshuram Kund by the pilgrimage during winter every year have directly or indirectly posed a threat to plant community structure of the area. This study on species diversity, composition and abundance will provide information for management and conservation strategies.

Keywords Kamlang wildlife sanctuary, Parshuram Kund, Species richness, Subtropical forest, Tree diversity.

INTRODUCTION

Eastern Himalayan Region (EHR), a largest reservoir of biodiversity is amongst the biologically richest areas with rugged and largely inaccessible landscape and terrain. North East India is a part of EHR and one of the 25 mega-biodiversity hotspots of the world with rich and diverse floral communities (Devi and Yadava 2006). Recently, Gatti *et al.* (2021) reported about 73,000 tree species on Earth which is 14% higher than the existing number of known tree species. It has been estimated that there are 40,000 – 53,000 tree species in the tropics accounting to 96% of all the tree

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species on Earth (Silk *et al.* 2015). Forest Survey of India reports estimated that 486 km^2 of forest was lost from 2003 to 2017 in Arunachal Pradesh (FSI 2017).

Globally, the forest ecosystems with almost 80% of the aboveground carbon, maintains the carbon balance and plays an important role in climate change mitigation (Whitehead 2011). Tropical and Subtropical forests in the EHR accounts the highest plant diversity with high carbon sequestration potential and acts as a major carbon sink (Maniatis *et al.* 2019). The implication of the relationship between human and forest has been increasing as a result of the conflict of increased population and crucial pressure on natural resources. Since time immemorial, the forest has been acted as a source of food, fiber, firewood, charcoal, timber and land for agricultural purposes that have led to forest fragmentation (Asifat *et al.* 2019). However, these forests are facing high degree of anthropogenic threats and are disappearing at alarming rates due to deforestation for extraction of timber and other non-timber forests products, increasing human pressure, agriculture expansion, infrastructure development and over exploitation of forest resources for livelihood and other uses (Corlett 2016, Gogoi and Sahoo 2018). These activities have drastically affected the plant species diversity thereby increasing the extent of forest fragmentation.

Parshuram Kund area in Lohit district of Arunachal Pradesh is characterized by steeply sloping landform, sub-tropical evergreen forest and high rainfall. Although the vegetation in this region is relatively undisturbed, patches of forests have been cleared for shifting cultivation along the banks of the river Lohit. Wherever the banks of the river are accessible, the forests have been cleared for human settlements and construction of roads and dams leading to impending ecological degradation.

Table 1. Phytosociological characteristics in Parshuram Kund area.

Items	Trees	Shrubs	Herb
Number of Family	34	6	13
Number of Genera	40	7	15
Number of Species	48	10	21
Shannon-Wiener index	3.47	2.21	2.80
Simpson's index	0.96	0.86	0.93

Plant community structure in subtropical forests of Parshuram Kund area of Kamlang Wildlife Sanctuary is facing disturbance at an alarming rate due to human intervention for various purposes. Parshuram Kund is a Hindu pilgrimage site situated to the north of the Kamlang Wildlife Sanctuary. This place is dedicated to sage Parshuram where thousands of pilgrims visit during winter every year, especially on the Makar Sankranti day for a holy dip in the sacred Kund which is believed to wash away one's sins. However, the regular visits and disturbance created by the tourists and pilgrims have directly or indirectly posed a threat to plant community structure of the area. To protect the plant species from declining, it is essential to estimate the current status of the species diversity, composition and abundance as it will provide information for management and conservation strategies.

MATERIALS AND METHODS

Study area

The study was conducted in the subtropical evergreen forest in the Parshuram Kund area of Kamlang Wildlife Sanctuary. It is situated in the South-Eastern part of Lohit District of Arunachal Pradesh (96º26' to 96º55'E longitudes and 27º40' to 28º00' N Latitude). The name Kamlang Wildlife Sanctuary comes from the river Kamlang, which flows through the Sanctuary and joins the Brahmaputra River. The Sanctuary is spread over an area of around 783 km^2 with all four big cat species such as leopard, the clouded leopard, tiger, and snow leopard. The Mishmi, Digaru Mishmi and Miju Mishmi tribal people who reside around the periphery of the sanctuary claim their descent from the King Rukmo of the epic Mahabharata. The rainy season is usually experienced between June and October. The climate is hot and highly humid in the lower elevations and in the valleys and mildly cold in the higher elevations. The winter prevails during the months from late November to early March.

Vegetation sampling and data analysis

The plant community structure was estimated by using nested quadrat method for trees, shrubs and

Table 2. Quantitative analysis of trees, shrubs and herbs in Parshuram Kund area of Kamlang Wildlife Sanctuary.

Sl. No.	Species name	Frequency (%)	Abun dance	Density	Relative density	Relative frequency	Relative abundance	IVI
1	*Actinodaphne obovata* (Nees) Bl.	13.3	3.0	0.4	0.85	1.67	1.13	3.63
2	*Adina cordifolia* (Roxb.) Brandis	3.3	4.0	0.1	0.28	0.42	1.50	0.82
3	*Ailanthus excelsa* Roxb.	6.7	3.0	0.2	0.42	0.83	1.13	1.93
4	*Alangium chinense* (Lour.) Harms	16.7	6.4	1.1	2.26	2.08	2.41	6.34
5	*Albizia lucida* Roxb.	26.7	8.0	2.1	4.51	3.33	3.01	13.78
6	*Albizia procera* (Roxb.) Benth.	6.7	5.0	0.3	0.70	0.83	1.88	2.16
7	*Altingia excelsa* Noronha	3.3	1.0	0.0	0.07	0.42	0.38	0.52
8	*Artocarpus chaplasha* Roxb.	23.3	6.7	1.6	3.31	2.92	2.52	9.09
9	*Bombax ceiba* L.	26.7	5.3	1.4	2.96	3.33	1.97	10.01
10	*Brassiopsis glomerulata* (Blume) Regel	3.3	6.0	0.2	0.42	0.42	2.25	1.44
11	*Callicarpa arborea* Roxb.	26.7	6.0	1.6	3.38	3.33	2.25	13.08
12	*Castanopsis indica* Roxb.	3.3	8.0	0.3	0.56	0.42	3.01	1.72
13	*Cinnamomum* sp.	23.3	7.4	1.7	3.66	2.92	2.79	8.82
14	*Cinnamomum tamala* (Buch. Ham)	3.3	8.0	0.3	0.56	0.42	3.01	1.17
15	*Cyanometra polyandra* (Roxb.)	20.0	7.0	1.4	2.96	2.50	2.63	6.82
16	*Dalbergia sissoo* (Roxb.)	43.3	6.8	3.0	6.27	5.42	2.57	18.69
17	*Duabanga grandiflora* (Roxb.) Walp	43.3	5.8	2.5	5.29	5.42	2.17	18.42
18	*Duabanga sonneratioides* Buch.-Ham.	3.3	10.0	0.3	0.70	0.42	3.76	1.87
19	*Dillenia indica* L.	43.3	5.8	2.5	5.36	5.42	2.20	15.32
20	*Dysoxylum binectariferum* (Roxb.)	6.7	2.5	0.2	0.35	0.83	0.94	1.50
21	*Engelhardtia spicata* Lechen ex Bl.	23.3	7.1	1.7	3.52	2.92	2.68	9.41
22	*Ficus benghalensis* L.	6.7	3.5	0.2	0.49	0.83	1.32	1.54
23	*Ficus roxburghii* Lour.	6.7	3.0	0.2	0.42	0.83	1.13	1.82
24	Ficus semicordata Buch.-Ham	16.7	4.8	0.8	1.69	2.08	1.80	5.17
25	*Garuga gamblei* (King ex W. Smith) Kalkman	26.7	4.8	1.3	2.68	3.33	1.79	8.98
26	*Gynocardia odorata* R.Br.	20.0	6.2	1.2	2.61	2.50	2.32	6.71
27	*Kydia calycina* Roxb.	36.7	5.4	2.0	4.16	4.58	2.02	11.05
28	*Laportea* sp. L.	6.7	9.0	0.6	1.27	0.83	3.38	2.55
29	Leea sp. L.	36.7	5.7	1.9	4.02	4.58	2.14	11.50
30	*Macaranga denticulate* (Bl.) Mull. Arg.	43.3	4.7	2.0	4.30	5.42	1.76	12.40
31	*Macropanax dispermus* Groerson	20.0	5.5	1.1	2.33	2.50	2.07	6.48
32	*Melia azadirachta* L.	3.3	3.0	0.1	0.21	0.42	1.13	0.88
33	*Mesua ferrea* L.	3.3	7.0	0.2	0.49	0.42	2.63	1.90
34	*Phyllanthus emblica* L.	3.3	3.0	0.1	0.21	0.42	1.13	0.73
35	*Pterospermum acerifolium* (L.) Willd	36.7	8.0	2.9	6.20	4.58	3.01	18.00
36	*Sapindus rarak* DC.	20.0	3.7	0.7	1.55	2.50	1.38	4.83
37	*Sarcosperma griffithii* Hook. f.ex C.B.Clarke	6.7	12.0	0.8	1.69	0.83	4.51	3.55
38	*Saurauria nepaulensis* DC.	6.7	9.5	0.6	1.34	0.83	3.57	5.94
39	*Shorea assamica* Dyer	6.7	4.5	0.3	0.63	0.83	1.69	3.55
40	*Syzygium cumini* (L.) Skeels	3.3	5.0	0.2	0.35	0.42	1.88	1.14
41	*Talauma hodgsonii* (Hook.f. and Thomson) H.keng	23.3	6.7	1.6	3.31	2.92	2.52	8.09
42	*Terminalia belerica* (Gaertn.) Roxb.	3.3	2.0	0.1	0.14	0.42	0.75	0.95
43	*Terminalia chebula* Retz.	6.7	2.5	0.2	0.35	0.83	0.94	1.74
44	*Terminalia myriocarpa* Van Heurck and Mull.Arg.	33.3	7.4	2.5	5.21	4.17	2.78	14.70

Table 2. Continued.

Sl. No.	Species name	Frequency (%)	Abundance	Density	Relative density	Relative frequency	Relative abundance	IVI
45	*Tetrameles nudiflora* R.Br.	3.3	3.0	0.1	0.21	0.42	1.13	1.96
46	*Toona ciliate* M. Roem.	33.3	5.9	2.0	4.16	4.17	2.22	12.94
47	*Trema orientalis* (L.) Blume	13.3	4.5	0.6	1.27	1.67	1.69	3.54
48	*Ziziphus mauritiana* Lam.	3.3	3.0	0.1	0.21	0.42	1.13	0.75
				SHRUBS				
1	*Artemisia nelagirica* L.	23.3	8.71	2.0	4.33	11.29	3.75	18.07
2	*Boehmeria longifolia* L.	16.7	46.40	7.7	16.45	8.06	19.96	38.97
3	*Calamus floribundus* (Griff.)	13.3	11.25	1.5	3.19	6.45	4.84	12.50
4	*Debregeasia longifolia* (Burm.f.)	20.0	60.50	12.1	25.74	9.68	26.03	60.41
5	*Girardinia diversifolia* (Link) Friis	23.3	18.86	4.4	9.36	11.29	8.11	30.52
6	*Grewia disperma* L.	20.0	18.00	3.6	7.66	9.68	7.74	34.37
7	*Piper griffithii* C.DC.	23.3	14.71	3.4	7.30	11.29	6.33	25.35
8	*Piper peepuloides* (Roxb.)	20.0	12.00	2.4	5.11	9.68	5.16	19.97
9	*Sida rhombifolia* L.	23.3	27.00	6.3	13.40	11.29	11.62	34.28
10	*Zanthoxylum nepalense* Babu.	23.3	15.00	3.5	7.45	11.29	6.45	25.51
				HERBS				
1	*Begonia* sp. L.	13.33	5.25	0.70	2.30	2.53	4.75	5.49
2	*Bidens pilosa* L.	53.33	8.31	4.43	14.58	10.13	7.51	41.78
3	*Cyanotis vaga* (Lour.)	26.67	4.38	1.17	3.84	5.06	3.95	12.70
4	*Cyperus* sp. L.	16.67	5.00	0.83	2.74	3.16	4.52	8.23
5	*Elatostemma* sp.	43.33	5.85	2.53	8.33	8.23	5.28	24.54
6	*Eupatorium adenophorum* (Spreng.)	40.00	6.33	2.53	8.33	7.59	5.72	24.22
7	*Imperata cylindrical* (L.) P. Beauv.	50.00	6.60	3.30	10.86	9.49	5.97	26.89
8	Mikania micrantha Kunth	13.33	3.50	0.47	1.54	2.53	3.16	4.79
9	*Molinera cucurboides* L.	10.00	6.33	0.63	2.08	1.90	5.72	6.22
10	*Nephrolepis cordifolia* L.	26.67	5.88	1.57	5.15	5.06	5.31	14.80
11	*Ophiopogon intermedius* D.Don	20.00	4.00	0.80	2.63	3.80	3.62	8.38
12	*Paederia foetida* L.	33.33	5.70	1.90	6.25	6.33	5.15	20.70
13	*Paspalum* sp. L.	16.67	4.40	0.73	2.41	3.16	3.98	7.18
14	*Polygonum capitatum* (Buch. -Ham)	13.33	3.50	0.47	1.54	2.53	3.16	6.25
15	*Polypodium* sp. L.	10.00	3.67	0.37	1.21	1.90	3.31	4.10
16	*Pothos scandens* Linnaeus	10.00	5.00	0.50	1.64	1.90	4.52	5.43
17	*Pteris* sp. L.	20.00	4.00	0.80	2.63	3.80	3.62	8.47
18	*Saccharum spontaneum* L.	33.33	6.00	2.00	6.58	6.33	5.42	22.29
19	*Sonchus oleraceus* L.	16.67	4.20	0.70	2.30	3.16	3.80	7.96
20	*Thysanolaena maxima* (Roxb.) Honda	23.33	5.29	1.23	4.06	4.43	4.78	12.84
21	*Urtica dioica* L.	36.67	7.45	2.73	8.99	6.96	6.74	27.10

herbs species and was analyzed for species richness, density and diversity. A total of 30 quadrats were laid out randomly where, trees were assessed by 10 m × 10 m size quadrats, shrubs by 5 m × 5 m size quadrats. Further, 1 m × 1 m size quadrats were randomly laid out within each 10 m × 10 m sized quadrat to estimate the herbaceous layer. In each sample plot, girth of all the trees (>10 cm) was measured at 1.37 m height from the ground using measuring tape and converted into diameter at breast height. The quantitative analyses such as density, frequency, abundance, relative density, relative frequency, relative dominance and

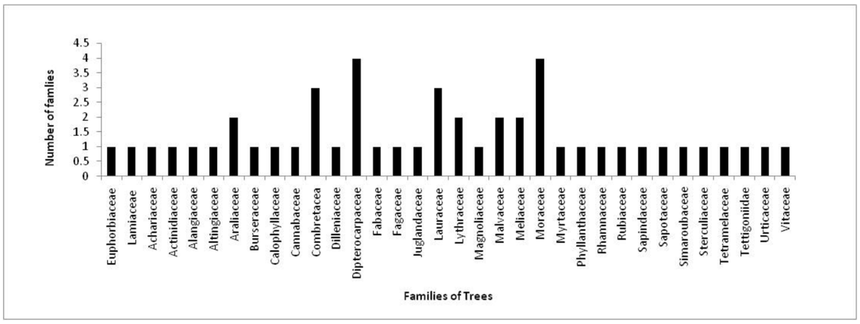

Fig. 1. Number of individual trees in each family.

Importance Value Index of all tree, shrub and herb species were determined as per Misra (1968). The species diversity was determined by using Shannon-Wiener index (Shannon and Wiener 1963).

RESULTS

The vegetation assessment emphasized that the Parshuram Kund area is rich in plant species. A total of 79 plant species (48 trees, 10 shrubs and 21 herbs) belonging to 62 genera (40 trees, 7 shrubs and 15 herbs) were enumerated from the study area (Table 1). The tree, shrub and herb species belonged to 34, 6 and 13 families respectively. The Shannon-Wiener diversity index for trees, shrubs and herbs were 3.47, 2.21 and 2.80 respectively. Simpson dominance index for trees were 0.96. The quantitative analysis of the species found is shown in Table 2. *Dalbergia sissoo* was the dominant tree species with highest IVI (18.69) followed by *Duabanga grandiflora* (18.42), *Pterospermum acerifolium* (18) whereas *Altingia excels* was the least dominant tree species with lowest IVI (0.52). The other trees included *Actinodaphne obovata, Adina cordifolia, Ailanthus excelsa, Alangium begoniaefolia, Albizia lucida, Albizia procera*, *Artocarpus chaplasha, Bombax ceiba, Brassiopsis glomerulata, Callicarpa arborea, Castanopsis indica, Cinnamomum* sp., *Cinnamomum tamala, Cyanometra polyandra, Daubanga sonneratioides, Dilenia indica, Dysoxylum binectariferum, Engelhardtia spicata, Ficus benghalensis, Ficus roxburghii, Ficus semicordata, Garuga gamblei, Gynocardia odorata, Kydia calycina, Laportea* sp., *Leea* sp., *Macaranga denticulate, Macropanax dispermus, Melia azadirachta*, *Mesua ferrea, Phyllanthus emblica, Sapindus rarak*, *Sarcosperma griffithii, Saurauria nepalensis, Shorea assamica, Syzygium cuminii, Talauma hodgsoni*, *Terminalia belerica, Terminalia chebula, Terminalia myriocarpa, Tetrameles nudiflora, Toona ciliate*, *Trema orientalis* and *Ziziphus mauritiana*.

The dominant families for trees were Dipterocarpaceae and Moraceae (with 4 species each) and was followed by Combretaceae, Lauraceae (with 3 species each), Araliaceae, Lythraceae, Magnoliaceae, Malvaceae, Meliaceae (with 2 species each) and Euphorbiaceae, Lamiaceae, Achariaceae, Actinidiaceae, Alangiaceae, Altingiaceae, Burseraceae, Calophyllaceae. Cannabaceae, Combretaceae, Cilleniaceae, Fabaceae, Fagaceae, Juglandaceae, Magnoliaceae, Myrtaceae, Phyllanthaceae, Rhamnaceae, Rubiaceae, Sapindaceae, Sapotaceae, Simaroubaceae, Sterculiaceae, Tetramelaceae, Urticaceae, Vitaceae (with 1 species each) (Fig. 1).

Among the shrub species, *Debregeasia longifolia* recorded the highest IVI (60.41) and was followed by *Boehmeria longifolia* (38.97) and *Grewia disperma* (34.37). *Calamus floribundus* was the least dominant species with lowest IVI (12.50). The other shrub species were *Artemisia nelagirica*, *Girardinia diversifolia*, *Piper griffithii*, *Piper peepuloides*, *Sida rhombifolia* and *Zanthoxylum nepalense*. *Bidens pilosa* was the dominant herb species with highest IVI (41.78) which was followed by *Urtica dioica* (27.10), *Elatostemma* sp. (24.54) and *Imperata cylindrica* (26.89) whereas *Polypodium* sp. was the least dominant species with lowest IVI (4.10). The other herbs were *Begonia* sp., *Bidens pilosa*, *Cyanotis vaga*, *Cyperus* sp., *Eupatorium adenophorum, Mikania*

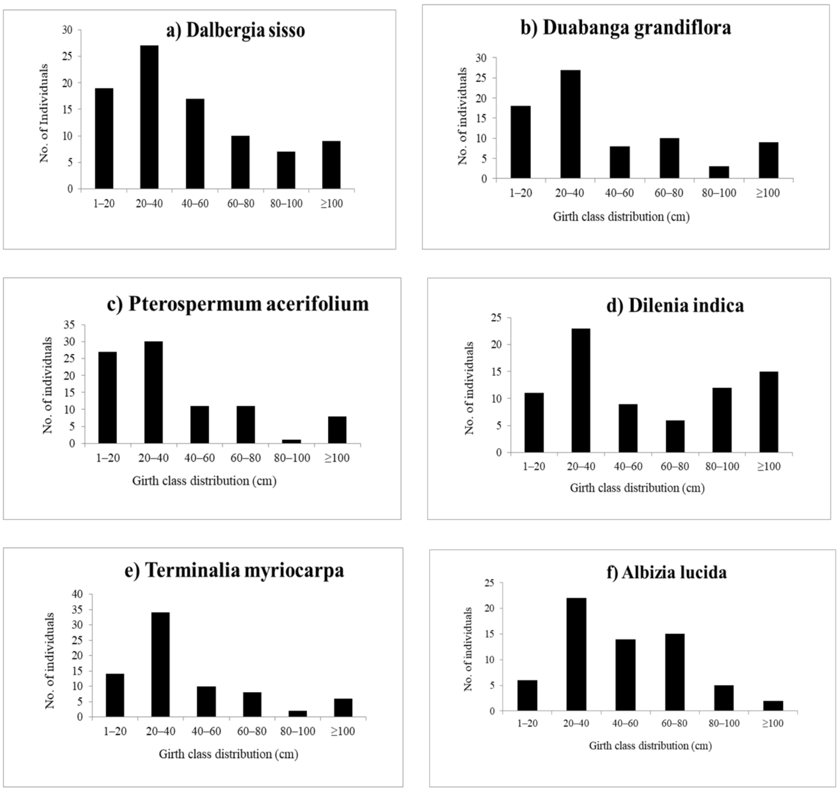

Fig. 2. Variation in Girth class distribution of dominant tree species (a) *Dalbersia sisoo,* (b) *Duabanga grandiflora* (c) *Pterospermum acerifolium* (d) *Dilenia indica* (e) *Terminalia myriocarpa* (f) *Albizia lucida.*

micrantha, Molinera cucurboides, Nephrolepis cordifolia, Ophiopogon intermedius, Paederia foetida, Paspalam sp., *Polygonum capitatum, Pothos scandens, Pteris* sp., *Saccharum spontaneum, Sonchu*s *oleraceus* and *Thysanolaena maxima*.

The girth class distribution pattern of the six most dominant tree species is shown in Fig. 2. The six most dominant tree species were *Dalbergia sissoo* (89 individuals), *Pterospermum acerifolium* (88 individuals), *Dillenia indica* (76 individuals), *Duabanga grandiflora* (75 individuals), *Terminalia myriocarpa* (74 individuals) and *Albizia lucida* (64 individuals). The individuals with 20–40 cm girth class were higher in all the dominant species whereas less individuals were recorded with 80-100 cm girth class in *Dalbergia sissoo*, *Duabanga grandiflora*, *Pterospermum acerifolium* and *Terminalia myriocarpa*. The minimum individuals in *Dillenia indica* and *Albizia lucida* was observed in the category of 60-80 cm and >100 girth class respectively.

DISCUSSION

Implementing the actions for decreasing carbon emissions in the forests ecosystems is important as part of the commitments of the national CBD and REDD+ policy. Understanding the species composition and diversity patterns in forest helps in framing the needs and importance for the conservation of natural habitats.

The present study shows that the Parshuram Kund area has diverse tree, shrub and herb species with few as dominant species. The natural pattern of abundance was altered to some extent by deforestation for infrastructure development. *Dalbergia sissoo, Duabanga grandiflora* and *Pterospermum* *acerifolium* with highest IVI acted as a dominant tree species in the study area. Singh *et al.* (2015) reported *Schima wallichii, Melia azedarach* and *Pterospermum acerifolium* as the dominant tree species in undisturbed, moderately disturbed and highly disturbed stands of subtropical forest of Mizoram. A sharp decline in the number of individuals belonging to the higher girth classes with increase in degree of disturbance has also been reported (Devi and Yadava 2006, Singh *et al*. 2015). Species diversity and density of vegetation is influenced by various environmental and anthropogenic factors. It varies with the habitat, topography and edaphic characteristics and species diversity is often correlated with rainfall and nutrient status. Anthropogenic disturbances such as felling of trees for timber, agriculture and extraction of various non timber forest produce decreases the species richness in subtropical forests (Grant *et al.* 2010, Singh *et al.* 2015).

Moraceae is one of the dominant family found in subtropical forests. Ao *et al.* (2021) also reported 118 tree species dominantly from Fagaceae, Moraceae, Anacardiaceae and Malvaceae in the subtropical forests of Mokokchung District of Nagaland. Dominance index ranging from 0.03–0.92 has been reported for various subtropical forest in India (Saikia *et al.* 2017, Akash *et al.* 2018, Ao *et al.* 2021).

The pattern of girth class distribution shows dominance of small girth size (20–40 cm girth class) trees in the study area. Similar findings have also been reported in subtropical forest of western Himalaya by Dangwal *et al.* (2022). Trees in early growth stage show highest rate of carbon sequestration thus contribute relatively higher amount of carbon stock in the forest ecosystem (Wang *et al.* 2016, Kohl *et al.* 2017). The study of six forest communities of Nagaland by Ao *et al*. (2021) revealed that areas with higher human population has more disturbance index. Tree stands located adjacent to human settlements has often less growth and lower basal area (Hinckley *et al.* 2013, Toyoma *et al.* 2015, Yousefpoor *et al*. 2016).

Species composition reduction may also be due to high anthropogenic disturbances by the local people living near the forest area. Saikia *et al.* (2017) argued that the variations of tree density in the forest area can also be ascribed to type of forest, species composition, forest age class, tree size class, site history including the edaphic and other factors. Such diverse, rich and valuable vegetation of the area signifies the need of proper conservation and management of the sanctuary. Increased anthropogenic activity can exert interference to the species composition and structure of the sanctuary, which if continues rapidly in future, may pose a serious threat to the existence and survival of the plant species in this area. The quantification of degree of disturbance is also essential to recognize the pressure and to analyse scrupulously the resulting effect on vegetation richness and diversity and also to find a feasible solution to address the current situation of a particular area for better management and conservation.

CONCLUSION

The quantification of plant communities in the Parshuram Kund area of Kamlang Wildlife Sanctuary shows a high diversity of trees, shrubs and herbs species. However, the growth of tree species and diversity has been altered due to various human intervention activities. A proper conservation and management strategies is inevitable to increase the forest cover and maintain the rich diversity of plants in this area. This study will provide an information to the policy makers for sustainable management of the forest in Parshuram Kund area of Kamlang Wildlife Sanctuary.

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