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Original Research

Assessing Natural Forest Conservation Using Diameter Size Class Distributions in Pakistan

Jamal Hussain[1,2]*, Muhammad Akbar[3], Shaukat Ali[2], Zhou Kui[1], Ghulam Raza[4], Anwar Khan[1], Muhammad Zafar[2], Nizami Moazzam Syed[5], Sujjad Hyder[2], Alamdar Hussain[4], Faisal Hussian[6]

[1]The West Center for Economics Research, Southwestern University of Finance and Economics, 55, Guanghuacun Street, Qingyang District, Chengdu, Sichuan, P. R. China, 610074
[2]Department of Environmental Science, Karakoram International University Main Campus University Road Gilgit (15100) Pakistan
[3]Wildlife Conservation Society, Husain Abad Colony, Jutial Gilgit, Gilgit-Baltistan, Pakistan, Pakistan
[4]Department of Biological Science, University of Baltistan, Skardu, Gilgit-Baltistan, Pakistan
[5]Department of Forestry, Karakoram International University Main Campus University Road Gilgit (15100) Pakistan
[6]Post Doctorate Fellow, Institute of Nature and Environmental Technology, Kanazawa University, Kakuma-mati, Kanazawa-920-1192, Japan

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Abstract

Forests of the Naltar Valley in Pakistan are constantly threatened by natural and anthropogenic disturbances. The study examines the natural and human-induced disturbance factors that determine natural forest conservation and management in a dry temperate mountainous region. To better assess anthropogenic disturbance factors, we randomly selected 26 stands of the forest by using the point-centered quarter (PCQ) method of Cottam and Curtis to collect the information about tree species during the summer season between July to September 2015. Results show that there is no ideal size class distribution of tree species noticed in selected sample stands. Gaps in small, middle, large and extra-large classes were observed in different locations representing noticeable natural (i.e., sliding, forest fire, flood, soil erosions, earthquakes) and anthropogenic (i.e., illegal cutting, looping, tapering, burning, and grazing) disturbances. To conserve biodiversity, it is therefore essential to introduce social forestry, preventing illegal anthropogenic activities, and provide alternative livelihood options for the inhabitant to reduce anthropogenic disturbance on these forests. This study would be helpful for exposing

*e-mail: jamal.hussain51214@gmail.com
hussain.jamal@smail.swufe.edu.cn

the present status and future trends of forest tree species, as well as more awareness about conservation of forests in the region by conducting a similar study in the remaining forested areas in Gilgit-Baltistan.

Keywords: anthropogenic disturbance, biodiversity, livelihood, Point centered quarter, Pakistan

Introduction

People have long exploited resources from all forest habitat, but the more lasting anthropogenic activities have been found in temperate forests [1]. The dry temperate mountainous regions are globally unique and these regional forests help as the world's primary source of firewood and timber products [2]. Forests provide environmental services to the society, but unfortunately in Pakistan's resting forests resources are fragile. Regardless of the government's current desperate need to increase forest cover since 1955, few practical advancements have been made. Indeed, natural forest conservation levels have been persistent at a disturbing rate due to such a situation making Pakistan one of the worst countries in the rest of the world to lose its forest resources in the upcoming 30 years [3]. The conservation of forests is vital as plants absorb CO_2 and produce O_2 during photosynthesis [4].

Studies of diameter structure of forest stands will capture better assessment of creating each diameter size class, and it has a vital role in a stand's production and growth [5]. For better decision making and sustainable forest management, evidence on existing diameter size class distribution of a forest stand lets us forecast of forest trends [6]. Few studies have looked at the diameter breast height of dry forest stands and species [7, 8]. The diameter distributions often help to illustrate stand structure and interpret future growth potential of a stand. Stand structure is usually considered with the frequency distribution of stems by size, and diameter breast height [9]. The estimation of the diameter distribution of a stand is essential to forest managers for assessing forest resources and planning the future [10].

The importance of the diameter size class distribution is elaborated upon from some moist temperate area of Pakistan by Siddiqui et al. [11]. The study of diameter size class distributions of trees highlights the potential of alternative models for predictions that suitably support forest conservation and management [12, 13]. Diameter distribution and the related statistical model can play an essential role in some forest-related issues, including forestry and being helpful for the better management practices of any forest [14]. Diameter size class distribution of forests provides a better image of current status and future trends of any forested area [8, 15]. The diameter distribution is one of the keys to forest management and is used for decision-making in harvesting stages and silvicultural practices in many countries [16].

Plant species provide beautiful landscape for any area – especially natural forests, which are very important for the beautiful landscaping in any field [17]. Natural forest is essential for recreational activities, and most developing countries invest in protecting the natural forest to utilize only recreation, and temporal and spatial proposals are vital to validate the results of any research [18, 19]. In this way, the value of forest conservation is considered to be very important for the tourism point of view as the forest is one of the significant components of natural parks [20-23]. The decay of plants is one of the most significant sources of soil nutrients as various essential element concentrations is directly associated with the primary producer [24]. On the other hand, environmental pollution caused the health of plants and using the raw materials of living plants, environmental pollution can be detected as the plants observed the nutrients in their bodies, so the forest is significant for analyzing the heavy metals concentration in any area [25-27]. Temporal and spatial studies are essential to authenticate the results of any research [28], so it is recommended to collect data on ground level to confirm the GIS-based studies [29-31].

At present, however, natural forest conservation using diameter-size class distributions in still is infancy in the existing literature's insights. Further research effort can provide more meaningful outcomes and open new prospects for academicians and practitioners. Hence, this study aims to investigate the diameter size class structure of Naltar Valley Forest and to select appropriate distributions by using statistic tools for the forest stand and the individual tree species. This research will be helpful for understanding the anthropogenic and natural disturbances of forest better and provide policy implications for the conservation and management of natural forests.

Materials and Methods

Description of Study Area

The Naltar Valley study area is located between 36^{o}145 to 36^{o}223 north latitude N and 74^{o}.108 to 74^{o}.230 east longitude E, covering a total area of 27,206 ha within the Karakoram highlands. It lies very close to Nagar District in the Karakoram Range of northern Pakistan, and 40 km from the Gilgit city. From the Hunza river a narrow, steep area starts, which ends up in the rocky terrain of Naltar.

Sampling

Data Collection

The point-centered quarter (PCQ) method of Cottam and Curtis [32] has been used in various studies, for example, Ahmed and Shaukat [33], and Siddiqui [11]. In each stand, 20 points were taken at 20-meter intervals. For this, a cross made by iron was used as PCQ to collect information about tree species. The data was collected during the summer between July to September 2015. A total of 26 stands were studied from the study area (Naltar Bala and Naltar Pain) during this field sampling.

Identification of Plants

Plants samples were obtained from the field and were transferred on Herbarium sheets in the lab for identification followed by the flora of Pakistan [34].

Determining Diameter Size Classes

Diameters at breast height (Dbh) of each tree species in a stand were taken using the Dbh tap and divided into (10cm Dbh) 14 size classes, and size structures of trees were determined using the MS Excel 2016 Package. Furthermore, in each stand, size classes divided into four categories, i.e., small size classes (10 to 30 cm Dbh), middle size classes (40 to 60 Dbh cm), and large size classes (70 to 90 cm Dbh) and above (90 cm Dbh) extra-large size classes following the studies [8, 15, 33, 35].

Statistical Analysis

After collection of data we fed it into soft form and analyzed it using MS Excel 2016. The findings are represented in both tables and graphs. Frequency, density, basal area, abundance and importance value index (IVI) of plant species were calculated following Mueller-Dombois and Ellenberg [36] and Ahmed and Shaukat [33]. The basal area of each tree species was calculated as B.A = Pi (1/2 Dbh)^2. The importance value index (IVI) of trees were calculated by summing the relative frequency, relative density and relative dominance for trees and shrubs. Importance value index was calculated from the values of relative frequency, relative basal area, and relative density. Table 1 depicts the formulas used to calculate the density, frequency, basal area, and importance value index (IVI) and their corresponding values.

Collection of Geographical Coordinates

Aspects and elevation of each stand were recorded using a GPS device. Slope angle was measured by the clinometers (Suunto Height and Normal slope meter PM-5/1520 PC).

Results and Discussion

In the study area a total of four tree species were identified. Among them, three species (i.e. *Pinus wallichiana, Picea smithiana* and *Juniperus excelsa*) were gymnospermic, while one of them, *Betula utilis*,

Table 1. Formulae used to analyze the parameters of the study.

S.No	Parameters	Symbols	Formulae
1	Mean Distance	d_1	{Σ of all distances/Σ of all points taken}
2	Mean Area	$(d_1)^2$ or M	{Square of Mean Distance or $(d_1)^2$}
3	Stand Density ha^{-1}	D_9	{10000/M} --------1 ha = 10000 meters
4	Frequency	F_1	No. of a Quadrates in which a specie occurs ÷ Total No. of Quadrates *100
5	Relative Frequency	F_3	F_1 of a specie ÷ ΣF_1 of all specie*100
6	Relative Density	D_3	No. of individual of a specie ÷ Total No. of individual of All aspects i.e.*100
7	Average Basal Area of a specie in cm^2	A.B.A	Total B.A of a specie÷ Total No. of individual of a specie
8	Relative Basal Area of a specie in cm^2	B_3	B.A of a specie ÷B.A of all species *100
9	Density ha^{-1} of a specie		{D3 of a specie*D9÷100}
10	Basal Area meter square per hectare	B.A m^{2}ha^{-1}	density per ha of a specie*Average B.A of same specie÷10000
11	Important Value Index	IVI	$\{F_3+D_3+B_3\}\div3$"

Reference: Mueller-Dombois and Ellenberg [36] and Ahmed and Shaukat [33]."

Table 2. Study area location, elevation, GPS readings and slope description.

STD	Name of forest	Location	Lat. (N)	Long. (E)	Ele. m	Aspect	Slope (◦)	Canopy
1	Plate	Skiing area	36.154	74.186	3008 m	NE	45°	Close
2	Ishkoman	Skiing area	36.146	74.177	3524 m	NE	45°	Close
3	Danoe Ghotom	Nagarah	36.145	74.181	3357 m	NW	45°	Open
4	Chimerso-A	Chimerso	36.189	74.147	3008 m	SE	25°	Open
5	Chimerso-B	Chimers	36.182	74.151	2988 m	SE	15°	Close
6	Shafda Nada	Kon-Kae	36.168	74.162	3130 m	SE	55°	Moderate
7	Koto-A	Naltar Lake	36.222	74.108	3289 m	SE	10°	Open
8	Koto-B	Koto	36.223	74.110	3247 m	SE	10°	Close
9	Koto-C	Naltar Bala	36.223	74.113	3219 m	SE	10°	Close
10	Bangala-A	Naltar Bala	36.221	74.115	3202 m	SE	05°	Close
11	Bangala-B	Naltar Bala	36.218	74.117	3188 m	SE	05°	Close
12	Besha Geri-A	Naltar Bala	36.212	74.128	3170 m	NE	12°	Moderate
13	Besha Geri-B	Naltar Bala	36.211	74.131	3163 m	NE	15°	Close
14	Besha Geri-C	Naltar Bala	36.209	74.133	3133 m	NE	10°	Close
15	Besha Geri-D	Naltar Bala	36.206	74.137	3103 m	NE	05°	Close
16	Lower Besha Geri	Naltar Bala	36.199	74.142	3090 m	NE	20°	Close
17	Faingi	Naltar Pain	36.116	74.222	3072 m	SE	50°	Moderate
18	Faingi Khurrung-A	Naltar Pain	36.116	74.223	3083 m	SE	45°	Moderate
19	Faingi Khurrung-B	Naltar Pain	36.116	74.224	3092 m	SE	45°	Moderate
20	Faingi Khurrung-C	Naltar Pain	36.116	74.225	3075 m	SE	45°	Open
21	Faingi Khurrung-D	Naltar Pain	36.115	74.230	3152 m	SE	40°	Close
22	Faingi Harchingah	Naltar Pain	36.207	074.125	3161 m	SE	40°	Close
23	Harchin Gah	Naltar Pain	36.185	074.134	3121 m	SE	35°	Close
24	Hodan Khori-A	Naltar Pain	36.206	074.118	3145 m	SE	45°	Close
25	Hodan Khori-B	Naltar Pain	36.202	074.126	3139 m	SE	35°	Close
26	Toli Buz	Naltar Pain	36.210	074.113	3182 m	SE	40°	Close

belongs to an angiosperm family. Diameter size class structure of each stand is presented in Fig. 1. Every forest stand is briefly discussed with sites, locations, environmental characteristics (i.e., elevation, slope angles, exposures) and graphical information (i.e., latitude and longitude) in Table 3. Physical and other observational characteristics of forests stands are also given. The size-class structure of all stands is detailed and discussed below.

This study showed that *Pinus wallichiana* is the first dominant tree species in 3 stands and as a pure stand present in 08 sides, while in 4 stands it is distributed as a second dominant tree. Similarly*, Picea smithiana* is the second dominant tree species in 2 stands and this species present in 4 stands as pure, while in 10 stands it is distributed as a first dominant tree. *Betula Utilis* was present in 2 stands as a pure stand and in 4 stands as a second plentiful species. *Juniperus excelsa* appeared as second dominant only in stand No. 16 (Lower Besha Giri) Naltar Bala, with 82.30 stems ha^{-1}. Most of the forests show gaps in earlier size classes with low density. This shows livestock overgrazing and cutting of young trees in which it is hard for young seedlings to survive. This situation may be overcome by promoting seedling regeneration in these areas, but many stands also show gaps in large size classes, indicating extensive cutting.

The distribution of each tree's individuals vs. size classes are investigated, and as a result it is observed that *Pinus wallichiana* was found as a dominant tree species having 170.6±30.77 mean density-ha^{1-} in the entire forested area, securing 1st dominant in eleven stands and 2nd dominant in five stands, while this species was never noticed as the 3rd species in any stands (Table 4). A similar study done by [37] in the area of

Table 3. Phytosociological attributes, rank, and total values of 26 stands in Naltar Valley Gilgit, Pakistan.

Location and sites	Species Name	Attributes of Phytosociology				Rank	Total values	
		R.F	R.D	R.B.A	IVI		D/ha^{-1}	BAm^{2}ha^{-1}
Naltar Bala								
Stand 1	*Picea smithiana*	100%	100%	100%	100	Pure	60.83	20.60
Stand 2	*Betula utilis*	100%	100%	100%	100	Pure	126.71	11.11
Stand 3	*Picea smithiana*	100%	100%	100%	100	Pure	93.91	32.40
Stand 4	*Pinus wallichiana*	80%	94%	90%	88	1st	220.20	27.33
	Picea smithiana	20%	6%	10%	12	2nd	14.06	0.20
Stand 5	*Pinus wallichiana*	100%	100%	100%	100	Pure	232.99	29.87
Stand 6	*Picea smithiana*	80%	94%	91%	88.33	1st	150.10	18.07
	Pinus wallichiana	20%	06%	09%	11.67	2nd	9.58	0.12
Stand 7	*Betula utilis*	100%	100%	100%	100	Pure	56.24	3.54
Stand 8	*Pinus wallichiana*	100%	100%	100%	100	Pure	258.80	39.47
Stand 9	*Pinus wallichiana*	100%	100%	100%	100	Pure	286.94	44.71
Stand 10	*Pinus wallichiana*	100%	100%	100%	100	Pure	307.41	62.40
Stand 11	*Pinus wallichiana*	69% 31%	85% 15%	83% 17%	79 21	1st 2nd	151.60 26.76	23.26 0.82
	Picea smithiana							
Stand 12	*Pinus wallichiana*	100%	100%	100%	100	Pure	159.41	18.20
Stand 13	*Pinus wallichiana*	100%	100%	100%	100	Pure	293.43	27.35
Stand 14	*Pinus wallichiana*	100%	100%	100%	100	Pure	331.13	44.70
Stand 15	*Pinus wallichiana*	100%	100%	100%	100	Pure	266.67	50.96
Stand 16	*Pinus wallichiana*	57%	68%	88%	71	1st	174.9	28.53
	Juniperus excels	43%	32%	12%	29	2nd	82.30	1.66
Naltar Pain								
Stand 17	*Picea smithiana*	91%	97%	98%	95.33	1st	118.07	14.22
	Pinus wallichiana	09%	03%	02%	4.67	2nd	11.70	0.07
Stand 18	*Picea smithiana*	95%	99%	99%	97.67	1st	126.58	43.92
	Pinus wallichiana	5%	1%	1%	2.33	2nd	1.30	0.01
Stand 19	*Picea smithiana*	87%	96%	96%	93	1st	141.55	60.00
	Pinus wallichiana	13%	4%	4%	7	2nd	5.90	0.07
Stand 20	*Picea smithiana*	100%	100%	100%	100	Pure	76.42	39.30
Stand 21	*Picea smithiana*	62	76	10	76	1st	134.70	20.78
	Betula utilis	38	24	90	24	2nd	42.50	0.74
Stand 22	*Picea smithiana*	69	85	88	80.67	1st	100.26	32.03
	Pinus wallichiana	31	15	12	19.33	2nd	17.70	0.77
Stand 23	*Picea smithiana*	61	73	91	75	1st	116.06	20.30
	Betula utilis	39	27	9	25	2nd	42.90	0.76
Stand 24	*Picea smithiana*	100	100	100	100	Pure	201.69	42.09
Stand 25	*Picea smithiana*	65	81	94	80	1st	119.70	1.76
	Betula utilis	35	19	06	20	2nd	28.10	0.41

Table 3. Continued.

Stand 26	*Picea smithiana*	71	86	85	80.67	1st	149.87	45.38
	Betula utilis	29	14	15	19.33	2nd	24.40	1.35

Key to abbreviations: R. F = Relative Frequency, R.D = Relative density, R.B.A = Relative Basal area, IVI = Importance value Index, D/ha^{-1}=Density/hector of species, BAm^{2}ha^{-1} = Basal area of species m^2/hectare, 1st = First dominant species, 2nd = Second dominant species, 3rd = Third dominant species, STD = Stand Number.

Table 4. Summary table of phytosociology of sampled trees species.

S.No	Spp. Code	PNST	Mean IVI	Mean D ha^{-1}	Mean B.A m^2 ha^{-1}	Dominant		
						1st	2nd	3rd
1	P.W	18	67.68±10.46	170.6 ±30.77	24.86 ±5.09	11	05	0
2	P.S	15	79.97±7.08	108.7±12.66	26.12 ±4.65	13	02	0
3	B.U	06	48.05±16.45	53.43 ±15.37	2.98 ±1.68	02	04	0
4	J.E	01	29±00	82.3±00	1.66±00	0	01	0

Key to Abbreviations: ±= Standard Error, PNST= Presence in Number of stands D = Density, B.A = Basal area, Sp = species, PW = *Pinus wallichiana*, P. S = *Picea smithiana*, J. E = *Juniperus excelsa*, B.U = *Betula utilis*

Miandam of the Himalayan Range, they recorded that the *Pinus wallichiana* 96 stems ha^{-1} with 18% relative basal. Moreover, from different climatic zones of Pakistan and Takht-e-Silaiman (Baluchistan), [38] recorded the densities of *Pinus wallichiana* 337 stem ha^{-1} and 232 stems ha^{-1} respectively. Himalayan pine also is known as the evergreen *Pinus wallichiana* tree, which is naturally distributed from Afghanistan across the entire Himalayan region, including Pakistan, India, Nepal and Bhutan, having altitude ranging from 1800-3900 m

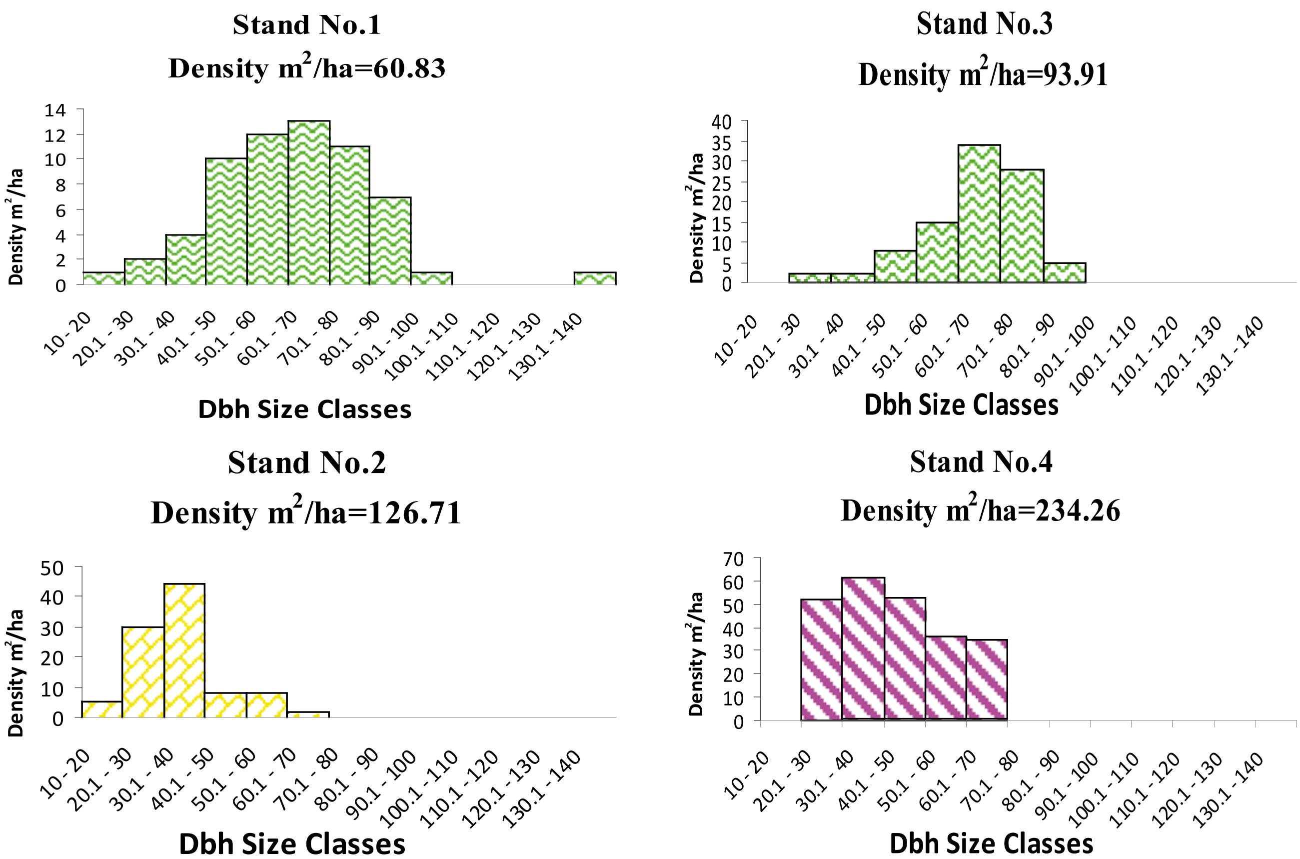

Fig. 1. Size class structure of 26 stands of the study area.

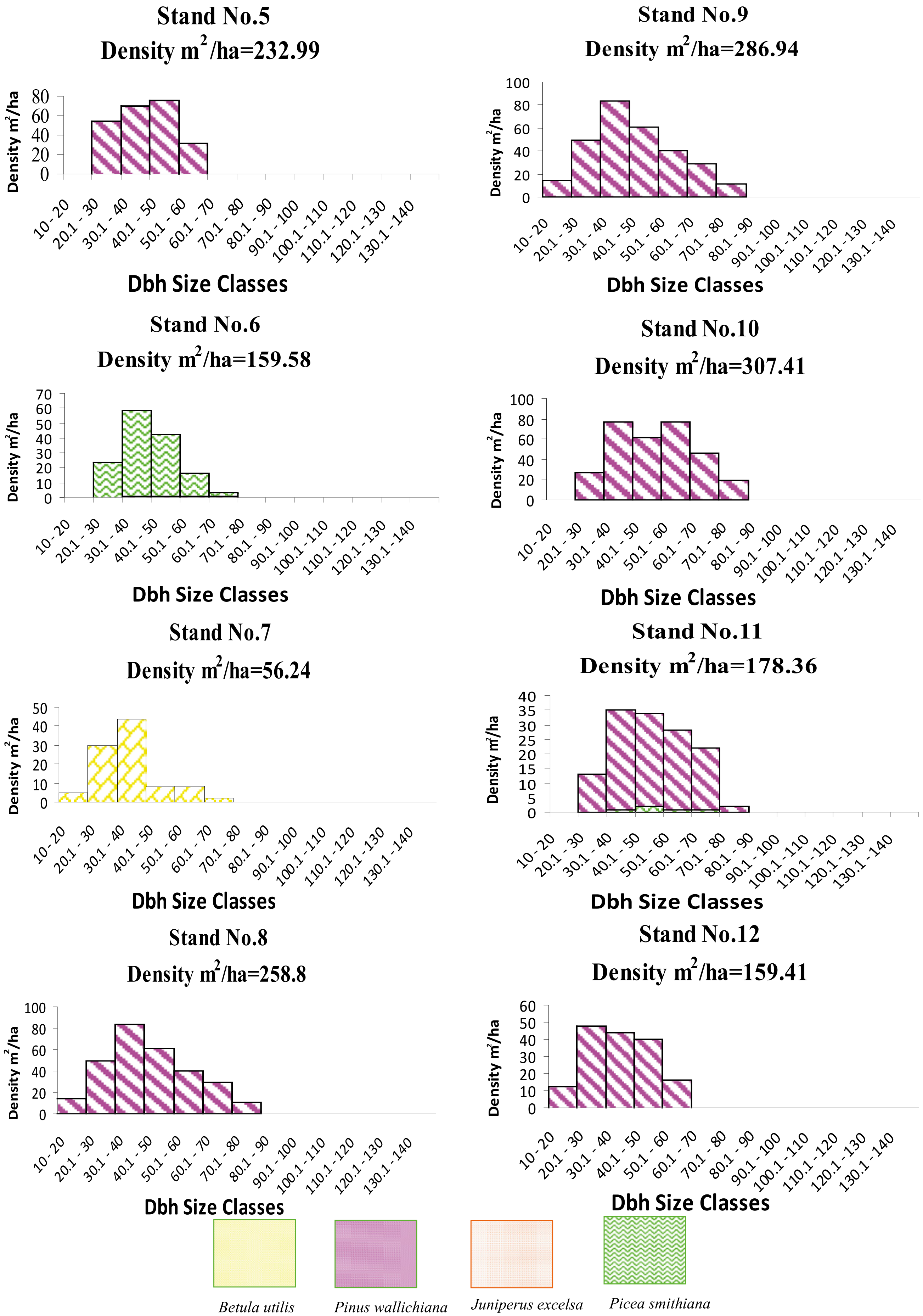

Fig. 1. Continued.

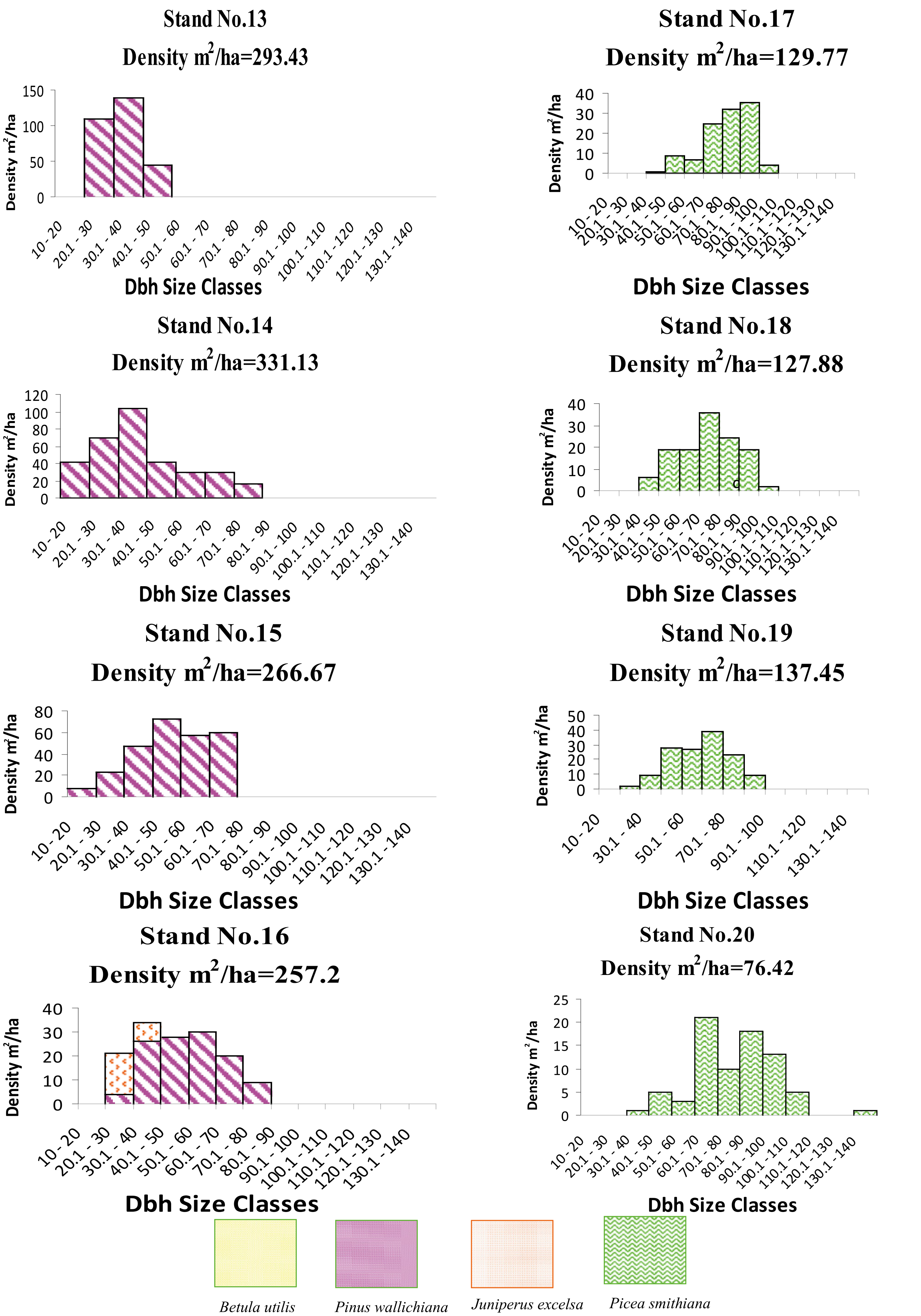

Fig. 1. Continued.

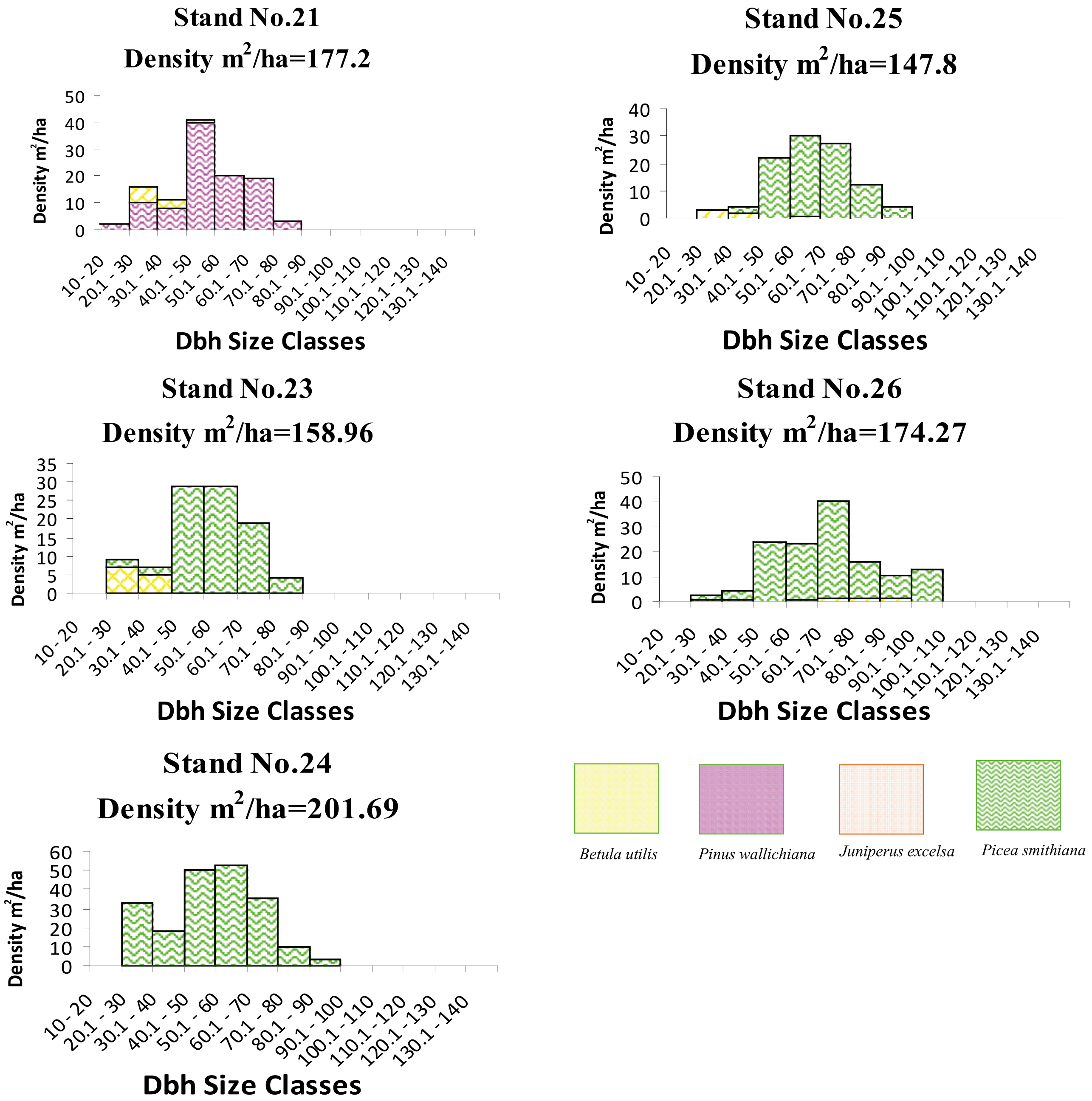

Fig. 1. Continued.

[38-40] described that *Pinus wallichiana* may grow in moist temperate as well as in dry temperate mountainous regions in Pakistan. This shows the full ecological amplitude of this species.

During this study, *Picea smithiana* tree species were recorded in 15 stands having 108.7±12.66 mean density ha^{-1}. This species found as 1st leading species in 13 locations and as 2nd leading in two stands (Table 4). Many other scholars also studied *Picea smithiana* (Wall). Boiss, in different parts of Pakistan, e.g., density 333 stems per hector having 167 basal area m^2 from Naltar (Gilgit) forest described by Ahmed et al. [38] and lowest density with 35 individuals ha^{-1} from Afghanistan recorded by Wahab et al. [35]. This huge difference of these forest is due to the large amount of cutting natural forest and other disturbances in these areas. Human-induced factors, overgrazing of livestock, cutting of timber for domestic needs, and other natural disturbances [41]. Similarly, Akbar et al. [15, 39] recorded 42 stems ha^{-1} from Mushken-B (Skardu).

An angiosperm broadleaved tree species, *Betula utilis*, was observed in only two sites as the 1st dominant species with 53.43±15.37 mean density ha^{-1} in the study area and in 4 stands as the second most-plentiful species (Table 4). Similarly, *Betula utilis*, a co-dominant species, was recorded by Ahmed et al. [38] from Nalter Valley Gilgit with 666 stems ha^{-1} and 30 m^2 ha^{-1} basal area. Akbar et al. [15] described that the *Betula utilis* employed the highest density 159 and 121 stems ha^{-1} from Joglotgah and Gasing Gilgit.

Among the all stands, *Juniperus excelsa* appeared in only one stand at Naltar Bala (stand No. 16 in Lower Besha Giri) as the second most-dominant species with 82.30 stems ha^{-1} (Table 4). Akbar et al. [42] also reported that *Juniperus excelsa* attained with 96 stems ha^{-1} the highest value from Gasing (Kharmang). The same species was also studied by Ahmed et al. [38] with 175 stems ha^{-1} and 42 m^2 ha^{-1} basal area from Baluchistan Province.

In this study gaps in early size classes of trees were recorded in 15 locations representing the less regeneration of seedlings, over grazing and cone collection by the inhabitance similar observation noticed by [8, 11, 35, 42] during their studies. Satisfactory individuals found in middle size classes, however, that the futures of the forest are under threat because of improper regeneration of early size classes.

Gaps in large and extra-large size classes were identified in the entire area. There are no single stands without gaps, indicating the server illegal cutting of mature trees in the studied forested area. Gaps in large and extra-large size classes were also observed by [15, 35, 38, 42-44] from the different locations of frosted areas in Pakistan. Diameter size class distribution is used for the better forest management and conservation needs and sustainable utilization in the developing countries frequently [7]. Without analyzing the distribution status of trees, better management and conservation could not be applied in any forest stands. Diameter distribution and the related statistical model can play an important role in some forest discipline, including forestry, and is helpful for the better management practices of forest conservation [45].

Conclusions

In light of this study, we concluded that gaps in small, middle, large and extra-large classes were observed in different locations representing noticeable disturbances, natural (i.e., sliding, forest fire, flood, soil erosions, earthquakes) and anthropogenic (i.e., illegal cutting, looping, tapering, burning, grazing and ranching). No single stand showed an ideal regeneration pattern, indicating the threat for future trends of these forests. Noticeable gaps in small, large and extra-large classes are also evident for the mentioned categories of disturbances. Introducing social forestry, preventing illegal anthropogenic activities, providing alternative livelihood options for inhabitants and exercising the legislative power form concern authorized departments of these valuable forests could be preserved for the sustainable use for future generations. This study is also helpful to expose the present status and future trends as well as could be utilized for better management and conservation practices in the region, conducting a similar study in the rest of forested areas in Gilgit-Baltistan.

Conflict of Interest

The authors declare no conflict of interest.

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