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SIZE CLASS STRUCTURE AND REGENERATION POTENTIAL OF *MONOTHECA BUXIFOLIA* (FALC.) A. DC. DOMINATED FORESTS DISTRICT DIR LOWER PAKISTAN

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ABSTRACT

This study deals with structure, dynamics and regeneration potential of *Monotheca buxifolia* and associated tree species. Fifteen stands at different locations in district Dir Hindukush range of Pakistan were chosen for the study. Point centered quarter method for trees and 5×5m size quadrats were used for sampling of understorey vegetation including shrubs, seedlings and saplings respectively. Size class structure and regeneration potential of *Monotheca buxifolia* and associated tree species, were examined that reflect the dynamics of species and consequently the forests where it dominates. The arboreal vegetation was mostly dominated by broad leaved species including *Monotheca buxifolia, Olea ferruginea, Acacia modesta, Punica granatum, Quercus baloot and Ficus palmata.* The understorey vegetation composed of *Dodonea viscosa, Justicia adhatoda, Otostegia limbata, Indigofera gerardiana, Plantago lanceolata, Rumex dentatus, Marrubium vulgaris, Fragaria nubicola, Geranium rotundifolium, Daphne oleoides, Solanum nigram, Ajuga bracteosa, Oxalis corniculata* seedlings of *Monotheca buxifolia*, *Quercus baloot* and *Punica granatum*. At the seedling and sapling stage, maximum number was observed for *Monotheca buxifolia* (27±5.75 and 38±7.1) followed by *Quercus baloot* (18±2.2 and 12±1.0) and *Olea ferruginea*. As for as regeneration status is concerned, 34% species show good regeneration, 50% species were facing the problem of poor regeneration while, only 16% species were not regenerating. Size class structure of *Monotheca buxifolia* and associated tree species for individual stands exhibited a few gaps. Relationships between density and basal area were significant but density and basal area with altitudinal and slope gradient showed non significant relation. Some recommendations are outlined for future research and sustainable management of these forests species.

Keywords: Regeneration potential, Deteriorating forests, Management plan, Size class structure, Vegetation description, Lower Dir, Pakistan

INTRODUCTION

Forest plays an important role not only in the economic growth of the country and provides, clean water, air, biodiversity and shelter but also supports human culture, value and their civilization. Unfortunately Pakistan has only 4% forested area in comparison to 23% elsewhere, and these forests are in a bad shape due to anthropogenic factors reported by various ecologists, biologist and foresters (Ahmed *et al.* 2006).

District Dir Hindukush range is subtropical Dry temperate area and embody a diverse and characteristics vegetation distribution over a wide range of topographical variation, Champion *et al*, (1965). The area have a subtropical dry temperate forest extends from 800m to 3100 m elevation in the Hindukush range is of immense significance for the environmental conservation and sustainable development viewpoint. District Dir has a ridge mountains and a number of valleys. The variable topography of the area support luxuriant vegetation ranging from sub tropical to alpine.

Most of the widely distributed broad leaved species which are reported by Champion *et al* (1965) are now rare (Ahmed *et al.* 1991). Among these broad-leaved tree species *Monotheca buxifolia* is one of the important tree species of Pakistan. This species is distributed in the mountains of Afghanistan, northern Oman, and in the south east Saudi Arabia (Shahina & Martin 1998). In Pakistan it is commonly found in, Gorakh Hills, Zhob, Loralai, Kohat, Drosh Chitral, Kala Chitta Hills, and Attock District (Nasir & Ali 1972).

This species is found either pure or associated with *Olea ferruginea, Acacia modesta* and *Punica granatum*. *Ficus palmata* and *Quercus baloot* are rarely found in association. At some locations *Dalbergia sissoo* is also sporadically associated with *Monotheca buxifolia* (Khan *et al.* 2010).

In comparison to several other species *Monotheca buxifolia* is the most preferred species in hilly areas. It is mainly used as a fuel, fodder, and small timber, and notably it is used as a fence around cultivated fields due to its thorny nature. This specie yield fruits locally called Gurguri which is a source of income for the local inhabitants (Khan *et al*, 2010). During the last 30 years this species is under extreme pressure and is completely eliminated from many parts of the District due to anthropogenic disturbances.

There are few published data on the size class structure and regeneration potential of forest species. Ahmed (1988a) made some population study of planted tree species near Quetta and Ahmed *et al.* (1990a) reported the structure and dynamics of *Juniperus excelsa* forest in Balochistan. Population structure and dynamics of *Juniperus excelsa* from Rodhmallazai was given by Ahmed *et al.* (1990b), while Population structure and dynamics of *Pinus gerardiana* forests in Balochistan was also presented by Ahmed *et al.* (1991). Ahmed *et al.* (2006) carried out extensive work on Phytosociology and structure of various Himalayan forests of Pakistan. Wahab *et al.* (2008) described Phytosociology and dynamics of some pine tree species of Afghanistan. Recently Ahmed *et al.* (2009) and Siddiqui *et al* (2009) described population structure and dynamics of Deodar, and Pinus roxburghii from Pakistan. Beside these studies by a few workers no comprehensive investigation on size class structure and regeneration potential was carried out.

The objective of the present instigation were to present data on size class structure, and regeneration potential of *Monotheca buxifolia* and associated tree species in District Dir in order to help in conservation for this ecologically and commercially important species.

MATERIALS AND METHODS

1. Study site:

The study area is located at 35° 10 to 35.16 N Latitude and 71° 50 to 71.83 E longitude in subtropical dry temperate part of Hindukush range (Fig 1). It covers an area of 1,582 km^2. The forests in the form of woodlots are located close to one another. The terrain is gently sloping and the altitude ranged from 1370 to 1670m above sea level. The climatic data showed that January is the coldest while June and July are the hottest month. In June the mean minimum and mean maximum temperature has been recorded as 15.67 °C to 32.52 °C respectively. The winter season is from mid November to March. December, January and February are the coldest months. During this period the temperature generally fall below freezing point. The mean minimum and maximum temperature is 2.39 °C to 11.22 °C. Maximum rainfall (i.e. 242.22mm) is received in March while lowest in July, October and November (Anonymous, 1998).

2. Vegetational study

Vegetation analysis was conducted using Point centered Quarter Method (PCQ) of Cottam & Curtis (1956) for tree species and 5 × 5m size quadrats for shrubs, seedling and saplings. Quadrats were taken in each stand and diameter of each tree was measured at breast height (1.3m above the ground) using a diameter tape. Slope was determined using a suunto clinometer. For each species, established seedlings, (diameter < 5cm Dbh), Saplings (diameter 5-9.9 cm Dbh) and trees (Dbh > 10cm Dbh) were identified, counted and diameters were determined. Seedlings were excluded from measuring Dbh in PCQ sampling. Chopped stump were also counted, and recorded to estimate the level of exploitation based on density/ha-1.

Field data were calculated for frequency, density and basal area. The values of frequency, density and basal area were sum and divide by 3 in order to obtain relative values, (Curtis and McIntosh, 1950). Herbs, Shrubs species other than main tree species were listed on the basis of presence/absence. The number of individuals/ha-1 (density) and composition of target tree species ≥ 5 cm Dbh were recorded in all stands. Regeneration status of species was totally based on population size of seedlings and saplings Khan *et al.* (1987). Good regeneration > saplings > adults; fair regeneration if seedlings > or ≤ adults; poor regeneration, if the spices survives only in sapling stage, but no seedlings (sapling may be <, > or = adults). If a species is present in adult form it is considered as not regenerating. Species is considered as new if the species has no adults but only seedling or saplings.

Data were analyzed in Microsoft Excel 98 to and stored to generate diameter size classes.

RESULTS

Locations, characteristic features of each sampling site, dominant tree species and absolute quantitative attributes are presented in Table 1**.** Elevation and slope do not show any significant correlation with stand density/basal area and *Monotheca buxifolia* density/basal area. Table 2 provides the summary of phytosociological sampling of 15 stands, mean importance values, absolute density ha^{-1}, basal area m^{2}ha^{-1} and order of dominance of *Monotheca buxifolia* and associated tree species. Regeneration status of the tree species is summarized in Table. 3.

A total of 15 stands were sampled and six tree species were recorded belonging to 6 families and 6 genera from the study area. *Monotheca buxifolia* was the leading dominant in all 15 stands while in 4 stands it occurred in an association with *Olea ferruginea* and in such stands average importance value of *Monotheca buxifolia* and *Olea ferruginea* was 82±3.9% and 24±4.5% respectively. *Punica granatum* showed its presence in 4 stands and was represented as the second dominant in 1 stands and third dominant in 3 stands. *Acacia modesta* was represented in 4 stands with an average importance value of 23±3.7%, occurring as second dominant in 4 stands. Besides, these broad leaved species two other tree species *Quercus baloot* and *Ficus palmata* occurred in 1 and 1 stands with an average importance values 35±0.34% and 4±00% respectively. Among these species, *Quercus baloot* attained second dominance in 1 while *Ficus palmata* showed no clear cut dominance. Both average absolute density and basal area were highest for *Monotheca buxifolia* 142±79 trees ha^{-1} and 11.65±1.8 m^2 ha^{-1} respectively. *Olea ferruginea* and *Quercus baloot* exhibited almost similar moderate average absolute density 42±8.3 trees ha^{-1} and basal area 2.06±0.73 – 0.73±0.04 m^2 ha^{-1}. *Punica granatum*, *Acacia modesta* and *Ficus palmata* exhibited low density (range 14 to 32 ha^{-1}) and basal area (range 2.05 to 3.58 m^2 ha^{-1}).

In herb shrub layer common species in all stands were *Dodonea viscosa (L.) Jacq* with 100% frequency in all stands. *Otostegia limbata (Benth.) Boiss* (40-80% frequency) *Indigofera gerardiana* (50 to 70%) *Mallotus philppensis Mule* (20-60%), *Fragaria nubicola* (20 to 60%), *Geranium rotundifolium* (20 to 50%) were dominant herb and shrubs. The least dominant species were *Justicia adhatoda L.* (20-40) and *Artemisia vulgaris L.*, (30-70). Other species on the forest floor were *Ajuga bracteosa Wall.ex Benth.*, (10-30), *Rumex hastatus D.Don.* (10-90), and *Oxalis corniculata L.*, with (40-90) frequency. The distribution pattern of most of the species was random and a few were distributed contagiously.

Fig.1. Map showing sampling site.

Tree density and regeneration potential

Regeneration potential and degree of disturbance were evaluated and the results were depicted into Table 3. The results shows that *Monotheca buxifolia* have a total density of 142±11 individuals/ha^{-1} and commonly found regenerating by both saplings (38±7.16) and seedlings (27±5.75 individuals/ha^{-1}). A total of 41±4.6 chopped stem of the same species were obtained from the forest floor. Similarly *Quercus baloot* shows regeneration potential with 12 to 18 individuals/ha^{-1} of both seedlings and saplings, with a relatively high number of chopped stems. *Olea ferruginea* and *Acacia modesta* show very poor regeneration with 7 to 17 and 9 to 15 individuals/ha^{-1} of seedlings and saplings.

Punica granatum also show poor regeneration status. *Ficus palmata* was not regenerating either through seedlings and Saplings, Table 3.

Size class structure

The frequencies of tree species in each Dbh Class for all fifteen stands are presented in Fig 2. The diameter class distribution of *Monotheca buxifolia* stands show a inverse J-shape distribution with stems frequencies decreasing with increase in diameter at breast height for forest stands (1, 4, 5,6, 7,8, 10, 11, 12, 13, 14,and 15) respectively. This type of size distribution is typically represented by most natural tree population. Some forest stand show almost flat structure, where the frequency of individuals in all classes are almost same. The figure indicates that stands are developing and regeneration in the forest is present. Looking very critically at stand 5 the histogram shows a reduction in the number of stems in diameter class 1, 2, and 5.

The frequency size classes vary from 4 to 6 classes at different altitudes. Minimum size classes were recorded at stands 3 (1380m), Stand10 (1555m), Stand 11 (1562m), stand 13 (1625m), stand 14(1660m) and stand 15 (1670m) elevation. Stand (1, 2, 4, 5, 7, 8, 9, and 12) showed five frequency size classes, Fig 2.

Maximum Diameter classes of *Monotheca buxifolia* was obtained at stand 6 at elevation 1422m a.s.l. where size classes extend to six due to the presence of high diameter trees. The maximum diameter (68 Dbh cm) was also obtained at this location.

At many stands the most frequent Dbh size classes of trees represents by 20 to 30 and 30 to 50 Dbh cm classes, while most of the co-dominated species were confine in 10 to 30 Dbh cm classes, with the exception of stand (1, 10, and 15). Generally there is better growth at Zaar (stand 6) Manogay (Stand 11) and Karapa (Stand 13) as compare to other sites, indicated by the movement of trees in various diameters. At these locations the tree density/ha^{-1} was range between 50 to 90 individual's ha^{-1} in small size classes. Gaps were observed in stand 7 and 9.

DISCUSSION

The tree population could generally grow and survive in certain range of environmental gradients i.e., temperature, precipitation slope and altitude (Block and Treter 2001). Optimal environmental conditions could enable a well developed population and limiting factors would result in poor growth of plant individuals. According to Watkinson (1997) reported that natural population of tree increase exponentially in suitable condition and when resources are free available. Barnes *et al.* (1997) view that increasingly physiographic characteristics of specific land form such as slope, aspect, parent materials, soil etc were also been used for characterizing vegetation over the space.

In the present investigations the density and basal area shows large variation from site to site and it is assumed that stem density depends on various historical and environmental factors (Ahmed 1984). However, in these forests anthropogenic disturbance could be an overriding factor. Gairola *et al.* (2008) stated that structure, composition and function are the three important attributes of forest ecosystem. These attributes change in response to climate, topography, soil and disturbance. Kharkwal *et al.* (2005) stated that plant community of a region is a function of time; however altitude and aspect play a role in the formation of plant communities and their composition.

According to Grubb *et al.* (1963) in undisturbed area density is closely related to slope**,** however, no significant relation was observed between slope and stand density, stand basal area, *Monotheca buxifolia* density and basal area. It was also recorded that East facing slopes supported highest stand (178± 26 ha^{-1}, 14 ± 3m^{2}ha^{-1}) density and basal respectively. Lowest stand density and basal area was recorded from West facing slope.

Some published results (Ahmed 1988a, b**,** Ahmed *et al.* 1990a**,** 1990b**,** 1991**,** 2006, 2010) of other forests in Pakistan are available for comparison of density and basal area. It is reported that near Nathiagali at an elevation of 2270 meters *Abies pindrow* and *Pinus wallichiana* have equal density of 276ha^{-1} while the basal area was 52**.**50 m^{2}ha^{-1} and 24.82m^{2}ha^{-1} respectively**.** At 2340 meter elevation, near Pine Hill Hotel, *Abies pindrow* attained a density of 174ha^{-1} with 40m^{2}ha^{-1} basal area. Near Ayubia on South facing slopes at an elevation of 2250 meter *Abies pindrow*, *Pinus wallichiana* and *Cedrus deodara* exhibited a density of 427, 164 and 17ha^{-1} while the basal area of these species were 33**,** 25 and 0.43 m^{2}ha^{-1} respectively.

It is also recorded that North facing slopes supported highest stand (289 ± 37) and *Cedrus deodara* density (195 ± 32ha^{-1}) while lowest stand density (182 ± 42) and *Cedrus deodara* density (128 ± 35ha^{-1}) were recorded from West facing slopes. Stand basal area was highest (54.67 ± 8.51) at South while *Cedrus deodara* showed highest basal area (34.76 ± 5.98m^{2}ha^{-1}) from North facing slopes, though no significant correlation was obtained between these two variables. Our results are in compliance with this proposition.

Most of the vegetation layers were distributed contagious especially in shrubs, saplings and seedlings. However, in trees layer most of the species found distributed random and few of them were contagious. Contagious distribution has been reported by several workers (Greig-Smith 1957; Kershw 1973; Singh and Yadav 1974. Odum 1971) have emphasized that contagious distribution is the commonest pattern in nature. Kumar and Bhatt (2006) also reported contagious distribution pattern in foot-hills forests of Garhwal Himalaya.

The density values of seedlings and saplings are considered as regeneration potential of the species. The presence of good regeneration potential shows suitability of a species to the environment. Climatic factors and biotic interference influence the regeneration of different species in the vegetation. Higher seedling density values get reduced to sapling due to biotic disturbance and competition for space and nutrients (Monaj *et al.* 2008). Good and Good (1972) have considered three major components which cause the successful regeneration of tree species. These components are the ability to initiate new seedlings, ability of seedlings and saplings to survive and ability of seedlings and saplings to grow.

Tree size class distribution can be used as indicator of changes in population structure and species composition (Newbery & Gartlan 1996). Distribution curves that drop exponentially with increasing Dbh (reverse J-shaped) are characteristics for species with continuous regeneration (Khamyoung *et al*, 2004). Curves showing little or no drop in the lower Dbh classes indicate the requirement is unsustainable and the long term change in species composition of the plant community studied is to be expected (Hall & Bawa 1993). *Monotheca buxifolia* shows reverse J-shaped distribution with greater number of individuals in small size classes. Such a trend has been reported from the forest of *Quercus baloot* in Chitral (Khan *et al.* 2010), and from sub-tropical *Olea ferruginea* dominated forest District Dir lower (Ahmed *et al.* 2010).

Successful regeneration of tree species might be considered to be a function of three major components ability to initiate new seedlings, ability of seedling and saplings to survive and ability of seedlings and saplings to grow (Good and Good, 1972). Measurement of these parameters provides greater insight into the regeneration of species in forest community. However it is almost impossible to collect data on population dynamics of all tree species in diverse forests at extensive level. Therefore, regeneration of population structure as percent of individuals by size classes remains the only workable method to analyze the regeneration status in forest communities.

Fewer individuals of the tree species in forests were probably because of overgrazing and other timber harvesting activities. Uncontrolled logging usually destroys mature and young trees, (Champion *et al.* 1965), Alamgir *et al.* 2004), the former through extraction and the latter through destruction of regeneration. A major environmental change that could have been created by logging in these forests is gap formation and its influence on the growth of light demanding species. Difference in stem densities in these forests could have resulted from the varying level of disturbances experienced over the years. The destruction of Plants and excessive opening of canopy gaps often stimulate growth of dense herbaceous and semi-woody tangles that suppress tree regeneration, (Omeja *et al*. 2004). This condition is expected to prevail in these forests for the foreseeable future because of tree harvesting to provide wood for timber, fuel and other proposes. *Olea ferruginea*, *Acacia modesta* and *Punica granatum* had <50 stem/ha^{-1} indicating that their population have been drastically reduced by cutting for fodder and fuel by the local inhabitants. *Ficus palmata* shows no regeneration and the species appeared to be extinct from the forests.

The regeneration pattern of the tree species varied in each forest. Human disturbances could have influenced seed dispersal mechanisms, fruits, germination and regeneration of each tree species. There were no mature *Acacia modesta*, *Punica granatum* and *Olea ferruginea* trees (>50 Dbh cm) in these forests because of intensive harvesting (Fig 2). The poor natural regeneration (about ten individuals per hectare in the ≤5cm Dbh) indicates that the seed sources were depleted through harvesting of mature trees. Enrichment planting could raise the population of *Olea ferruginea* and *Punica granatum* forest. A similar management intervention could be undertake in Kattan bala forest where the population density of *Olea ferruginea* and *Punica granatum* about 20 individuals or less per hectare.

There were relatively more *Monotheca buxifolia* in 10 to 30 cm Dbh classes (Fig 3). The population structure of *Monotheca buxifolia* could show a normal trend in future, as there are mature seed sources and plenty of seedling and saplings in the forest undergrowth. The *Quercus baloot* were regenerating from seedling as well as saplings in the forest. There was more than 30 stems ha-1 in 10 to 20 Dbh cm classes range, which is a range sign of recovery from past exploitation. Regeneration rates of *Punica granatum* and *Olea ferruginea* were poorer in Kattan Lower (Stand 13) and Karapa forests (Stand 14) than in Porighar (Stand 1). Ninety five percent of the species recorded in Porighar with 10 to 20 Dbh cm classes.

Over exploitation has reduced the density *Ficus palmata* in the 20 to 30 Dbh cm class as exemplified by less 5 individuals per hectare in the Kattan lower forest (Fig 3). This population of this species will be extinct due to the fruits which are edible by Human and birds and as a results very negligible number of seed are germinate.

Punica granatum seed can germinate and the seedlings and saplings establish under open and close canopy. This means that their populations would always be higher than the population of *Acacia modesta*.

Punica granatum produce sour fruits which are use by the local people in Cappli Kabab, and as fresh fruit, and also eaten by a diversity of birds, monkeys (Cercopithecus ascanius).

Table 1. Characteristic features, dominant tree species and absolute values of the study sites.

Forest Stands	Location	Latitude N	Longitude E	Altitude (m)	Dominant species	Density ha^{-1}	Basal area m^2ha^{-1}
I	Porighar	34 º 71	71 º 82	1370	1,2	214	12.77
II	Gidar	34 º 70	71 º 67	1375	1	162	16.84
III	Shagokas	34º 65	71 º 60	1380	1,6	161	19.83
IV	Doda	34 º 70	71 º 68	1405	1	120	11.71
V	Deere	34º 43	71º 53	1420	1	110	8.40
VI	Zaar	34 º 43	71 º 48	1422	1,3	305	33.51
VII	Gatko	34 º 71	71 º 81	1434	1,5	164	12.84
VIII	Palosin	34 º 68	71 º 79	1440	1	139	9.91
IX	Chal Kamar	34 º 70	71 º 65	1455	1,5	123	12.92
X	Pingal	34 º 78	71 º 80	1555	1,5	181	11.20
XI	Manogay	34 º 70	71 º 77	1562	1,5	191	13.97
XII	Sur Kamar	34 º 70	71 º 80	1568	1	136	9.46
XIII	Karapa	34 º 69	71 º 72	1625	1,2,3	193	10.83
XIV	Kattan Lower	34 º 70	71 º 83	1660	1,2,3,4	225	14.14
XV	Kattan Upper	34 º 70	71 º 83	1670	1,2,3	156	11.62

Species code: 1. *Monotheca buxifolia (Falc.) A. DC. 2. Olea ferruginea Royle 3. Punica granatum L. 4. Ficus.*

Table 2: Phytosociological summary of tree species.

Tree Species	PR	Min IVI	Max IVI	Mean	Min D/Ha	Max D/Ha	Mean	Min B.A	Max B.A	Mean	1st Dominance	2	3
Monotheca buxifolia	15	62.44	100	82±3.9	94.59	285.82	142.79±11.31	7.23	32.06	11.65±1.58	15	0	0
Olea ferruginea	4	17.7	37.56	23.95± 4.5	29.29	67.04	42.72±8.36	0.56	4.06	2.06±0.73	0	4	0
Punica granatum	4	8.2	14.2	10.14± 1.3	12.84	32.13	20.08±4.21	1	8.4	3.18±1.74	0	1	3
Acacia modesta	4	16.16	33.31	23.15± 3.7	23.95	48.87	32.13±5.65	1.33	3.36	2.05±0.45	0	4	0
Ficus palmata	1	4	4	4±00	14.26	14.26	14.26±00	3.58	3.58	3.58±00	0	0	0
Quercus baloot	1	35.34	35.35	35.34± 00	42	42	42±00	0.73	0.73	0.73±00	0	1	0

Note: 1. Presence in number of stands; 2. Minimum Importance value index; 3. Maximum Importance value index; 4. Minimum density/ha^{-1}; 5. Maximum dendsity/ha^{-1}; 6. Minimum Basal area m2/ha^{-1}; 7. Maximum Basal area m2/ha^{-1}. 8. Dominance in stands

Table 3. Regeneration status and degree of disturbance of *Monotheca buxifolia* and associated tree species.

Tree species	Density/ha^{-1} Mean±SE	Seedlings/ha^{-1} Mean±SE	Saplings/ha^{-1} Mean±SE	Chopped trees/ha^{-1} Mean±SE	Status
Monotheca buxifolia	142±11.3	27±5.75	38±7.16	41±4.64	G
Olea ferruginea	42±8.36	15±2.25	17±3.14	9±3.56	P
Punica granatum	20±4.21	4±2.40	5±1.43	2±1.10	P
Acacia modesta	14±00	9±1.50	7±1.79	13±2.19	P
Quercus baloot	32±5.65	18±00	12±00	24±00	G
Ficus palmata	42±00	0	2±00	0	N

G- Good regeneration, P- Poor regeneration and N- No regeneration

The diameter size classes of *Acacia modesta* indicate that the species has poorer regeneration in the four forests than the other two major species. The paucity at certain size classes suggests that the recruitment process may have been affected by a combination of factors at different temporal and spatial scales. A similar trend in the diameter size class of *Punica granatum* was also observed. The absence of some diameter size classes can possibly be attributed to different gap sizes and conditions in the forests. It was also observed that tree harvesting in *Monotheca buxifolia* forests create large open canopies thereby increasing light intensities and soil temperature. These factors often trigger the germination and growth of weedy plants such as *Dodonea viscosa*, *Otostegia limbata*, *Artemisia vulgarus* and *Artemisia maritima* including the exotic species like *Eucalyptus* that form very thick undergrowth in the forest and suppressed the colonization of gaps of *Punica granatum*.

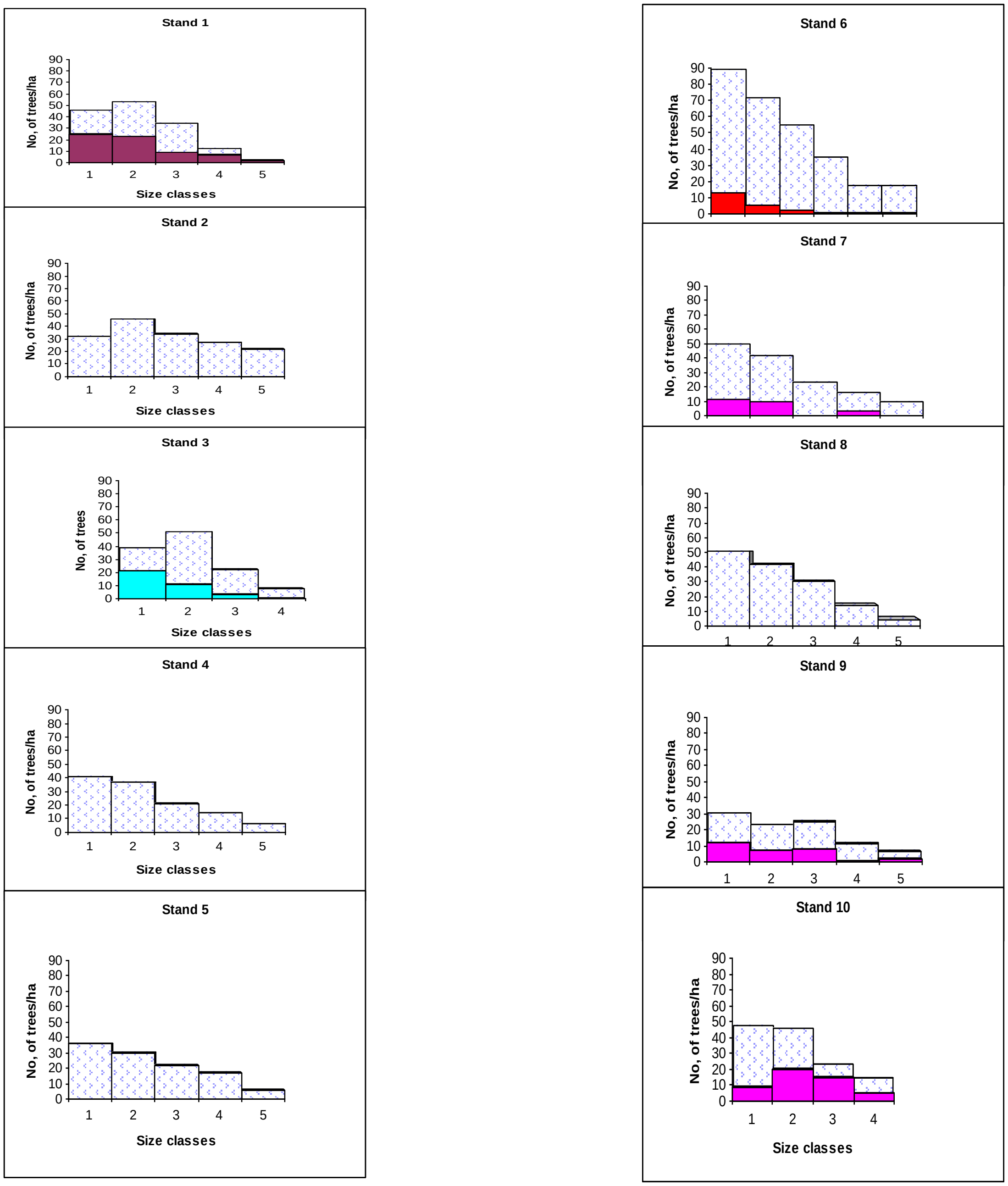
The relatively low number of *Punica granatum* forests can also be attributed to the creation of few large gaps in the recent past. These gaps may be due to deaths, harvesting of trees and up growth. The reduction of stems at stand 1 is caused by Cutting for fuel wood. The reasons for these gaps were still unknown probably it may be due to cutting. In developing forest management strategies for these forests it would be important to focus on the protection of the above tree species from depletion.

CONCLUSIONS

1. There are differences in the number of mature individuals of, *Olea ferruginea*, *Acacia modesta* and *Punica granatum* while the population of *Monotheca buxifolia* is almost the same in all forests.
2. *Monotheca buxifolia* are the most abundant and *Ficus palmata* is rare among the mature trees.
3. The intensity of use and concentration on a limited number of the most favored timber and fruits yielding trees species have resulted in localized over-exploitation with potential ecological knock-on effects on the forest health.

RECOMMENDATIONS

1. More strict control on commercial logging is needed for *Monotheca buxifolia* and associated tree species in order to conserve the forest structure.
2. There is need to raise awareness of the local communities living in the nearby villages around forests about the declining status of these economically important species.
3. Taking into account the *Monotheca buxifolia* which yield fruits the local community should strictly ban not to cut the branches of this specie for fodder and fencing purposes.
4. Local communities should be enlightened not to waste the seeds after consuming fruits. They must save the seeds and hand over to the forest department for preservation and regeneration purposes.
5. *Monotheca buxifolia* and associated tree species are slow growing taking long to mature. Tree plantation in Agroforestry system outside of the forest in order to develop alternative stocks should be encouraged. This would help to reduce further degradation of the forest and depletion of the species.



6. Forest Department should take initiatives for making nurseries. So as to disperse the obtained seedlings to the local community and should also look after their preservation.

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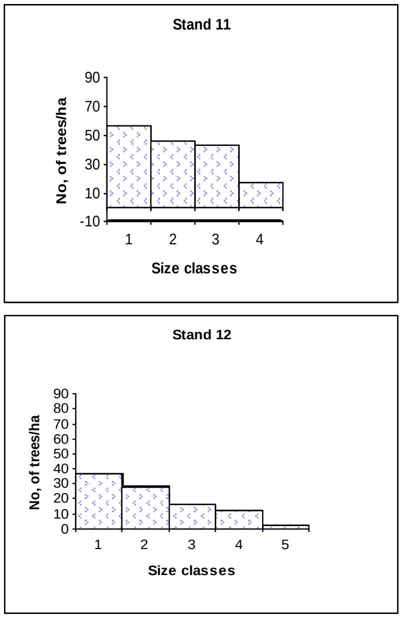

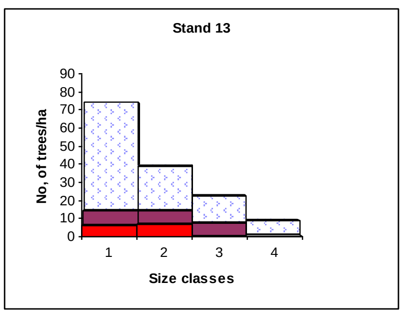

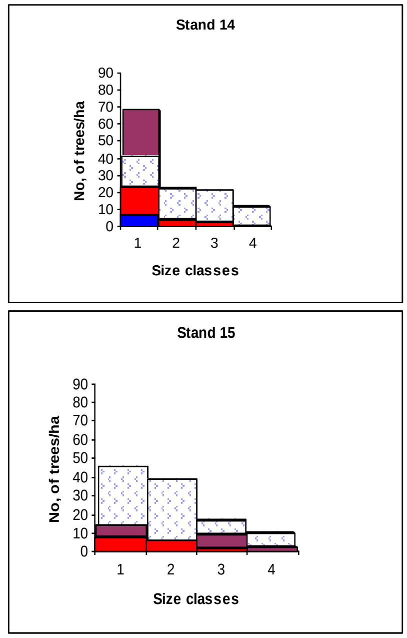

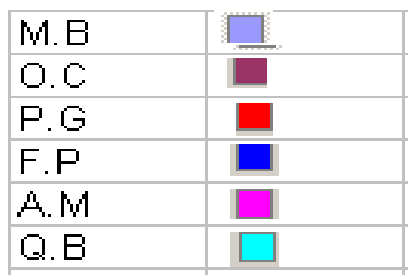

Fig. 2. Size class structure of each stand.

REFERENCES

Anonymous (1998) District Censes Report Population censes organization statistics Division Islamabad Pakistan, pp. 2-14.

Ahmed, M. (1984). *Ecology and dendrochronology of Agathis austrilis in New Zealand*, Ph.D. thesis, Department of Botany, University of Auckland, New Zealand.

Ahmed, M., A. Mohammad, A. Mohammad and S. Mohammad (1991). Vegetation structure and dynamics of *Pinus gerardiana* forest in Balochistan. *Pakistan. J. Veg. Sci*., 2: 119-124.

Ahmed, M., S.S. Shaukat and A.H. Buzdar (1990). Population structure and dynamics of *Juniperus excelsa* in Balochistan, Pakistan. *J. Veg. Sci*., 1: 271-276.

Ahmed M**,** Khan N, Wahab M, Salma H, Siddiqui F, Nazim K, and Uzair (2009). Description and Structure of Olea ferruginea (Royle) forests of Dir lower District of Pakistan (*Accepted Pak.J.Bot*).

Ahmed, M. (1988a). Plant communities of some northern temperate forests of Pakistan. *Pakistan Journal of Forestry* 38: 33-40.

Ahmed, M. (1988b). Population studies of some planted tree species of Quetta. *Journal of Pure Applied Sciences* 7:25-29.

Ahmed, M., E. E. Nagi., and E. L. M. Wang (1990a). Present state of *Juniper* Rodhmallazi forest of Baluchistan, Pakistan. *Pakistn Journal of Forestry*. 227-236.

Ahmed, M., S. S. Shaukat and A. H . Buzdar (1990b). Population structure and dynamics of *Juniperus excelsa* in Baluchistan, Pakistan. *Journal of Vegetation Science* 1: 271-276.

Ahmed, M., M, Ashfaq., M, Amjad and M. Saeed (1991). Vegetation structure and dynamics of *Pinus gerardiana* forest in Baluchistan, Pakistan. *Journal of Vegetation Science,* 2: 119-124.

Ahmed, M., T. Hussain, A.H. Sheikh, S.S.Hussain and M.F. Siddiqui (2006). Phytosociology structure of Himalayan Forest. from different climatic zones of Pakistan. *Pakistan Journal of Botany* 38: 361-382.

Ahmed, M., S. S. Shaukat and F.M. Siddiqui (2010). Multivariate analysis and dynamic of *Cedrus deodara* forests from Hindukush and Himalayan range of Pakistan. Submitted *Acta Botanica.*

Alamgir, K.G. (2004). A study on the condition, use, management and trends of major forest types in Chitral District.

Beg A.R. and M.H. Khan (1984). Some more plant communities and the future of dry oak forest Zone in Swat valley. *Pak. J. For*., 34: 25-35.

Block, J. and U. Treter (2001). The limiting factors at the upper and lower forest limits in the mountain-woodland steppe of Northwest Mongolia Joachim Block and Uwe Treter. In: Kaennel Dobbertin, M., Bräker O.U. (Eds.), Proceedings of the International Conference on Tree Rings and People. Davos, 2001, pp. 22–26.

Curtis J.T and R.P. McIntosh (1950). The interrelation of certain analytical and synthetic Phytosociological characters. *Ecology*. 31: 434-455.

Champion, G. Harry and S.K. Seth (1965). *Forest types of Pakistan*. Pakistan Forest Institute, Peshawar. 233 pp.

Cottam, G. and J.T. Curtis (1956). The use of distance measures in Phytosociological sampling. *Ecology*, 37(3): 451-460.

Gairola, S., R. S. Rawal and N.P. Todaria (2008). Forest vegetation patterns along an altitudinal gradient in sub-alpine zone of west Himalayan India. *African Journal of Plant Science*. 2(6): 042-048

Grubb, P. J., J.R. Lloyd, T.D. Pennington and T.C. Whitmore (1963). A comparison of mountain and lowland rainforest in Ecuador. I. The forest structure, physiognomy and floristic. *Journal of Ecology* 51: 567-601.

Grieg-Smith P. (1957). *Quantative Plant Ecology*, 2nd edition. Butterworth, London.

Good, N.F. and R.E. Good (1972). Population dynamics of tree seedlings and saplings in mature Eastern hardwood forest. *Bull Torrey Bot. Club*., 99.

Hall, P. and K. Bawa (1993). Methods to assess the impact of extraction of non-timber forest products on plant populations. *Econ. Bot*. 47: 34–247.

Khan, N. M. Ahmed, M. Wahab and M. Ajaib (2010). Phytosociology, structure and Physiochemical analysis of soil in *Quercus baloot* Griff, District Chitral Pakistan. (Accepted, Pakistan Journal of Botany).

Khan, M.L. J.P.N. Rai and R.S. Tripathi (1987). Population structure of some tree species in disturbed and protected sub-tropical forests of north-east India. *Acta Oecologia*:*Oecologia Applicata* (France) 8: 247- 255.

Khamyong, S., A.M. Lykke, D. Seramethakun and A.S. Barfod (2004). Species composition and vegetation structure of an upper montane forest at summit of Mt. Doi Inthanon, *Thailand. Nordic Journal of Botany*, 23: 83-97.

Kumar, M and V.P. Bhatt (2006). Plant biodiversity and conservation of forests in foot hills of Garhwal Himalayan. *Journal of Ecology and Application.*, 11(2): 43-59.

Manoj, D. D. A., S. Bhatt and M. Kumar (2008). Community structure and regeneration potential of natural forest site in Gangotri, India. *Journal of Basic and applied Sciences, Vol*. 4(1): 49-52.

Nasir, E and S.I. Ali. (1972). *Flora of West Pakistan*.

Newbery, D.Mc.C. and J.S. Gartlan (1996). A structural analysis of rain forests at Korup and Douala-Edea, Cameroon. *Proceedings of Royal Society Edinburgh*,104B: 107-224.

Odum, E.P. (1971). *Fundamental of Ecology*. III ed. W.B. Saunders Co., Philadelphia USA. Of Wisconsin, Madison., 657 pp.

Omeja, P., O. Joseph and A.B. Cunningham (2004). Regeneration, density and size class distribution of tree species used drum making in central Uganda. *Afr. J. Ecol.* 42: 129-136.

Siddiqui, F.M., M. Ahmed, M. Wahab, N. Khan, K.M. Uzair, N. Kanwal and S.S. Hussain (2009). Phytosociology of *Pinus roxburghii* Sargent. (Chir Pine) in Lesser Himalayan and Hindukush Range of Pakistan. *Pak. J. Bot.*, 41(5): 2357-2369.

Shahina, A. G. and F. Martin (1998). *Vegetation of Arabian Peninsula*. Kluwer Academic publisher, Netherlands Page 74-75.

Singh, J.S. and P.S. Yadav (1974). Seasonal variation in composition, plant biomass and net primary productivity of tropical grassland of Kurukshetra, India. *Ecology Monograph.*, 44: 351-375.

Wahab, M., M. Ahmed and N. Khan (2008). Phytosociology of some Pine forest from Afghanistan, *Pak.J.Bot,*. 40(30: 1071-1079.

Watkinson, A.R. (1997). *Plant population dynamics*. In: Crawley, M.J. (ed.), Plant Ecology (2nd ed), Blackwell Science Ltd. U.K.

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