A STUDY OF STAND STRUCTURE OF TEMPERATE FORESTS OF KAGHAN VALLEY, MANSEHRA, KHYBER PAKHTUNKHWA

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ABSTRACT

Kaghan valley is located in Balakot Sub-Division of District Mansehra. The valley lies between 34° 15' and 34° 57' North latitudes and 73^0 20' and 73° 57' East longitudes. A study on stand structure of the forests of Kaghan Valley was conducted during August-November, 2017. Systematic random sampling technique was used for collecting data in the field using a grid of 700 x700 m. Data was collected from 304 sample plots. The tree species sampled predominantly consisted of conifers (85%). The remaining 15% trees were broad-leaved trees belonging to 23 different species. In conifers, Fir (*Abies pindrow*) is the dominant species (38%) followed by Kail (*Pinus wallichiana*) with 35%, Deodar (*Cedrus deodara*) 11% and Spruce (*Picea smithiana*) with 10% share. The average stocking/density was estimated at 250 trees per ha. In Reserved Forests, the average number of trees per ha was estimated at 285 whereas in Guzara Forests, the tree density was 176 stems per ha. The results of the inventory show that the forests of Kaghan Valley are well represented by all age classes. About 65% of the trees fall in immature class followed by sub-mature with 18% sample trees. Thus, about 83% of the trees are young and sub-mature and about 17% of the sample trees are mature. This shows that sufficient mature trees are available in Kaghan Valley. In coniferous species, about 65% of the trees fall in young and 22% fall in sub-mature stages whereas only 13% are mature. Highest percentage of mature trees are present in spruce (17%) followed by fir (15%). Deodar and Kail have 12% and 11% mature trees respectively. It was found that the mean canopy cover in the forest area is 47% indicating forest degradation in the area. Canopy cover in Reserved Forests is higher than Guzara Forests indicating that Guzara Forests are more degraded than Reserved Forests. Basal area of trees in Reserved forests is also significantly higher than Guzara forests. A poor regeneration condition was recorded in the forest area of Kaghan. There were 332 plants per ha in the forest area. Reserved forests have significantly higher number of regeneration than Guzara Forests. It was astonishing to know that the highest number of regeneration was recorded for Fir which was 43%, followed by Kail as 27%, deodar 14%, Spruce 12% and *Taxus wallichiana* as 4%. The study recommends adoption of assisted natural regeneration techniques and opening of canopy for improvement of stand structure.

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Introduction

Pakistan is a forest deficient country with only 5% forest cover. Out of its 87.98 million hectare area only 4.51 m ha is under forest cover (Bukhari et al., 2012). Due to the sharp variation in altitude different forest types are found in the country. Though most of the forest area is under natural coniferous and broad-leaved forests, some of the forests consist of man-made plantations. From the alpine and temperate forests in the northern Himalayas to the mangrove forests in the coastal zones, the wide variety of forest ecosystems in the country has varying potential for carbon sequestration.

Mountain temperate forests are the most important forest type of Pakistan. These forests are located in the Hindukush Himalayan part of the country in the northern mountains mostly in Khyber Pakhtunkhwa, Gilgit Baltistan and Azad Kashmir at altitude 1600-3300 m asl. These forests are further subdivided into Dry Temperate forests and Moist Temperate Forests. Dry Temperate Forests are distributed throughout the dry inner mountain ranges, beyond the effective reach of monsoon rains. Most of the precipitation occurs in the form of heavy snowfall in winter. They occur at elevation of 1525 to 3350 m or even higher (Sheikh, 1993). These forests are found in Chitral, Kohistan, Upper Dir, Gilgit Baltistan and Baluchistan. Deodar, Chilghoza pine, Juniper, Kail and Spruce are the major coniferous species. Oak, Ash and Acer are the broad-leaved associates.

Moist Temperate forests are characterized by the extensive growth of conifers. These forests are situated in outer ranges of the Himalayas at altitude 1600 m to 3100m asl and receiving sufficient rainfall in summer and snowfall in winter. Annual precipitation ranges between 630 to 1500 mm and mean annual temperature is 12°C. Kail is the dominant tree species followed by deodar, fir and spruce. *Quercus dilatata, Alnus nitida, Prunus padus, Ulmus wallichiana* and *Populus celiata* are the broad-leaved associates (Sheikh, 1993). Moist Temperate forests are found in Hazara and Malakand Forest Regions of Khyber Pakhtunkhwa, Murree in Punjab and Azad Kashmir. The Western Himalayan moist temperate forests ecosystem of Pakistan is included in the list of global 200 priority ecosystems of the Millennium Ecosystem Assessment.

Kaghan valley is located in Balakot Sub-Division of District Mansehra. The valley lies between 34° 15’ and 34° 57’ North latitudes and 73° 20’ and 73° 57’ East longitudes. The tract is bounded on the east by Azad Jammu and Kashmir, on the north by Chilas District of Gilgit Baltistan, on the west by Allai and Kohistan and on the south by Abbottabad District and southeast by Mansehra Sub-Division. Balakot and Garhi Habibullah are the main towns in the lower part of the valley (Khan, 2004). The valley’s length from south-west to north east, as the crow flies, is 60 miles. By road from Babusar pass to Balakot it is

159 kilometers. Average width is about 24 kilometers. The valley is drained by the Kunhar River which originates from Lulusar Lake near Gittidas in the northeastern part of the valley and meets river Jhelum at Domishi below Garhi Habibullah town after a fairly turbulent course of about 180 kilometers.

A study was conducted under Sustainable Forest Management Project to assess the stand structure of moist temperate forests of Kaghan to improve its management.

Methodology

A field survey was conducted in the forests of Kaghan Valley during August-November, 2017. Two inventory teams were constituted for the field inventory comprising a forestry graduate as a team leader, two Field Assistants, a driver and a helper. Before start of the field work, the team was properly trained for the field work and acquainted with the inventory design. Forest area was determined and mapped through interpretation of high resolution satellite imageries. The estimates of forest are of different compartments were obtained from Planning and Monitoring Circle of Khyber Pakhtunkhwa Forest Department. The details of methods employed for field survey are given in the following sections.

Field Survey

Before designing the field survey, relevant literature and guidelines were collected and extensively reviewed to devise a methodology in conformity with international standards. Data on timber and fuelwood collected from Kaghan Valley was collected from the office records of Forest Department. Working Plans and other documents of the area were also consulted for the study. The inventory methodology consists of the following key elements.

Inventory Design

Systematic random sampling technique was used for collecting data in the field. This sampling design is efficient in reducing the possibility of bias, determining a valid sampling error and ensuring uniform coverage of the target area. Sample plots were laid out on a geo-referenced map using a grid of 700x700 m. The coordinates of the centers of the sample plots were noted from the maps and uploaded onto GPS and navigated in the field accordingly. Beside forest compartment maps, GT sheets were also used to locate the actual position of the sampling units in the field. The plots were permanently marked on the ground by inserting iron rods in the centre of the sample plots for verification and future monitoring.

Sample Size

The total number of sample plots was determined through the following formula:

$$N = \frac{(CV)^2 x t^2}{E^2}$$

Where

N= Number of required sample plots
CV= Coefficient of Variation
t= Student t-test value (1.96 at 95% Confidence Level)
E= Allowable Error

CV was determined on the basis of data collected by the Carbon Stock Assessment of Forests of Khyber Pakhtunkhwa. Based on this data, CV was determined at 89. The number of the required sample plots was calculated as follows:

$$N = \frac{(89)^2 x 1.96^2}{10^2} = 304$$

Thus a total of 304 plots were required for the given sampling precision.

Field Measurements

As the field survey is aimed at investigation the status and structure of different layers of vegetation of the forest ecosystem, nested circular plot approach was applied for collecting the requisite data. Circular plot shape was chosen for the inventory due to its easiness in establishment particularly in sloping terrains and to reduce the problem of edge effect associated with rectangular plots. As illustrated in the Figure 1, three subplots were established within each plot for specific purposes. The outermost circular plot with radius 17.84m (or 8.92 m in case of dense forest) was used for measurement of trees. The second circular plot with radius 5.64 m was used for measurement of shrubs and sapling; and the innermost plot with radius of 0.56 m was used for measurement of leaf, litter and grasses as well as soil.

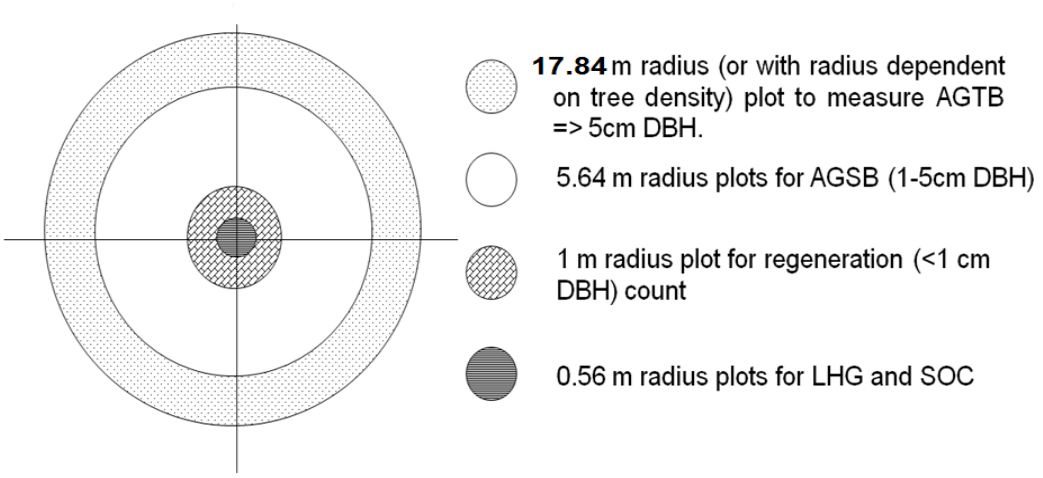

Fig. 1. Nested Circular Plot

Results and Discussion

Landuse

The total area of Kaghan Valley is 258,151 ha. Forest is the dominant landuse (30%), followed by alpine pasture (28%), glaciers (17%), rangelands (10%), agriculture (9%) and other land (6%) (Khan, 2017). Grassland comprising alpine pastures and rangeland covers 38% of the total area and is highly important for livestock production. Forest land and grassland have high potential for carbon storage and sequestration. According to the latest census, population of the valley is 273,089 with a density of 112.1 people per square Kilometer. The population count has witnessed an increase of 1.27 percent from 1998 to 2017.

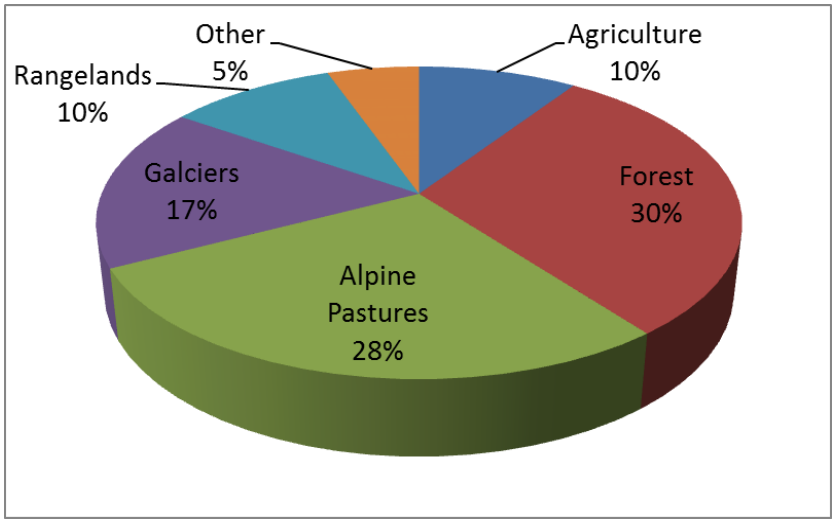

Fig. 2: Landuse in Kaghan Valley

Forest area

The total forest area of Kaghan valley is 77,725 ha. Legally, the forest area can be classified into Reserve forest, Guzara forest and Un-demarcated forest as shown in Figure 3. Reserve forests are state-owned forests with no rights of the community whereas Guzara forests are owned by the local community either jointly or individually and managed by the Forest Department. On the other hand, un-demarcated forests are privately owned woodland but their status is not legally defined. Out of the total forest area, 19,525 ha (25%) are reserve forests, 37,137 ha (48%) are Guzara forests and 20,000 ha (26%) are un-demarcated forests (Khan, 2017).

It is worth mentioning here that the actual forest cover determined through analysis of satellite data (sopt-5) is less than the reported forest area. Currently the actual forest cover is 51,829 ha i.e. 67% of the forest area. This is probably due to deforestation in the area. A comparison of the forest area and actual forest cover for different categories of the forest is given in the Table 1.

Table 1. Assessment of forest cover in Kaghan Valley

Forest Tenure Category	Total area (ha)	Actual forest cover (ha)	Blank area inside forest (ha)
Reserved Forest	19,525	16,900	2,625
Guzara Forest	37,137	21,353	15,784
Un-demarcated forest	21,063	13,576	7,487
Total	77,725	51,829	25,896

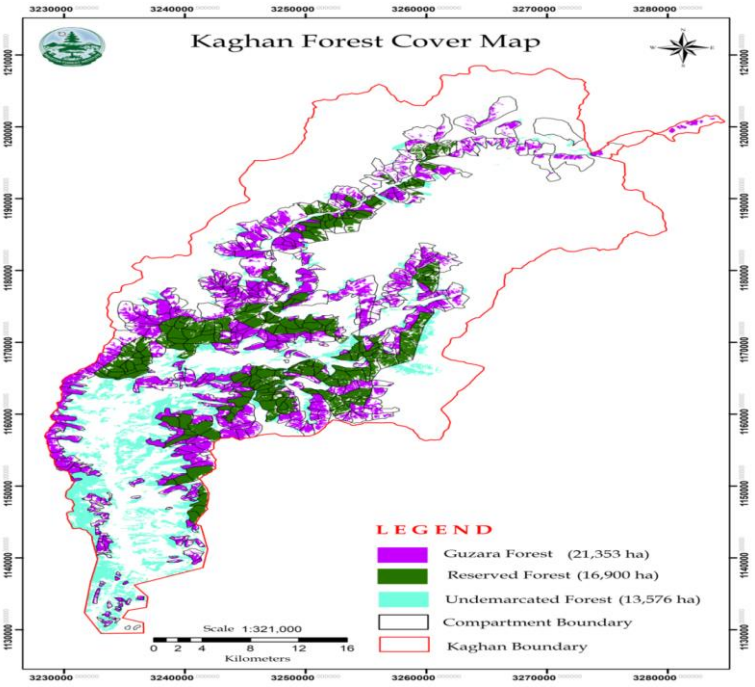

Fig. 3. Forest Cover Map of Kaghan Valley

Growing Stock Composition

A total of 5,644 trees belonging to 29 different species were tallied during the field measurements. The tree species sampled predominantly consisted of conifers (85%). The remaining 15% trees were broad-leaved trees belonging to 23 different species. The species composition is shown in the Figure 4. In conifers, Fir (*Abies pindrow*) is the dominant species (38%) followed by Kail (*Pinus wallichiana*) with 35%, Deodar (*Cedrus deodara*) 11% and Spruce (*Picea smithiana*) with 10% share. *Taxus wallichiana* and chirpine have only 3% and 0.6% shares in the conifers as given in Table No 2.

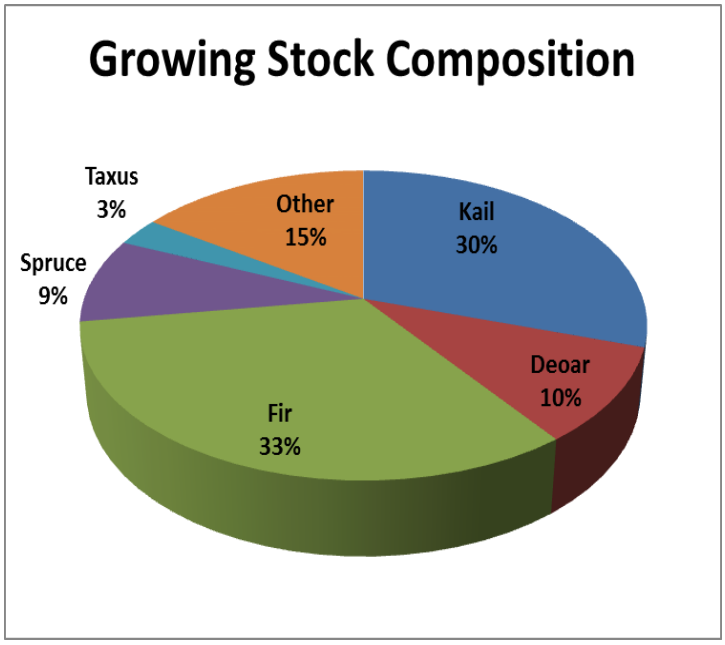

Fig. 4. Growing Stock Composition by number of trees

Table 2. Frequency of Coniferous Species

Species	No. of stems	%age
Kail	1691	35.26
Deoar	560	11.68
Fir	1849	38.55
Spruce	500	10.43
Taxus	167	3.48
Chirpine	29	0.60
Total	**4796**	**100**

Tree Stocking/Density

The average stocking/density was estimated at 250 trees per ha. In Reserved Forests, the average number of trees per ha was estimated at 285 whereas in Guzara Forests, the tree density was 176 stems per ha. This shows that Guzara forests are more degraded than Reserved Forests, because Guzara Forests are owned by the community and located close to habitations due to which they are subjected to more anthropogenic pressure. The detail is given in the Table 3.

Table 3. Tree Stocking/Density

S.No	Forest Type	No of trees/ha
1	Reserved Forest	285
2	Guzara Forest	176
Overall Average		250

Stand Structure

The results of the inventory show that the forests of Kaghan Valley are well represented by all age classes as shown in Figure 5. About 65% of the trees fall in immature class followed by sub-mature with 18% sample trees (Table 4). Thus, about 83% of the trees are young and sub-mature and about 17% of the sample trees are mature. This shows that sufficient mature trees are available in Kaghan Valley.

Table 4. Stand Structure

Development Stage	No of trees	%age
Young (<30 cm)	3883	64.78
Sub-mature (30-60 cm)	1083	18.07
Mature (>60 cm)	1028	17.15
Total	5994	100

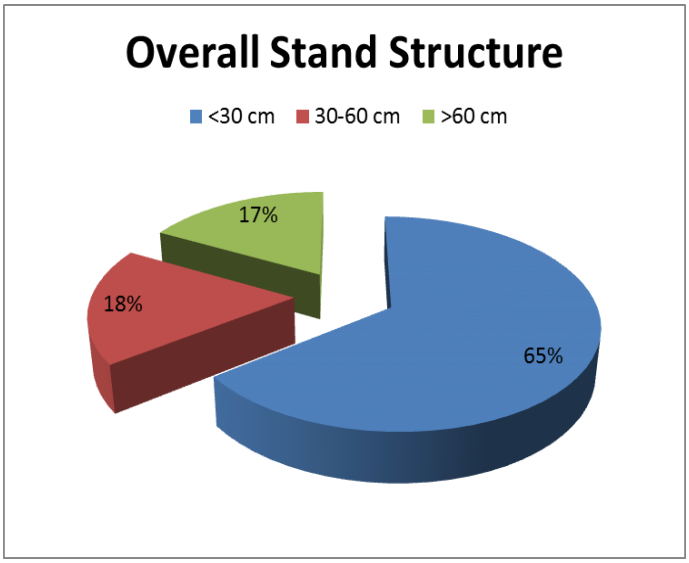

Fig. 5. Stand Structure

Development stages of coniferous species

The stand structure of conifers is depicted in Figure 6. About 65% of the trees fall in young and 22% fall in sub-mature stages whereas only 13% mature in all coniferous species. The developmental stages of different coniferous species are shown in the Figure 5. Highest percentage of mature trees are present in spruce (17%) followed by fir (15%). Deodar and Kail have 12% and 11% mature trees respectively. The detail is given in Table 5. Thus, it is clear that sufficient numbers of mature trees are present in all coniferous species. This is probably due to the prevailing ban on harvesting of green trees in the area.

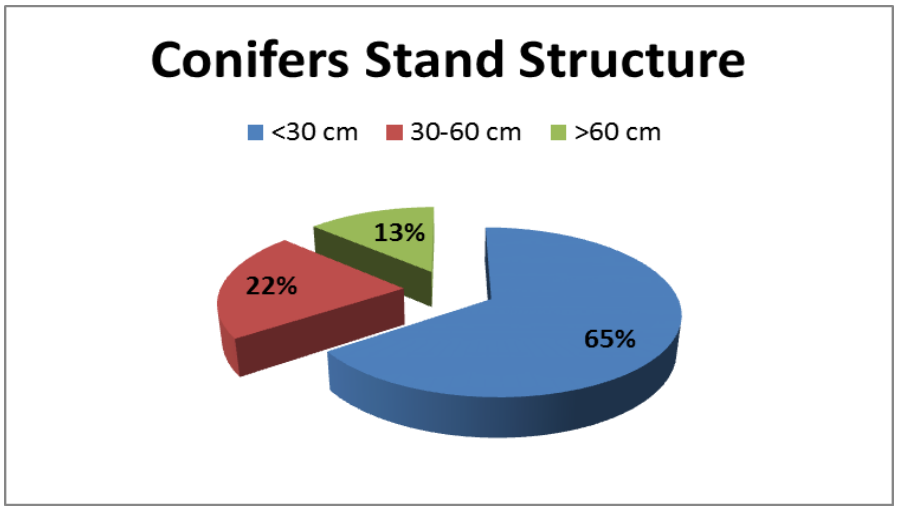

Fig. 6. Stand Structure of Conifers

Table 5: Developmental Stages of Coniferous Species

Species	Young	Sub-mature	Mature
Deodar	64	24	12
Kail	65	24	11
Fir	68	17	15
Spruce	58	25	17
Bermi	63	28	9

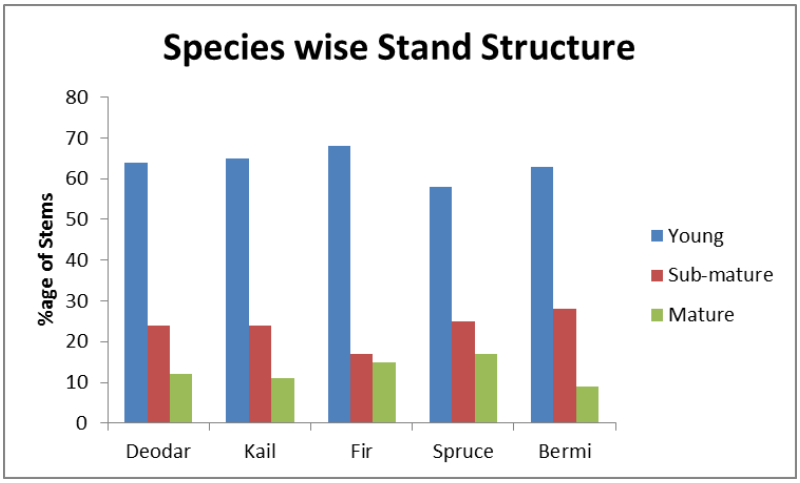

Fig. 7. Development stages of coniferous species

Stand Characteristics

The forests of Kaghan valley are situated on steep slopes. The average slope in the forest area was estimated as 77% which is obviously very steep posing several challenges for forest harvesting and logging operations. There was no significant difference between Guzara Forests and Reserved Forests in terms of slope. It was found that the mean canopy cover in the forest area is 47% indicating forest degradation in the area. In Reserved Forests the mean canopy cover is 51% whereas in Guzara Forests, the mean canopy cover is 34%. This indicates that Guzara Forests are more degraded than Reserved Forests. Basal area is also an indicator of forest health and productivity. Mean basal area of the forest was found as 26.1 m^3/ha. In Reserved Forests the mean basal area is 30.3 m^3/ha whereas in Guzara Forests, the mean basal area is 19.3 m^3/ha.

Table 6. Stand Characteristics

Forest Type	Slope (%)	Canopy Cover (%)	BA (m^3/ha)
Guzara Forest	74	34	19.3
Reserved Forest	79	51	30.3
Total	77	47	26.1

Status of Regeneration

A poor regeneration condition was recorded in the forest area of Kaghan due to open grazing. There were 332 plants per ha in the forest area. Reserved

forests have significantly higher number of regeneration than Guzara Forests. In Reserved Forests there were 400 regeneration plants per ha whereas in Guzara Forests, the number of regeneration plants was 182 per ha. It was astonishing to know that the highest number of regeneration was recorded for Fir which was 43%, followed by Kail as 27%, deodar 14%, Spruce 12% and *Taxus wallichiana* as 4%.

Table 7. Status of Regeneration

Forest Type	No. of Regeneration per ha
Guzara Forest	182
Reserved Forest	400
Total	332

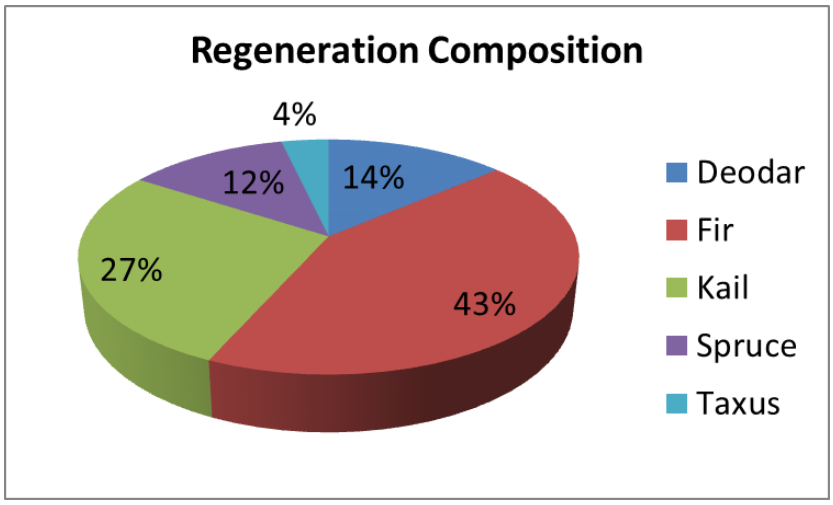

Fig. 8. Regeneration Composition in Kaghan Valley

CONCLUSIONS AND RECOMMENDATIONS

About 29 different tree species were recorded during field survey. The tree species predominantly consisted of conifers (85%). The remaining 15% trees were broad-leaved trees belonging to 23 different species. In conifers, Fir (*Abies pindrow*) is the dominant species (38%) followed by Kail (*Pinus wallichiana*) with 35%, Deodar (*Cedrus deodara*) 11% and Spruce (*Picea smithiana*) with 10% share. *Taxus wallichiana* and *Pinus roxberghii* have only 3% and 0.6% shares in the conifers. The average stocking/density was estimated at 250 trees per ha. In Reserved Forests, the average number of trees per ha was estimated at 285 whereas in Guzara Forests, the tree density was 176 stems per

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It was found that the mean canopy cover in the forest area is 47% indicating forest degradation in the area. Canopy cover in Reserved Forests is higher than Guzara Forests indicating that Guzara Forests are more degraded than Reserved Forests. Basal area of trees in Reserved forests is also significantly higher than Guzara forests.

A poor regeneration condition was recorded in the forest area of Kaghan. There were 332 plants per ha in the forest area. Reserved forests have significantly higher number of regeneration than Guzara Forests. It was astonishing to know that the highest number of regeneration was recorded for Fir which was 43%, followed by Kail as 27%, deodar 14%, Spruce 12% and *Taxus wallichiana* as 4%.

The study recommends adoption of assisted natural regeneration techniques such as establishment of closures in degraded areas, control on open grazing and opening of canopy for improvement of stand structure. It is also recommended to conduct compartment wise study on the stand structure and tree growth to have more detailed information about the forests.

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