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Regeneration status of spruce (*Picea Smithiana* wall. Boiss) along the altitudinal gradient in North Kashmir Himalayas (India)

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Abstract
The regeneration survey conducted to determine the status of regeneration at the selected sites was done in 100×10 m plot which was further subdivided into 10×10m plots for trees and 5×5 m for seedlings and saplings and 1×1m for recruits. The study revealed progressive decrease in recruits, seedling, sapling and tree density from lower altitudes to upper altitudes. Regeneration status was recorded as fair at all the selected sites. On the basis of parameters studied, the study concluded that an altitude of 2,200-2,600m is the best as far as regeneration status is concerned in North Kashmir for *Picea smithiana*. The study was concentrated along the three altitudinal gradients *viz*. 2,200-2,600 m (Langate), 2,600-3,000 m (Jhelum) and 3,000-3,400 m (Kamraj), at each altitude two sites were randomly selected for the study. The regeneration at all the sites was fair.

Keywords: spruce (*Picea smithiana)*, regeneration status, north Kashmir, altitudes

1. Introduction
In Himalayas, the three conifer species especially *Pinus*, *Cedrus* and *Picea* are distributed on an altitudinal line one above the other in tires, in pure or in mixed species combination. Four genera *Abies*, *Cedrus*, *Picea* and *Pinus* form extensive forest of great economic value in the Himalayas. Spruce (*Picea smithiana* Wall. Boiss) commonly referred as high level conifer, it produce good seeds at an interval of 4-6 years (Singh and Singh, 1984) [20]. The *P. smithina* occurs throughout the western Himalayas from Afghanistan eastwards at least as far as Kumaun, Uttrakhand in India chiefly at elevation of 2,100-3,350 m amsl, though occasionally descending lower on northern aspects and ascending higher on southern aspects.
Regeneration is the key feature of the forest dynamics, progress and restoration of degraded forest lands. It depends on number of seedlings, saplings and their distribution pattern in the region. Forest reveals variation in pattern of regeneration both through differences in their constituent species and the environmental variables in which they grow (Demel, 1997; Denslow, 1987) [3, 4]. With the increase in population, both human as well as livestock, the forests of J&K state are under tremendous pressure due to open grazing, heavy exploitation and other excessive biotic pressures. The situation has become so alarming that in most of the areas the forests are lacking in natural regeneration and are at different stages of degradation.
The augmentation of natural regeneration and eco-restoration of degraded forests with a view to increase productivity are the major concerns. The assessment of natural regeneration is an important aspect which influences the production and management system in many forest species. This is most relevant especially during working plan preparation/revisions. The main object of such survey is to assess whether or not there is adequate regeneration (established and unestablished) in the forest area/species. The basic elements necessary for successful natural regeneration are a sufficient supply of viable seeds, a respective seed beds, favourable climatic conditions for germination and establishment and protection from damaging agents. Therefore if any of these elements is missing, regeneration is unlikely to be successful (Boyer, 1998; Janusz and Winston, 2004; Juntunen, 2006) [2, 9, 10]. Natural regeneration in Himalayan spruce is, however, generally deficient and conspicuous in many areas by its absence.
The problem of natural regeneration in the species is constantly engaging the attention of the forest scientists. Thick layer of humus, accumulation of debris, dense weed growth and continuous grazing (Hafizullah, 1970; Kaul, 1970) [7, 11], are considered responsible for the

absence of natural regeneration. Allelopathy may be one of the reasons that inhibit the regeneration of the spruce. Fisher (1987) [5] showed that allelopathy in many instances played a major role in the natural regeneration failure. Infrequent seed years and low germination capacity of the seeds are also important factors contributing to the absence of natural regeneration in this species. Keeping in the ecological importance and vulnerability of this species the present study was carried out with the objective to quantify the regeneration status of *Picea smithiana* along the altitudinal gradient in North Kashmir Himalayas (India).

2. Material and Methods

The study on natural regeneration status of *Picea smithiana* was conducted along the three altitudinal gradients (each having 2 sites) ranged of 2,200-2,600 m, 2,600-3,000 m and 3,000-3,400 m in North Kashmir Himalayas (Table 1) during the years 2014 & 2015. The study sites was located between latitude of 34-˚13/ to 34˚-30/ North and longitude of 73˚-56/ to 74˚-26/ east (Langate), 33˚-55/ to 34˚-15/ North and longitude of 73˚-55/ to 74˚-30/ east (Jhelum valley), 34˚-16/ to 34˚-42/ North and longitude of 74˚-12/ to 74˚-23/ east. (Kamraj)

Table 1: Details of the study area

S. No.	Name of Forest Division	Sites	Altitudes (m)
1.	Langate	Wadder Bawn	2,200-2,600
2.	Jhelum valley	Nowgam Buta pathri	2,600-3,000
3.	Kamraj	Warnow Puthshahi	3,000-3,400

The regeneration status of *Picea smithiana* at the selected sites in three Forest Divisions of North Kashmir situated at different altitudes determined by the procedure followed by Shankar (2001) [19].

2.1 Sampling methodology

Step I: From each division two sites were selected along the altitudinal transect viz. 2,200-2,600 m, 2,600-3,000 m and, 3,000-3,400 m.

Step II: Four vertical transect were laid at each site along the altitudinal gradient.

Step III: Four plots measuring 100×10 m were selected within each transect for collecting the requisite information.

Step IV: Within each 100×10 m plot, (10×10 m) quadrates were laid randomly for collecting information pertaining to mature trees.

Step V: Within each 10×10 m quadrate (5×5 m) quadrates were laid for recording the information pertaining to seedlings and saplings.

Step VI: Within each 5×5 quadrate (1×1 m) quadrates was laid for collecting information pertaining to recruits.

2.1.1 Mature trees with stems of

A. ≥30 cm girth at breast height (1.37 m)
B. >13 m height

2.1.2 Saplings with stems of

A. ≥10 cm to < 30 cm girth
B. > 0.5 m to < 2 m height.

2.1.3 Seedlings

A. < 10 cm girth
B. ≥ 30cm height

2.1.4 Recruits

< 20cm height

The regeneration status of the *Picea smithiana* were assessed and evaluated based on following categories.

Good: If present in the order of seedling > sapling > mature strata

Fair: If present in the order of seedling > sapling < mature strata

Poor: If a species survive only in the sapling stage, but not as seedlings (even though saplings may be less than, more than, or equal to mature).

3. Results

Natural regeneration status of *Picea smithiana*

The assessment of regeneration is a vital aspect to estimate stocking index, composition, competition and problems of forests under management. The present study on natural regeneration status of *Picea smithiana* was assessed along the altitudinal gradient in North Kashmir J&K, India (Western Himalayas). The species was found mixed with Pine at lower altitude and with *Abies* at upper altitude. While as the well-established stands of the species were found in the lower altitude.

Significant variation in the regeneration was recorded along the altitudinal gradients with respect to various parameters of regeneration, *viz*. number of recruits, number of seedling, number of saplings and number of trees. Maximum number of recruits (1,151.67 ha-1), number of seedlings (1049.64ha-1) number of saplings (358.12 ha-1) and trees (410.69 ha-1) was present at lower altitude (2,200-2,600 m). In terms of individual sites the maximum number of recruits, seedlings, saplings and trees 1220.75, 1117.53, 410.44 and 433.56 ha-1 respectively was recorded at Wadder. Whereas the minimum number of recruits (330.44), seedlings (310.50) saplings (165.66) and trees (185.75) ha-1was recorded at Puthshahi which represented the upper altitude (3,000-3,400) m (Table 2).

Table 2: Regeneration status of spruce (*Picea smithiana*) at different altitudes in North Kashmir

Altitude (M)/site		Recruits (ha^{-1})	Seedlings (ha^{-1})	Saplings (ha^{-1})	Tree (ha^{-1})	Regeneration status
2,200-2,600	Wadder	1220.75	1117.53	410.44	433.56	Fair regeneration
	Bawn	1082.60	981.75	305.81	387.83	Fair regeneration
Mean		1,151.67	1,049.64	358.12	410.69	
2,600-3,000	Nowgam	1030.67	928.88	342.84	376.41	Fair regeneration
	Buta pathri	885.81	794.82	311.06	325.48	Fair regeneration
Mean		958.24	861.85	326.95	350.94	

3,000-3,400	Warnow	429.47	376.88	176.78	194.63	Fair regeneration
	Puthshahi	330.44	310.50	165.66	185.75	Fair regeneration
Mean		379.95	343.69	171.22	190.19	

4. Discussion

Regeneration is a key feature of the forest dynamics, progress and restoration of degraded forest lands. It depends on member of seedlings/saplings and their distribution pattern in the region. If the seedlings/saplings are less than the mature trees, it indicates declining trend and poor regeneration capacity. Variation in regeneration pattern is observed vis-à-vis differences in the constituent species and environmental variables in which they grow (Denslow, 1987; Whitemore, 1996) [4, 23]. Regeneration of any species is confined to a peculiar range of habitat conditions and the extent of these conditions is a major determinant of its geographic distribution (Grubb, 1977) [6]. Regeneration of forest tree species under natural habitat is important in modern forestry. Working plans for regeneration are carried out to compare the status at the beginning and at completion of the plan, so as to prepare a stock map for the area proposed to be regenerated.

Variation in the regeneration were recorded at all the three altitudinal gradients in North Kashmir with respect to various regeneration parameters *viz*. number of recruits, seedlings, saplings and number of trees. Maximum number of recruits (1151.67 ha-1), number of seedlings (1049.64 ha-1), number of saplings (358.12 ha-1)and number of trees(410.69 ha-1) were recorded at lower altitude (2,200-2,600 m) and minimum number of recruits (379.95 ha-1), number of seedlings (343.69 ha-1), number of saplings(171.22 ha-1)and number of trees(190.19 ha-1) were recorded at higher altitudinal elevation (3,000-3,400 m). Regarding individual sites maximum number of recruits (1220.75 ha-1), number of seedlings (1117.53 ha-1), number of saplings (410.44 ha-1) and number of trees (433.56 ha-1) were recorded at Wadder site. Maternal effect in trees growing at a particular altitude plays a role through seed mass, which can affect the seedling growth rate during first year (Oleksyn *et al*. 1998) [17]. At higher altitudes seed germination per cent is initially low after seed dispersal, but subsequently the remaining dormant seeds grow in the next season, involving opportunistic, adaptive strategy to take advantage of weather/climatic conditions that subsequently helps natural selection (Isik, 1986) [8].

Yashpal (2006) [24] reported that natural regeneration of spruce and fir was poor in all the selected sites of Jubbal forests (H.P). A high of 33.11 per cent stocking was observed at middle elevation, which decreased at higher altitudinal elevations. Mir *et al.* (2017) [14] also reported the decrease in the regeneration pattern of *Betula utilis* in north western Himalayas of Kashmir with the maximum regeneration success percentage of 11.53 and 11.16%. Thadani and Ashton (1995) [21] and Mir *et al*. (2017) [14] from their respective studies concluded that dense canopy of the forest does not promote satisfactory establishment of the understory, the moderate disturbance appears to benefit the regeneration success, Besides browsing, growth rate and species composition of the natural regeneration success are mainly determined by the light conditions. Malik *et al*. (2012) [13] reported that the maximum established regeneration of *Pinus geradiana* was 291.66 ha-1 in Kinaur district of H.P. Overall natural regeneration was poor. Lanker *et al*. (2010) [12] reported that recruitment of *Taxus baccata* was maximum at higher elevation due to reduced anthropogenic pressures, while at lower altitude association species had better recruitment and regeneration.

The regeneration was fair at all the three altitudes in spruce (*Picea smithiana*) which is mainly due to low seed production, wide gap between good seed years, human interference, and grazing by sheep and goat and other climatic factors. Natural regeneration of different tree species through seed depends upon their production and germination capacity and subsequent successful establishment of seedlings/saplings. Seeds from healthy well-formed trees provide greater assurance that the resulting stock will have good form, survival and resistance against stress conditions. Under favorable conditions a higher growth rate increases species competitive ability, survival and long term success. Growth rate is therefore a crucial rate, especially in the first year of establishment (Vitasse *et al*. 2009) [22]. During our study recruits were found growing in large quantities under shade and moisture availability. The results are in line up with Acharya (2004) [1], in mixed *Abies spectabilis* forest of Manang, where high human interference was the main factor leading to the destruction of species of high girth classes and less natural regeneration of *Abies spectabilis* due to low moisture and high human pressure. Parkash (1991) [18] indicated that favourable conditions of snowfall, good seed year and soil conditions in respect of raw humus, resulted in profuse natural regeneration in the *Cedrus deodara*. Environmental factors in combination with genetic and physiological ones play an important role in determining a forest tree species potential for seed quality. Depending on the tree species, seed germination response is affected by latitude altitude, soil moisture, soil nutrient profile, temperature, light, and density of plant cover and decomposition status of humus, thickness of forest litter and degree of habitat intervention by man/animals (Mukherjee *et al*. 2004) [16]. Lack of sufficient regeneration is a major problem of mountain forests and most sub-alpine forests have poor seedling recruitment in under storeys of undistributed old growth forests (Mori and Takeda, 2004) [15].

5. Conclusion

Regeneration status in the natural habitat was fair at all sites across the altitudinal gradients. The number of recruits, seedlings, saplings, and trees was maximum at lower altitudinal gradient. Anthropogenic/animal interventions need to the minimized. Logging of mature trees should be based on scientific operations to reduce physical damage to the young seeding/sapling population.

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6.1 Competing interests

Authors have declared that no competing interest exists.

6.2 Authors contribution

This work was carried out with the assistance with the authors mentioned in the manuscript. Authors BAL and AHM designed the study and wrote first drift of the manuscript. All authors read and approved the final manuscript.

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