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Regeneration Pattern in Subtropical and Moist Temperate Forest Stands of Kashmir Himalayas

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Abstract Forest regeneration is a thrust area of vegetation studies having important implications and contributions for sustainable forest management. Regeneration pattern was investigated in western Himalayan moist temperate and subtropical forest sites in Bagh district, Azad Jammu and Kashmir. The anthropogenic pressure in terms of grazing and tree felling intensity was investigated. A very low regeneration values of 121 seedlings/ha was recorded for the whole area. Subtropical forests showed relatively higher regeneration value of 211 seedlings/ha. The seedling count for moist temperate forest sites was calculated as 119/ha. Stem/stump value of 1.62 was recorded for the forest stands showing immense tree felling intensity. Available grazing area per grazing unit was calculated as 0.16ha/grazing unit whereas average herd size was 3. Persistent grazing activity was recorded at all of the investigated forest sites. Multivariate statistical analyses revealed that anthropogenic disturbance stimuli were significantly correlated with retarded forest regeneration patterns. A gradual decline in tree felling and grazing intensity was observed with increasing altitude and distance from settlements; followed with an increase in seedling count.

Keywords Forest Regeneration, Seedling Count, Stem/Stump Value, Grazing Area, Himalayas

1. Introduction

Forest regeneration investigations are one of the thrust areas of vegetation studies having important implications and contributions for conservation, planning, decision making and sustainable forest management [1]. Forest structure and composition cannot be completely understood unless the regeneration patterns and factors governing them are not addressed [2]. Sufficient seedling population in the mature forest stands ensures successful regeneration as well as guarantees a secure future forest composition [3]. Forest regeneration is determined by a mosaic of different climax factors acting simultaneously including frequency and intensity of disturbances and microclimatic conditions of the site. Microclimate requirements vary from species to species depending upon their ecological niches [4]. The Himalayan conifers like *Abies pindrow, Pinus wallichiana, Cedrus deodara* and *Picea smithiana* prefer to grow in closed canopies with exposed mineral soils without thick litter cover [5, 6, 7]. Western Himalayan forests are severely degraded due to population rise and urbanization [8]. The disturbed forests with open canopies are characterized by abundant herbaceous under story due to higher light availability. Vigorous growth of sedges, bushes and herbs increases completion for the native tree seedlings by efficient resource utilization, severely retarding the regeneration patterns and delaying the succession [9, 10, 11, 12].

Himalayan communities exhibit traditional agro-pastoral life style with live stocks as an integral part of them. Livestock grazing in forests is a common practice as forest floors are the most important source of fodder round the year [13]. The composition of forest ground flora is significantly altered and modified by grazing practices. The areas with open livestock access exhibit noticeable decline in vegetation diversity, distribution patterns, and community structure and regeneration patterns [14]. The unsustainable livestock grazing practices are reported to have detrimental impacts on forest regeneration patterns in conifer forests due to browsing, trampling, increased soil erosion, soil compaction and reduced water infiltration [15, 16]. Overgrazing can be caused either by too many animals or uncontrolled their grazing activity. With lesser available grazing area, grazers can switch to the woody vegetation along with grasses and shrubs [17]. Goats and sheep by nature prefer the leaves and twigs of trees as compared to grasses and herbs, eventually resulting in deterioration of tree vegetation. Goats are reported to consume the needle conifer leaves up to 220 cm by bending the trees down or climbing up, especially devastating for the seedlings. In some grazing-regeneration experiments the plant cover was found to be reduced to just 1%, showing up to 90% basal cover destruction [18].

2. Materials and Methods

The research was carried out in moist temperate and

subtropical forest stands of western Himalayas, in Bagh district, Azad Jammu & Kashmir, Pakistan. Area lies at 73°75 East longitudes and 33° 90 North latitudes; having subtropical to moist temperate vegetation with 54.58% area under forest cover [19]. The general elevation is between 1200 m in west to 3500 m in East. Average annual temperature is 16°C, ranging from 2°C in January to 30°C in July. The annual precipitation is about 1500 mm [20].

The study was carried out during June to March 2015 starting with a preliminary survey in the 18 villages to investigate the socio-economic trends of communities as well as their dependence on natural resources and livestock. In each village 20 households were chosen involving people having different socio-economic backgrounds. Questionnaires were administrated and data about land holding, herd size, available grazing area and summer pasture migration practices was collected from inhabitants [21].

Figure 1. Location of the study area and satellite imagery of the investigated sites

Fifteen Sites including 12 moist temperate and 3 subtropical broad-leaved forests were selected for the study (Fig. 1). Sampling was stared at each site from the beginning of forest, at an average distance of 100 meters from the initial margins. Than onwards, quadrates were laid at every 250 meter distance, to record the gradual changes in vegetation dynamics and intensity of the anthropogenic and grazing pressure. The sampling was carried out until the vegetation climax community; showing minimum disturbance was reached [22]. 15 quadrates each were taken in blue pine, fir/spruce and oak zones. Co-ordinates including altitude, longitude and latitude of each studied site were recorded by using GPS. The regeneration of tree species was recorded by seedling count at each individual 900m²quadrate. The lumbering and tree felling intensity was recorded by counting the number of stumps and logs at each studied individual 900m² quadrate. Stump to tree value/ha were calculated using the recorded primary data. Grazing pressure in the studied sites was estimated by using visual indicators like browsed vegetation, cattle droppings, hoof marks and trampling trails for categorization of sites into low, moderate and highly grazed classes. Results were analyzed using multivariate techniques including Principal Component Analyses (PCA) and Cluster Analyses (CA).

3. Results

An average seedling count of 124/ha was calculated for the whole area forest stands with a lowest of 34/ha at Bann (moist temperate site) whereas maximum of 399/ha at Nampra (Subtropical site). Significant variations were observed in regeneration patterns within the studied individual sites as well as the vegetation zones. *Pinus roxburghii-Quercus dilatata-Olea cuspidata* forest zone prevailed in the lower altitudinal range of 1000-1400m. Three of the 15 forest sites lie in this zone including Nampra, Maira and Saiyagalla. An average seedling count of 211/ha was recorded in this zone. *Abies pindrow-Pinus wallichiana* forest zone prevails in upper altitudinal range of 1900-3000m. This is the most dominant moist temperate forest type, the identity of Western Himalayans. Twelve out of the 15 studied forest sites lay in this zone. An average seedling count of 122/ha was recorded from the area. Bann showed the least seedling count of 33/ha whereas Jabray showed the highest value of 224/ha (Table 1). The initial forest zone within 200m from forest edge showed the highest seedling count at each site with an average of 145/ha). An abrupt fall in seedling number was calculated at each site for the next 500m with an average value of 88-100/ha. This value than increased linearly till the middle of forest sites reaching maximum in the range of 140-155/ha; and at the end it once again decreased gradually till the forest ends to 110-120/ha, showing a parabolic curve. An average land holding of 0.89ha with a herd size of 3 was determined in study area. Average grazing area of 0.16ha per grazing unit was calculated for the study area. Moist temperate zone with *Abies pindrow-Pinus wallichiana* forests had an average grazing area of 0.109 ha per grazing unit. Broad leaved subtropical zone with Q*uercus dilatata-Pinus roxburghii-Olea cuspidata* forest stands showed relatively higher grazing area of 0.22ha per grazing unit. An average stem/stump ratio of 1.62 was determined for the forest stands (Table 2). Nangapir forest site represented the most severe deforestation rates having a stem/stump value of 0.47. Tollipir forest site showed the highest value of 2.31. Significant variations were observed in tree logging practices along altitudinal gradient in all the forest sites. The initial quadrates within 1 km of forest edges showed the lowest stem/stump ratios in the range of 0.95-1.05 (Fig 2). Especially the middle forest areas showed the least values, representing severe forest degradation by lumbering and logging. With increasing distance from the forest edges, value increased gradually. None of the 19 sites qualified for the low grazed class. 10 sites fell into moderately grazed class whereas 9 sites were included in heavily grazed class category.

Table 1. Seedling count recorded along a distance gradient at the studies forest sites.

Site name↓	Forest type	**Distance from settlements** (meters) → → →										
		100	350	600	850	1100	1350	1600	1850	2100	2350	Av/900m²
		Number of seedlings/quadrate (900m²) ↓ ↓ ↓										
Maira	**Subtropical broad leaved**	29	21	23	17	12	29	33	29	41	45	28
Nampra		41	32	17	23	12	12	3	7	12	14	18
Saiyagalla		0	2	13	11	22	9	16	11	13	9	11
Chatti	**Moist temperate Coniferous**	2	3	4	7	7	5	6	6	7	5	6
Tollipir		15	3	9	13	11	21	6	9	5	7	10
Sudhan Gali		2	4	3	7	10	5	7	8	2	7	6
Chattu		0	4	3	4	13	9	23	31	25	21	14
Daira		6	4	7	6	19	9	5	7	13	10	9
Jabray		31	7	6	17	23	37	24	17	21	16	20
Panjal		5	3	5	7	13	5	3	3	7	2	6
Kharla		31	23	14	12	22	11	12	14	3	9	15
Chowki		12	9	12	9	10	9	5	7	2	1	8
Nangapir		12	9	11	10	19	13	7	11	7	4	11
Bann		2	0	0	1	7	3	5	1	7	2	3
Khori		2	1	5	0	13	7	1	5	4	3	4.
Av/900m²		13	8	9	10	14	12	10	11	11	10	11
Average/hectare		**145**	**91**	**101**	**113**	**154**	**132**	**113**	**123**	**123**	**111**	**121**

Table 2. Stem/stump values recorded at the studied forest sites.

Site name↓	Vegetation type	**Distance from settlements.(Meters)→→**										
		100	350	600	850	1100	1350	1600	1850	2100	2350	**Average**
		Stem/stump values/ha↓ ↓										
Maira	**Subtropical Broad leaved**	0.79	1.24	0.69	0.44	2.13	3	1.52	1.59	2.04	2.45	**1.6**
Nampra		1.81	1.83	1.06	1.41	1.62	1.59	2.29	1.34	4	2.24	**1.9**
Saiyagalla		0.86	0.64	0.47	0.57	0.67	0.87	2.64	3.1	5.15	6.6	**2.2**
Chatti	**Moist temperate Coniferous**	0.89	0.47	0.46	0.4	3	1.43	2	3	3.8	7	**2.3**
Tollipir		2.09	3.1	1.53	1.74	1.67	3.19	1.82	2.12	2.84	3	**2.4**
Sudhangalli		1.34	0.82	0.93	0.87	0.72	1.2	1	2.34	0.22	0.9	**1.1**
Chattu		0.25	0.48	0.38	0.48	0.64	1	3.5	4	3.63	4	**1.9**
Daira		0.17	0.5	0.75	1.2	0.38	0.48	0.62	1.25	0.67	0.47	**0.7**
Jabray		1.89	1.25	1.12	1.2	0.69	1.35	2.08	1.86	2	4.29	**1.8**
Panjal		0.06	0.19	0.34	0.54	0.57	0.62	1.67	1.72	3.67	3.25	**1.3**
Kharla		0.27	0.43	0.18	0.31	0.14	0.87	0.84	1.24	4.67	7	**1.6**
Chowki		0.86	0.69	0.75	1.23	0.42	1.3	0.45	2.17	1.43	3.5	**1.3**
Nangapir		0.18	0.43	0.29	0.69	0.55	0.43	0.34	0.77	0.19	0.78	**0.5**
Bann		2.17	1.43	5.5	2.34	0.36	1.15	1.58	1.14	1	3.6	**2.1**
Khori		2	2	2.5	2.17	0.81	1.47	3.75	0.89	3	2.38	**2.1**
Average		**1.05**	**1.04**	**1.13**	**1.04**	**0.96**	**1.34**	**1.74**	**1.91**	**2.56**	**3.44**	**1.62**

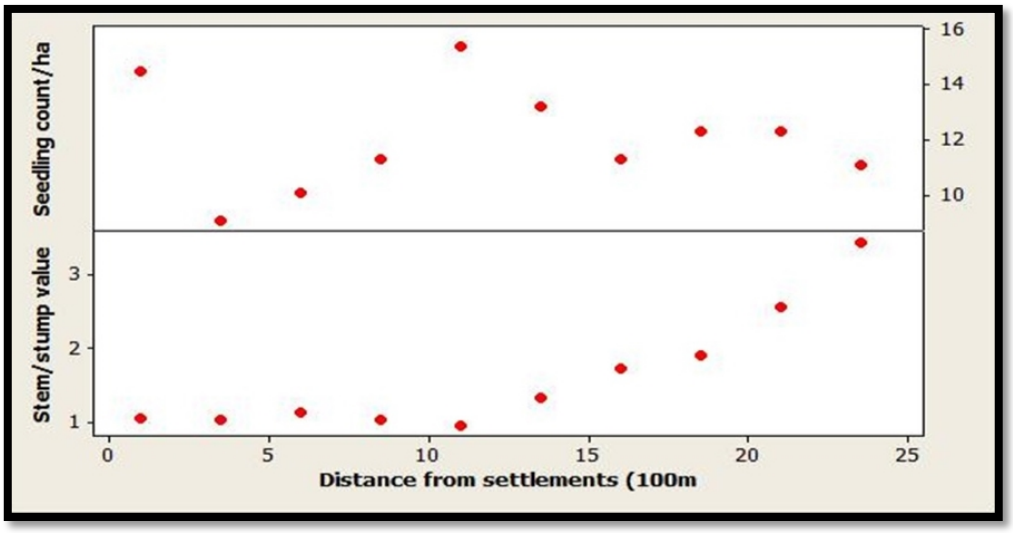

Figure 2. Matrix plot of Stem/stump value and seedlings/ha vs. distance from settlements/ha

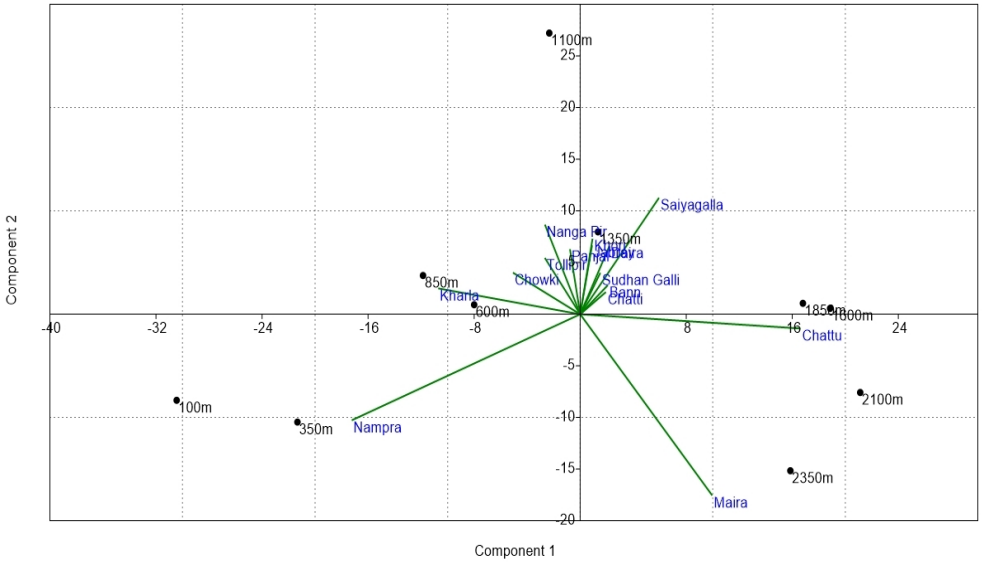

Figure 3. Principal Component Analyses of forest sites along a distance gradient.

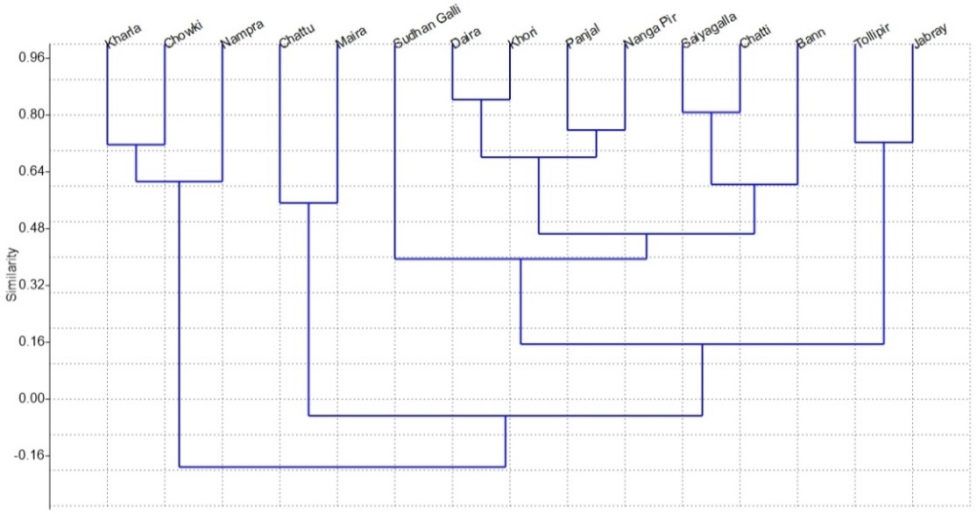

Figure 4. Cluster analyses dendrogram of forest sites based on Euclidean Distance.

PCA explained 81% of the variance in the data along the 1st two axes. Majority of the sites were clustered in the center on biplot characterized by low seedling counts (Fig. 3). Sites with highest regeneration at specific distance gradient points were clearly separated from the rest like Nampra, Maira and Saiya Galla. CA separated the sites based on Euclidean distance in 3 distinct clusters. The 1st cluster at the extreme left of dendrogram comprised of the sites with highest regeneration values whereas the sites with moderate counts were clustered in the center in 2nd group. The last cluster at extreme right consisted of sites with least seedling count (Fig. 4).

4. Discussion

The local forests showed extremely low tree regeneration rate of 124 seedlings/ha as compared to 1500-2300 seedlings/ha in Sikkim Himalayan subtropical forests [23]; 1750-3100 seedlings/ha in Himalayan forest of Bhutan [24]; 1977-3416 seedlings/ha in sub alpine and moist temperate forests of western Himalayas [25]. The factors responsible include absence of seedling care from grazing, trampling and harsh climatic conditions in most of the State Mountains; and immense lumbering and tree felling practices resulting in lower tree densities and lesser seed production [26]. Heavy uncontrolled grazing and trampling of approximately 400,000 local cattle along with 20,000 nomad grazers having more than 600,000 sheep and cattle is the primary reason of seedling depletion [27, 28]. Unfavorable and harsh climatic conditions of the area also contribute to the retarded forest regeneration.

Average grazing area was calculated due to its direct relationship with trends in forest regeneration. The lesser available grazing area results in shifting of grazing pressure to the surrounding forest lands having severe impacts on seedlings and shrubs. Average herd size in area was estimated to be 3 cattle/ household with an average grazing area of 0.16ha, which is 21 times lesser than the ecologically permissible limit of 3.45 ha/grazing unit/year for Himalayan moist temperate region [29]. This minimum value of 0.16 ha further decreased to 0.109ha in Upper Bagh villages lying in the immediate vicinity of coniferous forests. Consequently the grazing pressure shifts to the surrounding forest reserves creating a massive stress on forest ground flora, shrubs and most important, the seedlings [30]. Normally with increase in degree of slope steepness the grazing intensity decreases as well [31]. But it was observed that in studied sites in spite of very steep slopes in the 60^0-75^0 range, still very heavy grazing and browsing activity was observed. Grazing practices are one of very important determinants of forest vegetation distribution patterns and having most obvious impact on the floral biodiversity of an area [32]. This was evident from the observed heavy grazing activity in most of the sites. Sites having very steep slopes inappropriate for cattle grazing also showed heavy grazing activity mainly due to huge sheep and goat flocks in the area [33]. Sheep and goats are very specialized and active grazers which due to light weight and slim body structure, can easily graze in apparently inaccessible and difficult terrains. It is recommended by vegetation scientists that grazing practices in these fragile communities above 2000 meter should be very limited and controlled, and should be carried out in late summer after the full vegetation growth [34]. But in Kashmir forests, grazing activities start soon after the snow melts, in early growing season and continues until it again starts snowing [35]. The degraded vegetation in higher coniferous zone is further not allowed to repair itself by harsh climatic conditions and short growing period. It is reported that available grazing area in Kashmir decreased from 0.15 ha/animal in 1977 to 0.10 ha/animal in 1990's and it continues to decrease thereafter. Continuous and uncontrolled grazing also leads to suppressed growth of palatable grass species in pastures resulting in dominance of unwanted weeds and shrubs [36]; spread and of alien invasive species [37, 08]; replacement of perennial, palatable grasses by less nutritious unwanted weeds [38].

The subtropical broadleaved forests showed higher regeneration rate of 211/ha than 122/ha for moist temperate coniferous zone. This can be attributed to high regeneration capability of *Quercus, Olea* and *Punica* stumps as well as a longer and favorable growing season in lower zone [39]. An increasing regeneration trend was observed from forest margins towards center, which is significantly correlated with the decreasing grazing intensity away from settlements [40]. Highest seedling concentrations (130-150/ha) were recorded in middle of forest stands as compared to the lower and upper forest margins (80-110/ha) because of maximum canopy coverage and lesser grazing. Upper forest margins showed poor seedling count due to harsh climatic conditions with increasing altitudes. The very initial forest margins showed higher seedling counts at some places, due to some of departmental plantation schemes [41].

4.1. Reforestation-Deforestation Equation

The reforestation-deforestation equation in Kashmir state seems to be highly unbalanced and inclined towards deforestation. State forests are facing a reported annual loss of 15,000 ha due to tree felling, theft and illicit extractions and encroachments [22, 42]. The department claims to maintain an annual reforestation rate of 10000 ha. But due to regular forest exploitation by disturbing stimuli, harsh climatic conditions, absence of seedling care, experts state that the success rate of plantation cannot be more than 50%, limiting it to >5,000 ha [43, 31]. An annual 10,000 ha forest loss is revealed on comparing 5,000 ha reforestation with 15,000 ha deforestation. Successful regeneration requires both seedlings' establishment as well as secure survival controlled by microclimate of the site and anthropogenic stimuli. Even high initial seedling densities cannot guarantee successful regeneration in the areas with higher disturbance

level like grazing and tree felling. Careful estimates reveal that if the current harvesting scenario goes on unchecked, the state forests will completely disappear by 2050 [44].

5. Conclusions

In the current scenario, moist temperate conifers with extremely low regeneration rates are expected to decline further in the future which can lead to the local extinction of these vital species in the area. High initial seedling densities cannot guarantee successful regeneration in the areas with higher disturbance. In these circumstances present reforestation rate does not seems sufficient to support the dying forests of state. Immediate planning and implementation of regeneration schemes is the need of hour to save the future of rapidly depleting forests of Kashmir Himalayas.

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