

**Regeneration status of Spruce (*Picea smithiana* Wall.
Boiss) in Daksum Range of Anantnag Forest Division**

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(MSF-2018-87)



Faculty of Forestry
**Sher-e-Kashmir University of Agricultural Sciences &
Technology of Kashmir**

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Thesis

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“Parents”

*Someone who hold us in arms as we enter this world
Someone who always encourage us with their loving words of praise
Someone who constantly support us
Someone who listens patiently to all our worries and stresses
Someone who's eyes shine with pride and happiness at our every little
Achievement*

DEDICATE MY THESIS

To the most beautiful creatures of God

“MY BELOVED PARENTS”

For their constant care, encouragement, unconditional love and sacrifices.

*(Rabbir - hamhuma - Kama - rabbayani - saghira)
“Ameen”*

Sher-e-Kashmir
University of Agricultural Sciences and Technology of Kashmir
Faculty of Forestry, Division of Silviculture and Agroforestry,
Benhama, Ganderbal

Certificate – I

This is to certify that the thesis entitled, “**Regeneration status of Spruce (*Picea smithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division**” submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science in Forestry (Silviculture and Agroforestry)**, to the **Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir** is a record of bonafide research work carried out by **Mr. Sameer Ahmad Wani (Regd. No. MSF-2018-87)** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that information received during the course of investigation has duly been acknowledged.

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Certificate – III

This is to certify that the thesis entitled, “**Regeneration status of Spruce (*Picea smithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division**” submitted by **Mr. Sameer Ahmad Wani (Regd. No. MSF-2018-87)** to the **Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir** in partial fulfilment of the requirements for the award of the degree of **Master of Science in Forestry (Silviculture and Agroforestry)** was examined and approved by the Advisory Committee and External Examiner on

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ABSTRACT

The study was carried out in Daksum range of Anantnag Forest division along the altitudinal gradation at three strata namely Ahlen (2200-2400 m), Deesu (2400-2600m) and Harkani (2600-2800m) amsl during the year 2018-2020. To carry out studies on community structure the sampling plots of 20 x 50m were laid on transects followed by quadrats of 10 x 10m for trees, 5 x 5m for shrubs and 1 x 1m for herbs while for regeneration studies quadrats or measuring units of 2 x 2m were laid in sampling plots. The studies on community structure of Spruce revealed that a total of 47 plant species belonging to 28 families out of which 4 tree species, 11 shrub species and 32 herb species were present in the study area. Community structure studies further revealed that *Abies pindrow*, *Acer cesium* and *Pinus wallichiana* were three tree associates of *Picea smithiana* in the study area. Among shrubs the dominant associates were *Berberis lyceum* at lower stratum and *Viburnum grandiflorum* at middle and higher stratum while among herbs *Poa annua*, at lower stratum and *Cynon dactylon* were dominant species in at middle and higher stratum. The total number of species decreased with increase in altitude of study area. The regeneration of Spruce at all the sites was low did not show any definite trend along the altitudinal gradient. The regeneration parameters depicted that the maximum recruits, unestablished regeneration, established regeneration, Stocking index and regeneration success was 1111.11,

659.72, 312.5, 0.1909 and 19.09 respectively at middle stratum Deesu with altitude (2400-2600) masl. and was recorded as the best stratum as far as regeneration status of *Picea smithiana* is concerned in Daksum forest range. The Crown Projection ratio was found maximum at middle stratum and did not showed a regular trend with altitude. There was a decrease in availability of OC, N, P, K, Fe and Zn with increase in soil depth. However, soil pH increased with increase in soil depth in all the strata of study area. There was an increase in availability of OC, N, P, K and Zn while decrease in pH and available Fe in soil with the increase in altitude of study area. The viability of soil seed bank of spruce was found to be very low (15.36 to 18.18 %) at study area.

Key words: Community structure, regeneration, *Picea smithiana*, soil characteristics, soil seed bank, crown projection ratio and solar influx

Signature of Student
Dated _____

Signature of Major Advisor
Dated _____

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Place: Benhama, Ganderbal

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Chapter-1

INTRODUCTION

Forests are the essential and most precious renewable natural resource which plays a key role in the lives of people living both in mountains and lowland areas by supplying fresh water and oxygen and act as repositories of terrestrial biological diversities (Sarkar *et al.*, 2017; Kala, 2004). The Himalayan zone is quite possibly the most climatically vulnerable geographic regions of the world and is highly significant because of biodiversity hotspots (Adil, 2019; Singh, *et al.*, 2018; Mir *et al.*, 2017; Cavaliere, 2009). The diversity of Himalayas is changing pattern and is declining rapidly because of anthropogenic activities, with the increase in population of both humans and livestock the forests are under great pressure due to grazing and heavy exploitation which have necessitated the qualitative and quantitative assessment of vegetation in the region (Hanief *et al.*, 2018; Rout *et al.*, 2018; Malik and Nautiyal, 2016; Sharma *et al.*, 2014).

In Himalayas the four main conifer species like Deodar, Kail, Fir and Spruce are distributed on along the altitudinal gradation one above another either in pure or in mixed species combination (Adil, 2019; Singh *et al.*, 2018; Bhat, 2017; Malik and Nautiyal, 2016; Rather, 2014). Spruce is a genus of 40-50 evergreen conifers native to temperate and boreal forests in the northern hemisphere of earth including Europe, Siberia, Japan, America, China, Asia and the Himalayas (Lone *et al.*, 2018; Parrey *et al.*, 2017). Two species of Spruce occur in India, one is Sikkim Spruce (*Picea spinulosa* Griff. A. Henry) native to Eastern Himalayas, Sikkim (India), Nepal and Bhutan between elevation of 2, 700-3, 600m amsl and another is West Himalayan Spruce or Morinda Spruce (*Picea smithiana* Wall. Boiss) native to Western Himalayas and adjacent mountains from Northeast Afghanistan, Northern Pakistan to Nepal between elevation of 2, 150-3, 350m amsl though occasionally descending lower on

northern aspects and ascending higher on southern aspects (Farjon and Rushforth, 2013).

West Himalayan Spruce (*Picea smithiana* Wall. Boiss) commonly referred as high level conifer is a very tall evergreen tree with horizontal conical crown, dropping branches and slender pendulous tassel like branchlets (Lone *et al.*, 2018; Mugloo *et al.*, 2016). Leaves are spirally arranged, 1-1.5 inch length, acicular obscurely, quadrangular, with usually two lines of stomata on each of four sides of leaf. It also has a stem like structures at the base of leaves called Pulvini or Sterigmata which remain as small projections on twigs of Spruce after the leaves fall off. Spruce have good seed interval of 4-6 years (Parrey. *et al.*, 2017; Singh, 1989). Spruce seeds are small in size, light in weight and have lower germinability. Higher germinability and maximum seed yield has been found in the seeds of cones with larger diameter under laboratory conditions (Mugloo *et al.*, 2016).

The term regeneration refers to process of production, dispersal, seed germination and the subsequent establishment of seedlings (Bhat *et al.*, 2015; Kulla *et al.*, 2009). Regeneration is the key feature of the forest dynamics and is essential for preservation and maintenance of biodiversity (Gatoo *et al.*, 2020; Rather, 2014; Rahman *et al.*, 2011). Natural regeneration is important as it addresses mainstream biodiversity concerns (Ramesh *et al.*, 2006). The presence or absence of natural regeneration predetermines the future of forest stand. Abundant supply of viable seeds, a respective seed bed, protection from damaging agents and favorable climatic conditions for germination are some elementary requirements for a sufficient natural regeneration (Pala *et al.*, 2013; Juntunen, 2006). Seedling establishment is a critical life history stage in which tree survival and growth are most influenced by the micro-site environment, with light and soil moisture being the primary limiting resources for tree regeneration. It is the development of new crop to a stage when the young generation is considered safe from normal adverse influences such as frost, drought or weeds and no longer

needs special protection or tending operations other than cleaning, thinning and pruning.

Regeneration is the most important process to maintain the stable age structure of plant species in a community, affected directly or indirectly by various climatic and edaphic factors (Shameem and Kangroo, 2011; Singh and Singh, 1987). An adequate number of seedlings, saplings and young trees of a tree species in a given population are indications of successful regeneration of that tree species (Pokhriyal *et al.*, 2010). The regeneration potential of a species can be determined by the amount of seedlings it produces and when the number of seedlings or saplings of a species is lower than and number of mature trees, then the regeneration is considered deficient and the population of the species in the forest is said to be declining (Negi & Nautiyal, 2005). Successful regeneration of tree species might be considered to a function of three major components: (i) ability to initiate new seedlings (ii) ability of seedlings and saplings to survive and (iii) ability of seedlings and saplings to grow (Hanief *et al.*, 2016; Pala *et al.*, 2013).

Natural regeneration of Spruce is mostly deficient and conspicuous in many areas of West Himalayas which is matter of concern for foresters and scientists. The composition and structure of the forests is an important indicator for understanding qualitative stages of succession which in turn can be used to evaluate the extent and status of natural regeneration (Schwartz *et al.*, 2017; Shahid and Joshi, 2016; Debushe *et al.*, 2015; Reddy and Ugle, 2008). Community structure is important for assessing regeneration potential determining the stability and survival of forest ecosystems and ultimately leads to conservation of biological diversity. The canopy closure, stand age and presence of tree species in a mature stand are the principal factors which are controlling the natural regeneration of Spruce (Kulla *et al.*, 2009). In addition thick layer of undecomposed acidic humus, accumulation of debris, dense weed growth, continuous grazing and excessive logging are some of the factors considered

responsible for poor natural regeneration of Spruce (Lone *et al.*, 2018; Parrey. *et al.*, 2017; Schwartz *et al.*, 2017). Allelopathy is one of the main reasons that cause natural regeneration failure (Singh *et al.*, 2011; Fisher, 1987). Leachates of humus and leaves of some specific plants like *Viburnum nervosum*, *Sarcococca saligna* and ferns are responsible for failure in regeneration of Spruce (Singh *et al.*, 2011).

According to Farjon and Rushforth (2013), the population of the West Himalayan Spruce (*Picea smithiana*) is currently decreasing and the biggest threat to the species is logging without sufficient natural regeneration. Keeping in view the above aspects the present study entitled “Regeneration status of Spruce (*Picea smithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division” was undertaken with the following objectives:

1. To study the community structure of Spruce.
2. To assess the natural regeneration of Spruce.
3. To study soil and site characteristics of Spruce forest stand.

Chapter-2

REVIEW OF LITERATURE

For the cohesiveness in representation, the pertinent information related to the present investigation entitled “Regeneration status of Spruce (*Picea smithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division” has been reviewed under following headings:

- 2.1 Community structure.
- 2.2 Assessment of natural regeneration.
- 2.3 Soil and site studies.
- 2.4 Soil seed bank.

2.1 Community structure

Adil (2019) carried out a study to investigate the community structure of Shopian forest range and identified 59 species of plants in the study area of which number of species of trees, shrubs and herbs were 5, 11 and 35 respectively. The dominant shrubs in the study area were *Viburnum grandiflorum*, *Berberis lyceum*, *Sambucus wightiana* and *Parrotia jacquemontiana* while the dominant herbs or grasses were *cynon dactylon*, *Fragaria vesical*, *Poa annua* and *Taraxacum officinale*.

Geelani *et al.* (2018) conducted a study in Romshi range of Shopian forest Division in Kashmir valley to evaluate the floral diversity of trees and shrubs and reported a total of 08 tree and 08 shrub species in the study area with highest species richness index and Shannon Weiner diversity index at Gadder (2400-2600m) site of study area.

Rout *et al.* (2018) evaluated floristic diversity of Kuldiha wildlife sanctuary, Odisha, India and documented 118 plant species belonging to 38 families of which trees, shrubs and herbs were 38, 38 and 32 respectively. The

maximum IVI recorded for tree, shrub and herb layers was for *Terminalia tomentosa* (292.27), *Shorea robusta* (50.89) and *Croton roxburghii* (17.11) respectively. Euphorbiaceae was the family with highest number of species in the study area.

Singh *et al.* (2018) studied the floristic diversity of grasslands in Daksum forest range of Anantnag forest division and identified 50 plant species of which number of species of trees, shrubs and herbs were 12, 12 and 26 respectively. The species richness decreased with increase in elevation of study area.

Bhat (2017) conducted a study to evaluate the community structure of conifers while assessing their regeneration status in Batkote block of Pahalgam range in Lidder forest division. The study found that a total of 38 herb species, 10 Shrub species, and 11 species of trees in the study area. The study further concluded that *Pinus wallichiana* and *Cedrus deodara* were the dominant tree species, *Viburnum grandiflorum* and *Parrotia Jacquemontiana* were the dominant shrub species and herbs like *Poa*, *Trifolium*, *Cynodon* and *Malva* were the dominant species in the Pahalgam forest range.

Malik and Nautiyal (2016) carried out a study in Tungnath, the Himalayan benchmark site of Himadri to assess the diversity along the altitudinal gradient and a total of 52 plant species belonging to 40 genera and 21 families were recorded from the study. The study concluded that diversity showed a slightly negative correlation ($r=-0.05$) with altitude of study area.

Kumar (2016) conducted a study in Rajgarh forest division of Himachal Pradesh to assess the plant biodiversity status of deodar (*Cedrus deodara*) plantations along altitudinal gradient and found that the northern aspects had the highest density and abundance of shrubs at a lower elevation than the higher elevation, while the southern aspect had the highest density and abundance of herbs at a middle elevation. The shrub diversity, dominance and richness were recorded highest in northern aspect at middle elevation.

Rather (2014) analyzed the floristic Diversity in Kandi range of Kamraj Forest Division of Kashmir and recorded a total of 61 plant species belonging to 53 genera and 25 families. The species included 5 trees, 17 shrubs and 39 grasses & herbs indicating that the forest range is rich in species composition. The study concluded that the Kandi forest exhibited low values for diversity index, richness index and concentration of dominance indicating that the forests of range are degraded.

Sharma *et al.* (2014) carried out a study to evaluate the floristic composition of plant species in Sangla valley of Himachal Pradesh and recorded 320 plant species which belonged to 75 families. Rosaceae, Asteraceae, Ranunculaceae and Apiaceae and were dominant families. Species like *Artemisia* followed by *Polygonum*, *Saussurea*, *Berberis* and *Thalictrum* were dominant.

Dangwal *et al.* (2012) assessed the diversity of plants in relation to disturbances effects in subtropical Chirpine forest of the Himalayas in Rajouri district of Jammu and Kashmir and reported high diversity of trees, shrubs and herbs in hill base as compared to hill top. Moreover, it was found that *Pinus roxburghii* was the dominant species which form Chirpine type of forest.

Shameem and Kangroo (2011) conducted a study to investigate the comparative assessment of edaphic factors affecting the phytodiversity of herbaceous vegetation on seasonal basis at two different ecosystems in lower Dachigam national park, Kashmir Himalaya. They found that in summer season the forests situated inside the Park had comparatively higher diversity as compared to pastureland located outside the park which falls within the catchment of the national park.

Mahajan (2010) studied the floristic composition while working on the effect of forest composition on regeneration and growth attributes of chirpine in Solan Forest Division of Himachal Pradesh and recorded that among tree species *Pinus roxburghii* and *Pyrus pashia* has dominated most of the sites of study area.

The study also found that the similarity index value was more than 50 per cent for both trees and shrubs indicating vegetational uniformity in the study area.

2.2 Assessment of natural regeneration

Gatoo *et al.* (2020) carried out a study in Sangla valley of Indian Himalayas to investigate the natural regeneration status of *Betula utilis*. They found that the regeneration parameters of *Betula utilis* were low and decreased with the increase in elevation.

Lone *et al.* (2018) carried out a study in Himalayas of north Kashmir to assess the natural regeneration status of Spruce (*Picea smithiana*) along the increasing elevations. The study found that there were progressive decrease in recruits, seedling, saplings and tree density from lower altitudes to higher altitudes. On the basis of parameters studied, the study concluded that the altitude of 2, 200-2, 600m amsl is the best as far as regeneration status is concerned in North Kashmir for Spruce. They also reported that unscientific logging operations of trees cause physical damage to the young seeding/sapling population and have impeded the regeneration of Spruce in Himalayas.

Mir *et al.* (2017) carried out a study and assessed the natural regeneration of Himalayan birch (*Betula utilis* D. Don) in Kashmir to find the drivers responsible for poor recruitment and establishment of Birch seedling establishment in the study area. The natural regeneration of *Betula utilis* in the whole study area was found to be poor and insufficient. The study found that Himalayan Birch has un-sustainable regeneration which did not show any regular pattern along the altitudinal gradient.

Parrey *et al.* (2017) carried out a study and assessed the regeneration status of Spruce (*Picea smithiana*) in south Kashmir area of Western Himalayas. The regeneration at all the sites was found to be poor to fair. Further they found that regeneration did not show any regular trend along the altitudinal gradient in the study site.

Bhat *et al.* (2015) assessed the regeneration status of *Pinus wallichiana* in four different Forest Divisions of Kashmir valley. They concluded that the altitudinal range of 1, 600-2, 400m amsl is suitable for proper growth and natural regeneration of *Pinus wallichiana* under temperate conditions of North Western Himalayas.

Bargali *et al.* (2013) investigated natural regeneration of Oak forests (Uttarakhand, India) and found that regeneration of both Oak species *Quercus floribunda* and *Quercus leucotrichophora* was lower in disturbed sites than the protected sites of study area.

Pala *et al.* (2013) carried out a study in Garhwal Himalayas to assess the natural regeneration of trees five protected and sacred forests and found that the regeneration status of lesser (auxiliary) species in the forests of study area was poorer than the species of dominant tree. They further concluded that the 47 tree species were present in the study area among which only 7 tree species showed either good or fair regeneration whereas more than half (17 species) showed either poor or no regeneration.

Malik *et al.* (2012) carried out a study in Kinnuar forests of Himachal Pradesh to assess the natural regeneration status of Chilgoza Pine (*Pinus gerardiana*). The results revealed that the natural regeneration status of the chilgoza Pine was very poor (15%). They further reported the semiarid zone on the western aspect of the area have maximum established regeneration of the species (291.66 plants/ha).

Kulla *et al.* (2009) carried out a study on the Slovak part of the Beskydy Mountains to assess the natural regeneration status in declining Spruce forests on the Slovak part of the Beskydy Mountains and reported that declining Spruce forests are able to regenerate themselves. They regenerated rather by small-scale in the gaps and under canopy. Their results further revealed that the canopy

closure, stand age and presence of tree species in a mature stand are the principal factors which are controlling the natural regeneration of Spruce.

Reddy and Ugle (2008) investigated the regeneration status in tropical dry and moist deciduous forests of Mudumalai Wildlife Sanctuary, Western Ghats, India and found that out of the 104 species (young and mature trees) recorded, 28.8% showed good regeneration, 5.8% represented fair, 33.7% poor, 29.8% showed no regeneration.

2.3 Soil and site studies

Mir *et al.* (2017) investigated the soil parameters of Himalayan birch (*Betula utilis* D. Don) in the two forest divisions of Kashmir with the major focus on regeneration status pertaining to the poor recruitment and seedling establishment in North Western Himalayas along the different altitudinal gradient and evaluated the soil parameters like pH, electrical conductance, Nitrogen, Carbon, and Phosphorus content which increased in magnitude with increasing altitude in both sites.

Dar *et al.* (2015) conducted a study to assess some physicochemical properties of soil in temperate coniferous forests of North Kashmir. They concluded that electrical conductance, moisture content, Carbon content, and organic matter were significantly higher while pH and bulk density were lower at Gulmarg site. They concluded that natural vegetation is the main contributor of soil quality and environmental as it maintained the soil organic Carbon stock.

Kumar (2016) conducted a study in Rajgarh forest division of Himachal Pradesh to evaluate the soil characteristics of deodar (*Cedrus deodara*) plantations along altitudinal gradient and found that the soil available nitrogen, phosphorus, organic carbon, soil moisture and soil humus depth were found higher in northern aspect while potassium was found highest in southern aspect

Ali (2011) carried out a study to analyze the soil and site studies of *Betula* forests in Sangla valley of Himachal Pradesh. The study found that the magnitude

of soil parameters increased with soil depth. The site characteristic such as Solar influx (%) remained almost same in different sites. Simple correlation coefficient revealed that regeneration of *Betula utilis* had a positive and significant correlation with soil organic Carbon, pH, organic matter layer and solar influx, soil moisture and soil nutrients, viz., Nitrogen, Phosphorus and Potassium availability.

Mahajan (2011) conducted a study in Nandal and Nagali forests of Solan forest Division of Himachal Pradesh to evaluate the soil and site characteristics of chirpine and found that the per cent organic carbon, available nitrogen and available phosphorus showed a decreasing value with increase in soil depth while, soil pH and available potassium showed a reverse trend. The study also concluded maximum solar intensity was under lower diameter classes and crown projection ratio decreased with increase in the size of diameter class.

Griffiths and Madritch (2009) carried out a study on to analyze the soil characteristics like soil pH, soil temperature, organic matter, moisture, mean annual precipitation, Available Nitrogen, Phosphorous and Potassium in the Oregon Cascade Mountains of United states of America. The study concluded that parameters like the pH and temperature of soil were significantly lower at the upper elevations while as the organic matter, moisture, mean annual precipitation, organic Carbon and available Nitrogen, Phosphorus and Potassium increased with elevation of study area.

2.4 Soil seed bank

Soil seed banks is the viable seed reservoir present in the soil which act as an important potential seed source for the restoration of plant communities (Nishihiro *et al.*, 2006; Fenner, 1985). After dispersal most seeds undergo a period of dormancy, which may last from few days to many decades depending on the species and the prevailing conditions. Sometimes the dormancy may last longer as long as these seeds remain buried deep into the soil. If some disturbance brings

them to the surface they will normally germinate, giving rise to plants whose parents may have existed many generations before (Fenner, 1985). The soil seed bank an important component which plays a significant role in vegetation development during the process of succession (Van der Valk and Davis, 1979).

Mndela *et al.* (2020) carried out a study on soil seed banking in semi-arid rangelands of Kgomokgomo and Maseding in North-West Province of South Africa they collected the seed from soil samples taken at three depths (0–10, 10–20 and 20–30 cm). The soil seed bank was tested using the seedling emergence process, and the analysis discovered that the soil seed bank was more diverse in cleared microsites of the study region than in uncleared microsites. The research also concluded that high soil seed bank densities in the forest's upper soil layer encourage the passive restoration of rangelands.

Anzures *et al.* (2009) carried out a study floor in natural forests of *Pinus montezumae* Lamb. to find the composition on soil seed bank in the forest floor in a natural forests of *Pinus montezumae* Lamb. They found that dominant conifer species in the stand (*Pinus montezumae*) and codominant species (*Abies religiosa*, *Alnus firmifolia* and *Pinus ayacahuite*) were poorly represented in the soil seed bank and the soil seed bank was found to be dominated by the array of annual and perennial herbs.

Berger *et al.* (2004) carried out a study in stands of Spruce (*Picea abies*) to investigate soil seed banking and reported that the mixed Spruce-Beech stands form the transient seed bank while pure Spruce stands form the persistent seed bank.

Houle (1998) conducted a study on soil seed banking in *Betula* (Birch) tree species and found that birch seeds are viable for less than 2 - 3 years under field conditions found that less than 2 % of birch seed remain viable in soil seed bank. The study concluded that the number of viable birch seeds decline with increasing soil depth.

Chapter-3

MATERIAL AND METHODS

The present study entitled “Regeneration status of Spruce (*Picea simithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division” was carried out at three strata or altitudes in Daksum range of Anantnag Forest division Kashmir. The details of the experimental sites, materials used and methodology adopted for this study are discussed in this chapter under the following segments:

3.1 Description of the study area

3.1.1 Location

The Anantnag Forest Division is situated between 33° 21' 56.63" N to 33° 50' 49.13" North Latitude and 75° 40' 4.60" E to 75° 32' 6.59" East Longitude and is represented by survey of India general Topography sheet no's 43-0/1, 0/2, 0/3, 0/5, 0/6, 0/7 and 0/10. The Anantnag Forest Division covers an area of 798.64 km² and occupies the south-eastern portion of Kashmir valley. It is bounded on the east and south by the lofty Pir Panjal mountain Range, separating it from Ramban and Kishtiwari Forest Divisions. The Mattan Range of Lidder division marks the boundary of Division on the western side (Balaji, 2015).

The Study was carried out along three altitudes of the Daksum Range spread over the area of 347.37 km². The Daksum Range is largest range in Anantnag forest division consisting of 43.5% area of Anantnag forest division. The elevation of the Daksum ranges from 1, 900 m at Vailoo to 3, 748 m at the Sinthan top above mean sea level. The area is almost hilly enveloped in lush coniferous trees and grassy meadows. The Daksum range has got Rajparain wildlife Sanctuary spread over the area of 20 km² from compartments 21-26 (Balaji, 2015).

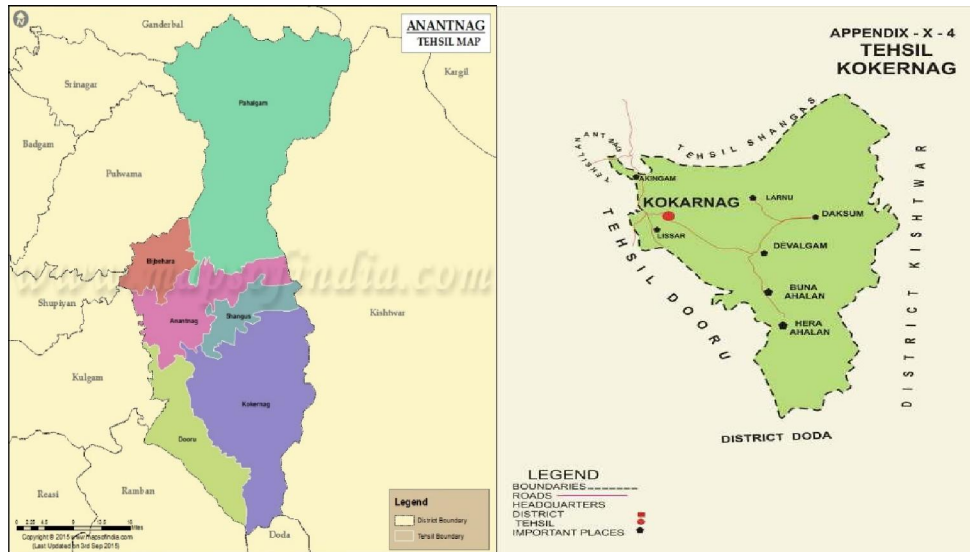


Plate 1: Map showing the Particular study area of Daksum Range

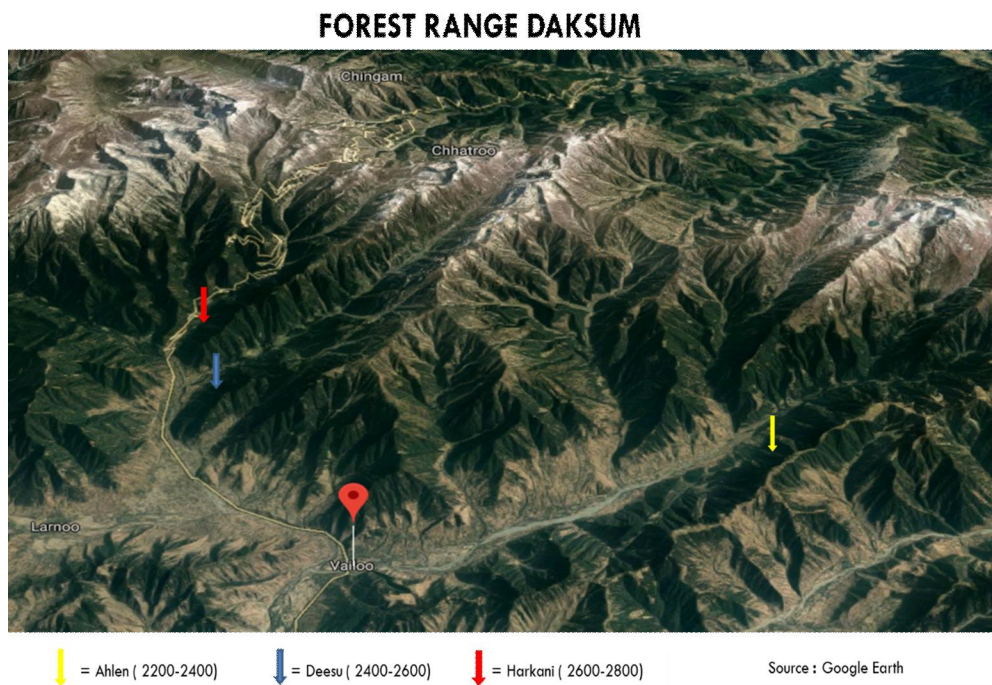


Plate 2: Google map showing the Particular study area of Daksum Range

3.1.2 Configuration of the ground

The area, in general, presents a hilly terrain with several picturesque and enticing low lying valleys. The mountainous topography spurts into numerous steep, rugged and perpetually snow covered peaks above the tree limit. The noted areas are Simthan Top and Margan Top. The tract lies within an elevation zonation of 1900 meters to 3840 meters. Almost all the aspects are represented. The principal forests occupy gentle to moderate slopes from 1900m to 3050 m altitude (Balaji, 2015).

3.1.3 Drainage

The river Bringi originates from the glaciers of Sinthan top filled with other streams from Ichoo and Mawar drains the water from Daksum forest range and forms one of the three major tributaries of river Jhelum.

3.1.4 Climate and rainfall

The climate varies considerable with the altitude. It is mild and salubrious in the lower elevations but very cold in higher ups. All the four seasons of the year are represented. Spring is cool and rather wet. Average minimum and maximum temperature varies from -11 to 33°C. Autumn is bright and pleasant while as winter is extremely cold and experiences heavy snow falls. Frost is experienced from middle of November onwards. The district Anantnag containing Daksum range receives an average annual precipitation of about 1103 mm in the form of rain and snow for about 70 days. Unlike the outer Himalayas there is no distinct rainy season in Kashmir Valley. The monsoon seldom crosses the formidable barrier of Pir Panjal mountain range. The main form of precipitation is snow in winter and some stray rains, showering in spring or the other months of year (Balaji, 2015).

3.1.5 Soil

Daksum is hilly and mountainous towards the north east and south west with broad intermountain valley. The altitude of the hill ranges up to 3840 m

amsl. The rocks of Cambrio-Silurian sequence in the Daksum Range are essentially detrital in character and show varying degree of metamorphism. They are composed mainly of pale, drab coloured, thin bedded slatty shale's and fine compacted earthy sandstones. These beds are frequently sandy or micaceous but never massive. In the higher parts calcareous layers are fund. These beds occur so intimately mixed up and folded together that till recently they were together mapped as Cambrio-Silurians. The above greywacke beds form a great steep anticlinal fold with North West, South East Axis, few Kms east of Anantnag, pitching towards North West. The rocks of this formation are exposed near Nowbugh, Larnoo, Khretti, Daksum and Arishan areas (Balaji, 2015).

3.1.5 Selection of the sites

The Anantnag division forests are classified in the revised classification of forest types by champion and Seth under the broad type groups 12, 13, 14 & 15 but do not strictly conform to on account of the diversity in structure and composition. The forest types of Daksum Range of Anantnag Forest Kashmir Forest Division, within the overall frame work of the Champion and Seth (1968) classification.

The broad groups are nomenclatured as follows:

- I. Kashmir valley Temperate Forests.
- II. Kashmir valley Sub Alpine Forests.
- III. Kashmir valley Alpine Forests.

The selection of the sites was done on the basis of presence of Spruce species along altitudinal gradient in the temperate forests of Daksum forest Range for the study purpose.

3.2 Sampling method

On the basis of altitudinal gradient selected forest range was divided into three sites. Each site was then divided into three transects laid vertically and was

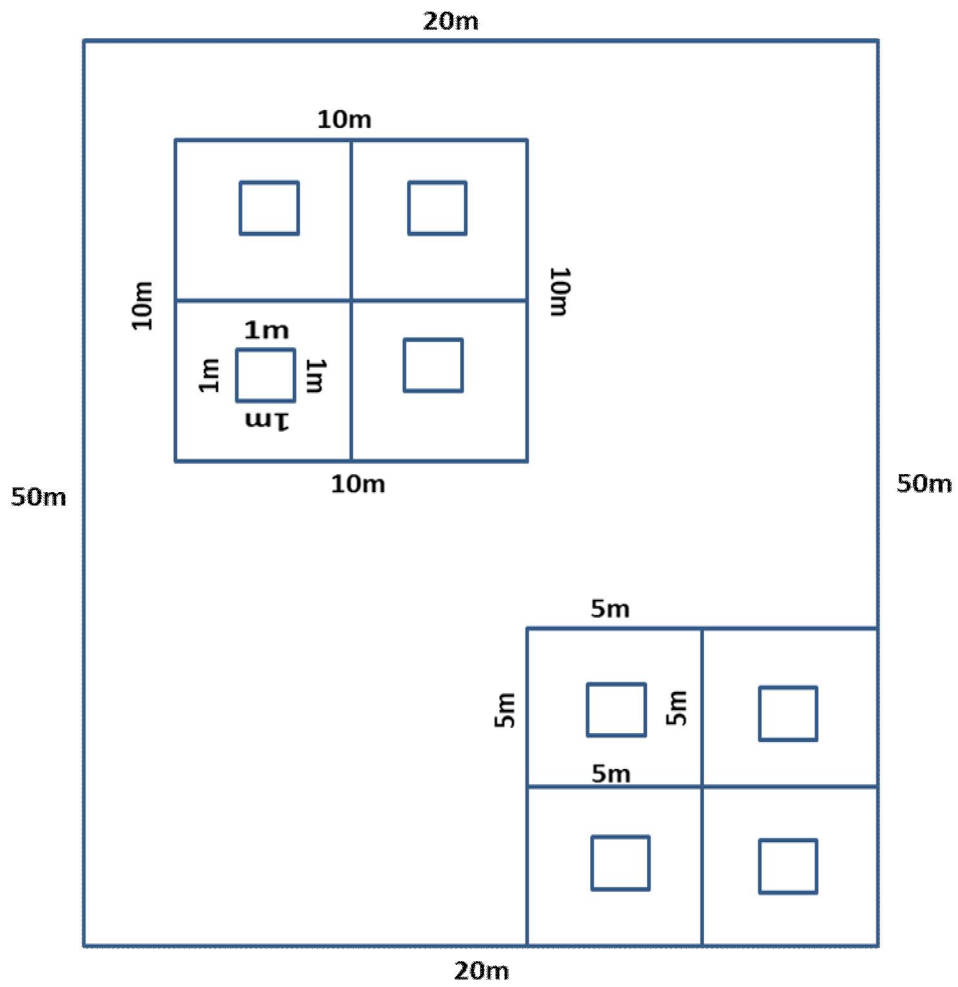


Fig. 1: Layout of the Quadrats in Sampling Plot

of 200m apart from each other to cover maximum area. Stratified random sampling method used to fulfill the objectives using sampling intensity of 0.01 %. The study area was divided into three sites or strata located along the altitudinal gradation in Daksum range.

S. No.	Strata	Site	Altitudinal range (masl)
1	Lower Stratum	Ahlan	2200-2400
2	Middle Stratum	Deesu	2400-2600
3	Higher Stratum	Harkani	2600-2800

3.3 Community structure of Spruce

Experimental design: -Community composition of Spruce in Daksum range, the vegetation analysis was carried out by stratified random sampling.

Following sampling procedure was followed:

- Sites : 03 (altitudes)
- Transect : 03 (per altitude)
- Blocks : 02 (per transect)
- Quadrates : 12 (per block)

The vegetation sampling was done by Quadrature method (Geelani *et al.*, 2018; Singh *et al.*, 2018; Shahid and Joshi, 2016; Sharma *et al.*, 2014; Misra, 1968). Two quadrates of 10 m × 10 m, four quadrates of 5 m × 5 m and eight quadrates of 1 m × 1 m for trees, shrubs and herbs respectively was laid in a sampling plots or blocks of 20m×50m size.

Plant community	Quadrat size	Quadrates laid
Trees	10 m × 10 m	36 (3×3×2×2)
Shrubs	5 m × 5 m	72 (3×3×4×2)
Herbs	1 m × 1 m	144 (3×3×8×2)
Total number of quadrates		252 (36+72+144)

- **Vegetative analysis:**

The important quantitative analysis such as frequency, density and abundance of tree species, shrubs and herbs were determined as per (Bhat, 2017; Hanief *et al.*, 2016; Dangwal *et al.*, 2012; Curtis and McIntosh, 1950). The relative values of frequency, density and basal area were determined as per (Dar *et al.*, 2011; Negi and Nautiyal, 2005; Phillips, 1959). These values were summed to represent IVI (Important Value Index) of individual species in order to represent the dominance, diversity and ecological success of the species.

- **Density**

$$Density = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}}$$

- **Frequency**

$$Frequency = \frac{\text{Number of quadrats in which species occurred}}{\text{Total number of quadrats studied}} \times 100$$

- **Basal area**

$$Basal\ area = \pi d^2/4,$$

where,

‘d’ is diameter

- **Relative Density (RD)**

$$\text{Relative density} = \frac{\text{Density of individual species}}{\text{Total density of all species}} \times 100$$

- **Relative Frequency (RF)**

$$\text{Relative frequency} = \frac{\text{Frequency of individual species}}{\text{Total frequency of all species}} \times 100$$

- **Relative Basal Area (RBA)**

$$\text{Relative Basal Area} = \frac{\text{Basal area of the species in all quadrats}}{\text{Total basal area of all the species in all quadrats}} \times 100$$

- **Importance Value Index (IVI):**

The Important Value Index (IVI) of the species was calculated as:

$$\text{Importance Value Index} = \frac{\text{Relative Density (RD)} + \text{Relative Frequency (RF)} + \text{Relative Basal Area (RBA)}}{3}$$

- **Diversity index (H')**:

Diversity index was calculated according to “Shannon-Weiner” diversity function prescribed by (Bhat, 2017; Margalef, 1968).

$$H' = -\sum_{i=1}^s \left[\left(\frac{n_i}{N} \right) \ln \left(\frac{n_i}{N} \right) \right]$$

Where,

H'= Shannon-wiener index of general diversity.

n_i = Total IVI of one species.

S= Total number of species at one site.

N =Total IVI of all the species at one site.

- **Concentration of Dominance or Simpson's index of Dominance:**

It was calculated as prescribed by (Rather, 2014; Ali, 2011; Simpson, 1949).

$$C_d = \frac{(n_i)^2}{N}$$

Where,

C_d = Simpson's index of dominance.

n_i = Number of individuals of one species.

N = Total IVI of all the species at one site.

3.4 Natural regeneration of Spruce

Natural regeneration of Spruce at three elevations along altitudinal gradient, the vegetation analysis was carried out by stratified random sampling. Quadrates or sampling units of 2 m × 2 m in the blocks or plots of 20 m × 50 m were laid at all the three sites.

Following sampling procedure was followed:

Sites	:	03 (altitudes)
Transect	:	03 (per altitude)
Blocks	:	02 (per transect)
Quadrates	:	12 (per block)

Total number of quadrates: 216 (3 × 3 × 2 × 12= 216)

The regeneration status of the Spruce was determined as per the procedure followed by (Gatoo *et al.*, 2020; Malik *et al.*, 2011; Chacko, 1965).

i. Recruits:

Recruits (r) are the seedlings with height less than 10 cm or current year seedlings.

$$(r)/ha = 2500 \sum_{i=1}^n \frac{r_i}{m}$$

ii. Un-established regeneration:

Un-established regeneration (u) is the number of seedlings other than recruits which have not yet established and with height less than 2 meter.

$$(u)/ha = 2500 \sum_{i=1}^n \frac{u_i}{m}$$

iii. Established regeneration:

Established regeneration (e) is the number of plants with height of more than 2 meter.

$$(e)/ha = 2500 \sum_{i=1}^n \frac{e_i}{m}$$

Where,

r_i – Total number of recruits in each quadrant or sampling unit.

u_i – Total number of un-established plants in each quadrat or sampling unit.

e_i – Total number of established plants in each quadrat or sampling unit.

n – Number of quadrats or sampling units laid in a recording unit (plot or block).

m – Total number of recording units (plots or blocks) laid in a stratum.

iv. Stocking Index (I_1)

$$I_1 = \frac{1}{2500} \left(\frac{\text{unestablished regeneration/ha}}{4} + \text{Established regeneration/ha} \right)$$

v. Regeneration success (%) = Stocking Index (I_1) × 100

3.5 Soil and site characteristics of Spruce forest stand.

3.5.1 Site characteristics

Solar Influx: - Light illumination was recorded by Lux meter under and outside the Spruce canopy in selected forest plots at various sites

separately during day time and the value in percentage of light intensity under canopy to that in the open was calculated as suggested by (Ali, 2011; Mahajan, 2010; Rao, 1998).

$$\text{Solar influx(\%)} = \frac{\text{Total solar radiation beneath the canopy}}{\text{Total Solar radiation in open}} \times 100$$

Crown width: Crown width is diameter of maximum and minimum axis of crown. The crown width was measured in two directions (North-South and East-West) and average was calculated as suggested by (Mahajan, 2010; Assmann, 1970).

$$CW = \frac{D_1 + D_2}{2}$$

Where,

CW – Crown width (m).

D₁ – First measured crown diameter (m).

D₂ – Second measured crown diameter at right angle to the first measurement (m).

Crown Projection ratio:

It is the ratio which states that by how many times the crown width is larger than the stem diameter of a tree (Mahajan, 2010; Assmann, 1970).

$$\text{Crown projection ratio} = \frac{b}{d}$$

Where,

b - Crown width (m).

d - Stem diameter (m).



Plate 3: Soil sampling and analysis

3.5.2 Soil Characteristics:-

- **Organic matter layer:**

It was measured as depth of the column from top of humus layer to the point under humus where soil exists. To record the depth of humus layer, a horizontal cut was given by a sharp knife through the humus layer and thickness of the humus was read on a graduated scale placed in front of the sharp cut (Ali, 2011; Mahajan, 2011).

- **Soil nutrient content:**

The soil samples were collected from all the selected strata of study area. The soil samples were collected from two depths, i.e., 0-15 cm and 15-30 cm. One composite soil sample was taken from each sample plot for each depth making the total six number of soil samples per stratum for single depth range. The samples were brought to laboratory at Faculty of Forestry for the nutrient analysis. Soil pH, Organic Carbon, Available N, P, K, Zn and Fe was determined by using 'Mridaparishak' a Minilab for Soil Testing developed by ICAR-Indian Institute of Soil Science, Bhopal.

- **Soil seed bank: -**

The soil seed bank is defined as a reservoir of all viable seeds that were buried into the soil and maintain their dormant state (Mndela *et al.*, 2020; Anzures *et al.*, 2009; Simpson *et al.*, 1989; Brown, 1992; Fenner, 1985).

Following procedure was followed to study the soil seed banking in Spruce as suggested by Gonzalez and Ghermandi (2012).

1. Soil core samples were taken from all the selected sites up to the 5 cm depth.
2. Spruce seeds were extracted manually from soil core samples after removing the soil, humus, litter layer etc.

3. Spruce seeds were brought to laboratory and subjected to viability testing using 1% tetrazolium solution.

3.6 Data analysis

The data collected in the field was analyzed using Microsoft Excel (Office 2013).

Chapter-4

EXPERIMENTAL FINDINGS

The results emerged out of the present investigation entitled “Regeneration status of Spruce (*Picea smithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division” conducted in Daksum range of Anantnag Forest division during the year 2018-2020. The salient findings obtained during the course of investigation are being presented in this chapter under following headings:

- 4.1 Community structure
- 4.2 Natural Regeneration
- 4.3 Soil and site studies

4.1 Community structure

The data on floristic composition and phytosociology of trees, shrubs and herbs in Spruce bearing forests of Daksum range of Anantnag Forest Division at three altitudes are presented in Table 1 to Table 5.

4.1.1 Floristic composition

The floristic composition of the study area at three altitudes along altitudinal gradient *viz.* Lower stratum at Ahlen (2200-2400m), Middle stratum at Deesu (2400-2600m) and Upper stratum at Harkani (2600-2800m) are depicted in Tables 1 gives the detailed information regarding the 47 species belonging to 28 families.

A close scrutiny of the data evince that the total number of species at Ahlen (2200-2400m), Deesu (2400-2600m) and Harkani (2600-2800m) are 37, 36 and 29 species respectively (Figure 1). In general, the total number of species decreased with increase in altitude of study area. Further 4 tree species *viz.* *Abies pindrow* Royle., *Acer caesium* Wall. Ex Brandis., *Picea smithiana* (Wall.) Boiss. and *Pinus wallichiana* A.B. Jackson were recorded in the study area in which maximum

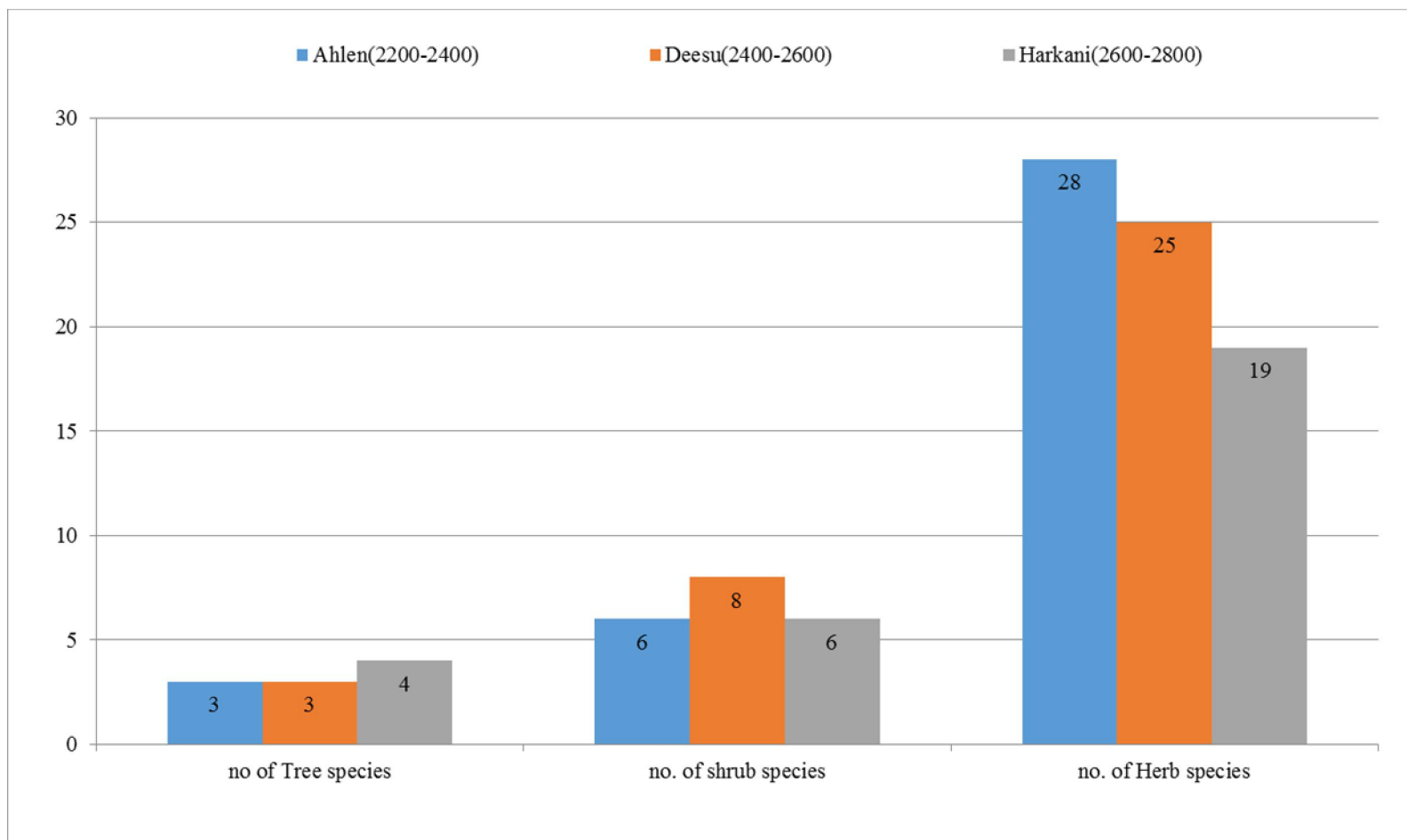


Fig. 2: Representative no. of tree, shrub and herb species present at different altitudes in the study area

number of tree species were present at Harkani (2200-2400m) with 4 tree species followed by Ahlen (2200-2400m) and Deesu (2400-2600m) where 3 tree species was recorded as shown in Figure 1. The tree species *Abies pindrow*, *Picea smithiana* and *Pinus wallichiana* were present at all the three strata. While in case of shrubs shown in (Table 1) 11 shrub species were recorded viz *Berberis lyceum* Royle., *Cotoneaster roseus* Edgew., *Rosa brunonii* L., *Indigofera hetrantha* Wall., *Parrotia jacquemontiana* (Decne.) Rehd., *Rosa rubiginosa* L., *Rubus irritans* Fockee., *Sambucus wightiana* Wall., *Sorbia tomentosa* (Lindl) Rehd., *Viburnum grandiflorum* Wall. Ex DC. and *Rhododendron campanulatum* D.Don. Out of which maximum number of shrub 8 species were present at Deesu (2400-2600m), 7 shrub species at Harkani (2200-2400m) and 6 shrub species at Ahlen (2200-2400m). *Berberis lyceum* and *Viburnum grandiflorum* were common shrub species to all strata. Further 32 herb species were recorded at the study site presented in (Table 1) viz. *Amaranthus caudatus* L., *Arisaema jacquemontiana* Blume., *Artemisia absinthium* L., *Bergenia ciliata* (Haw.) Sternb., *Cannabis sativa* L., *Capsella bursa pastoris* (L.) Medik., *Cardus edelbergii* L., *Chenopodium album* L., *Cirsium falcorneri* Hook. f., *Cynodon dactylon* (L.) Pers., *Dactylis glomerata* L., *Fragaria vesca* L., *Geranium wallichianum* Oliv., *Impatiens thomsonii* Hook. f., *Malva neglecta* Wallr., *Matricaria chamomilla* L., *Mentha speciata* L., *Phytolacca acinosa* L., *Plantago major* L., *Plantago lanceolata* L., *Poa annua* L., *Poa bulbosa* L., *Poa pratensis* L., *Ranunculus hirtellus* Royle., *Rumex nepalensis* L., *Taraxacum officinale* Weber., *Stipa sibirica* (L.) Lam., *Strobilanthus wallichi* Nees., *Trifolium pratense* L., *Trifolium repens* L., *Urtica dioica* L. and *Verbascum thapsus* L. Out of which the maximum number of herb species i.e. 28 were present at Ahlen (2200-2400m), followed by 25 at Deesu (2400-2600m) and lowest herb species 19 were recorded at Harkani (2600-2800m). 13 herb species like *Arisaema jacquemontiana*, *Capsella bursa pastoris*, *Cirsium falcorneri*, *Cynodon dactylon*, *Impatiens thomsonii*, *Poa annua*, *Poa bulbosa*, *Poa pratensis*, *Ranunculus hirtellus*, *Rumex dentatus*, *Taraxacum officinale*, *Stipa sibirica* and *Verbascum thapsus* were common to all the three strata as depicted in Table 1.

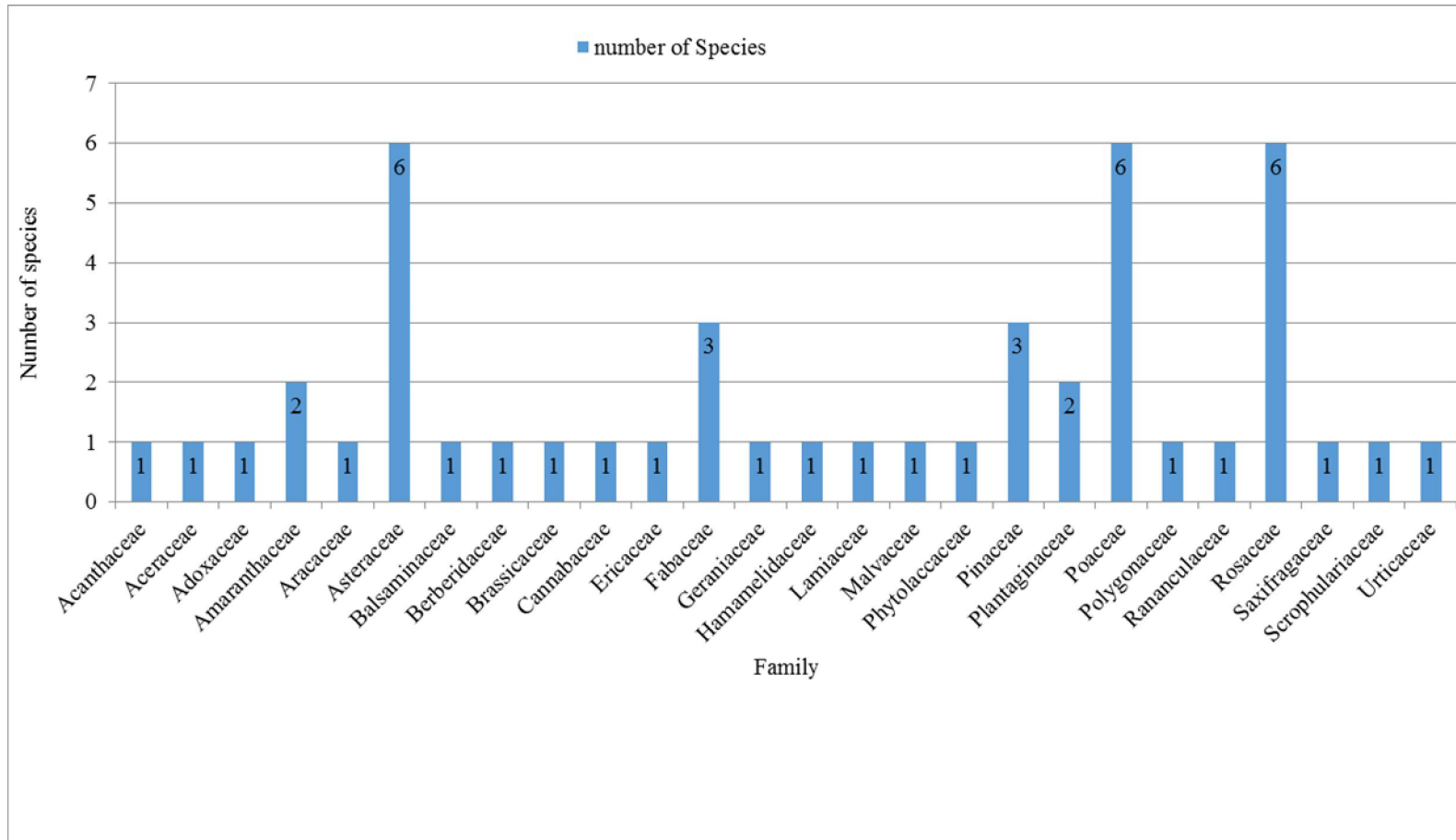


Fig. 3: Representative structure of various families in the study area

Table 1: Floristic Diversity of the study area

Life form	Scientific name	Family	Common Name	Local Name	Site (masl)		
					I	II	III
Trees	<i>Abies pindrow</i> Royle	Pinaceae	Fir	Budlu	+	+	+
	<i>Acer caesium</i> Wall. Ex Brandis	Aceraceae	Himalayan Maple		-	-	+
	<i>Picea smithiana</i> Wall. Boiss	Pinaceae	Spruce	Raeil/ Rai Badul	+	+	+
	<i>Pinus wallichiana</i> A.B. Jackson	Pinaceae	Kail	Kayur	+	+	+
Shrubs	<i>Berberis lyceum</i> Royle	Berberidaceae	Berberis	Kaw dach	+	+	+
	<i>Cotoneaster roseus</i> Edgew.	Rosaceae	Cotoneater	Luin	-	-	+
	<i>Rosa brunonii</i> Lindl.	Rosaceae	Himalayan Musk rose	Kieche	+	+	-
	<i>Indigofera hetrantha</i> Wall.	Fabaceae	himalayan Indigo	Kanhchu	-	+	+
	<i>Parrotia Jacquemontiana</i> (Decne.) Rehd.	Hamamelidaceae	Parrotia	Poh	+	-	-
	<i>Rosa rubiginosa</i> L.	Rosaceae	Sweet brier	Gulaab kuj	-	+	+
	<i>Rubus irritans</i> Fockee.	Rosaceae	Blackberry	Jhansh	-	+	+
	<i>Sambucus wightiana</i> Wall.	Sambucaceae	Elder	Fhakee	+	+	-
	<i>Sorbia tomentosa</i> (Lindl) Rehd.	Rosaceae	Kashmir False Spirea		+	+	-
	<i>Viburnum grandiflorum</i> Wall. Ex DC	Adoxaceae	Grand viburnum	Kul maach	+	+	+
<i>Rhododendron campanulatum</i> D.Don.	Ericaceae	Bell Rhododendron		-	-	+	
Herbs	<i>Amaranthus caudatus</i> L.	Amaranthaceae	Velvet flower	Ganhaar/Leesa	+	-	-
	<i>Arisaema Jacquemontiana</i> Blume.	Aracaceae	Jacquemont's cobra-lily		+	+	+
	<i>Artemisia absinthium</i> L.	Asteraceae	Worm wood	Tethwen	+	+	-
	<i>Bergenia ciliata</i> (Haw.) Sternb.	Saxifragaceae	Hairy bergenia	Zakm-e-Hayaat	-	-	+
	<i>Cannabis sativa</i> L.	Cannabaceae	Hemp	Bhang	+	+	-
	<i>Capsella bursa pastoris</i> L.	Brassicaceae	Shepherd's purse	Kral mound	+	+	+
	<i>Cardus edelbergii</i> L.	Asteraceae	Edelberg's cotton Thistle		-	+	-
	<i>Chenopodium album</i> L.	Amaranthaceae	Lamb's quarters	Kunne	+	-	-
<i>Cirsium falcorneri</i> Hook. f.	Asteraceae	Thistle		+	+	+	

Contd....

Table 1 contd....

Life form	Scientific name	Family	Common Name	Local Name	Site (masl)		
					I	II	III
	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Couch grass	Dramun	+	+	+
	<i>Dactylis glomerata</i> L.	Poaceae	Orchard grass		+	-	-
	<i>Fragaria vesca</i> L.	Rosaceae	Himalayan strawberry	Ringrech	-	+	+
	<i>Geranium wallichianum</i> Oliv.	Geraniaceae	Rose sented geranium	Patherfad	+	+	-
	<i>Impatiens thomsonii</i> Hook. f.	Balsaminaceae	Spurless Balsam		+	+	+
	<i>Malva neglecta</i> Wallr.	Malvaceae	Common mallow	Kashir sochel	+	+	+
	<i>Matricaria chamomilla</i> L.	Caryophyllaceae	May scented weed	Fackh gaas	+	-	-
	<i>Mentha speciosa</i> L.	Lamiaceae	Spear mint	Pudna	-	-	+
	<i>Phytolacca acinosa</i> L.	Phytolaccaceae	Indian pokeweed	Hapat Makai	+	+	-
	<i>Plantago major</i> L.	Plantaginaceae	common plantain	Boud gull	+	+	-
	<i>Plantago lanceolata</i> L.	Plantaginaceae	English plantain		+	-	-
	<i>Poa annua</i> L.	Poaceae	Annual meadow grass		+	+	+
	<i>Poa bulbosa</i> L.	Poaceae	Bulbous meadow grass		+	+	+
	<i>Poa pratensis</i> L.	Poaceae	Smooth meadow grass	Gud gaas	+	+	+
	<i>Ranunculus hirtellus</i> Royle.	Ranunculaceae	Softly hairy butter cup		+	+	+
	<i>Rumex dentatus</i> L.	Polygonaceae	Common Sorrel	Abej	+	+	+
	<i>Taraxacum officinale</i> Weber.	Asteraceae	Common dandelion	Hand	+	+	+
	<i>Stipa sibirica</i> (L.) Lam.	Poaceae	Needle grass	Saraf gass	+	+	+
	<i>Strobilanthes wallichii</i> Nees	Acanthaceae	Kashmir acanthus		+	+	-
	<i>Trifolium pratense</i> L.	Fabaceae	Red clover	Batakh leunt	+	+	-
	<i>Trifolium repens</i> L.	Fabaceae	white clover	Safed batakh leunt	+	+	-
	<i>Urtica dioica</i> L.	Urticaceae	Stinging nettle	Soi	+	+	-
	<i>Verbascum thapsus</i> L.	Scrophulariaceae	Great mullein		+	+	+

masl = meters above sea level ; (+) = Present; (-) = Absent ; I = Ahlen(2200-2400); II = Deesu (2400-2600) ; III = Harkani (2600-2800)

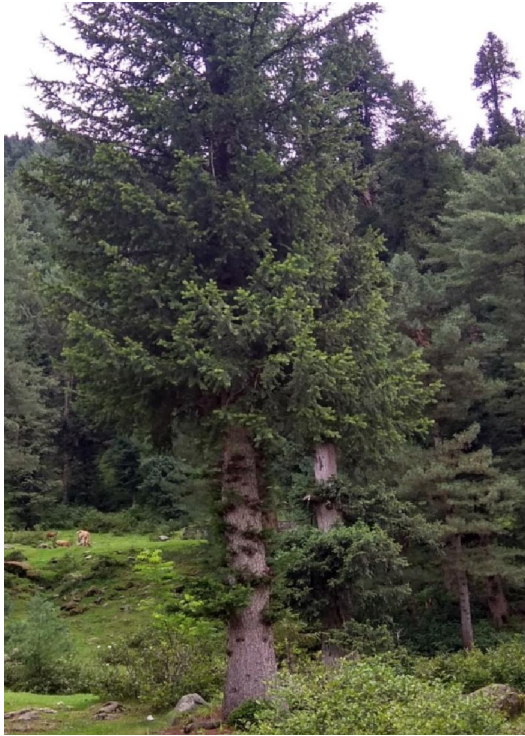
Table 2: Floristic composition and phytosociological attributes of tree species at different altitudes of study area (n = 6)

Site Altitude (masl)	Name of species	Avg. density/ha.	Frequency (%)	Avg. basal area(m ²)/ha	RD	RF	RBA	IVI
		(Mean ± S.E)			(%)			
Ahlen (2200-2400)	<i>Abies pindrow</i>	141.66 ± 45.5	58.33 ± 15.37	64.26 ± 1.95	17.89	26.92	21.02	65.84
	<i>Picea smithiana</i>	258.33 ± 23.86	66.76 ± 10.54	111.22 ± 6.31	32.63	30.77	36.39	99.79
	<i>Pinus wallichiana</i>	391.66 ± 41.67	91.66 ± 8.33	130.17 ± 8.42	49.47	42.31	42.59	134.37
Total		791.66	216.67	305.66	100	100	100	300
Deesu (2400-2600)	<i>Abies pindrow</i>	266.66 ± 24.72	83.33 ± 10.54	107.60 ± 4.35	32.32	35.71	34.57	102.62
	<i>Picea smithiana</i>	375 ± 38.13	91.66 ± 8.35	161.45 ± 9.17	45.45	39.28	51.89	136.63
	<i>Pinus wallichiana</i>	183.33 ± 27.89	58.33 ± 8.83	42.05 ± 2.7	22.22	25	13.51	60.73
Total		825	233.63	311.11	100	100	100	300
Harkani (2600-2800)	<i>Abies pindrow</i>	283.33 ± 16.67	83.33 ± 10.54	118.54 ± 1.87	41.46	34.48	43.42	119.37
	<i>Acer caesium</i>	41.66 ± 15.36	25 ± 11.18	6.62 ± 0.17	6.09	10.34	2.42	8.52
	<i>Picea smithiana</i>	241.66 ± 35.16	75 ± 11.18	112.56 ± 4.43	35.36	31.03	41.23	107.63
	<i>Pinus wallichiana</i>	116.66 ± 21.08	58.33 ± 8.33	35.22 ± 1.31	17.07	24.13	12.90	54.11
TOTAL		683.33	241.66	272.96	100	100	100	300

IVI- importance value Index; R F- Relative Frequency; RD- Relative density; RBA- Relative basal area; n= no. of sampling plots



Pinus wallichiana A.B. Jackson



Picea smithiana (Wall.) Boiss.



Acer caesium Wall. Ex Brandis

Plate 4: Tree species of study area

4.1.2 Phyto-sociological study at three strata

The phyto-sociological parameters like per cent frequency (F), Density (D), Basal area (BA) and Important Value Index (IVI) of Trees and Shrubs and herbs/grasses have been presented in Tables 2 to Table 4 for all the three strata along the altitudinal gradient viz., Ahlen (2200-2400m), Deesu (2400-2600m) and Harkani (2600-2800m) respectively.

4.1.3 Phytosociology of trees

A scrutiny of data presented in Table 2 revealed that the lower stratum was dominated by *Pinus wallichiana* followed by *Picea smithiana* with their respective Important Value Index 134.37 and 99.79 respectively. The density, frequency and basal area for *Pinus wallichiana* were recorded as 391.66 ± 41.67 trees/ha, 91.66 ± 8.33 per cent and 130.17 ± 8.42 m²/ha respectively followed by *Picea smithiana* with density (258.33 ± 23.86 tree/ha), frequency (66.76 ± 10.54 %) and basal area (111.22 ± 6.31 m²/ha) respectively. The lowest density (141.66 ± 45.5 trees/ha), frequency (58.33 ± 15.37 %), basal area (64.26 ± 1.95) and Important value index (65.84) were recorded for *Abies pindrow* at lower stratum. Sample plots drawn from middle stratum depicted in Table 2 were dominated by *Picea smithiana* and *Abies pindrow* with their respective important value index 136.63 and 102.62 respectively. The density (375 ± 38.13 trees/ha), Frequency (91.66 ± 8.35 %) and basal area (161.45 ± 9.17 m²/ha) were recorded highest for *Picea smithiana* followed by *Abies pindrow* with density (266.66 ± 24.72 trees/ha), frequency (83.33 ± 10.54 %) and basal area (107.60 ± 4.35). At middle stratum the lowest density (183.33 ± 27.89), frequency (58.33 ± 8.83 %), Basal area (42.05 ± 2.7 m²/ha) and Important value index (60.73) were recorded in case of *Pinus wallichiana*. Further the data tabulated in Table 2 evinces that higher stratum Harkani (2600-2800m) was dominated by *Abies pindrow* and *Picea smithiana* tree species with their important value index of 119.37 and 107.63 respectively. The density, frequency and basal area for *Abies pindrow* were recorded as 283.33 ± 16.67 trees/ha, 83.33 ± 10.54 % and 118.54 ± 1.87 m²/ha, respectively followed by *Picea smithiana* with density (241.66 ± 35.16 tree/ha),

frequency (75 ± 11.18 %) and basal area 112.56 ± 4.43 m²/ha. The rarely distributed species at higher stratum were *Acer caesium* and *Pinus wallichiana* with their importance value index 8.52 and 54.11 respectively. The lowest density (41.66 ± 15.36 trees/ha), frequency (25 ± 11.18 %) and basal area (6.62 ± 0.17 m²/ha) were recorded in case of *Acer caesium*.

4.1.4 Phytosociology of shrubs

The data pertaining to shrubs in Table 3 revealed that lower stratum was dominated by *Berberis lyceum*, *Sorbia tomentosa* and *Parrotia jacquemontiana* shrub species with their Important Value Index of 75.00, 60.45 and 49.02 respectively. The density, frequency and basal area recorded for *Berberis lyceum* were 383.33 ± 47.74 shrubs/ha, 54.16 ± 7.68 % and 2.29 ± 0.46 m²/ha respectively followed by *Sorbia tomentosa* with density (333.33 ± 105.4 shrubs/ha), frequency (37.5 ± 12.36 %) and basal area (1.94 ± 0.19 m²/ha). The rarely distributed shrub species were *Rosa brunonii*, *Viburnum grandiflorum* and *Parrotia jacquemontiana* with their important value index 33.15, 37.08 and 45.27 respectively. The lowest density (150 ± 42.83 shrubs/ha), frequency (29.16 ± 7.68 %) was recorded for *Viburnum grandiflorum* and whereas lowest basal area (0.69 ± 0.01 m²/ha) was recorded for *Rosa brunonii* at this stratum. At middle stratum presented in Table 3, the dominant shrub species were *Viburnum grandiflorum*, *Sorbia tomentosa*, *Sambucus wightiana*, *Rubus irritans*, *Berberis lyceum*, *Indigofera hetrantha* and *Rosa rubiginosa* with Importance value index 75.15, 47.87, 38.02, 37.53, 34.54, 23.83 and 23.50 respectively. Shrub species with highest density (433.33 ± 55.78 shrubs/ha), Frequency (79.16 ± 10.03 %) and basal area (3.60 ± 0.28 m²/ha) was *Viburnum grandiflorum* followed by *Sorbia tomentosa* with density, frequency and basal area 366.66 ± 122.9 shrubs/ha, 62.5 ± 20.16 %, and 1.49 ± 0.10 m²/ha respectively.

Table 3: Floristic composition and phytosociological attributes of Shrub species at different altitudes of study area(n= 6)

Site Altitude (masl)	Name of species	Avg. density/ha.	Frequency (%)	Avg. basal area(m ² /ha	RD	RF	RBA	IVI
		(Mean ± S.E)			(%)			
Ahlen (2200- 2400)	<i>Berberis lyceum</i>	383.33 ± 47.74	54.16 ± 7.68	2.29 ± 0.46	23.46	23.63	27.89	75.00
	<i>Rosa brunonii</i>	166.66 ± 55.79	33.33 ± 10.54	0.69 ± 0.01	10.20	14.54	8.40	33.15
	<i>Parrotia jacquemontiana</i>	183.33 ± 54.27	45.83 ± 13.56	1.46 ± 0.16	11.22	20	17.79	49.02
	<i>Sambucus s wightiana</i>	416.66 ± 87.26	29.16 ± 11.93	0.57 ± 0.04	25.51	12.72	7.035	45.27
	<i>Sorbia tomentosa</i>	333.33 ± 105.4	37.5 ± 12.36	1.94 ± 0.19	20.40	16.36	23.68	60.45
	<i>Viburnum grandiflorum</i>	150 ± 42.83	29.16 ± 7.68	1.24 ± 0.10	9.18	12.72	15.17	37.08
Total		1633.33	229.16	8.22	100	100	100	300
Deesu (2400- 2600)	<i>Berberis lyceum</i>	216.66 ± 47.73	45.83 ± 7.68	1.29 ± 0.26	10.07	12.35	12.10	34.54
	<i>Rosa brunonii</i>	150 ± 42.82	25 ± 6.45	0.62 ± 0.01	6.97	6.74	5.80	19.52
	<i>Indigofera hetrantha</i>	166.66 ± 33.34	33.33 ± 5.27	0.76 ± 0.02	7.75	8.98	7.09	23.83
	<i>Rosa rubiginosa</i>	183.33 ± 65.41	29.16 ± 10.03	0.95 ± 0.05	8.52	7.86	7.11	23.50
	<i>Rubus irritans</i>	333.33 ± 105.43	41.66 ± 10.54	1.15 ± 0.15	15.50	11.23	10.79	37.53
	<i>Sambucus wightiana</i>	300 ± 63.25	54.16 ± 11.93	1.01 ± 0.06	13.95	14.60	9.46	38.02
	<i>Sorbia tomentosa</i>	366.66 ± 122.9	62.5 ± 20.16	1.49 ± 0.10	17.05	16.85	13.96	47.87
<i>Viburnum grandiflorum</i>	433.33 ± 55.78	79.16 ± 10.03	3.60 ± 0.28	20.15	21.34	33.65	75.15	
Total		2150	370.83	10.70	100	100	100	300
Harkani (2600- 2800)	<i>Berberis lyceum</i>	383.33 ± 60.10	58.33 ± 10.5	2.29 ± 0.46	21.69	20.89	26.18	68.78
	<i>Cotoneaster roseus</i>	233.33 ± 42.17	45.83 ± 7.68	0.84 ± 0.02	13.20	16.41	9.63	39.26
	<i>Rosa rubiginosa</i>	216.66 ± 47.73	37.5 ± 5.59	0.67 ± 0.07	12.26	13.43	7.65	33.35
	<i>Rubus irritans</i>	250 ± 76.39	29.16 ± 4.17	1.07 ± 0.13	14.15	10.44	12.29	36.89
	<i>Viburnum grandiflorum</i>	483.33 ± 83.35	75 ± 12.9	3.29 ± 0.11	27.35	26.86	37.60	91.82
	<i>Rhododendron campanulatum</i>	200 ± 44.73	33.33 ± 8.33	0.57 ± 0.02	11.32	11.94	6.62	29.88
Total		1766.66	279.16	8.76	100	100	100	300

IVI- importance value Index; R F- Relative Frequency; RD- Relative density; RBA- Relative basal area; n= no. of sampling plots

masl = meters above sea level; S. E. = Standard Error



Berberis lyceum Royle.



Indigofera hetrantha Wall.



Rhododendron campanulatum D.Don.



Rosa brunonii Lindl.



Sambucus wightiana Wall.



Sorbia tomentosa (Lindl) Rehd.



Viburnum grandiflorum Wall. Ex DC



Parrotia jacquemontiana (Decne.) Rehd.

Plate 5: Shrub species of study area

The lowest density (150 ± 42.82 shrubs/ha), frequency (25 ± 6.45 %), basal area (0.62 ± 0.01 m²/ha) and Importance value index (19.52) was recorded for *Rosa brunonii* at middle stratum. Further the data tabulated in Table 3, higher stratum envisages that the dominant shrub species *Viburnum grandiflorum*, *Berberis lyceum* and *Cotoneaster roseus* were with their importance value index 91.82, 68.78 and 39.26 respectively. The rarely distributed shrub species were *Rhododendron campanulatum*, *Rosa rubiginosa* and *Rubus irritans* with their importance value index of 29.88, 33.35 and 36.89 respectively. Shrub species with highest density (483.33 ± 83.35 shrubs/ha), Frequency (75 ± 12.9 %) and basal area (3.29 ± 0.11 m²/ha) was *Viburnum grandiflorum* followed by *Berberis lyceum* with density, frequency and basal area 383.33 ± 60.10 shrubs/ha, 58.33 ± 10.5 % and 2.29 ± 0.46 m²/ha respectively. The lowest density (200 ± 44.73 shrubs/ha), frequency (33.33 ± 8.33 %), basal area (0.57 ± 0.02 m²/ha) and Importance value index (19.52) was recorded for *Rhododendron campanulatum* at higher stratum.

4.1.5 Phytosociology of herbs

Regarding the herb species in lower stratum as tabulated in (Table 4) the dominant herb species were *Poa annua*, *Poa bulbosa* and *Cynodon dactylon* with their Importance value Index 24.85, 19.51 and 18.37 respectively. The species recorded with highest density (9.91 ± 1.57 tillers/m²) was *Poa annua* whereas species with lowest density (0.89 ± 0.18 tillers/m²) was *Verbascum thapsus*, the species with highest frequency (79.16 ± 7.68 %) was *Poa annua* whereas species with lowest frequency (33.33 ± 8.93 %) was *Taraxacum officinale* and the species with highest basal area (6.59 ± 0.82 cm²/m²) was *Cirium falcorneri* whereas species with lowest basal area (0.97 ± 0.23 cm²/m²) was *Urtica dioica*. The rarely distributed species were *Urtica dioica*, *Geranium wallichianum* and *Impatiens brachycentrus* with their importance value index of 5.43, 6.24 and 6.25 respectively. Further the data tabulated in Table 4 at middle stratum at the dominant herb species were *Cynodon dactylon*, *Poa annua* and *Stipa sibirica* with their Importance value Index of 33.70, 24.24 and 24.13 respectively.

Table 4: Floristic composition and phytosociological attributes of Herb species at different altitudes of study area (n=6)

Site Altitude (masl)	Name of species	Avg. Density tillers /m ²	Frequency (%)	Av. Basal area(cm ² /m ²)	RD	RF	RBA	IVI
		(Mean ± S.E)			(%)			
Ahlen (2200-2400)	<i>Amaranthus caudatus</i>	1.12 ± 0.18	56.25 ± 9.54	1.49 ± 0.05	1.60	3.38	1.75	6.74
	<i>Arisaema jacquemontiana</i>	2.33 ± 0.53	77.08 ± 11.82	2.15 ± 0.75	3.33	4.64	2.52	10.50
	<i>Artemisia absinthium</i>	1.77 ± 0.29	54.16 ± 7.68	6.17 ± 1.81	2.53	3.26	7.25	13.04
	<i>Cannabis sativa</i>	0.89 ± 0.29	45.83 ± 11.48	2.98 ± 1.07	1.28	2.76	3.50	7.54
	<i>Capsella bursa pastoris</i>	1.60 ± 0.29	62.5 ± 12.07	2.04 ± 1.02	2.29	3.76	2.40	8.46
	<i>Chenopodium album</i>	1.22 ± 0.34	70.83 ± 18.73	2.53 ± 0.53	1.75	4.26	2.96	8.98
	<i>Cirsium falconeri</i>	1.33 ± 0.35	64.58 ± 13.47	6.59 ± 0.82	1.90	3.88	7.73	13.52
	<i>Cynodon dactylon</i>	7.41 ± 1.25	72.91 ± 6.78	2.88 ± 0.39	10.60	4.39	3.38	18.37
	<i>Dactylis glomerata</i>	1.97 ± 1.01	33.33 ± 8.93	6.90 ± 2.02	2.82	2.00	8.10	12.94
	<i>Geranium wallichianum</i>	0.97 ± 0.25	70.83 ± 6.97	0.49 ± 0.07	1.40	4.26	0.58	6.24
	<i>Impatiens brachycentrus</i>	0.93 ± 0.24	58.33 ± 13.17	1.19 ± 0.59	1.34	3.51	1.40	6.25
	<i>Malva neglecta</i>	0.70 ± 0.20	47.91 ± 11.82	3.51 ± 0.54	1.01	2.88	4.12	8.02
	<i>Matricaria chamomilla</i>	0.58 ± 0.16	39.58 ± 11.37	0.37 ± 0.06	0.83	2.38	0.44	3.65
	<i>Phytolacca acinosa</i>	1.60 ± 0.28	62.5 ± 12.07	1.47 ± 0.52	2.29	3.76	1.73	7.79
	<i>Plantago major</i>	1.45 ± 0.24	75 ± 15.81	3.85 ± 1.10	2.08	4.51	4.52	11.12
	<i>Plantago lanceolate</i>	2.45 ± 0.31	54.16 ± 8.33	3.79 ± 0.29	3.51	3.26	4.45	11.22
<i>Poa annua</i>	9.91 ± 1.57	79.16 ± 7.68	5.03 ± 0.72	14.17	4.76	5.90	24.85	
<i>Poa bulbosa</i>	7.29 ± 1.09	60.41 ± 8.79	4.64 ± 0.23	10.43	3.63	5.44	19.51	

Contd....

Table 4: contd....

	<i>Poa pratensis</i>	5.95 ± 0.89	50 ± 5.59	3.79 ± 0.19	8.51	3.01	4.45	15.98
	<i>Ranunculus hirtellus</i>	2.43 ± 0.71	77.08 ± 11.82	1.22 ± 0.07	3.48	4.64	1.43	9.56
	<i>Rumex dentatus</i>	1.5 ± 0.38	43.75 ± 11.52	3.96 ± 1.13	2.14	2.63	4.65	9.43
	<i>Taraxacum officinale</i>	0.93 ± 0.41	33.33 ± 8.93	3.27 ± 0.45	1.34	2.00	3.84	7.19
	<i>Stipa sibirica</i>	2.70 ± 0.60	87.5 ± 4.56	6.20 ± 0.83	3.87	5.26	7.27	16.43
	<i>Strobilanthus wallichii</i>	1.29 ± 0.20	56.25 ± 13.21	1.64 ± 0.84	1.84	3.38	1.93	7.16
	<i>Trifolium pretense</i>	3.75 ± 0.49	64.58 ± 7.51	1.10 ± 0.28	5.36	3.88	1.29	10.55
	<i>Trifolium repens</i>	3.5 ± 0.65	75 ± 15.81	1.15 ± 0.57	5.00	4.51	1.35	10.87
	<i>Urtica dioica</i>	1.33 ± 0.35	39.58 ± 13.07	0.97 ± 0.23	1.90	2.38	1.14	5.43
	<i>Verbascum Thapsus</i>	0.89 ± 0.18	47.91 ± 9.90	3.72 ± 0.18	1.28	2.88	4.37	8.53
TOTAL		69.93	1660.41	85.23	100	100	100	300
Deesu (2400-2600)	<i>Arisaema jacquemontiana</i>	3.02 ± 0.47	87.5 ± 4.56	3.09 ± 1.60	4.62	6.27	4.82	15.72
	<i>Artemisia absinthium</i>	0.91 ± 0.16	39.58 ± 12.67	3.19 ± 0.93	1.40	2.84	4.98	9.23
	<i>Cannabis sativa</i>	0.37 ± 0.12	29.16 ± 8.93	1.61 ± 0.43	0.57	2.09	2.51	5.18
	<i>Capsella bursa pastoris</i>	0.97 ± 0.34	35.41 ± 8.79	1.25 ± 0.62	1.49	2.54	1.95	5.98
	<i>Cardus edelbergii</i>	0.68 ± 0.12	37.5 ± 7.90	1.06 ± 0.08	1.05	2.69	1.65	5.39
	<i>Cirsium falcorneri</i>	0.85 ± 0.16	64.58 ± 10.41	4.22 ± 0.52	1.30	4.63	6.58	12.52
	<i>Cynodon dactylon</i>	12.97 ± 1.60	83.33 ± 4.16	5.04 ± 0.69	19.85	5.97	7.86	33.70
	<i>Fragaraia vesca</i>	1.29 ± 0.20	45.83 ± 8.93	4.51 ± 0.63	1.97	3.28	7.04	12.31
	<i>Geranium wallichianum</i>	4.25 ± 0.29	66.66 ± 7.68	2.15 ± 0.30	6.50	4.78	3.36	14.65
	<i>Impatiens brachycentrus</i>	1.33 ± 0.17	58.33 ± 11.02	1.70 ± 0.85	2.04	4.18	2.65	8.88
	<i>Malva neglecta</i>	0.45 ± 0.11	37.5 ± 7.21	2.26 ± 0.28	0.70	2.69	3.53	6.92

Contd....

Table 4: contd....

	<i>Phytolacca acinosa</i>	0.66 ± 0.19	45.83 ± 13.17	1.35 ± 0.17	1.02	3.28	2.10	6.41
	<i>Plantago major</i>	0.583 ± 0.16	50 ± 10.20	1.54 ± 0.44	0.89	3.58	2.40	6.88
	<i>Poa annua</i>	8.125 ± 0.84	75 ± 10.70	4.12 ± 0.59	12.43	5.38	6.43	24.24
	<i>Poa bulbosa</i>	6.25 ± 1.21	77.08 ± 7.51	3.97 ± 0.20	9.56	5.53	6.20	21.30
	<i>Poa pratensis</i>	5.39 ± 0.60	56.25 ± 7.74	2.73 ± 0.39	8.25	4.03	4.27	16.56
	<i>Ranunculus hirtellus</i>	1.97 ± 0.33	79.16 ± 7.68	1.00 ± 0.14	3.02	5.68	1.56	10.27
	<i>Rumex dentatus</i>	0.97 ± 0.12	52.08 ± 8.17	0.62 ± 0.03	1.49	3.73	0.97	6.20
	<i>Taraxacum officinale</i>	0.68 ± 0.17	39.58 ± 8.79	2.40 ± 0.35	1.05	2.84	3.75	7.64
	<i>Stipa sibirica</i>	3.5 ± 0.42	87.5 ± 5.59	8.01 ± 1.08	5.35	6.27	12.49	24.13
	<i>Strobilanthus wallichii</i>	0.93 ± 0.13	45.83 ± 10.03	2.38 ± 0.15	1.43	3.28	3.72	8.44
	<i>Trifolium pretense</i>	5.10 ± 0.68	72.91 ± 9.90	1.48 ± 0.34	7.81	5.23	2.32	15.36
	<i>Trifolium repens</i>	2.58 ± 0.33	43.75 ± 6.25	0.78 ± 0.28	3.95	3.13	1.22	8.31
	<i>Urtica dioica</i>	0.66 ± 0.13	35.41 ± 8.79	0.42 ± 0.05	1.02	2.54	0.66	4.22
	<i>Verbascum Thapsus</i>	0.75 ± 0.15	47.91 ± 12.25	3.11 ± 0.07	1.14	3.43	4.85	9.44
TOTAL		65.35	1393.75	64.11	100	100	100	300
Harkani (2600-2800)	<i>Arisaema jacquemontiana</i>	1.81 ± 0.38	60.41 ± 7.51	1.85 ± 0.96	3.25	5.11	3.74	12.11
	<i>Bergenia ciliate</i>	2.85 ± 0.36	70.83 ± 6.18	3.78 ± 0.13	5.12	5.99	7.63	18.76
	<i>Capsella bursa pastoris</i>	1.21 ± 0.25	56.25 ± 12.8	1.31 ± 0.22	2.17	4.76	2.64	9.57
	<i>Cirsium falcorneri</i>	0.68 ± 0.10	29.16 ± 5.27	3.51 ± 1.75	1.23	2.46	7.07	10.78
	<i>Cynodon dactylon</i>	10.66 ± 1.46	77.08 ± 7.52	4.12 ± 0.44	19.16	6.52	8.31	34.01
	<i>Fragaria vesca</i>	1.14 ± 0.23	47.91 ± 7.54	2.32 ± 0.33	2.05	4.05	4.68	10.80

Contd....

Table 4: contd....

<i>Impatiens brachycentrus</i>	0.79 ± 0.14	56.25 ± 6.25	0.90 ± 0.11	1.42	4.76	1.81	8.00
<i>Malva neglecta</i>	0.70 ± 0.15	45.83 ± 8.93	2.69 ± 0.14	1.27	3.88	5.43	10.58
<i>Mentha speciata</i>	1.29 ± 0.19	56.25 ± 7.03	2.62 ± 0.37	2.32	4.76	5.28	12.36
<i>Poa annua</i>	5.72 ± 0.33	66.66 ± 8.93	2.90 ± 0.41	10.29	5.64	5.86	21.80
<i>Poa bulbosa</i>	2.58 ± 0.32	54.16 ± 6.18	1.31 ± 0.18	4.64	4.58	2.64	11.87
<i>Poa pratensis</i>	8.08 ± 0.91	85.4 ± 8.17	5.15 ± 0.33	14.52	7.23	10.38	32.13
<i>Ranunculus hirtellus</i>	2.79 ± 0.39	66.66 ± 5.27	1.53 ± 0.68	5.01	5.64	3.10	13.76
<i>Rumex dentatus</i>	1.97 ± 0.29	58.33 ± 14.31	1.26 ± 0.08	3.55	4.93	2.54	11.06
<i>Taraxacum officinale</i>	2.43 ± 0.34	72.91 ± 9.90	1.23 ± 0.17	4.38	6.17	2.49	13.04
<i>Stipa sibirica</i>	2.20 ± 0.41	77.08 ± 11.82	5.02 ± 0.34	3.96	6.52	10.12	20.61
<i>Trifolium pretense</i>	4.58 ± 1.07	85.41 ± 8.17	2.30 ± 0.06	8.23	7.23	4.64	20.11
<i>Trifolium repens</i>	2.91 ± 0.90	52.08 ± 8.14	0.83 ± 0.13	5.25	4.40	1.68	11.33
<i>Verbascum Thapsus</i>	1.16 ± 0.34	62.5 ± 14.79	4.90 ± 0.73	2.09	5.29	9.88	17.27
TOTAL	55.64	1181.25	49.61	100	100	100	300

IVI- importance value Index; R F- Relative Frequency; RD- Relative density; RBA- Relative basal area; n= no. of sampling plots
masl = meters above sea level; S. E. = Standard Error

The species recorded with highest density (12.97 ± 1.60 tillers/m²) was *Cynodon dactylon* whereas species with lowest density (0.37 ± 0.12 tillers/m²) was *Cannabis sativa* the species with highest frequency (87.57 ± 5.59 %) was *Stipa sibirica* whereas species with lowest frequency (29.16 ± 8.93 %) was *Cannabis sativa* and the species with highest basal area (8.01 ± 1.08 cm²/m²) was *Stipa sibirica* whereas species with lowest basal area (0.62 ± 0.03 cm²/m²) was *Rumex dentatus*. The rarely distributed species were *Urtica dioica*, *Cannabis sativa* and *Cardus edelbergii* with their importance value index 4.22, 5.18 and 5.39 respectively. The data pertaining to Table 4 for higher stratum envisages that the herb species was dominated were *Cynodon dactylon*, *Poa pratensis* and *Stipa sibirica* with their Importance value Index 32.13, 21.80 and 20.61 respectively. The species recorded with highest density (10.66 ± 1.46 tillers/m²) was *Cynodon dactylon* whereas species with lowest density (0.68 ± 0.10 tillers/m²) was *Cirsium falconeri*, the species with highest frequency (85.41 ± 8.17 %) was *Trifolium pretense* whereas species with lowest frequency (29.16 ± 5.27 %) was *Cirsium falconeri* and the species with highest basal area (5.15 ± 0.33 cm²/m²) was *Poa pratensis* whereas species with lowest basal area (0.83 ± 0.13 cm²/m²) was *trifolium ripens*. The rarely distributed species were *Impatiens brachycentrus*, *Capsella bursa pastoris* and *Malva neglecta* with their importance value index of 8.00, 9.57 and 10.58 respectively.

4.1.6 Diversity Index and Dominance Index

A scrutiny of data presented in Table 5 revealed that the value for Shannon Weiner diversity index (H') for trees was found maximum (1.144) at higher stratum followed by (1.068) at lower stratum and was recorded minimum (1.48) at middle stratum. In case of shrubs the maximum (1.992) value for Shannon Weiner diversity index (H') was found at middle stratum followed by (1.753) at lower stratum and was recorded minimum (1.698) at higher stratum. In case of herbs the maximum value (3.244) for Shannon Weiner diversity index (H') was found at lower stratum followed by (3.063) at middle stratum and was recorded minimum (2.855) at higher stratum.



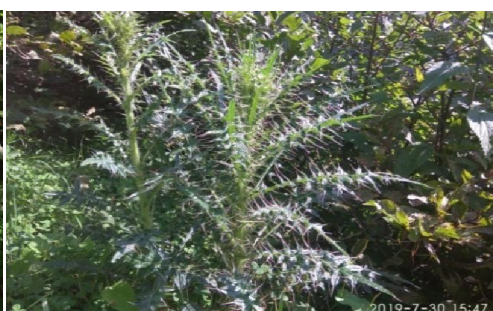
Stipa sibirica (L.) Lam.



Mentha speciata L.



Strobilanthus wallichii Nees.



Cirsium falconeri Hook. f.



Ranunculus hirtellus Royle.



Fragaria vesca L.



Rumex dentates L.



Phytolacca acinosa L.

Plate 6a: Herb species of study area



Trifolium pratense L.



Geranium wallichianum Oliv.



Bergenia ciliata (Haw.) Sternb.



Verbascum Thapsus L.



Malva neglecta Wallr.



Impatiens thomsonii Hook. f.



Arisaema jacquemontiana Blume.



Urtica dioica L.

Plate 6b: Herb species of study area

Table 5: Diversity index and Dominance index of trees, shrubs and herbs at different altitudes of study area

Site (masl)	Shannon Weiner diversity index (H')			Simpson's index of dominance (C _d)		
	Trees	Shrubs	Herbs	Trees	Shrubs	Herbs
Ahlen (2200-2400)	1.068	1.753	3.244	0.359	0.180	0.042
Deesu (2400-2600)	1.048	1.992	3.063	0.365	0.149	0.054
Harkani (2600-2800)	1.144	1.698	2.855	0.320	0.200	0.063

masl = meters above sea level

The data pertaining to Table 5 also envisaged that Simpson's index of dominance (C_d) for trees was found maximum (0.365) at middle stratum followed by (0.359) at lower stratum and was recorded minimum (0.320) at higher stratum. In case of shrubs the value for Simpson's index of dominance (C_d) was found maximum (0.200) at higher stratum followed by (0.180) at lower stratum and was recorded minimum (0.149) at higher stratum. In case of herbs the value for Simpson's index of dominance (C_d) was found maximum (0.063) at higher stratum followed by (0.054) at middle stratum and was recorded minimum (0.042) at lower stratum.

4.2 Natural Regeneration of *Picea smithiana*

The data pertaining to regeneration status of *Picea smithiana* presented under sub heading of number of recruits/ha, number of un-established regeneration/ha, number of established regeneration/ha, stocking index, and regeneration success percent.

4.2.1 Recruits/ha.

The data presented in Table 6 exhibited a greater variation with respect to number of recruits/ha of Spruce recorded along the altitudinal gradient in the selected strata of Daksum Forest range. The maximum (1111.11 ± 180.46) number of recruits/ha was recorded at middle stratum followed by (833.33 ± 126.18) at lower stratum and minimum number of recruits/ha (729.16 ± 96.99) were present at higher stratum.

4.2.2 Unestablished Regeneration /ha.

The data tabulated in Table 6 revealed that the number of unestablished regeneration /ha also varied along the altitudinal gradient in the selected strata of Daksum Forest range. The maximum (659.72 ± 146.52) number unestablished regeneration /ha was recorded at middle stratum followed by (451.38 ± 136.28) at lower stratum and minimum number of unestablished regeneration /ha (381.94 ± 64.03) were present at higher stratum.

Table 6: Natural regeneration status of *Picea smithiana* at different altitudes of study area (n = 6)

Site (masl)	Recruits/ha	Unestab. Reg. /ha	Estab. Reg. /ha	Stocking index (I ₁)	Regeneration success (%) (I ₁ ×100)
	(Mean ± S.E)				
Ahlen (2200-2400)	833.33 ± 126.18	451.38 ± 136.28	243.05 ± 38.04	0.1423	14.23
Deesu (2400-2600)	1111.11 ± 180.46	659.72 ± 146.52	312.5 ± 46.59	0.1909	19.09
Harkani (2600-2800)	729.16 ± 96.99	381.94 ± 64.03	208.33 ± 85.06	0.1215	12.15

n = number of sampling plots; masl = meters above sea level; S. E. = Standard Error



Recruits of Spruce



Unestablished regeneration of spruce

Plate 7: Regeneration of Spruce at Daksum Range

4.2.3 Established regeneration/ha

The data tabulated in Table 6 further revealed that the number of established regeneration /ha also varied along the altitudinal gradient in the selected strata of Daksum Forest range. The maximum (312.5 ± 46.59) number established regeneration /ha was recorded at middle stratum followed by (243.05 ± 38.04) at lower stratum and minimum number of established regeneration /ha (208.33 ± 85.06) were present at higher stratum.

4.2.4 Stocking index (I_1)

The data summarized in Table 6 revealed that the maximum value (0.1909) of Stocking index (I_1) was recorded at middle stratum followed by (0.1423) at lower stratum and minimum value (0.1215) of Stocking index (I_1) was found at higher stratum.

4.2.5 Regeneration per cent

Data presented in Table 6 further depicts that the maximum value (19.09 %) of regeneration per cent was recorded at middle stratum followed by (14.23) at lower stratum and minimum value (12.15) of regeneration per cent was found at higher stratum.

4.3 Soil and site Studies

4.3.1 Solar influx (%)

The perusal of data in Table 7 revealed that the solar influx decreased with increase in elevation. The maximum solar influx outside canopy (7230 lux) was recorded at lower stratum followed by (7180 lux) at middle stratum and was recorded minimum (6862 lux) at higher stratum. The data in table 7 further revealed that the maximum solar influx inside canopy (1884 lux) was recorded at lower stratum followed by (1475 lux) at middle stratum and was recorded minimum (1345 lux) at higher stratum. The table7 further depicted that the maximum solar influx (26.05 %) was recorded at lower stratum followed by (20.54 %) at middle stratum and was recorded minimum (19.60%) at higher stratum.

4.3.2 Organic matter layer (cm)

The data tabulated in Table 7 revealed that depth of organic matter layer increased with altitude of study sites in Daksum forest range. The maximum depth of organic matter layer (3.59 ± 0.47 cm) was recorded at higher stratum followed by (2.97 ± 0.27 cm) at middle stratum and was recorded minimum (2.03 ± 0.25 cm) at lower stratum.

4.3.3 Crown Projection ratio

Data presented in Table 8 further depicts that the maximum value (19.09 %) of Average crown width (2.877 ± 0.097 m) was recorded at middle stratum followed by (2.465 ± 0.340 m) at lower stratum and minimum value (2.208 ± 0.309 m) was recorded at higher stratum. The table 8 further depicted that the maximum average stem diameter (0.363 ± 0.088 m) was recorded at higher stratum followed by (0.335 ± 0.082 m) at middle stratum and was recorded minimum (0.274 ± 0.050 m) at lower stratum. The data further revealed that the maximum value (16.864) of Crown Projection ratio was found at middle stratum followed by (12.296) at lower stratum and minimum value (11.077) was found at higher stratum.

Table 7: Site characteristics at different altitudes of study area

Site (masl)	Solar influx (lux)		Solar influx (%)	Organic matter layer(cm)
	Outside canopy(Open)	Under Canopy		(Mean ± S.E) n = 10
Ahlen (2200- 2400)	7230	1884	26.05	2.03 ± 0.25
Deesu (2400- 2600)	7180	1475	20.54	2.97 ± 0.27
Harkani (2600- 2800)	6862	1345	19.60	3.59 ± 0.47

Table 8: Crown Projection Ratio of *Picea smithiana* at different altitudes of study area (n = 30)

Site (masl)	Av. crown width (m)	Av. stem diameter (m)	CPR
	(Mean ± S.E)		
Ahlen (2200-2400)	2.465 ± 0.340	0.274 ± 0.050	12.296
Deesu (2400-2600)	2.877 ± 0.097	0.335 ± 0.082	16.864
Harkani (2600-2800)	2.208 ± 0.309	0.363 ± 0.088	11.077

CPR = Crown Projection Ratio; masl = meters above sea level; S. E. = Standard Error

4.3.4 Soil characteristics

The available concentration of different soil nutrient (N, P, K, Fe and Zn), soil pH, and organic carbon at different strata of Daksum forest range has been given in Table 9 as under:

4.3.4.1 Soil pH

Data presented in Table 9 depicts that at depth 0-15 cm, the maximum soil pH (5.91) was recorded at lower stratum followed by (5.61) at middle stratum and minimum soil pH of (5.43) was recorded at higher stratum. Similarly at depth 15-30 cm, the maximum soil pH (6.06) was recorded at lower stratum followed by (5.82) at middle stratum and minimum soil pH of (5.57) was recorded at higher stratum.

4.3.4.2 Organic Carbon (%)

The data tabulated in Table 9 revealed that at depth 0-15 cm, the maximum soil organic Carbon (2.21 %) was recorded at higher stratum followed by (2.09 %) at middle stratum and minimum soil organic Carbon of (1.82 %) at lower stratum. Similarly at depth 15-30 cm, the maximum Organic Carbon (1.93 %) was recorded at higher stratum followed by (1.91 %) at middle stratum and minimum soil organic Carbon of (1.68%) at lower stratum.

4.3.4.3 Available Nitrogen (kg/ha)

The data tabulated in Table 9 revealed that at depth 0-15 cm, the maximum available soil Nitrogen (413.23 kg/ha) was recorded at higher stratum followed by (391.85 kg/ha) at middle stratum and minimum available soil Nitrogen (359.22 kg/ha) was found at lower stratum. Similarly at depth 15-30 cm, the maximum available soil Nitrogen (395.14 kg/ha) was recorded at higher stratum followed by (382.00 kg/ha) at middle stratum and minimum available soil Nitrogen (354.18 kg/ha) was recorded at lower stratum.

4.3.4.4 Available Phosphorus (kg/ha)

Data presented in Table 9 depicts that at depth 0-15 cm, the maximum available soil Phosphorus of (14.28 kg/ha) was recorded at higher stratum followed by (14.10 kg/ha) at middle stratum and minimum available soil Phosphorus of (12.95 kg/ha) was recorded at lower stratum. Similarly at depth 15-30 cm, the maximum available soil Phosphorous (13.67 kg/ha) was recorded at higher stratum followed by (13.04 kg/ha) at middle stratum and minimum available soil Phosphorus of (12.78 kg/ha) was recorded at lower stratum.

4.3.4.5 Available Potassium (kg/ha)

The data tabulated in Table 9 revealed that at depth 0-15 cm, the maximum available soil Potassium (305.61 kg/ha) was recorded at higher stratum followed by (293.18kg/ha) at middle stratum and minimum available soil Potassium (274.79 kg/ha) was found at lower stratum. Similarly at depth 15-30 cm, the maximum available soil Potassium (296.21 kg/ha) was recorded at higher stratum followed by (279.71 kg/ha) at middle stratum and minimum available soil Potassium (266.63 kg/ha) was recorded at lower stratum.

4.3.4.6 Available Zinc (mg/kg)

Data presented in Table 9 depicts that at depth 0-15 cm, the maximum available soil Zinc (1.39 mg/kg) was recorded at higher stratum followed by (1.15 mg/kg) at middle stratum and minimum available soil Zinc (1.06mg/kg) was found at lower stratum. Similarly at depth 15-30 cm, the maximum available Zinc (1.23 mg/kg) was recorded at higher stratum followed by (1.04 mg/kg) at middle stratum and minimum available Zinc (0.97mg/kg) was recorded at lower stratum.

4.3.4.7 Available Iron (mg/kg)

Data presented in Table 9 depicts that at depth 0-15 cm, the maximum available soil Iron (15.09 mg/kg) was recorded at higher stratum followed by (14.29 mg/kg) at middle stratum and minimum available soil Iron (14.03 mg/kg) was found at lower stratum. Similarly at depth 15-30 cm, the maximum available

Table 9: Chemical properties of soil at different altitudes of study area

Parameters	Site (masl)					
	Ahlen (2200-2400)		Deesu (2400-2600)		Harkani (2600-2800)	
	Depths(cm)					
	0-15	15-30	0-15	15-30	0-15	15-30
Soil pH	5.91	6.06	5.61	5.82	5.43	5.57
Organic Carbon (%)	1.82	1.68	2.09	1.91	2.21	1.93
Available Nitrogen (kg/ha)	359.22	354.18	391.85	382.00	413.23	395.14
Available Phosphorus (kg/ha)	12.95	12.78	14.10	13.04	14.28	13.67
Available Potassium (kg/ha)	274.79	266.63	293.18	279.71	305.61	296.21
Available Zinc (mg/kg)	1.06	0.97	1.15	1.04	1.39	1.23
Available Iron (mg/kg)	14.03	13.11	14.29	13.74	15.09	14.26

Table 10: Seed viability percent of soil seed bank of *Picea smithiana* at different altitudes of study area

Altitudes	Seed viability (%)
Ahlen (2200-2400m)	18.18
Deesu (2400-2600m)	15.38
Harkani (2600-2800)	16.36

masl = meters above sea level

Iron (14.26 mg/kg) was recorded at higher stratum followed by (13.74 mg/kg) at middle stratum and minimum available Iron (13.11 mg/kg) was recorded at lower stratum.

4.3.5 Soil seed bank

Data presented in Table 10 depicts that the maximum viability (18.18 %) of soil seed bank was recorded at lower stratum followed by (15.38 %) at middle stratum and minimum viability of (16.36 %) was recorded at higher stratum.

Chapter-5

DISCUSSION

The results emerged out of the present investigation entitled “Regeneration status of Spruce (*Picea smithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division” presented in the previous chapter have been discussed in this chapter under the following headings:

- 5.1 Community structure
- 5.2 Natural Regeneration
- 5.3 Soil and site studies

5.1 Community structure

The study on community structure offers the comprehensive details about the composition of trees, shrubs and herbs populations and understanding the factors affecting plant community growth in high elevation environments requires documentation of plant community composition and structure. The structure of a community is determined by dominating plant species (Mir *et al.* 2017; Odum, 1971). In the present study significant differences in floristic composition of trees, shrubs and grass species in three sites were observed. It may be due to the fact that the sites were located far distant from one another and there was great variation in altitude. It may be also due to the change in micro climatic conditions of the sites because of change in altitude. There was a change in understory and ground vegetation with change in dominance of above storey tree species which may be due to well adaptability of these species under those dominant tree species. The plant community organizational analysis of the study area revealed a total of 47 plant species belonging to 28 families out of which 4 tree species, 11 shrub species and 32 herb species were recorded at all the three study sites. Out of 47 plant species (table 1) recorded only 18 species were common to all three study sites, which include 03 tree species (*Abies pindrow*, *Pinus wallichiana* and *Picea*

smithiana), 02 shrub species (*Berberis lyceum* and *Viburnum grandiflorum*) 13 herb species (*Arisaema jacquemontiana*, *Capsella bursa pastoris*, *Cirsium falcorneri*, *Cynodon dactylon*, *Impatiens thomsonii*, *Malva neglecta*, *Poa annua*, *Poa bulbosa*, *Poa pratensis*, *Ranunculus hirtellus*, *Rumex dentatus*, *Taraxacum officinale*, *Stipa sibirica* and *Verbascum Thapsus*). The result of the present study are in line to that of 48 species belonging to 28 families from temperate forest between 3000-3600m altitude of Sindh Forest division of Sonamarg and 54 plants species belonging to 28 families from temperate forest of Gulmarg Forests of Tangmarg Forest division of Kashmir Himalayas reported by Mir *et al.* (2017). The results were also in concurrence with the reports of Singh *et al.* (2018) who reported 50 species belonging to 21 families in the form of herbs, shrubs and trees in Range grasslands of Daksum range grasslands in Kashmir valley. The species richness of the vegetation in the present study follow the trend as herb layer > shrub layer > tree layer i.e., 32 herb species, 11 shrub species and 04 tree species which is similar to that reported by Bhat (2017) as 38 herb species, 11 shrub species and 04 tree conifers in Batkote block of Pahalgam range of Kashmir Himalayas and 39 herb species, 17 shrub species and 05 tree species reported by Rather (2014) in Kandi Range of Kamraj Forest Division and Dar *et al.* (2011) have also reported in Branwar temperate coniferous forests of Kashmir which comprised of 05 tree, 07 shrub and 64 herb and grass species.

The highest number of plant species (06) recorded at all study sites belonged to families Asteraceae, Poaceae and Rosaceae followed by (03) for Fabaceae and Pinaceae (02) for Amaranthaceae and Plantaginaceae while Aceraceae, Adoxaceae, Aracaceae, Balsaminaceae, Berberidaceae, Brassicaceae, Cannabaceae, Ericaceae, Geraniaceae, Hamamelidaceae, Lamiaceae, Malvaceae, Phytolaccaceae, Polygonaceae, Ranunculaceae, Saxifragaceae, Scrophulariaceae and Urticaceae were represented by one species each. Singh *et al.* (2018) and Adil (2019) have also reported similar dominant families (Asteraceae, Fabaceae,

Rosaceae, Pinaceae and Poaceae) from Daksum grasslands of Kashmir valley and conifer forests of Shopian Forest Range respectively.

The density of trees ranged from minimum of 41.66 ± 15.36 individuals/ha for *Acer caesium* at higher stratum to a maximum of 391.66 ± 41.67 individuals/ha for *Pinus wallichiana* at lower stratum (Table 2). The tree density is in the range value of 83 to 288 individuals/ha reported by Bhat (2017) in conifers in Batkote block of Pahalgam range of Kashmir. The frequency of trees ranged from minimum of 25 ± 11.18 percent for *Acer caesium* at higher stratum to a maximum of 91.66 ± 8.33 percent for *Pinus wallichiana* at lower stratum (Table 2) which is in range of 29 percent to 100 percent as reported by Adil (2019) in conifer forests of Shopian Forest Range respectively. The basal area of trees 6.62 ± 0.17 m²/ha for *Acer caesium* at higher stratum to that of *Picea smithiana* 161.45 ± 9.17 m²/ha at middle stratum which is in line with 02.53 to 98.97 m²/ha reported by Singh *et al.* (2018) Daksum Forest Range. The IVI of the tree species shown in Table 2 shows that *Pinus wallichiana* were dominant at lower stratum, *Picea simthiana* was dominant at middle stratum respectively, whereas at higher stratum most dominant species was *Abies pindrow*. For lower stratum *Pinus wallichiana* was the dominant species with IVI value of 134.37 followed by *Picea simthiana* (99.79). *Picea smithiana* had the highest IVI value of (136.62) at middle stratum followed by *Abies pindrow* with IVI value of (102.62). *Abies pindrow* with IVI value of 119.37 was the most dominant species at higher stratum followed by *Picea smithiana* (107.63) and *Pinus wallichiana* (54.11). Rather (2014) in Kandi Range of Kamraj Forest Division reported that *Cedrus deodara* and *Pinus wallichaina* were the most dominant species on lower altitude site while *Abies pindrow* and *Picea smithiana* were the dominant species on middle and upper altitude ranges. These results are supported by studies conducted by Adil (2019) who stated similar results in conifer forests of Shopian Forest Range respectively.

The total shrub population varied considerably among the selected sites. The structural characteristics like density and basal area showed marked variation

among different sites. The density of shrubs ranged from minimum of 150 ± 42.82 individuals/ha for *Rosa brunonii* at middle stratum to a maximum of 483.33 ± 83.35 individuals/ha for *Viburnum grandiflorum* at higher stratum (Table 3). The density of shrub is within the range of 144.44 to 488.66 individuals/ha reported by Bhat (2017) in Batkote block of Pahalgam range of Kashmir Himalayas. The frequency of shrubs ranged from minimum of 25 ± 6.45 % for *Rosa brunonii* at middle stratum to a maximum of 79.16 ± 10.03 % for *Viburnum grandiflorum* at middle stratum (Table 3). The basal area of shrubs ranged from minimum of 0.62 ± 0.01 m²/ha for *Rosa brunonii* at middle stratum to a maximum of 3.60 ± 0.28 m²/ha *Viburnum grandiflorum* at higher stratum (Table 3). Among the shrubs lower stratum was dominated by *Berberis lyceum* with IVI of 75.00 and *Viburnum grandiflorum* was dominant at middle and higher stratum with IVI of 75.15 and 91.82 respectively as presented in Table 3. The IVI values are in the range of 34.04 to 130.60 reported by Geelani *et al.* (2018) in Romshi Range of Shopian forest division.

Similarly, in case of herb population the highest density was recorded in (9.91 ± 1.57 tillers/m²) for *Poa annua* at lower stratum and *Cynodon dactylon* was with highest density at both middle and higher stratum with density of (12.97 ± 1.60 tillers/m²) and (10.66 ± 1.46 tillers/m²) respectively. The density of herb species ranged from minimum of (0.58 ± 0.16 tillers/m²) for *Matricaria chamomilla* at lower stratum to a maximum of (12.97 ± 1.60 tillers/m²) for *Cynodon dactylon* at middle stratum (Table 4). The density of herbs fall in line with the 0.93 - 11.27 tillers/m² reported by Adil (2017) in conifer forests of Shopian Forest Range respectively. The frequency of herb species ranged from minimum of (29.16 ± 5.27 %) for *Cirsium falconeri* at higher stratum to a maximum of (87.5 ± 4.56 %) for *Stipa sibirica* at lower stratum. The basal area of herb species ranged from minimum of (0.42 ± 0.05 cm²/ m²) for *Urtica dioica* at middle stratum to a maximum of (8.01 ± 1.08 cm²/ m²) for *Stipa sibirica* at middle stratum (Table 4). Among the herbs lower stratum was dominated by *Poa annua*,

with IVI of 24.85 and was dominant at middle and higher stratum with IVI of 33.70 and 32.13 respectively as presented in Table 3. The IVI values are in the range of 4.81 to 24.90 reported by Mir *et al.*, 2017 in *Betula utilis* stands in the high altitude forests of Central and North Kashmir.

The spatial variation of Shannon-Weiner diversity index of plant communities can be a basic but powerful predictor for assessing community diversity (Mir *et al.*, 2017). The value for Shannon Weiner diversity index (H') for trees ranged from minimum of (1.14) at middle stratum was recorded maximum (1.48) at higher stratum (Table 5). The values fall within the range of 1.76 to 2.16 reported by Bhat (2017) in conifers in Batkote block of Pahalgam range of Kashmir. The value for Shannon Weiner diversity index (H') for Shrubs ranged from minimum of (1.698) at middle stratum was recorded minimum (1.992) at higher stratum (Table 5). The values fall within the range of 1.76 to 2.16 reported by Bhat (2017) in conifers in Batkote block of Pahalgam range of Kashmir. The value for Shannon Weiner diversity index (H') for herbs was (3.244) at lower stratum (3.063) at middle stratum and (2.855) at higher stratum (Table 5). The reason for decrease can be attributed to reduction in herb diversity or number of herb species with increase in elevation. The results are in conformity with that of Singh *et al.* (2018) while he was working in Daksum grasslands of Kashmir valley.

The spatial variation Simpson's index of dominance (C_d) followed the inverse of Shannon-Weiner diversity index. Dominance index ranged from (0.320-0.359) in case of trees (0.180-0.200) in shrubs and (0.42-0.63) in case of herbs (Table 5). These results find support from the findings of Bhat (2017) while working on phytosociology in Batkote block of Pahalgam forest range.

5.2 Natural Regeneration

With respect to different regeneration parameters of *Picea smithiana* viz. number of recruits/ha, number of un-established regeneration/ha, number of

established regeneration/ha, stocking index and regeneration success percent, variation in regeneration was observed in all three strata along the altitudinal gradient in the Daksum forest region. The value for number of recruits/ha ranged from minimum of (729.16 ± 96.99) at higher stratum was recorded maximum (1111.11 ± 180.46) at middle stratum (Table 6). The results are in conformity with the findings of Parrey *et al.* (2017) who reported the range of $(617.19-1093.25)$ recruits/ha of *Picea smithiana* in forests of South-Kashmir Himalayas. The value for un-established regeneration/ha number of ranged from minimum of (381.94 ± 64.03) at higher stratum was recorded maximum (659.72 ± 146.52) at middle stratum (Table 6). The value for established regeneration/ha number of ranged from minimum of (312.5 ± 46.59) at higher stratum was recorded maximum (243.05 ± 38.04) at middle stratum (Table 6). The present results are in conformity with the earlier works of Parrey *et al.* (2017) in south Kashmir, Bhat (2017) in conifers in Batkote block of Pahalgam range of Kashmir and Adil (2019) in conifer forests of Shopian Forest Range. Stocking index ranged from 0.1215 to 0.1909 at middle and higher stratum respectively similarly regeneration success percent ranged from 12.15 at middle stratum to 19.09 at higher stratum (Table 6). The results are thus in concurrence with the Malik *et al.* (2012) where they had reported similar results in Chilgoza Pine (*Pinus gerardiana*) species. The regeneration was not satisfactory in *Picea smithiana* and do not showed a regular trend along altitudinal gradient and the regeneration parameters of *Picea smithiana* viz. number of recruits/ha, number of un-established regeneration/ha, number of established regeneration/ha, stocking index and regeneration success percent were highest at middle stratum (Deesu) at elevation range of 2400-2600m masl (Table 6) and which can be attributed to better density/ha and IVI of *Picea smithiana* at the middle stratum. The results are thus in accordance with that of Parrey *et al.* (2017) in South Kashmir Himalayas where they had reported similar results in *Picea smithiana*, Lone *et al.* (2018) in North Kashmir Himalayas where they conducted a study on the regeneration status of Spruce (*Picea smithiana*)

along the altitudinal gradient and Ali (2011) while working on regeneration of Betula in Sangla Valley of Himachal Pradesh

5.3 Soil and site studies

The solar influx (%) was found to be highest (26.05 %) for lower stratum followed by (20.54 %) at middle stratum and lowest (19.60 %) for Higher stratum (Table 7). The values fall within the range of (15.37 – 30.47 %) reported by Mahajan (2010) in Solan forest division while assessing the regeneration and growth attributes of Chirpine. The solar influx (%) decreased with increase in altitude of study area as supported by the findings of Ali (2011) who worked on solar influx in the Betula forests of Sangla valley of Himachal Pradesh.

Forest habitats contribute a large amount of organic matter to soil in the form of needles, leaves, twigs, stems, flowers, and fruits, which after decomposition by microorganisms result in the formation of organic carbon and the release of various nutrients (Rather, 2014; Ali, 2011). The depth of organic matter layer (3.59 ± 0.47 cm) was recorded highest at higher stratum followed by (2.97 ± 0.27 cm) at middle stratum and was recorded minimum (2.03 ± 0.25 cm) at lower stratum (Table 7). The values are found lesser (4.80 ± 0.55 to 6.20 ± 0.40 cm) as recorded by Ali (2011) in Betula forests Himachal Pradesh. The depth of organic matter layer increased with increase in altitude in the study area. This can be attributed to lower decomposition of organic matter due to low solar influx (Table 7) at higher altitude.

The Crown Projection ratio was found highest (16.864) at middle stratum followed by (12.296) at lower stratum and minimum value (11.077) was found at higher stratum (Table 8). This can be attributed to higher number of recruits and unestablished regeneration (Table 4) at middle stratum which owing to lesser stem diameter and wider crown width show higher crown projection ratio. The results are supported by the studies conducted by Mahajan (2010) in Solan forest which

showed decreasing trend of Crown projection ratio with the increase in diameter of trees the in forests of Chirpine.

The pH of the soil was acidic ranged from 5.43 at (0-15cm) depth of higher stratum to 6.06 at (15-30 cm) depth of lower stratum (Table 9). The acidic nature of the forest soil is generally attributed to the release of greater number of H^+ ions from the decomposing resinous organic residues. The pH decreased with increasing altitude of the study area which can be attributed to higher levels of organic matter at higher altitude (Table 7) results in greater cation exchange which tends to decrease the soil pH with increase in altitude. These results are in accordance with the findings of Mahajan (2010), Rather (2014) and Mir *et al.* (2017).

The organic carbon (%) of the soil was high ranged from 1.68 % at (15-30cm) depth of lower stratum to 2.21 % at (0-15 cm) depth of higher stratum (Table 9). The percentage organic carbon increased with increasing altitude of the study area. This can be attributed to higher depth organic matter layer at higher altitudes (table 7) which after decomposition by microorganisms result in the formation of organic carbon (Mir *et al.*, 2017; Rather, 2014; Ali, 2011).

The available Nitrogen of the soil was medium to high ranged from (354.18 kg/ha) at (15-30 cm) depth of lower stratum to (413.23 kg/ha) at (0-15 cm) depth of higher stratum (Table 9).The results are in line with the (177 – 310 kg/ha) reported of Rather (2014) in Kandi Range of Kamraj Forest Division. The available Phosphorus of the soil was medium ranged from (12.78 kg/ha) at (15-30cm) depth of lower stratum to (14.28 kg/ha) at (0-15 cm) depth of higher stratum (Table 9). The results are in line with the (3.73 - 11.23) kg/ha reported of Rather (2014) in Kandi Range of Kamraj Forest Division and lesser (23.60-36.45) kg/ha reported by Ali (2011) in Betula forests of Sangla Valley in Himachal Pradesh. The available Potassium of the soil was medium to high ranged from (266.33 kg/ha) at (15-30 cm) depth of lower stratum to (305.61 kg/ha) at (0-15 cm) depth of higher stratum (Table 9). The results are in line with

the (285.65-368.00 kg/ha) reported by Ali (2011) in *Betula* forests of Sangla Valley in Himachal Pradesh and (171.14-219.54kg/ha) reported by Mir *et al.* (2017) in the high altitude forests of Central and North Kashmir. The available Zinc of the ranged from (1.06 mg/kg) at (15-30 cm) depth of lower stratum to (1.39 mg/kg) at (0-15 cm) depth of higher stratum (Table 9) which is in range of (0.25 – 1.53 mg/kg) reported by Nazir and Samweel (2013) in Pine and oak forests in Temperate valley of Garhwal Himalaya. The available Iron of the soil ranged from (13.11 mg/kg) at (15-30cm) depth of lower stratum to (15.09 mg/kg) at (0-15 cm) depth of higher stratum (Table 9) which lies in the range of (9.23-98.67 mg/kg) reported by Nazir and Samweel (2013) in Pine and oak forests in Temperate valley of Garhwal Himalaya. There was gradual decline in the availability of nutrients towards lower soil layers which could be due to low aeration, microbial activities and C/N ratio in sub surface soils. Another cause may be nutrient photo-cycling, in which the deep tap root system extracts components from lower layers and deposits them in surface soils. The source of Nitrogen, Phosphorus, and Zinc in the soil is organic matter. Singh and Singh (1987) observed highest nitrogen content in the litter of *Abies pindrow* (1.47%) followed by *Picea smithiana* (0.82%) and *Pinus wallichiana* (0.77%). The available N, P, and Zn increased with increase in altitude of the study area which can be attributed to higher depth organic matter layer at higher altitudes (table 7) which after decomposition by microorganisms result in the formation of Nitrogen, Phosphorous and Zinc. The results are also in accordance with the findings of number of researchers like Padder (2017), Rather (2014) and Ali (2011). Similar results of increase in availability of N, P and Zn values with increase in altitude draw support from work of Mahajan (2010) and Malik (1992) for chirpine forests of Himachal Pradesh.

The viability of soil seed bank of Spruce was found very low at the study area ranged from 15.36 % at middle stratum to 18.18 % at lower stratum which can be attributed to timing of preceding good seed year (2017) which occurred 2-3

years before the extraction of soil seed bank from study area. The findings are backed up by a number of researchers who found that the viability of naturally dispersed seeds of spruces (*Picea*) and a variety of pines (*Pinus*) usually lasts for one and rarely for two growing seasons (Azures *et al.*, 2009; Stein *et al.*, 1974). The well-known inability of conifer seeds to survive in seed banks for more than a year has been recorded in a variety of forest communities throughout North America as seed bank studies from both the United States and Canada have documented very short seed longevity of 1-2 years in soil seed bank for major conifers (Azures *et al.*, 2009; Zasada *et al.*, 1983).

Chapter-6

SUMMARY AND CONCLUSION

In order to meet the objectives of the study entitled “Regeneration status of Spruce (*Picea smithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division” conducted in Daksum range of Anantnag Forest division research was carried out using stratified random sampling of 0.01% along the altitudinal gradation at three strata namely Ahlen (2200-2400 m), Deesu (2400-2600m) and Harkani (2600-2800m) during the year 2019-2020. In the study area 6 sample plots of size 20m x 50m were laid randomly on 3 transects laid vertically 200m apart from each stratum to record the observations for different parameters of research work. For community structure studies 12 quadrats for trees of size 10 x 10m, 24 quadrats for shrubs of 5 x 5m and 48 quadrats of 1 x 1m for herbs were laid at each stratum. To assess the regeneration of Spruce, data were collected for the number of recruits, established plants and number unestablished regeneration, 72 sampling units each having size 2m x 2m were randomly selected from the 6 main plots of 20 x 50m laid on 3 transects at each stratum. Studies on soil chemical characteristics were carried out by taking composite samples at two depths, i.e., 0-15cm and 15-30cm separately for all the strata of study area. These samples were analyzed for estimation of pH, organic carbon (%), available Nitrogen, Phosphorus, Potassium, Iron and Zinc. At every stratum observation like stem diameter, crown width and crown projection ratio of Spruce were also recorded. The information regarding soil seed bank, depth of organic matter layer and solar influx were also collected from the selected plots. The results of the investigation are summarized and conclusions arrived at are mentioned here in

6.1 Community structure

A total of 47 plant species belonging to 28 families consisting of 4 tree species, 11 shrub species and 32 herb species were recorded in the study area. The higher number of plant species 37 (3 trees, 6 shrubs and 28 grasses & herbs) was

recorded on lower stratum, followed by 36 (3 trees, 8 shrubs and 25 grasses & herbs) on middle stratum and 31(4 trees, 8 shrubs and 19 grasses & herbs) on higher stratum (figure 1). The density of trees, shrubs and herbaceous species ranged between (41.66 ± 15.36 to 391.66 ± 41.67) trees/ha, (150 ± 42.82 to 433.33 ± 55.78) shrubs/ha and (0.58 ± 0.16 to 12.97 ± 1.60) tillers/m² respectively at all the three strata. The frequency of trees, shrubs and herbs ranged between (25 ± 11.18 to 91.66 ± 8.33) % , (25 ± 6.45 to 79.16 ± 10.03) % and (29.16 ± 5.27 to 87.5 ± 4.56) % respectively at all the three strata. The basal area of trees, shrubs and herbs ranged between (6.62 ± 0.17 to 161.45 ± 9.17) m²/ha, (0.62 ± 0.01 to 3.60 ± 0.28) m²/ha and (0.42 ± 0.05 to 8.01 ± 1.08) cm²/ m² respectively at all the three strata. The IVI value of trees, shrubs and herbs ranged between (8.52 to 134.37), (23.50 to 91.82) and (3.65 to 34.01) respectively at all the three strata. Shannon-Weiner diversity index followed the sequence herbs > shrubs > trees which ranged between (1.048 to 1.144) for trees (1.698 to 1.992) for shrubs and (2.855 to 3.244) for herbs. Simpson's index of dominance followed the sequence trees > shrubs > herbs which ranged between (0.320 to 0.365) for trees (0.149-0.200) for shrubs (0.042 to 0.063) for herbs (Table 5).

6.2 Natural regeneration

The variation in regeneration parameters of *Picea smithiana* was observed in all three strata along the altitudinal gradient in the Daksum forest region. The results on regeneration studies depicted that the maximum number of recruits (/ha), unestablished regeneration, established regeneration, Stocking index and Regeneration success recorded for *Picea smithiana* was found at middle stratum Deesu with altitude (2400-2600) masl was 1111.11, 659.72, 312.5, 0.1909 and 19.09 respectively and was recorded the best stratum as far as regeneration status of *Picea smithiana* is concerned in Daksum forest range.

6.3 Soil and site characteristics

The solar influx (%) decreased with altitude of different strata of study

area and ranged from 19.60 % to 26.05 % (Table7). The depth of organic matter layer increased with altitude of study area and ranged from $(2.03 \pm 0.25$ to $3.59 \pm 0.47)$ cm (Table7). The Crown Projection ratio was found maximum (16.864) at middle stratum with altitude of (2400-2600) masl (Table 8).

The variation in soil chemical properties was observed across the altitudinal gradient. Soil pH data of study area indicate that the soil is acidic in nature ranged from 5.23 to 6.07. The pH decreased with increasing altitude of the study area. Higher levels of organic matter at higher altitude (Table 7) which results into greater cation exchange tend to decrease the soil pH with increase in altitude. The OC available N, P, K and Zn of soil was ranged between (1.68- 2.21 %), (354.18 – 43.23 kg/ha), (12.78-14.28 kg/ha), (266.33 - 305.61 kg/ha) and (1.06 - 1.39 mg/kg) respectively. The available N, P, and Zn increased with increase in altitude of the study area which can be attributed to higher depth organic matter layer at higher altitudes (table 7) which after decomposition by microorganisms result in the formation of Nitrogen, Phosphorous and Zinc. The available Iron of the soil ranged between (13.11-15.09 mg/kg) which increased with altitude. The viability of soil seed bank of Spruce was found very low at the study area ranged between (15.36 to 18.18 %).

CONCLUSION

The present investigation study entitled “Regeneration status of Spruce (*Picea smithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division” can be concluded as:

- The studies on community structure of Spruce of the study area manifested presence of 47 plant species of 04 tree species, 11 shrub species and 32 herb species belonging to 28 families
- i. Lower stratum Ahlen of altitude (2200-2400m) hosted 37 plant species of which trees, shrubs and herb species were 03, 06 and 28 respectively.

- ii. Middle stratum Deesu of altitude (2400-2600m) hosted 36 plant species of which trees, shrubs and herb species were 03, 08 and 25 respectively.
 - iii. Higher stratum Harkani of altitude (2600-2800m) hosted 31 plant species of which trees, shrubs and herb species were 04, 08 and 19 respectively.
- The study area host a remarkable floristic richness with majority of species belong to the belonged to families Asteraceae, Poaceae and Rosaceae followed by Fabaceae and Pinaceae.
 - With change in tree associates of Spruce, the shrub and herb vegetational components also changed at all three strata.
 - The species composition and structure reveals that Daksum forest range is a Fir/Spruce dominated forest.
 - The community structure of Spruce revealed that among trees species *Pinus wallichiana*, *Abies pindrow* and *Acer ceasium* were associated with the Spruce in the study area. The dominant shrub associates of Spruce were *Viburnum grandiflorum*, *Berberis lyceum*, *Sorbia tomentosa* and *Rosa* spp. while the dominant herb species were *Poa* spp., *Cynodon dactylon*, *Stipa sibirica*, *Arisaema jacquemontiana* and *Trifolium* spp.
 - Shannon-Weiner diversity index of herbs > shrubs > trees in the study area while Simpson's index of dominance of trees > shrubs > herbs in the study area.
 - The regeneration of Spruce was low and but did not showed any definite trend along the altitudinal gradient.
 - Based on the regeneration parameters, the regeneration of Spruce at middle stratum (Deesu) of altitude 2200-2400m masl has been found best

far as regeneration status of Spruce is concerned in Daksum range of Anantnag forest division.

- The solar influx (%) decreased while the depth of organic matter layer increased with altitude of study. The Crown Projection ratio and was found maximum at middle stratum and so not showed a regular trend with altitude.
- There was a decrease in availability of OC, N, P, K, Fe and Zn with increase in soil depth. However, soil pH increased with increase in soil depth in all the strata of study area.
- There was an increase in soil availability of OC, N, P, K and Zn while decrease in pH and available Fe with the increase in altitude of study area.
- The viability of soil seed bank of spruce was found to be very low at study area.
- It may be concluded that the Spruce forests of Daksum range and all other ecosystems needs to be controlled and managed so as to increase the regeneration and species diversity of forests.

RECOMMENDATIONS:

- The spruce stands were found highly associated with *Viburnum* in Study area. Leachates of humus and foliage of *Viburnum* have been reported to be responsible for regeneration failure of Spruce (Singh *et al.*, 2011). Herbs like *Strobilanthus* and *Impatiens* which are considered indicators of unfavorable condition for natural regeneration of Spruce were also found on all the three elevation of study area. So, we must keep a check on above mentioned undergrowth in Spruce bearing stands.
- The Spruce bearing forests should be declared as reboisement areas where nature needs to be aided to restock them by artificial regeneration and more forest compartments containing Spruce should be managed under

ecological and protection working circle at least till sufficient regeneration establishment is attained.

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CERTIFICATE

Certified that all the corrections/amendments as suggested by External Examiner Dr. Mehraj A. Sheikh, D.F.O Lidder Forest Division during Viva-Voce examination held on 27-04-2021 have been incorporated in the manuscript entitled “**Regeneration status of Spruce (*Picea smithiana* Wall. Boiss) in Daksum Range of Anantnag Forest Division**” submitted by **Mr. Sameer Ahmad Wani (Regd. No. MSF-2018-87)**.

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