

# TEMPORAL CHANGES IN TREE SPECIES COMPOSITION IN KARSOG FOREST DIVISION, MANDI, HIMACHAL PRADESH

*STATUS REPORT*

HP State Centre on Climate Change, HIMCOSTE

Wednesday, 11 September 2019

## ACKNOWLEDGEMENT

The State Centre on Climate Change under the aegis of the HP Council for Science Technology & Environment (HIMCOSTE) acknowledges the assistance provided by the HIMCOSTE in the preparation of this report on Kullu district. Also express deep sense of gratitude and regards to Member Secretary (EC) for his inspiring guidance, constant encouragement, valuable suggestions and indefatigable supervision. Climate Change Centre extends deep gratitude all the forest divisions of Kullu districts for providing necessary data for achieving the objectives of status report.

Special thanks to Prof. (Dr) Kartar S. Verma (Former Director of Research Dr. YSP University of Horticulture & Forestry, Solan HP.) for evaluating the report and giving their valuable comments.

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## Introduction

The Himalayas cover a vast expanse of 595,000 square kilometres with 2,400 km of parallel mountain ranges encompassing parts of India, Pakistan, Afghanistan, China, Bhutan, Nepal, and Tibet. Situated between 72<sup>o</sup>- 91<sup>o</sup> E Longitudes and 27<sup>o</sup>-36<sup>o</sup> N Latitudes, the Himalayas separate the alluvial plains of Indian subcontinent on the south from the Plateau of Tibet to the north; and connects the mountains of near East and Central Asia with those in the East Asia. Further, the Himalayan landscape is characterised with a unique geographic and ecological profile and serves as a home to an array of rivers such as Yangtze Ganga, Brahmaputra, Ganga, Indus, Yarlung, Yangtze, Yellow, Mekong, and Nujiang, which serve as a critical water source for Asian countries.

The Himalayan ecological diversity is altitude dependent where climatic and topographic effects on ecosystems and biota become more pronounced with increasing gradient. Further, there exist stark differences between the eastern and the western Himalayas in altitude, precipitation, and vegetation patterns. The eastern Himalayas are four-times wetter than the western Himalayas with higher snowline, and rich biodiversity. Meanwhile, the western Himalayan ranges are farther apart from the plains with precipitous landscape and colder-drier climate. The altitude gradient and climatic conditions play a decisive role in determining the vegetative pattern in the bio-diverse rich ecology of the Himalayas. At the mountain foothills, there are tropical and sub-tropical broadleaf forests; temperate broadleaf mixed forests with a dominant canopy of oak and maple at the middle; and coniferous, sub-alpine, and alpine vegetation at the higher altitudes adorned with pine, hemlock, spruce, and fir conifers. Areas under inaccessible landscapes are characterised with alpine grasslands, high-altitude meadows, scrubland which is followed by snowline.

### *The Indian Himalayan Region*

The Indian Himalayan Region (IHR) is home to over 72 million people living in over 10 states covering 95 districts in a total geographic area of 5 lacks square km. With its foot-hills in Shivaliks at the south, the vast Himalayan region

expands to the Tibetan Plateau on the north, thus, serving as a natural northern boundary for India. The region covers three bio-geographic zones – trans Himalaya (cold deserts of Ladakh and Kargil in Jammu & Kashmir, Lahaul & Spiti in Himachal Pradesh), the Himalaya (north west parts of Jammu & Kashmir and Himachal Pradesh, Uttarakhand on west), and Eastern & North-east India (Sikkim, Arunachal Pradesh, and Darjeeling district of West Bengal, Manipur, Meghalaya, Mizoram, Nagaland, Tripura). According to the State Forest Report, 2011, around 42 per cent of the total IHR area is covered under forests (one-third of the total forest area in India) offering invaluable ecological security and resources to the country. As per the State of Forest Report 2017, around 22 per cent of India's total geographical area was found to be under forest cover, of which 2.99 per cent was under Very Dense Forest, 9.38 per cent under Moderately Dense Forest, and 9.18 per cent under Open Forest Area. In the Himalayan region, the extent of forest cover varies significantly across the Himalayan states. In terms of percentage of total geographic area under administrative boundary, in North-west region, Jammu & Kashmir, Himachal Pradesh, and Uttarakhand have 10.46%, 27.12%, and 45.43% of total area under forest cover, respectively; in Eastern region, Sikkim and Arunachal Pradesh had 47.14% and 79.96% respectively; and in North-Eastern region, states of Manipur, Meghalaya, Mizoram, Nagaland, Tripura had 77.69%, 76.45%, 86.27%, 75.33%, and 73.68% of their respective geographic area under forest cover.

### *Forests of Himachal Pradesh*

Himachal Pradesh is a mountainous state in the northernmost part of India, situated in the western Himalayas between latitude  $30^{\circ} 22' 40''$  N to  $33^{\circ} 12' 40''$  N and longitude  $75^{\circ} 45' 55''$  E to  $79^{\circ} 04' 20''$  E. Two-thirds of Himachal Pradesh's area (55,673 square km) comes under recorded forest area, however, only 27.12 per cent of this area is accounted under forest and tree cover. One-third of the state's geographic area remains permanently under snow glaciers and inaccessible cold deserts, thus is permanently beyond the tree line. Administratively, the forests are classified as Reserved (5.13 per cent), Protected (89.46 per cent), and Un-classed forest (5.41 per cent), within which

certain areas are categorised for specific wildlife, flora, and natural ecosystem protection.

**Table 1: Forest Classifications for Himachal Pradesh**

Forest Type	Altitude	Rainfall	Dominant Forests
<b>Tropical Dry Deciduous Forests</b>	>1000 m above mean sea level	100-150 cm/annum	<i>Shorea robusta</i> and other associates such as <i>Acacia catechu</i> , <i>Aegle marmelos</i> , <i>Feronia limonia</i> , <i>Anogeissus latifolia</i> , <i>Buchanania lanzan</i> , <i>Woodfordia fruitcosa</i> , <i>Indigofera pulchella</i> , <i>Eulaliopsis binata</i>
<b>Tropical Moist Deciduous forests</b>	>1000 m above mean sea level	100-200 cm/annum	<i>Olea cuspidata</i> , <i>Acacia modesta</i> and other associates such as <i>Pyrus pashia</i> , <i>Coriaria nepalensis</i> , <i>Rhus continus</i> , <i>Indigofera gerardiana</i> , <i>Prinsepia utilis</i>
<b>Subtropical Pine Forests</b>	1000-1800m above mean sea level	90-250 cm/annum	<i>Pinus roxburghii</i> and other associates such as <i>Terminalia chebula</i> , <i>Mallotus philippensis</i> , <i>Pyrus pashia</i> , <i>Syzygium cumini</i> , <i>Albizia chinensis</i> , <i>Emblica sp.</i> , <i>Acacia catechu</i> , <i>Murraya spp.</i> , <i>Rosa moschata</i>
<b>Himalayan Moist Temperate Forests</b>	1500-3300m above mean sea level	150-250 cm/annum	Chief Oaks - <i>Quercus leucotrichophora</i> , <i>Q. dilatata</i> Other associates such as <i>Rhododendron</i> , <i>Acer</i> , <i>Aesculus</i> , <i>Cedrus deodara</i>
<b>Himalayan Dry Temperate Forests</b>	>1,700m above mean sea level	< 100 cm/annum	Conifers - <i>Cedrus deodara</i> , <i>Pinus gerardiana</i> , <i>Junipers</i> , <i>Abies</i> , <i>Pinus wallichiana</i> Broad-leaved – <i>Acer</i> , <i>Quercus</i>
<b>Sub-Alpine Forests</b>	2,900-3,500m above mean sea level		Conifers – <i>Abies</i> , <i>Pinus wallichiana</i> Deciduous trees – <i>Betula utilis</i> , <i>Quercus semecarpifolia</i> , <i>Rhododendron</i>
<b>Moist Alpine Scrub</b>	>3,350 m above mean sea level		<i>Betula utilis</i> , <i>Berberis</i> , <i>Salix</i> , <i>Rosa</i> , <i>Aconitum</i> , <i>Lonicera</i>
<b>Dry Alpine Scrub</b>	>6,000 m above mean sea level		<i>Juniperus</i> , <i>Artemisia</i> , <i>Lonicera</i> , <i>Salix</i> , <i>Myricaria</i>

The forest types are also stratified as per the altitude driven four agro-ecological zones in Himachal Pradesh.

**Table 2: Agro-Ecological profile – Himachal Pradesh**

	Zone I	Zone II	Zone III	Zone IV
<b>Ecology</b>	Sub Montane & Low Hill Sub-tropical	Mid Hills Sub-humid	High Hills Temperate Wet	High Hill Temperate Dry
<b>Geographic Area (%)</b>	18.43	8.37	16.54	56.61
<b>Altitude</b>	240-1,000	1,001-1,500	1,501-3250	Above 2501



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(m)				
<b>Mean Annual Temp</b>	15°C - 23°C	14°C - 22°C	9.1°C - 20.6°C	9°C - 20°C
<b>Rainfall (mm)</b>	1,100	1,500	1,000	>1,500
<b>Dominant Forest</b>	Tropical mixed deciduous and thorn scrub	Sub-tropical pine forest	Himalayan Moist Temperate forest	Sub-alpine
<b>Native Species</b>	<i>Acacia catechu</i> , <i>Emblica officinalis</i> , <i>Dalbergia sissoo</i> , <i>Terminalia chebula</i> , <i>Cassia fistula</i> , <i>Anogeissus latifolia</i> , <i>Ziziphus jujube</i> <b>Shrubs -</b> <i>Euphorbia royleana</i> , <i>Adhatoda vasica</i> , <i>Vitex negundo</i> , <i>Woodfordia fruticosa</i>	<i>Pinus roxburghii</i> and its sub-types <i>Quercus incana</i> , <i>Lannea sp.</i> , <i>Lyonia ovalifolia</i> , <i>Rhododendron arboreum</i> , <i>Indigofera sp.</i> , <i>Myrsine sp.</i> , <i>Rubus sp.</i> <b>Himalayan Scrub -</b> <i>Diospyros melanoxylon</i> , <i>Emblica officinalis</i> , <i>Carrissa sp.</i> , <i>Dodonaea viscosa</i> , <i>Acacia catechu</i> , <i>Anogeissus sp.</i> <i>Lannea sp.</i> , <i>Cassia fistula</i> Dry evergreen bush- <i>Olea cuspidata</i> , <i>Punica granatum</i>	<b>Conifers -</b> <i>Pinus wallichiana</i> , <i>Cedrus deodara</i> , <i>Picea smithiana</i> , <i>Abies pindrow</i> <b>Broad-leaved -</b> <i>Quercus incana</i> , <i>Q. semecarpifolia</i> , <i>Q. dilatata</i> <i>Aesculus indica</i> , <i>Acer caesium</i> , <i>Prunus padus</i> , <i>Populu sciliata</i>	<b>Grass -</b> <i>Agropyron longeristatum</i> , <i>A. semicostatum</i> , <i>Brachypodium sylvaticum</i> , <i>Bromus asper</i> <b>Mesophytic Herbs -</b> <i>Primula</i> , <i>Anemone</i> , <i>Fritillaria</i> , <i>Iris</i> , <i>Gentiana spp.</i> <b>Other Herbs -</b> <i>Sedum crassipes</i> , <i>Primula minutissima</i> , <i>Saxifraga imbricata</i> , <i>Potentilla fruticosa</i> <b>Dwarf shrub -</b> <i>Juniperus wallichiana</i> , <i>J. communis</i> , <i>Caragana sp.</i>
<b>Districts</b>	Kangra, Una, Hamirpur, Bilaspur, Solan, and Parts of Chamba, Sirmaur	Parts of Chamba, Kangra, Mandi, Shimla, Sirmaur, Kullu, Kinnaur, Hamirpur, Bilaspur	Shimla, Chamba, Kangra, Mandi, Kullu, Solan, Sirmaur, Kinnaur, Lahaul&Spiti	Kangra, Lahaul&Spiti, Kinnaur, and Parts of Chamba, Mandi, Kullu, Sirmaur, Shimla

Himachal Pradesh is blessed with a rich biodiversity adorned with diverse natural ecosystems comprising 8 forest types, 38 sub-types, which are home to 3,295 plant species of the 45,000 found in India. 95 per cent of these species are endemic to the state and only 5 per cent known as exotic species have been introduced in the last 150 years. The state's forest ecosystem offers critical ecological, environmental, economic, and social support to the populace serving as a primary source of food, fuel, fodder, timber, and other non-timber forest

produce for both urban and rural population. However, these forest resources are currently experiencing greater stress with increasing pressure from burgeoning population and rising impact of anthropogenic activities. This temporal study was designed to get a preliminary insight into the current status of vegetation *viz.* species composition in Karsog Forest Division under the Mandi Forest Circle.

The next section outlines the details on study area and the adopted methodology with information on data sources and applied techniques of assessments. Following which, the section on Results and Findings discusses the outcomes for Mandi Forest divisions. The report concludes with a categorised and consolidated snapshot of species composition in the Mandi Forest Circle with information on tree community level variation with respect to altitudinal gradients and diameter classes.

## *Study area and methods*

### *District Mandi – A Background*

Mandi district (earlier known as Mandavya Nagar) is one of the central districts of Himachal Pradesh State in northern India. Mandi town is the headquarters of Mandi district. The town has mythological and historical significance and boasts of unique temple architecture. It is referred to as Chhota Kashi as there are many ancient temples in the city and on the banks of river Beas. District Mandi is situated between 31° 13'' to 32° 04' N and 76°37' to 77°23' E in the centre of Himachal Pradesh having total area 3959.604 sq. km. Karsog in district Mandi is a beautiful valley situated in the lap of Himalayas, near Shimla, at a height of 1,404 metres. It lies in the PirPanjal range of Himalayas bordering Shimla and Kullu districts.

Karsog falls under 'North Western Himalayan Hill Zone', agro-climatic region of India and 'agro-ecological sub-region- 14.3A15 (B/A) 9' defined by the planning commission of India (Project Report, 2011). Agro climatically Karsog fall under sub temperate humid region. The soil of the area is mainly sandy loam

to silty clay loam. The depth of the soil is shallow to moderate deep. The topography of area is moderate to steep having slope of 15-60%.

*CLIMATE*

Mandi falls in the mid-hills-sub-humid zone and high hills temperate wet agro climatic zone of Himachal Pradesh. The district receives the highest rainfall in the state and the annual average rainfall over the 15 years is 1239.98 mm. The rainfall varies in between 1000 to 2376 mm in the district. Maximum rainfall occurs in the month of June to September followed by January to March whereas least rainfall occurs in the month of November followed by December, October and April (Fig). About 63 percent rainfall occurs in monsoon season *i.e.* from June to September and rest of the precipitation occurs due to western disturbances. Lower areas of the district experience hot summer (up to 40°C temp.) and cold winter with frost and fog. Hilly area experiences mild summer and cold winter with low to high snowfall and mist in rainy season. The area of Badar, Chohar, Seraj and Sonar usually has sufficient snowfall every year from January to March.

*FOREST*

Table 3 below gives a snapshot of forest profile for Mandi Forest Circle with specific details on ecological zones, land use, forest administrative setup and ecosystem for the three forest divisions.

**Table 3: Profile - Mandi Forest Circle**

<i>Forest Profile -Mandi Forest Circle</i>				
<b>Land Use</b>	<b>Geographical Area (sq. km):</b>	<b>Total Forest Cover (sq. km):</b>	<b>% of Forest Area</b>	<b>% of HP Forest Area:</b>
	3950	1761	44.58	11.6

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<b>Forest Areas*</b>	<b>Geographical area (sq. km):</b>  3950	<b>Forest Area by Revenue department. (sq. km):</b>  1742	<b>Forest Area by Forest Department. (sq. km):</b>  1860	<b>Actual Forest cover by Forest Survey (sq. km):</b>  1648
<b>Key Biodiversity Areas</b>	<b>Bandli Wildlife Sanctuary</b>		32.11(sq. km)	
	<b>Nargu Wildlife Sanctuary</b>		278 (sq. km)	
	<b>Shikari Devi</b>		29.94 (sq. km)	
<b>Forest Divisions and ranges</b>	<i>Forest Circle</i>	<i>Forest Division</i>	<i>Forest Range</i>	
	Mandi	Karsog	Pangna Karsog Seri Magroo	

\*See Commissioner (Revenue) H.P, Annual Season and Crop Report for the Year 1999-2000, p-38; and. see H.P. Forest Statistics, Forest Deptt. of H.P, 2005, pp-38-41; and, also see State of Forest Report, Forest Survey of India, 2003, p-60.

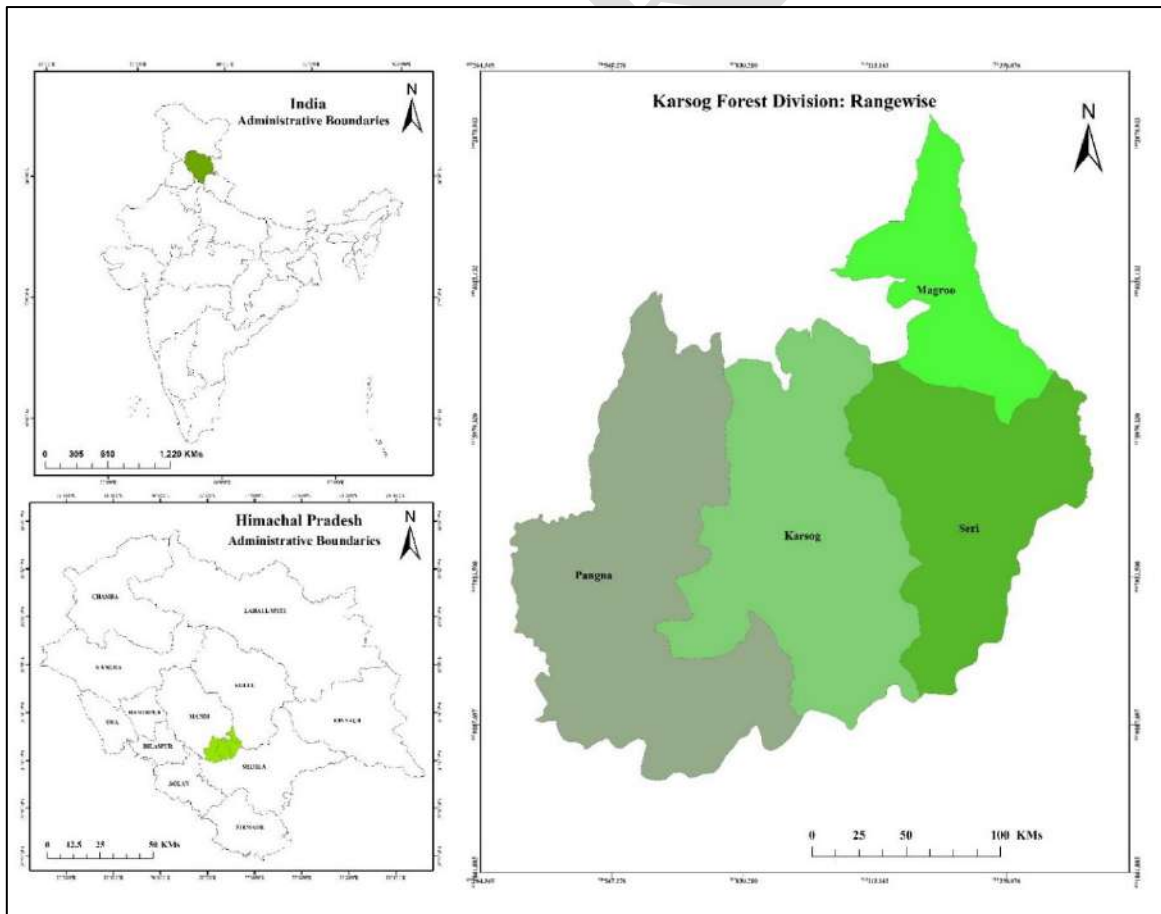


Figure 1: Maps Karsog Forest Division, Mandi Forest Circle

*Methods*

To ascertain the temporal changes in different tree species composition in Karsog Forest Division of Mandi Forest Circle, three-tier assessment was conducted, covering: 1) *tree community based variation*; 2) *altitude gradient driven variation*; and 3) *diameter class wise variations in tree composition*.

There are five forest divisions in Mandi forest circle viz., Mandi, Joginder Nagar, SuketNachan and Karsog Forest Division. Due to the non-availability of data records, only Karsog Forest Division was assessed for this study. Hence, enumerated data was collected and analysed for their respective forest ranges for the Karsog Forest Division only.

***Karsog Forest Division*** – There are four forest ranges in this division viz., Karsog, Pangna, Seri and Magroo forest range. The total area of these forest ranges is 22365.9 ha out of which 6523.46 ha was assessed in this study.

**Table 1. Status of Karsog Forest Division (As per Working plan 1986-1987) showing Forest ranges, locations, number of compartments and total area of ranges.**

<b>Status of Karsog Forest Division</b>				
<b>S.N.</b>	<b>Forest Range</b>	<b>Location Under Forest Range</b>	<b>No. of Forest/Comp.</b>	<b>Total Area (ha)</b>
<b>1</b>	Karsog Forest Range	Tehsil Karsog	47	6565.16
<b>2</b>	Pangna Forest Range	Sub Tehsil Nihri	8	1593.67
		Tehsil Karsog	45	5028.2
<b>3</b>	Seri Forest Range	Tehsil Karsog	25	5565.37
<b>4</b>	Magroo Forest Range	Karsog Tehsil	5	1503.9
		Thunag Tehsil	20	2109.6
	<b>Total 4 Ranges</b>	<b>Total</b>	<b>150</b>	<b>22365.9</b>

## DATA SOURCES AND TECHNIQUES

Working plans from the Himachal Pradesh Forest Department and Compartment History files were consulted and the species composition change during the successive working plans was analysed for three forest division. The time period for each division is different as per enumerated information available through these working plans.

### ***Karsog Forest Division: 1986-2013***

Respective files were collected from the Library of Himachal Pradesh Forest Department, and offices of the three forest divisions and their respective ranges.

Based on the information from the Working Plans for the Mandi Forest Circle and information from the Compartment History files, tree communities were identified.

Working plan is a written scheme of management that aims to ensure continuity of policy action, and controlled treatment of a forest. Within a working plan, Forest Division is the basic unit. This document is utilized to evaluate status of forests and the biodiversity resources within a particular division.

**Table 4: Detail on Tree Community and respective Altitudinal gradients, Forest Compartments, Area Assessed under Karsog Forest Division**

S.N.	Communities	No. of Forests/ Compartments	Alt. ranges (Min-Max)	Area (ha)	Forest Ranges
1	<i>Pinus roxburghii</i>	84	800-2420	3973.9	Karsog, Pangna, Seri, Magroo
2	<i>Pinus wallichiana</i>	11	1500-2284	394.96	Seri, Magroo
3	<i>Cedrus deodara</i>	19	1460-2834	902.33	Karsog, Pangna, Seri, Magroo
4	<i>Picea smithiana</i>	5	1828-3090	300.02	Magroo
5	<i>Abies pindrow</i>	4	1960-2980	152.38	Magroo
6	<i>Quercus leucotrichophora</i>	3	1180-2140	168.95	Karsog, Seri
7	<i>Pinus roxburghii</i> - <i>Pinus wallichiana</i>	5	1360-2112	336.55	Karsog, Pangna, Seri, Magroo
8	<i>Pinus roxburghii</i> - Broad leaved	2	1360-1800	45.17	Karsog, Seri
9	<i>Pinus</i>	1	2160-2330	38.52	Magroo

	<i>wallichiana - Quercus leucotrichophora</i>				
<b>10</b>	<i>Quercus leucotrichophora</i> -Broad leaved	1	2160-2500	27.37	Magroo
<b>11</b>	<i>Cedrus deodara</i> - Broad leaved	1	1828-2499	44.15	Magroo
<b>12</b>	<i>Cedrus deodara - Pinus wallichiana</i>	4	1768-2560	131.02	Magroo
<b>13</b>	<i>Pinus wallichiana - Broad leaved</i>	1	1860-2200	31.19	Magroo
	<b>Total</b>	<b>141</b>		<b>6523.46</b>	<b>4</b>

For the assessment purpose, the forests were categorized according to the delineated communities *i.e.* if for a single species the relative density is more than 50 per cent, then the tree community was identified as *single species dominant community*. For cases where more than one species collectively accounted for 50 per cent of the relative density, the tree community was referred as *mixed community*. Forests were further classified in different altitudinal gradients- 1,000-1,500m, 1,500-2,000m; 2,000-2,500m; 2,500-3,000m. Species composition was assessed for changes in the Tree Density, where *individuals per hectare* were calculated for the two time period *i.e.*, 1986-2013. The area under the assessed forest compartments for respective divisions was taken to be more than 10 per cent of the total forest area.

The next section elaborates the employed assessment techniques for 1) *tree community based variation*; 2) *altitude gradient driven variation*; and 3) *diameter class wise variations in tree composition*.

## ASSESSMENT TECHNIQUES

### Tree Community-based Variations

Each forest division constitutes different tree communities where dominant species is identified based on its relative density (more than 50 per cent

categorised as dominant community; and a collective majority as mixed community). For each of the identified pure species in Karsog Forest Division, variations in density were determined for the two time periods *i.e.* 1986-87 and 2013-14.

### **Altitude Gradient driven Variations**

Four altitudes were selected for comprehensive representation of all tree species in the Karsog Forest Division – 1,000-1,500m, 1,500-2000m, 2,000-2,500m and 2,500-3,000m. In the Working Plan documents, different values of altitudinal ranges were observed for certain species, which were normalized by using the range average values. Further, the forest in a given altitude range was categorised according to species and their total number in both years was calculated. The density (individuals per hectare) was calculated for all species for respective altitudes that represented concentration of individual species in one hectare. This altitudinal based study was aimed to indicate species status, its density, and movement along altitudinal gradients.

### **Diameter Class-wise Variations with Altitude Gradient**

On the basis of above mentioned altitudinal gradients, the data of different forest/compartments were analysed and studied for their density variations in different classes of 10-20cm, 20-30cm, 30-40cm, 40-50cm, 50-60cm, 60-70cm, 70-80cm, 80-90cm, 90-100cm, >100cm. This assessment was conducted for aggregated species for individual diameter class at three altitude levels; and for individual species as well. Diameter class wise distribution is analysed to represent the population structure of forests.

### **Key Terminologies**

**Tree community:** Group or association of populations of two or more different tree species that occupy the same geographical area at a particular time period

**Forest compartment:** A section of forest with homogeneous growth



## Results & Findings

This section presents the findings from the assessment of the tree community composition for Karsog Forest Divisions and their respective species.

### *Karsog Forest Division*

Based on the assessment of Working Plans from the Himachal Pradesh Forest Department and Compartment History files from Karsog, Pangna, Seri and Magroo forest ranges, six pure communities (having one dominant species) *i.e.* *Pinus roxburghii* (PR), *Pinus wallichiana* (PW), *Cedrus deodara* (CD), *Picea smithiana* (PS), *Abies pindrow* (AP), *Quercus leucotrichophora* (QL) tree community and seven mixed communities *viz.* *Pinus roxburghii*-*Pinus wallichiana*, *Pinus roxburghii*-Broad leaved, *Pinus wallichiana*- *Quercus leucotrichophora*, *Quercus leucotrichophora*- Broad leaved, *Cedrus deodara*-Broad leaved, *Cedrus deodara*- *Pinus wallichiana*, *Pinus wallichiana*- Broad leaved mixed tree community were identified.

As highlighted earlier in

Table 4 these tree communities were assessed from 141 forest compartments spread over a total area of 6523.46ha.

### *The Tree Community based Variations*

The following section discusses the tree community based variations in density for the species identified.

#### **1. *Pinus roxburghii* tree community:**

The data was collected from 86 forest compartments covering total area 3973.9 ha and have altitudinal ranges from 800-2420 amsl. *Pinus roxburghii* (PR) tree community occurs in all four forest ranges *viz.*, Karsog, Pangna, Seri and Magroo. As illustrated in Figure 2, in its dominant tree community, density of *Pinus roxburghii* was increased from 210.3 Ind/ha to 321.9 Ind/ha. In these forest compartments, representation (density) of other species is as follows –

density of *Pinus wallichiana* increased from 12.9 Ind/ha in 1986 to 17.4Ind/ha in 2013, density of *Quercus leucotrichophora* is too declined from 26.9 Ind/ha to 7.2 Ind/ha; while the density of *Picea smithiana*, *Cedrus deodara* and Broad Leaved showed marginal changes in the density between two years as shown in Figure 2.

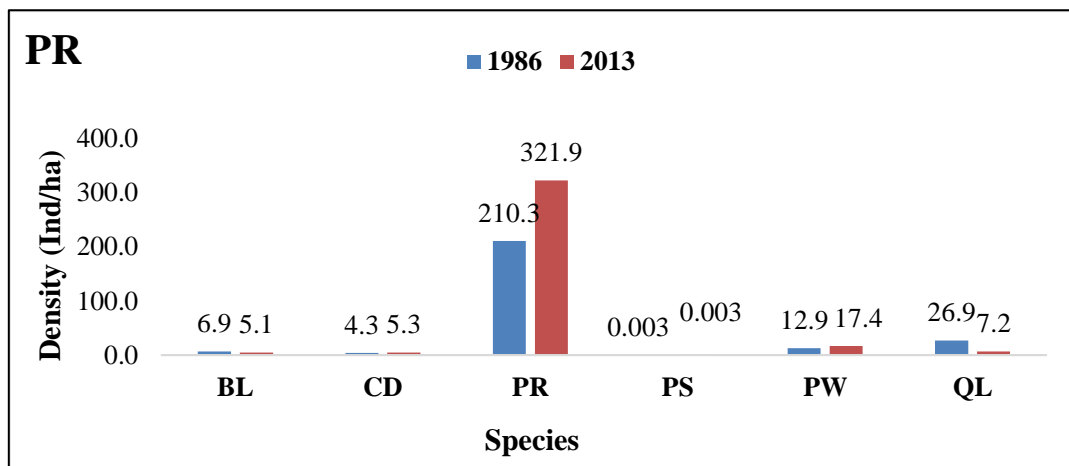


Figure 2. Density Variations in Species Composition in *Pinus roxburghii* community, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, PS=*Picea smithiana*, BL= Broad-leaved; PR=*Pinus roxburghii*; QL=*Quercus leucotrichophora*

## 2. *Pinus wallichiana* tree community:

The total numbers of forests compartments in *Pinus wallichiana* tree community are 11, covering area 394.96 ha and altitude ranges from 1500-2284 amsl. This tree community is falling only in two forest ranges of Karsog Forest Division *i.e.* Seri and Magroo forest range. The density of *Pinus wallichiana* was decreased from 70 Ind/ha to 55.5 Ind/ha from year 1986-2013 respectively (Figure 3). The *Cedrus deodara*, *Pinus Roxburghii*, *Quercus leucotrichophora* and Broad leaved showed decreased density as shown in the Figure 3.

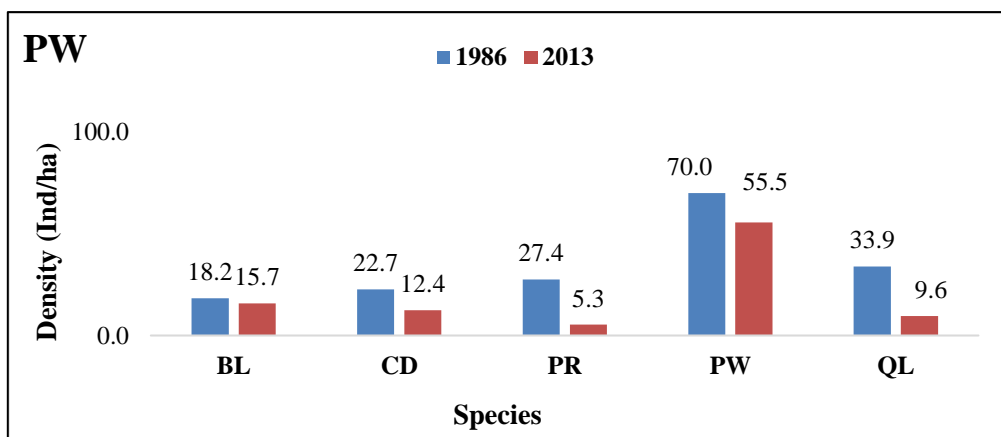


Figure 3: Density Variations in Species Composition in *Pinus wallichiana* community, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, BL= Broad-leaved; PR=*Pinus roxburghii*; QL=*Quercus leucotrichophora*

### 3. *Cedrus deodara* tree community:

The deodar tree community comprises 19 forests/compartments covering an area of 902.33 ha spread over four forest ranges (Seri, Pangna, Karsog and Magroo). The altitudinal ranges varies from 1460-2834 m from the mean sea level. In this tree community the density of *Cedrus deodara* was 259 Ind/ha in year 1986 which were reduced to 173 Ind/ha in 2013. The density of *Pinus roxburghii*, *Picea smithiana*, *Pinus wallichiana*, *Quercus leucotrichophora* and Broad leaved were reduced from 1986-2013 as shown in Figure 4.

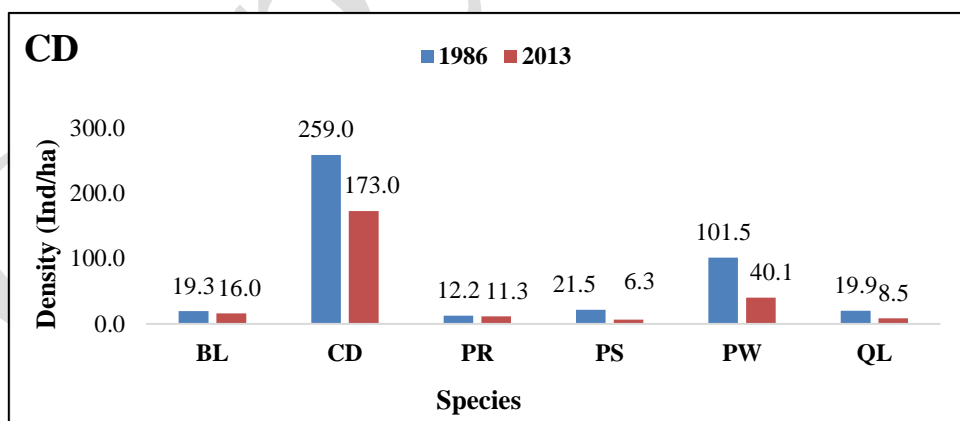


Figure 4: Density Variations in Species Composition in *Cedrus deodara* community, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, BL= Broad-leaved; PR=*Pinus roxburghii*; QL=*Quercus leucotrichophora*; PS=*Picea smithiana*

**4. *Picea smithiana* tree community:**

The data collected from 5 forest compartments covering an area of 300.2 ha and altitude ranges from 1828-3090 m which falls in Magroo forest range only. There are two main species showing its presence in the tree community *i.e.* *Picea smithiana* and *Pinus wallichiana*. Former is the dominant, density of *Picea smithiana* was reduced from 238.1 Ind/ha to 55.3 Ind/ha and *Pinus wallichiana* from 56.5 Ind/ha to 16 Ind/ha in two different years of enumerations. Two more species *viz.*, *Cedrus deodara* and Broad Leaved (Figure5.) were also showing its presence in the community but is not showing any significant change in the density.

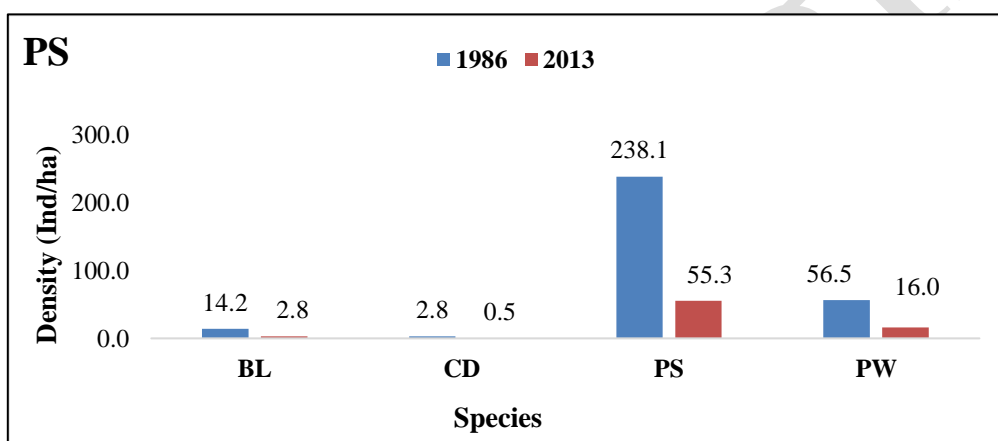


Figure 5: Density Variations in Species Composition in *Picea smithiana* community, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, BL= Broad-leaved; PS=*Picea smithiana*

**5. *Abies pindrow* tree community:**

The data collected from 4 forest compartments, having an area of 152.38 ha. The altitude ranges from 1960-2980 m which falls in Magroo forest range of Karsog Forest Division. The density of *Abies pindrow* was increased from 122.2 to 134.8 Ind/ha in year 1986 to 2013 respectively. Besides increasing the density of dominant species, broad leaved, *Cedrus deodara*, *Pinus wallichiana*, *Quercus floribunda* and *Taxus baccata* also show increased density as shown in Figure 6. However, the population density of *Quercus floribunda* was very less in this community.

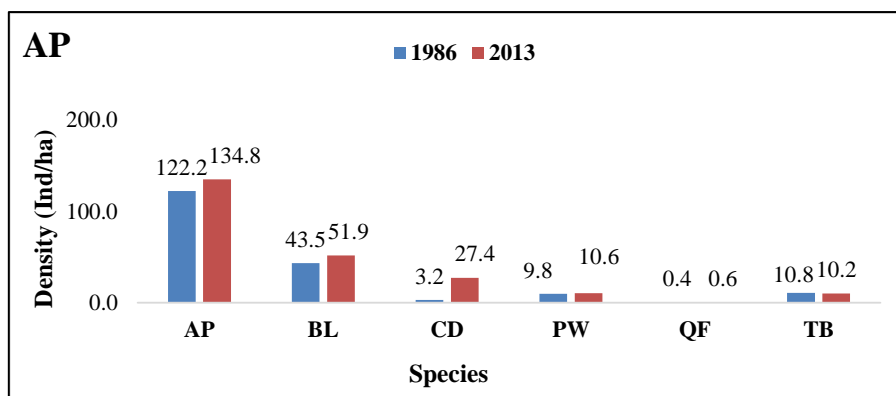


Figure 6: Density Variations in Species Composition in *Abies pindrow* community, Karsog Forest Division, 1986-2013

Abbreviations: AP=*Abies pindrow*; CD=*Cedrus deodara*; PW=*Pinus wallichiana*, BL= Broad-leaved; QF=*Quercus floribunda*; TB=*Taxus baccata*

### 6. *Quercus leucotrichophora* tree community:

The data collected from 3 forests compartments covering a total area of 168.95 ha. The altitude ranges from 1180-2140 m which falls in two ranges *i.e.*, Karsog and Seri forest range of Karsog Forest Division. The density of *Quercus leucotrichophora* was increased from 41.9 Ind/ha to 46.4 Ind/ha in year 1986-2013 respectively. In enumeration year 1986, these compartments are dominated by *Pinus roxburghii*, but in 2013, it was significantly reduced from 94.7 Ind/ha to 26.5 Ind/ha. The density of *Pinus wallichiana* and Broad Leaved were reduced from 7.8 to 5.5 Ind/ha and 19.2 to 13.9 Ind/ha, respectively while the individuals of *Cedrus deodara* was very less as shown in Figure 7.

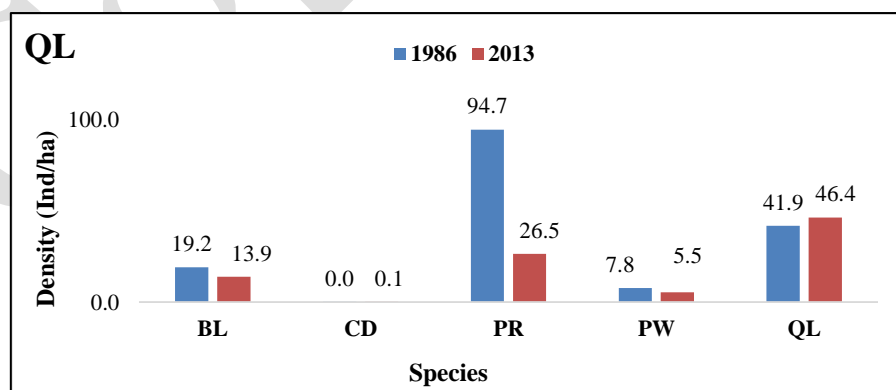


Figure 7: Density Variations in Species Composition in *Quercus leucotrichophora* community, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, BL= Broad-leaved; QL=*Quercus leucotrichophora*; PR=*Pinus roxburghii*

**7. *Pinus roxburghii*-*Pinus wallichiana* mixed tree community:**

In this mixed tree community, data collected from 5 compartments covering total area 336.55 ha. The altitudinal range for this community is ranges from 1360-2112m which falls in all four forest ranges of Karsog Forest Division. The density of *Pinus wallichiana* was increased from 41.1 Ind/ha to 72.3 Ind/ha while the co-dominant species (*Pinus roxburghii*) was reduced from 94.5 Ind/ha to 71.2 Ind/ha but still maintained its density as in *Pinus wallichiana*. The other species viz. *Cedrus deodar*, *Quercus leucotrichophora* and Broad Leaved of this mixed tree community showed increased density in enumeration year 2013 as Shown in Figure 8.

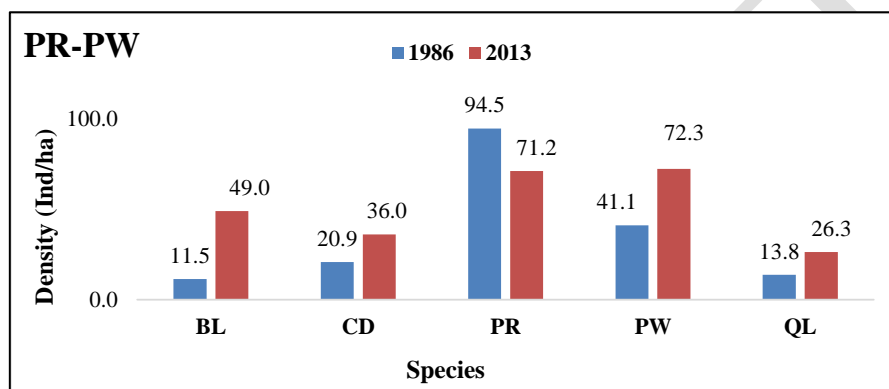


Figure 8: Density Variations in Species Composition in *Pinus roxburghii*-*Pinus wallichiana* community, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, BL= Broad-leaved; QL=*Quercus leucotrichophora*; PR=*Pinus roxburghii*

**8. *Pinus roxburghii*-Broad leaved mixed tree community:**

The forest compartments in this tree community were only 2 covering a total area of 45.17 ha and the altitude ranges from 1360-1800 m, falls in Karsog and Seri forest ranges. Density of both the representative species i.e. *Pinus roxburghii* and Broad leaved showed significant increase from 101.5 Ind/ha to 195.7 Ind/ha and 131.9 Ind/ha to 246.5 Ind/ha respectively. Other species viz., *Cedrus deodara*, *Pinus wallichiana* and *Quercus leucotrichophora* also showed increased density in two years of enumerations shown in Figure 9.

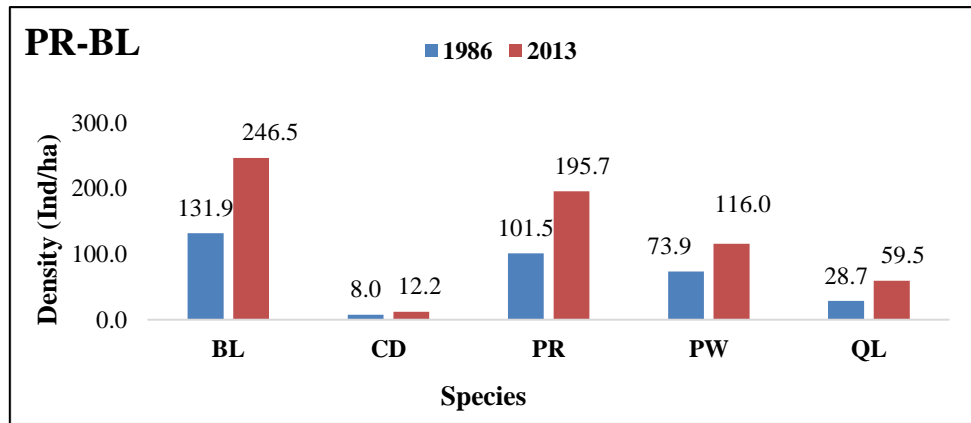


Figure 9: Density Variations in Species Composition in *Pinus roxburghii*-Broad-leavedcommunity, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, BL= Broad-leaved; QL=*Quercus leucotrichophora*; PR=*Pinus roxburghii*

**9. *Pinus wallichiana*- *Quercus leucotrichophora* mixed tree community:**

*Pinus wallichiana*-*Quercus leucotrichophora* mixed tree community is the only community which has only one compartment, having total area of 38.52 ha and the altitude range from 2160-2330m of Magroo forest ranges of the division. All species falling in this tree community showed increase in the density as shown in Figure 10. But the density of *Pinus wallichiana*, *Quercus leucotrichophora* and *Cedrus deodara* were significantly increased then *Picea smithiana*.

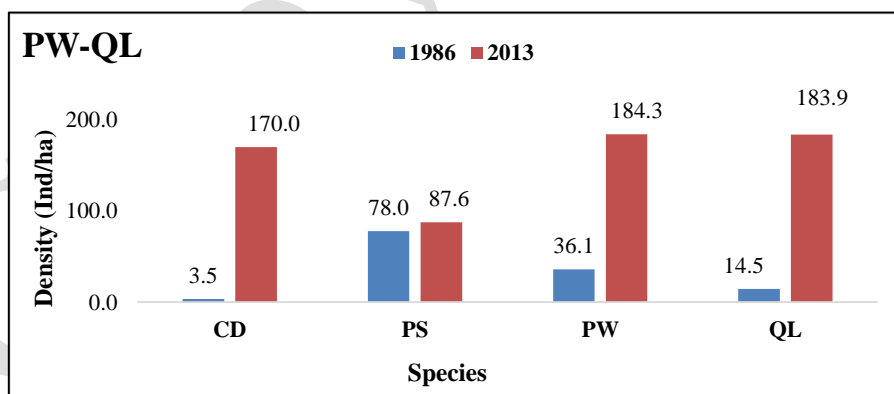


Figure 10: Density Variations in Species Composition in *Pinus wallichiana*-*Quercus leucotrichophora* community, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, PS=*Picea smithiana*; QL=*Quercus leucotrichophora*

**10. *Quercus leucotrichophora*- Broad leaved mixed tree community:**

*Quercus leucotrichophora*-Broad leaved mixed tree community is represented by only one compartment falling in Magroo forest range having total area 27.37 ha

with altitudes ranging from 2160-2500 m from mean sea level. Both the representative species (*Quercus leucotrichophora* and Broad leaved) and *Picea smithiana* of the tree community showed decreased density in different years of enumerations as shown in Figure 11. While the density of *Cedrus deodara* and *Pinus wallichiana* were increased from 0.6 Ind/ha to 15.3 Ind/ha and 83.4 Ind/ha to 96.7 Ind/ha respectively.

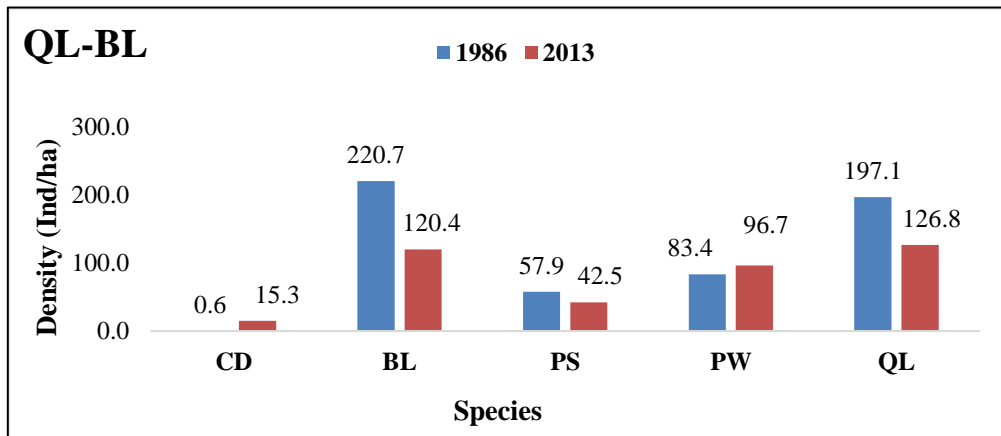


Figure 11: Density Variations in Species Composition in *Quercus leucotrichophora*-Broad leaved community, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, PS=*Picea smithiana*; QL=*Quercus leucotrichophora*

### 11. *Cedrus deodara*- Broad leaved mixed tree community:

*Cedrus deodara*- Broad leaved mixed tree community is represented by only one compartment falling in Magroo forest range having total area of 44.15 ha and the altitudes ranges form 1828-2499 m from mean sea level. The density of both the representative species along with *Picea smithiana* and Broad leaved showed decreased density as shown in Figure 12. While *Pinus wallichiana* and *Quercus leucotrichophora* showed increase from 70.2 Ind/ha to 96 Ind/ha and 16 Ind/ha to 20.8 Ind/ha respectively.



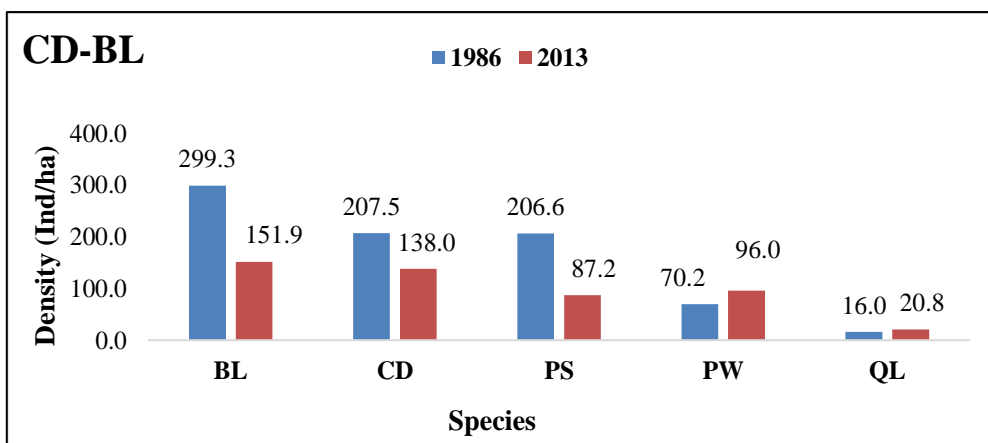


Figure 12: Density Variations in Species Composition in *Cedrus deodara*-Broad leaved community, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*, PS=*Picea smithiana*; QL=*Quercus leucotrichophora*; BL=Broad Leaved

### 12. *Cedrus deodara*-*Pinus wallichiana* mixed tree community:

The data collected from four compartments falling in Magroo forest range in Magroo forest range having total area of 131.02 ha and the altitude ranges from 1768 to 2560 m from mean sea level. *Cedrus deodara* of this mixed tree community showed slight decrease in density from 95 Ind/ha to 92.8 Ind/ha while the *Pinus wallichiana* density was increased from 81 Ind/ha to 83.6 Ind/ha. Except *Abies pindrow*, the density of *Quercus leucotrichophora*, *Picea smithiana* and Broad leaved showed increased density from year 1986-2013 (Shown in Figure 13).

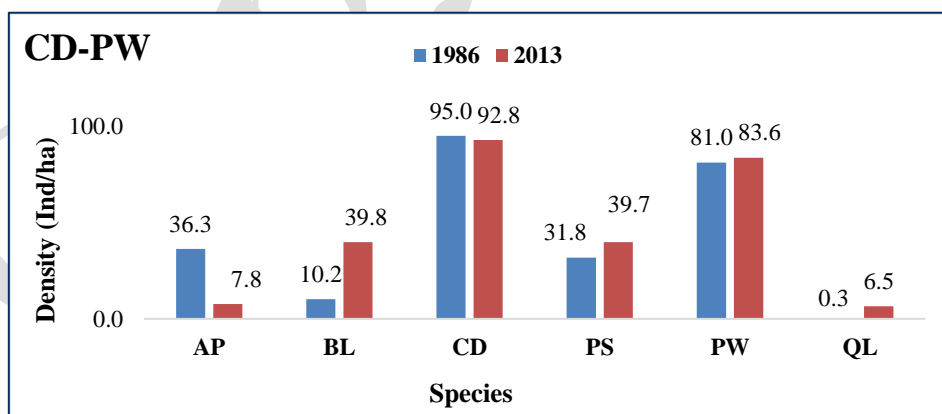


Figure 13: Density Variations in Species Composition in *Cedrus deodara*-*Pinus wallichiana* community, Karsog Forest Division, 1986-2013

Abbreviations: AP=*Abies pindrow*; CD=*Cedrus deodara*; PW=*Pinus wallichiana*, PS=*Picea smithiana*; QL=*Quercus leucotrichophora*; BL=Broad Leaved

### 13. *Pinus wallichiana*-Broad leaved mixed tree community:

This mixed tree community is represented by one compartment falling in Magroo forest range only having total area 31.19 ha and the altitudes ranges from 1860-2200 m from mean sea level. The co-dominant species as well as the other species viz. *Cedrus deodara* and *Quercus leucotrichophora* of this tree community showed increasing trends in the density (Figure 14).

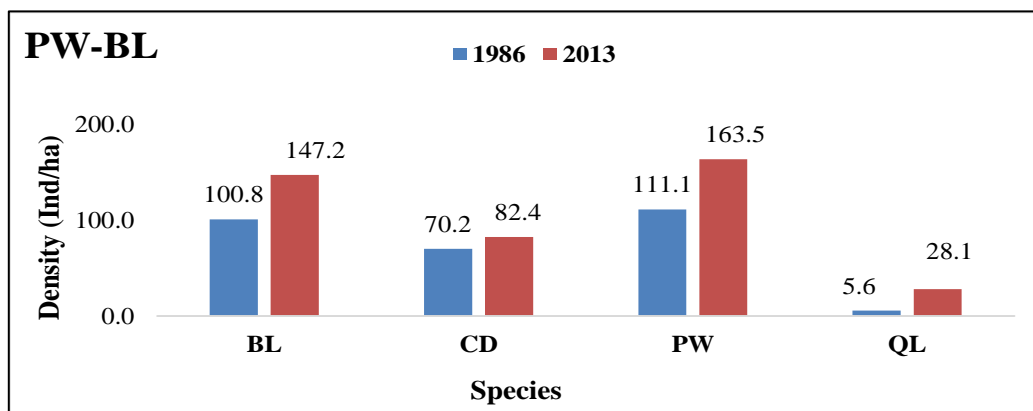


Figure 14: Density Variations in Species Composition in *Pinus wallichiana*-Broad Leaved community, Karsog Forest Division, 1986-2013

Abbreviations: AP=*Abies pindrow*; CD=*Cedrus deodara*; PW=*Pinus wallichiana*, PS=*Picea smithiana*; QL=*Quercus leucotrichophora*; BL=Broad Leaved

### Altitude Gradient driven Variations

In this study, the forests compartments of Karsog Forest Division were divided into 4 altitudinal ranges i.e. 1000-1500m, 1500-2000m, 2000-2500m, and 2500-3000m. The forests in particular altitudinal range were categorized species wise, then their total number was calculated for both years i.e. 1986 and 2013. The density (individual per hectare) was then calculated for all species at respective altitudes representing individual in one hectare. This altitudinal based study showing the status of species, density, preferable species to particular altitude and their up and down shifting along altitudinal gradients.

Studies Based on Altitudinal ranges of Karsog Forest Division					
S.N.	Altitudinal Ranges	No. of forest/Comp.	Total Area	Periodic Block	Forest Ranges
1	1000-1500m	14	496.21	I, II, III, IV	Seri, Karsog, Pangna

2	1500-2000m	88	4143.2	I, II, III, IV	Seri, Karsog, Pangna, Magroo
3	2000-2500m	31	1353.23	I, II, III, IV	Seri, Karsog, Pangna, Magroo
4	2500-3000m	7	369.48	II, IV	Magroo
	<b>Grand Total</b>	<b>140</b>	<b>6362.12</b>	<b>4</b>	<b>4</b>

Table 5: Altitudinal zonations of Karsog Forest Division showing altitudinal gradients, number of compartments and total area, periodic blocks and respective ranges.

**1. 1000-1500m:**

There are 14 forest compartments at this altitude gradient with a total area of 496.21 ha falling under Seri, Karsog and Pangna forest ranges. At 1000-1500m altitude range, all species witnessed decreased density except *Pinus roxburghii* and Broad leaved with maximum representation of *Pinus roxburghii* whose density increased from 143.6 Ind/ha to 213.6 Ind/ha from enumeration year 1986 to 2013. Other species enumerated in this altitudinal gradients were have very less population density as shown in the Figure 15. This indicates that the lower belt of Karsog Forest Division is dominantly covered by the *Pinus roxburghii* while the other species showed fewer occurrences.

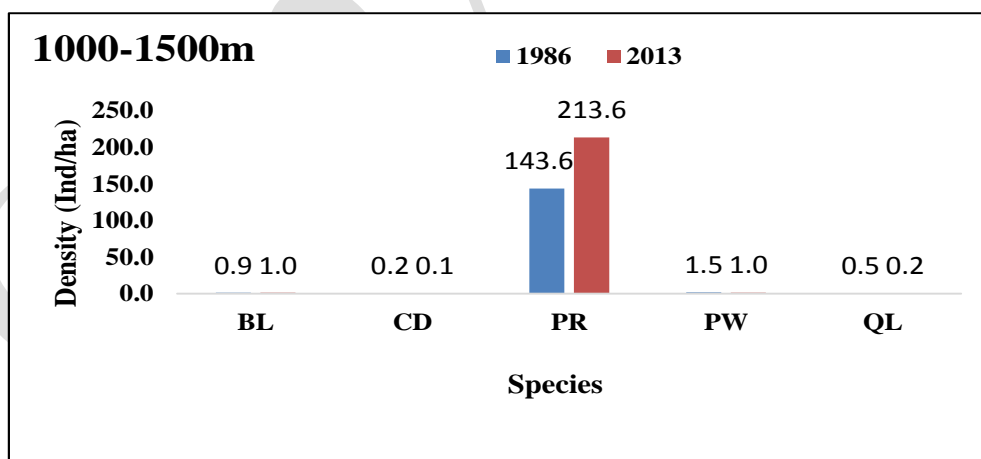


Figure 15: Density Variations in Species Composition at 1000-1500m Altitude, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*; QL=*Quercus leucotrichophora*; BL=Broad Leaved; PR=*Pinus roxburghii*

**2. 1500-2000m:**

The data collected from 88 forest compartments of altitudinal gradients 1500-2000m above mean sea level covers total area 4143.2 ha falling in Seri, Karsog, Magroo and Pangna forest range. Here the *Pinus roxburghii* also dominated then other species as the density of *Pinus roxburghii* was 182 Ind/ha in year 1986 which increased significantly to 283 Ind/ha in year 2013. Other species like broad leaved, *Cedrus deodara*, *Picea smithiana* and *Pinus wallichiana* were also present showed slight increase in density except *Quercus leucotrichophora* which was decreased from 27 Ind/ha to 10 Ind/ha shown in Figure 16.

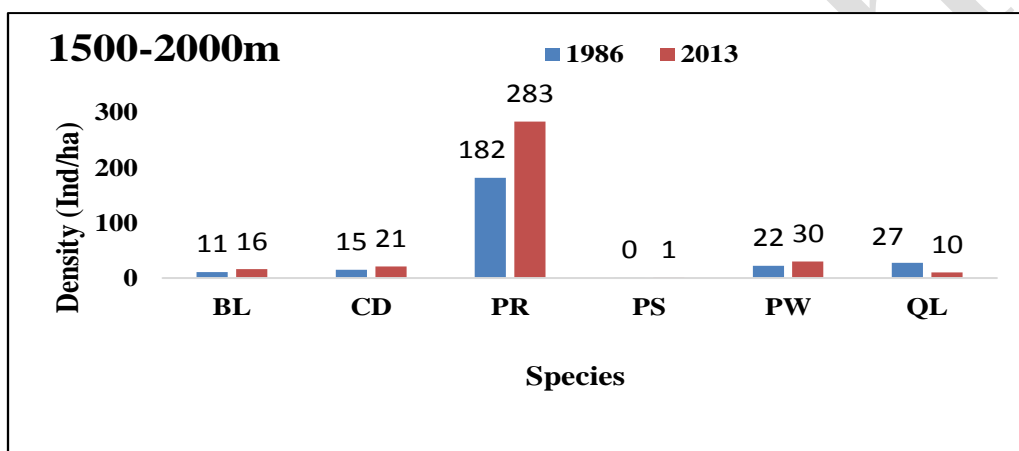


Figure 16: Density Variations in Species Composition at 1500-2000m Altitude, Karsog Forest Division, 1986-2013

Abbreviations: CD=*Cedrus deodara*; PW=*Pinus wallichiana*; QL=*Quercus leucotrichophora*; BL=Broad Leaved; PR=*Pinus roxburghii*; PS=*Picea smithiana*

**3. 2000-2500 m:**

This altitudinal range covers 1353.23 hectare area under 31 forest compartments falling under all four forest ranges viz., Seri, Karsog and Pangna. There are a maximum of 09 species i.e., *Abies pindrow*, *Cedrus deodara*, *Pinus wallichiana*, *Quercus leucotrichophora*, *Quercus floribunda*, Broad Leaved, *Pinus roxburghii*, *Picea smithiana*, *Taxus baccata* enumerated as per Compartment History Files 1986 and 2013 (Figure 17). *Cedrus deodara* and *Pinus wallichiana* were have the maximum population density (104 Ind/ha and 48 Ind/ha) in this gradients while the other have less. The population density of *Cedrus deodara*, *Picea smithiana* and *Pinus wallichiana* showed remarkable decrease in the

density while the other species viz. Broad leaved, *Pinus roxburghii*, *Quercus leucotrichophora* slightly decreased. Whereas, *Abies pindrow* and *Taxus baccata* showed marginal increase in the density but *Quercus floribunda* remain unchanged.

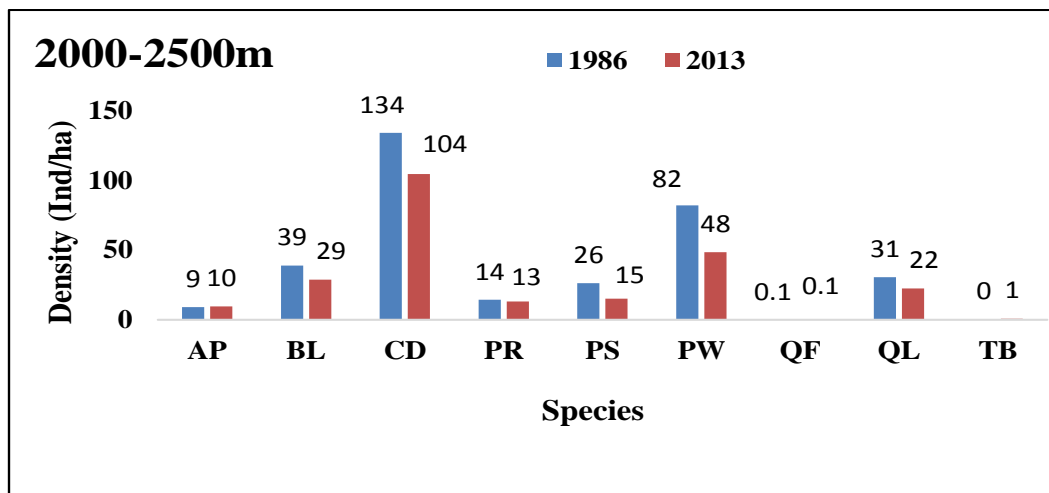


Figure 17: Density Variations in Species Composition at 2000-2500m Altitude, Karsog Forest Division, 1986-2013

Abbreviations: AP=*Abies pindrow*; CD=*Cedrus deodara*; PW=*Pinus wallichiana*; QL=*Quercus leucotrichophora*; BL=Broad Leaved; PR=*Pinus roxburghii*; PS=*Picea smithiana*; TB=*Taxus baccata*

#### 4. 2500-3000 m:

There were only 7 forest compartments in this altitude gradient which is widespread in 369.48 ha area in Magroo forest range. There are seven species enumerated viz. *Abies pindrow*, *Cedrus deodara*, *Pinus wallichiana*, *Quercus leucotrichophora*, Broad Leaved, *Picea smithiana*, *Taxus baccata* shown in figure 18. The density of *Cedrus deodara*, *Picea smithiana* and *Pinus wallichiana* showed a significant drop in the density from 134 Ind/ha to 14 Ind/ha, 198 Ind/ha to 42 Ind/ha and 68 Ind/ha to 12 Ind/ha respectively. Two species viz. *Abies pindrow* and *Quercus leucotrichophora* showed a slight increase in density while other species i.e. Broad Leaved and *Taxus baccata* showed marginal decrease in density.

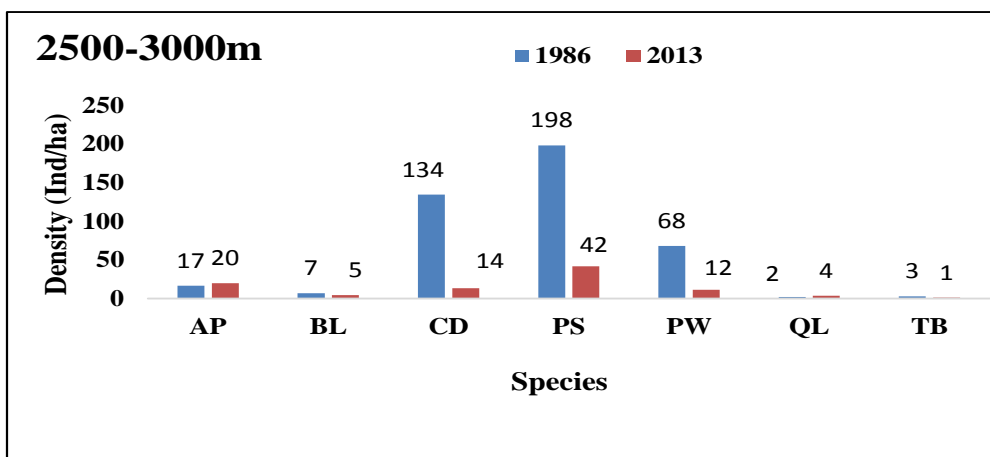


Figure 18: Density Variations in Species Composition at 2500-3000m Altitude, Karsog Forest Division, 1986-2013

Abbreviations: AP=*Abies pindrow*; CD=*Cedrus deodara*; PW=*Pinus wallichiana*; QL=*Quercus leucotrichophora*; BL=Broad Leaved; PS=*Picea smithiana*; TB=*Taxus baccata*

### Diameter Class-wise Variations with Altitude Gradient

For the mentioned altitudinal gradients *i.e.* 1000-1500m, 1500-2000m, 2000-2500m, 2500-3000m, data from different forest compartments was analysed for variation in diameter classes of 10-20cm, 20-30cm, 30-40cm, 40-50cm, 50-60cm, 60-70cm, 70-80cm, 80-90cm, 90-100cm, >100cm for each of the identified species in Karsog Forest Division.

**Broad Leaved:** The total density of Broad leaved showed a negligible increase from 1000m-1500m (from 0.9 to 1.0 Ind/ha) and only tree saplings showed their presence in diameter classes from 10cm-40cm. Broad leaved at 1500m to 2000m showed increased values in all diameter classes when compared with two years data. Altitude gradient from 2000-3000m, showed decreased density as we move from lower to higher diameter classes. The density was maximum at diameter classes *i.e.*, 10-20cm and 20-30cm at 2000-2500m and 2500-3000m as shown in Figure 19. The figures showed that only small trees of broad leaves are present in all altitudinal gradients except few classes of 50-60cm, 60-70cm, 70-80cm, 80-90cm and 90-100cm diameter classes of altitudinal gradients from 2500m to 3000m.

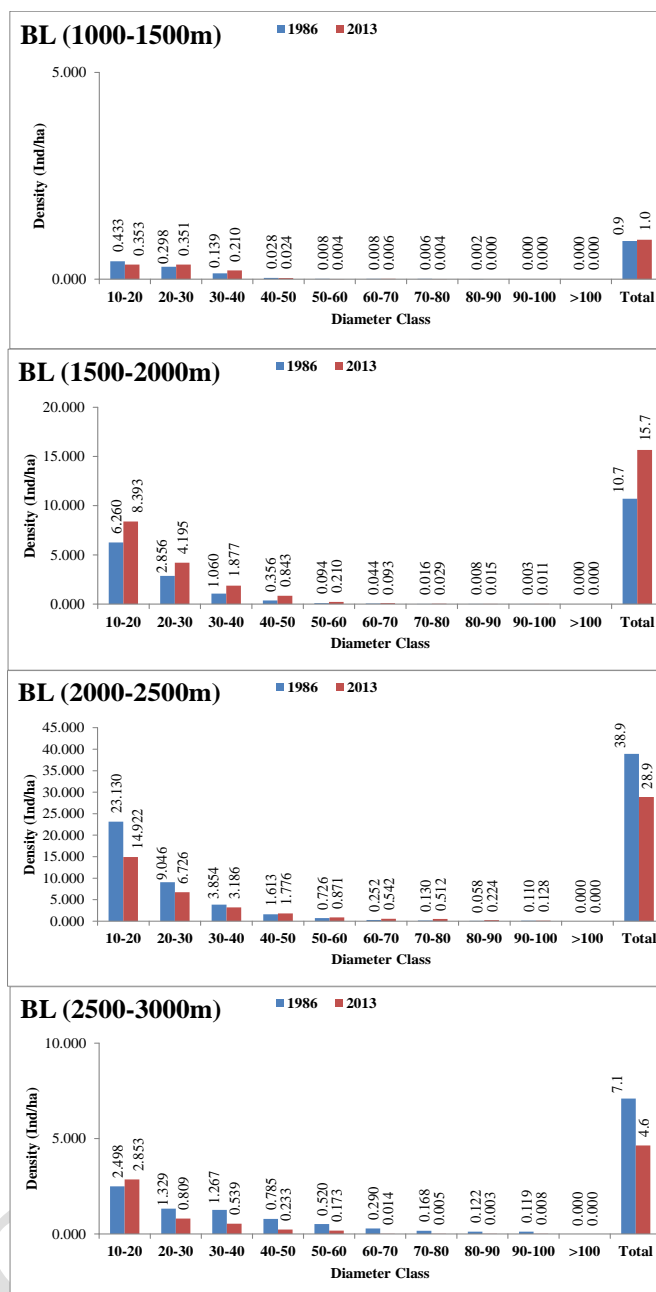


Figure 19. Density Variations in Broad Leaved community at Different Diameter Classes, Karsog Forest Division, 1986-2013

**Abies pindrow:**

There were two altitudinal gradients viz. 2000-2500m and 2500-3000m in which *Abies pindrow* was present. The density of *Abies pindrow* was increased from 2.8 to 4.09 Ind/ha and 4.06 to 10.05 Ind/ha in 10-20cm diameter classes at 2000-2500m and 2500-3000m, respectively. The density kept on decreasing (at 2000-2500m) as we proceed from 20-30cm to 50-60cm diameter classes on comparing with the previous year (1986) as shown in Figure 20. After diameter classes from 50-60cm towards higher classes (i.e. 60-70cm to more than 100cm)

the tree density increased, while altitudinal gradient of 2500-3000m showed similar result as in case of 2000-2500m. Finding from the analysis showed that there was more density of younger trees in both the altitudinal gradients while the mature trees did not show any remarkable change in tree density. While comparing the overall density of all the diameter classes of both the altitudinal gradients, showed increased values (Figure 20).

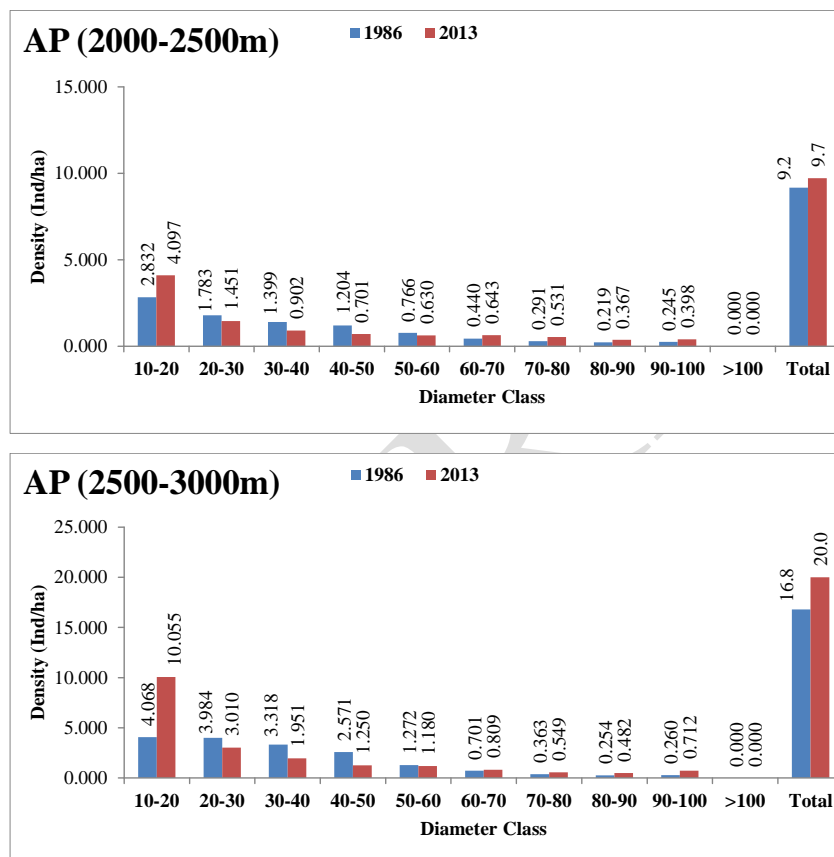


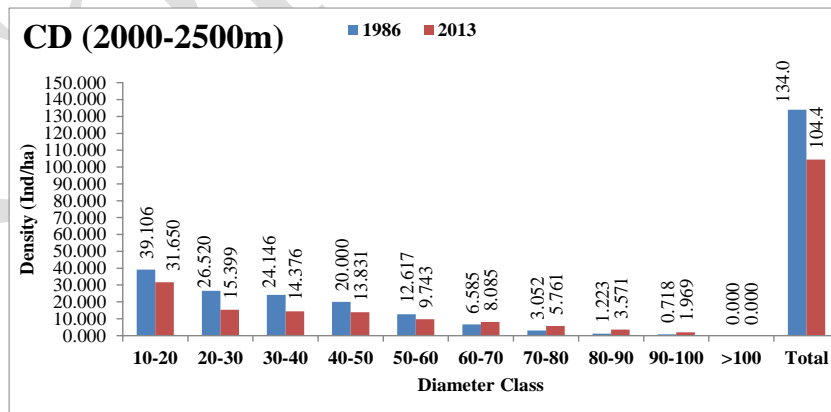
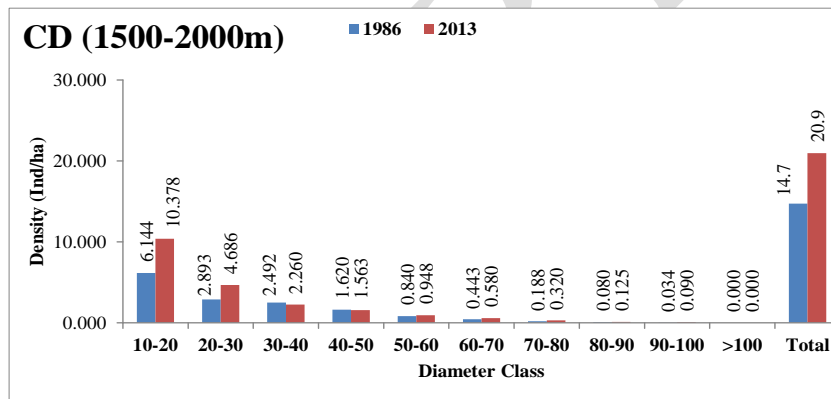
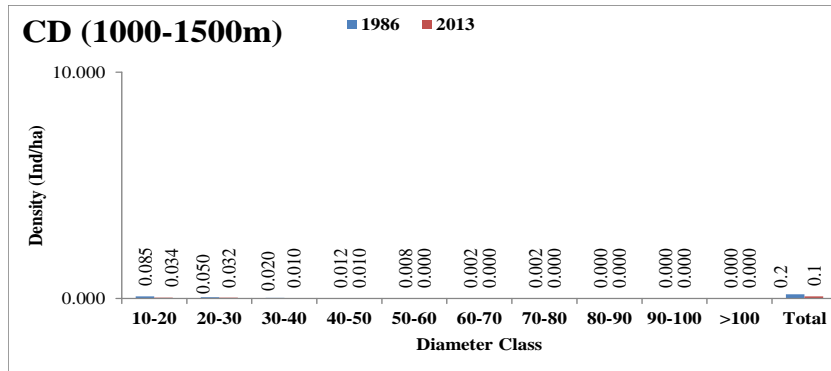
Figure 20. Density Variations in *Abies pindrow* community at Different Diameter Classes, Karsog Forest Division, 1986-2013

***Cedrus deodara*:**

The species occurred in all four altitudinal gradients viz., 1000-1500m; 1500-2000m; 2000-2500m and 2500-3000m of Karsog Forest Division. At 1000-1500m, the value of tree density was very less (up to 0.08 Ind/ha). While the total tree density decreased with time (from 1986 to 2013) i.e., 0.2 to 0.1 Ind/ha this is due to the fact that the lower reaches of Karsog Forest Division is dominated by *Pinus roxburghii* species. At 1500-2000m, the density was increased in all diameter classes except 30-40cm and 40-50 cm. Altitudinal gradients from 2000-2500m, the density of *Cedrus deodara* is decreased in diameter classes from 10-20cm to 50-60cm beyond which a reverse trend was found.



However the total density was decreased from 134 Ind/ha to 104.4 Ind/ha when comparing both the years (from 1986 to 2013). At 2500-3000m, the tree density of the *Cedrus deodara* showed a considerable decline in all diameter classes for both the years, therefore showed a significant drop in density (Figure 21). Finding from the above results revealed that among all the altitudinal gradients, the tree density is decreased except at 1500-2000m altitudinal gradients.



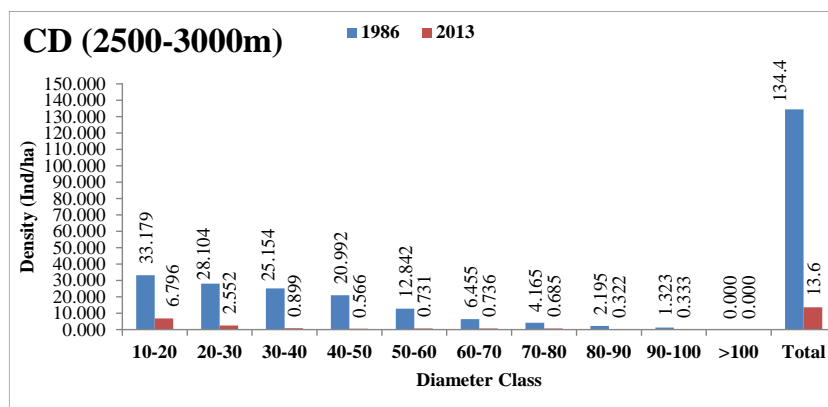


Figure 21. Density Variations in *Cedrus deodara* community at Different Diameter Classes, Karsog Forest Division, 1986-2013

***Pinus roxburghii*:**

The species occurred in three elevations *i.e.* 1000-1500m, 1500-2000m and 2000-2500m of Karsog Forest Division. Altitude gradient from 1000-1500m showed increased density in all the diameter classes except from 40-50cm and 50-60cm. The maximum value was in lowest diameter classes (10-20cm and 20-30cm and the total density was increased from 143.6 to 213.6 Ind/ha in the year 1986 to 2013, respectively. At altitude 1500-2000m the density of young tree was very high which increased from 113.61 to 175.97 (10-20cm); 28.61 to 70.08 (20-30cm) and 18.72 to 20.05 (30-40cm) Ind/ha while the older tree density were increased except above 100cm diameter class. The total tree density of *Pinus roxburghii* increased from 181.9 to 283.5 Ind/ha in year 1986 to 2013, respectively. Altitudinal range from 2000-2500m, showed its maximum density of 9.370 (10-20cm) while all the other diameter classes showed a negligible change in density in the two years of enumeration. Even the total density also did not show any remarkable change *i.e.* from 14.3 to 13.1 Ind/ha in year 1986 to 2013, respectively as shown in Figure 22. Thus it can be said that *Pinus roxburghii* were showing its maximum dominance in lower altitudes (1000-1500m and 1500-2000m) while it decreases as we move to higher altitude (2000 to 2500m).

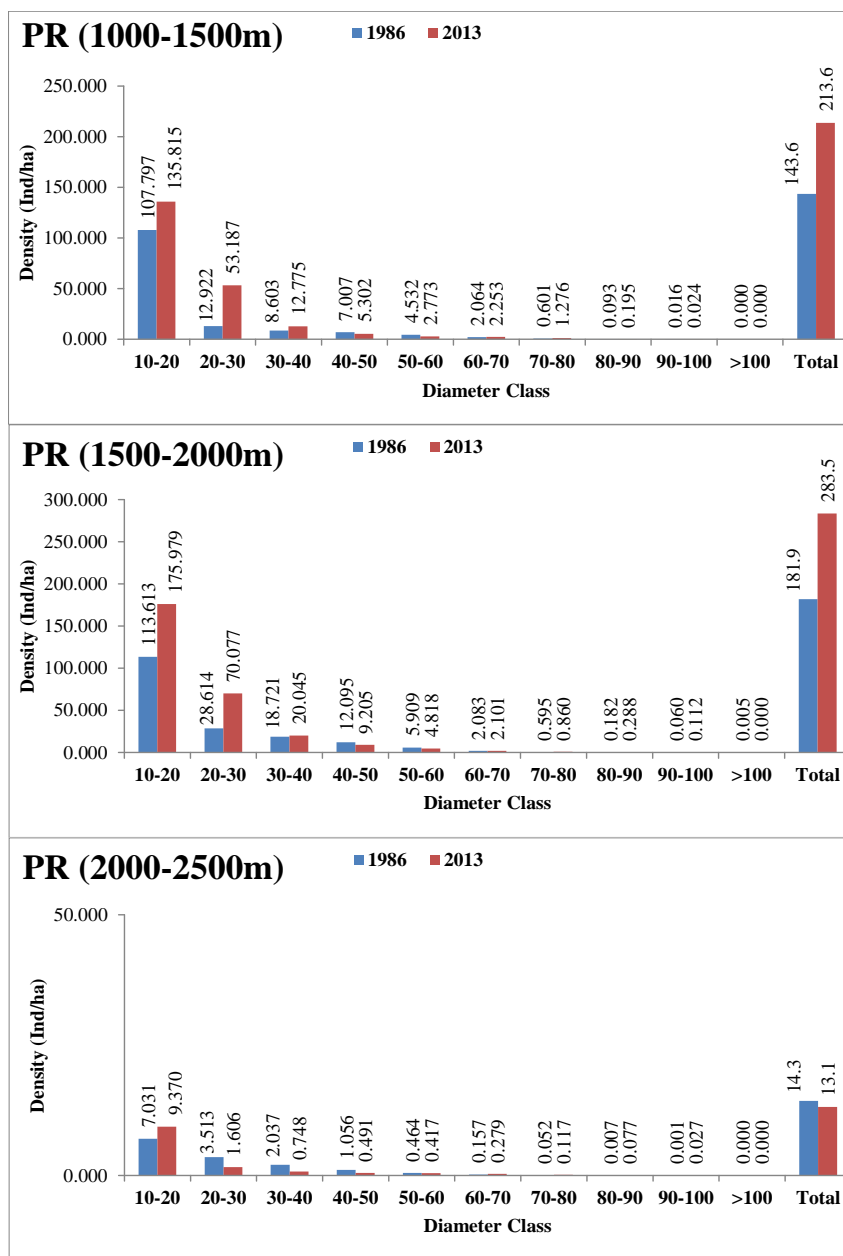
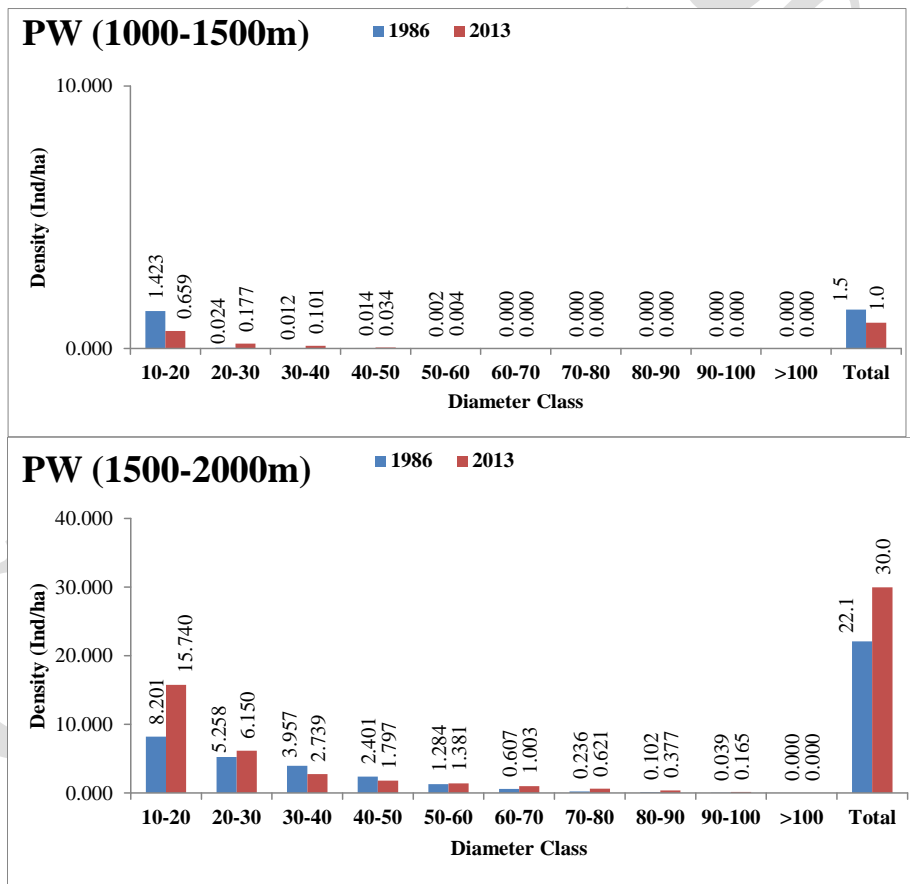


Figure 22. Density Variations in *Pinus roxburghii* community at Different Diameter Classes, Karsog Forest Division, 1986-2013

***Pinus wallichiana*:**

The species is found in all the four altitudinal gradients of Karsog Forest Division. The lowest altitudinal gradient (1000-1500m) had the maximum tree density in diameter class of 10-20cm which decreased from 1.423 to 0.659 Ind/ha with overall decrease from year 1986 to 2013, respectively. At 1500-2000m, diameter class of 10-20cm and 20-30cm showed the maximum density which increased from 8.201 to 15.74 Ind/ha and 5.258 to 6.150 Ind/ha, respectively. The density of young trees of diameter classes *i.e.* 30-40cm and 40-50cm is decreased while the mature trees (from 50-60 cm to more

than 100cm) were increased. In general, the total density is increased from 22.1 to 30 Ind/ha. The density at altitude ranges from 2000-2500m was decreased up to 60-70cm diameter classes and above these classes slight increase was observed from year 1986 to 2013. But the total density of *Pinus wallichiana* showed almost 50% decline in tree density from 82.1 to 48.5 Ind/ha for the year 1986 to 2013, respectively. In altitude gradient ranging from 2500-3000m, the tree density was good in lower diameter classes in year 1986 but 2013 the density was greatly reduced as shown in Figure 23. Finding from this gradient showed that there was a stark increase in *Pinus wallichiana* density from 67.9 to 11.6 Ind/ha. Therefore, it is observed that among all the four altitudinal gradients the middle gradients (1500-2000m and 2000-2500m) showed the maximum number of individuals unlike the lowest (1000-1500m) and highest (2500-3000m) ones.



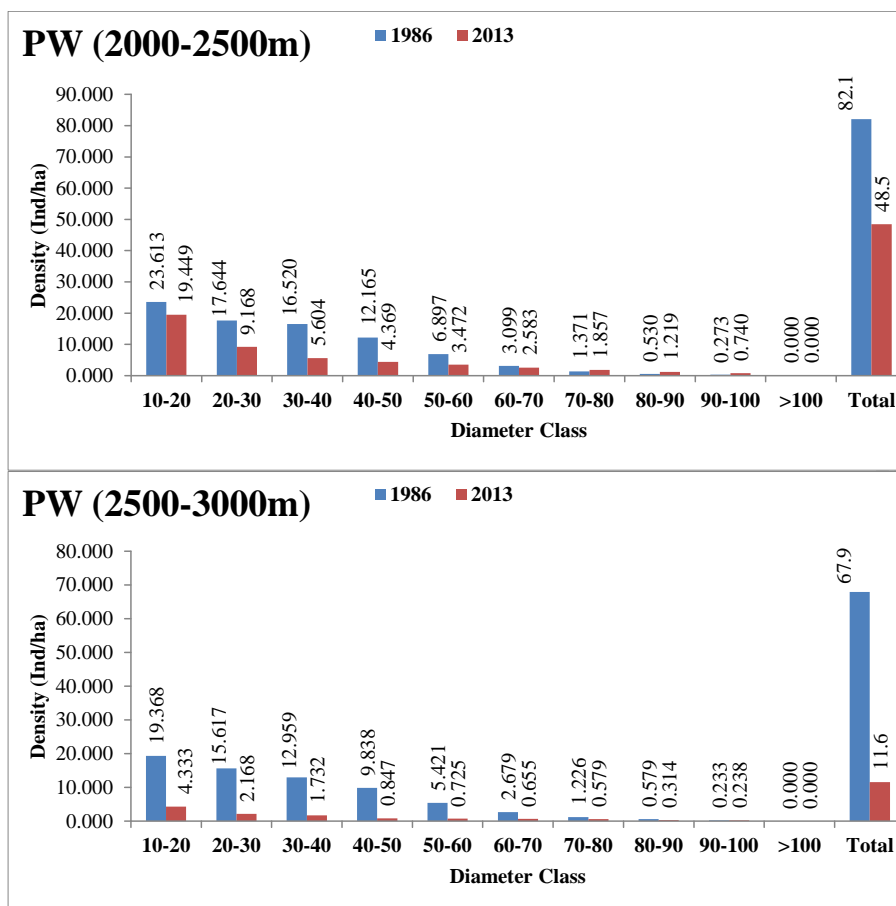
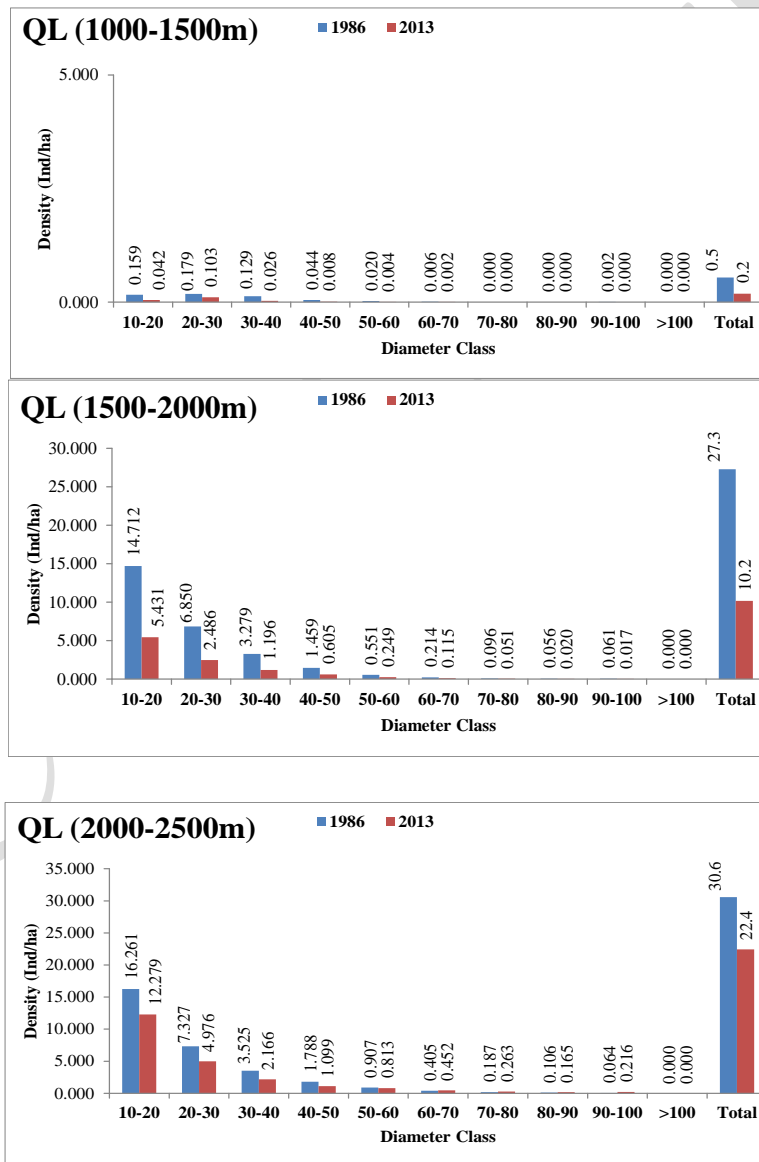


Figure 23. Density Variations in *Pinus wallichiana* community at Different Diameter Classes, Karsog Forest Division, 1986-2013

***Quercus leucotrichophora*:**

The species was found in all the four altitudinal gradients of Karsog Forest Division. The lowest altitudinal gradient (1000-1500m) had the minimum tree density as compared to all the other three altitudes. The maximum density was of lower diameter class trees (10-20 cm to 30-40 cm). Regarding the total density of individuals, the values declined (from 0.5 to 0.2 Ind/ha). At 1500-2000m, the maximum density of tree individuals of *Quercus leucotrichophora* was at lowest diameter class (10-20 cm) with a value of 14.71 which gets declined to 5.43 Ind/ha for the year 1986 to 2013, respectively. There occurred a decreasing trend in trees density while moving from lower to higher diameter classes *i.e.*, from 10-20 cm to more than 100 cm. The total density showed a sharp decrease with time *i.e.*, from 1986 to 2013 with a value of 27.3 to 10.2 Ind/ha, respectively.

At 2000-2500m, there was a declining trend of tree density from 10-20cm to 50-60cm diameter classes for both the initial (year 1986) and final (year 2013) years of assessment with a decreased value for the final year in each for up to 50-60 cm, beyond which the values showed a slight increase with time. While considering the overall tree density, a decrease in value was observed from 1986 (with a value of 30.6 Ind/ha) to 2013 (with a value of 22.4 Ind/ha). Similarly, at 2500-3000m, there occurred an decreasing trend of tree density from 10-20cm to 50-60cm diameter classes for both the initial (year 1986) and final (year 2013) years of assessment with a increased value for the final year (unlike the case of all the remaining altitudes) in each for up to 50-60 cm, beyond which the values showed a slight decrease with time (Figure 24).



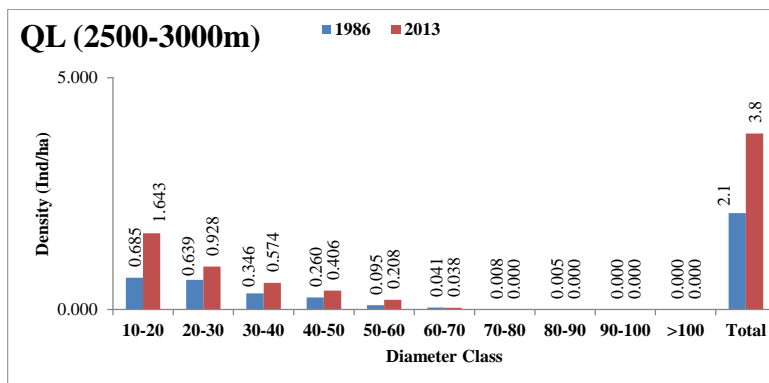
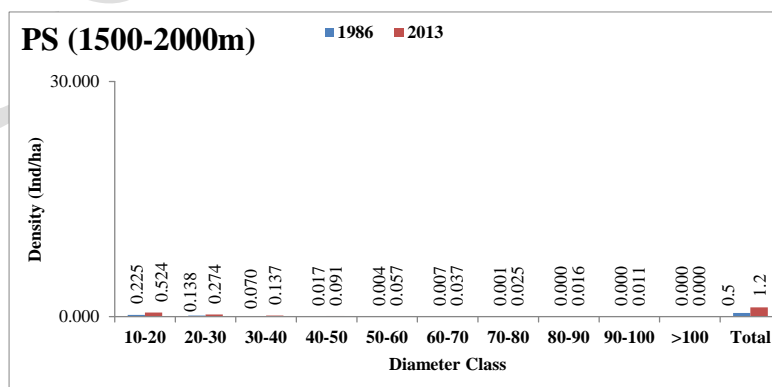


Figure 24. Density Variations in *Quercus leucotrichophora* community at Different Diameter Classes, Karsog Forest Division, 1986-2013

***Picea smithiana*:**

The species is found in only three altitudinal gradients of Karsog Forest Division, viz., 1500-2000m; 2000-2500m and 2500-3000m. Among all the three altitudinal gradients, the lowest one (1500-2000m) did not show remarkable or noticeable change in trees density and the total density showed a slight increase from the year 1986 to 2013 with their respective values as 0.5 to 1.2 Ind/ha. At 2000-2500m, there occurred a decreasing trend in terms of tree density while moving from lower to higher diameter classes. It is also noticed from the Figure 25 that while comparing two years density, the latest year (2013) showed more density than the old year (1986). The total tree density also showed the similar result (with less numbers of trees individuals per hectare in the latest year, 2013). While the highest altitudinal gradient (at 2500-3000m), total number of tree individuals showed a stark decrease from the old to latest year, i.e., 198.0 to 41.9 Ind/ha. The maximum tree density was found to be 54.56 Ind/ha at the lowest diameter class of 10-20cm in the year 1986 which falls to 10.78 Ind/ha in year 2013 (Figure 25).



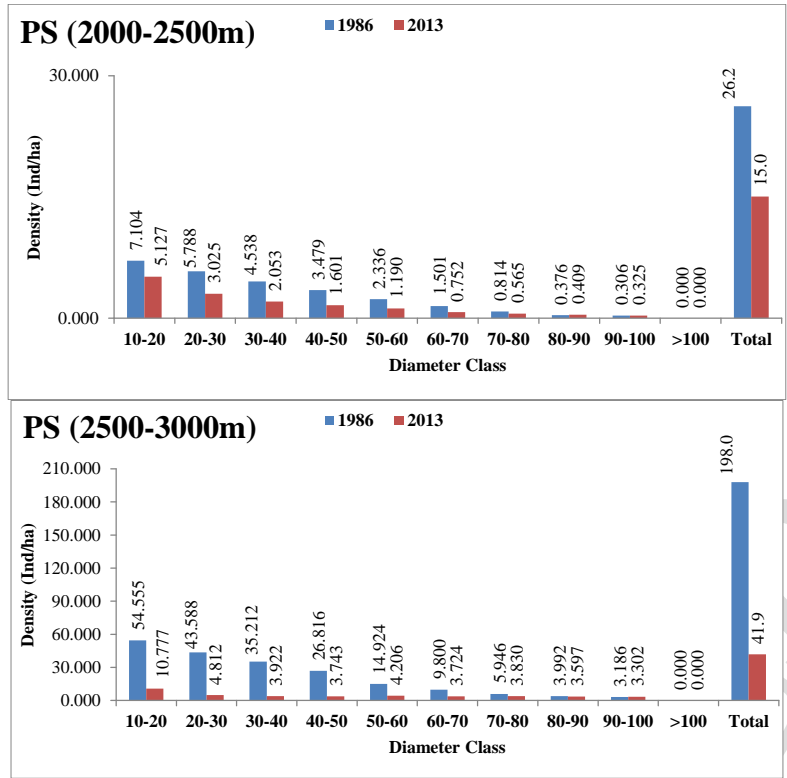


Figure 25. Density Variations in *Picea smithiana* community at Different Diameter Classes, Karsog Forest Division, 1986-2013

***Quercus floribunda*:**

Regarding this species (Figure 26) which showed its presence in only one altitudinal gradient *i.e.*, at 2000-2500m, although the density was found to be very less, the maximum number of tree individuals was at 10-20 cm showing a value of 0.030 Ind/ha in the year 1986 which falls to 0.015 Ind/ha for 2013. Regarding the total number of tree individuals, the tree individuals showed their increased density with the passage of time from the year 1986 towards the year 2013.

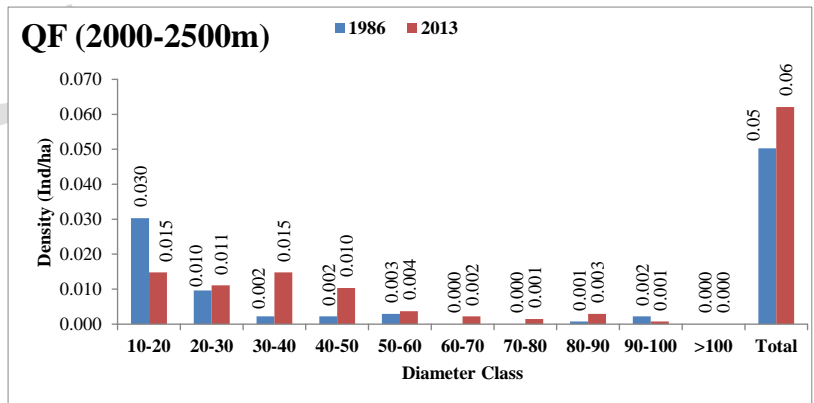


Figure 26. Density Variations in *Quercus floribunda* community at Different Diameter Classes, Karsog Forest Division, 1986-2013



***Taxus baccata:***

The species is found in only two altitudinal gradients of 2000-2500m and 2500-3000m as per the enumeration records assessed. This species showed its presence at altitude range from 2000-2500m, the diameter classes from 10-20cm to 50-60cm showed increased density in year 2013 while comparing the results with enumeration year 1986 (Figure 27). This increase results in overall increase in the density from 0.4 to 0.8 Ind/ha for the year 1986 and 2013, respectively. Altitude range from 2500-3000m showed a maximum of 1.76 Ind/ha for the year 1986 for the lowest diameter class of 10-20 cm. There occurred a decreasing trend in terms of tree density as we proceed from lowest to highest diameter class. The total density showed a fall in density with time from 2.9 to 1.3 Ind/ha for the year 1986 to 2013, respectively (Figure 27).

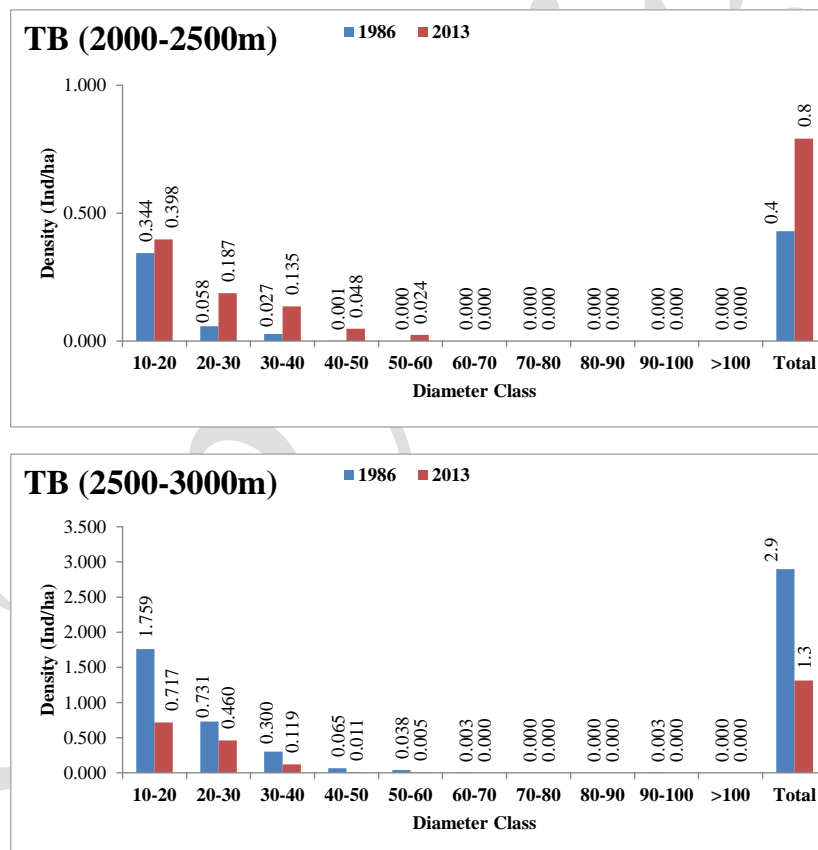


Figure 27. Density Variations in *Taxus baccata* community at Different Diameter Classes, Karsog Forest Division, 1986-2013

## Conclusion

The temporal study was commission with a view to get a preliminary insight in to the current status of vegetation viz., species composition in the Karsog Forest Divisions under the Mandi Forest Circle. To ascertain the temporal changes in different tree species composition three aspects were considered: 1) *tree community based variation*; 2) *altitude gradient driven variation*; and 3) *diameter class wise variations in tree composition*.

### Karsog Forest Division

There were six pure communities (having one dominant species) viz., *Pinus roxburghii* (PR), *Pinus wallichiana* (PW), *Cedrus deodara* (CD), *Picea smithiana* (PS), *Abies pindrow* (AP), *Quercus leucotrichophora* (QL) tree community and seven mixed communities viz. *Pinus roxburghii*-*Pinus wallichiana*, *Pinus roxburghii*-Broad leaved, *Pinus wallichiana*- *Quercus leucotrichophora*, *Quercus leucotrichophora*- Broad leaved, *Cedrus deodara*- Broad leaved, *Cedrus deodara*-*Pinus wallichiana*, *Pinus wallichiana*- Broad leaved mixed tree community were identified.

***Abies pindrow***: The density of *Abies pindrow* in its own tree community was increased from 122 to 133 Ind/ha in year 1986 to 2013 respectively. *Abies pindrow* was present at 2000-2500m and 2500-3000m altitude gradients only. The density of *Abies pindrow* was increased from 2.8 to 4.09 Ind/ha and 4.06 to 10.05 Ind/ha in 10-20cm diameter classes at 2000-2500m and 2500-3000m, respectively indicating its more regeneration potential and higher adaptability in the Karsog Forest Division at higher altitudes.

In both the gradients the tree density of larger diameter trees increased. The significant increase in *Abies pindrow* species might be due to the good regeneration, habitat suitability and less anthropogenic pressure as these forest compartments in which this species occurred is far away from the villages.

***Cedrus deodara***: The density of *Cedrus deodara* was decreased temporally from 259 to 173 Ind/ha in its own community. The density was increased at lowest elevation of 1500-2000m in all diameter classes except 30-40cm and 40-50cm. Whereas at 2000-2500m, the density of *Cedrus deodara* was decreased in diameter classes from 10-20cm to 50-60cm beyond which a reverse trend was observed. However, the total density

was decreased by a value of 29.6 Ind/ha from 1986 to 2013 and at 2500-3000m, showed a significant drop in density.

Thus, for *Cedrus deodara* it can be concluded that the altitude gradient from 1500-2000m showed increased density except other gradients. In this gradient only younger trees were observed as a result of more plantation activities and other measures by the HP Forest Department. This altitudinal gradient showed a number of temples where the species is conserved due to the religious faiths of the localities also. The other reasons behind their decline are people dependency for timber, replacement of some forest areas with agriculture/horticulture and land encroachments.

***Pinus roxburghii***: The density of *Pinus roxburghii* is increased from 210.3 Ind/ha to 321.9 Ind/ha in its own tree community. Findings revealed its maximum tree density in lower altitudes (1000-1500m and 1500-2000m). This increase is due to the habitat suitability, hardiness, high adaptability and high regeneration capacity of this species. Another reason of its increase are extensive plantation measures taken up by H.P. government, for pine resin extraction to generate revenue income (as per official of H.P. govt. report *Pinus roxburghii* resin extraction for year 2016 was 5931 quintal in Karsog forest division). With the rise in altitude (2000 to 2500m), the tree density slightly decreased (14.3 to 13.1 Ind/ha).

The decrease is due to the dependency of the local people on *Pinus roxburghii* for fuelwood as this zone is dominated by the other conifers also (*Pinus wallichiana*, *Cedrus deodara* etc.) which are not used for fuel purpose. That is why, *Pinus roxburghii* is over-utilized. Other reasons are frequent fires (ineffective fire protection), over-felling of trees, and no control over grazing and untrained staff.

***Picea smithiana***: The species occurred in Magroo forest range only of Karsog Forest Division where the species showed a significant declined value from 238.1 Ind/ha to 55.3 Ind/ha. It was observed that there were three altitudinal gradients where the species occurred, the suitable gradient of this species above 2000m showed a decrease in their density while the lowest altitude gradient (1500-2000m) showed a marginal increase. This indicates that besides being present in higher altitudes, the species starts adapting in the lower gradients also. Behind this decline no possible reasons were studied much and are not validated so far.

Hence, being an important species of Himachal Himalayas, it can be suggested that there is a need to study this species and reasons behind their abrupt changes.

***Pinus wallichiana***: The *Pinus wallichiana* forests are extensively located in Seri and Magroo ranges of the division. The total density of *Pinus wallichiana* community decreases from 70 to 55.5 Ind/ha in two respective years *i.e.* 1986 and 2013. The species is found in all the four altitudinal gradients of the Division. The altitudinal gradient (1500-2000m) showed the increased tree density temporally as compared to the other gradients. It is observed that younger trees are contributing more to the increase than the old/mature tree.

The decreased density in the remaining three gradients of the division is due to the fact that Seri and Magroo forest ranges of Karsog forest division have good moisture regime and ecology which is suitable for horticulture crops and exclusively recommended for apple orchard. Therefore, unregulated felling, heavy encroachment and dependency of local people for fuel and timber might result in declining its population.

***Quercus leucotrichophora***: The density of *Quercus leucotrichophora* is increased from 41.9 Ind/ha to 46.4 Ind/ha in year 1986-2013 respectively in its own tree community. The species was found in all the four altitudinal gradients of Karsog Forest Division. The tree density of *Quercus leucotrichophora* is decreased in all the altitudinal gradient except the highest gradients (2500-3000m). The forest fire is the main reason for its decline because of its mosaic occurrence in *Pinus roxburghii*, *Pinus wallichiana* forests which affects this species most. While the viability of this species after forest fire is very low (due to its sensitiveness and susceptibility to temperature) as compared to other broad leaved species. The other reasons behind its decline are dependency of the local people for quality fuel, fodder and agriculture tools, etc.

There occurred an increase in tree density at its highest altitudinal gradients (2500-3000m). This indicates that besides being a broad leaved species, it starts acclimatizing with the prevailing environmental conditions of the higher altitude.

***Quercus floribunda***: This species showed its presence in only one altitudinal gradient *i.e.*, at 2000-2500m, although the density was found to be very less, the maximum tree density was at 10-20 cm showing a value of 0.030 Ind/ha in the year 1986 which falls to 0.015 Ind/ha for 2013. However, no remarkable change was observed.

***Taxus baccata***: The species is found in only two altitudinal gradients of 2000-2500m and 2500-3000m as per the enumeration records assessed. This species grows optimally at these altitudes but it is found to decrease as per forest compartments

assessed for this study. These indications alarmed us to save such endangered species of the forest ecosystem.

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