



# Temporal Change in Dominant Tree Species in Temperate Forests of Himachal Pradesh

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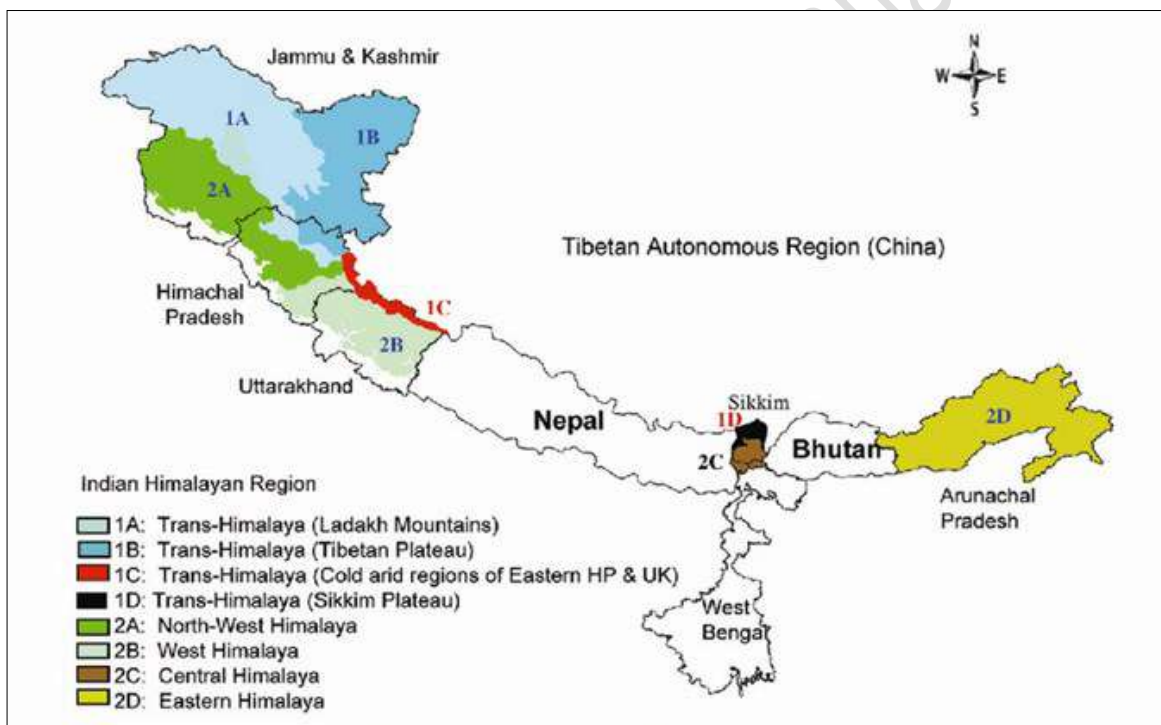
## Introduction

The Himalayas cover a vast expanse of 595,000 sq km with 2,400 km of parallel mountain ranges encompassing parts of India, Pakistan, Afghanistan, China, Bhutan, Nepal, and Tibet. Situated between 72<sup>0</sup>-91<sup>0</sup> E Longitudes and 27<sup>0</sup>-36<sup>0</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 is home to an array of rivers such as Yangtze, Ganges, Brahmaputra, Ganga, Indus, Yarlung, 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 a higher snowline, and a rich biodiversity. Meanwhile, the Western Himalayan ranges are farther apart from the plains with precipitous landscape and a 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; whereas 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 lacs sq km. With its foot-hills in Shivalik at the south, the vast Himalayan region expands to the Tibetan Plateau on the north, thus, serving as a natural northern boundary for India (Figure 1). The region covers three bio-geographic zones – the Trans Himalaya (cold deserts of Ladakh and Kargil in Jammu & Kashmir and Lahaul & Spiti in Himachal Pradesh), the Himalaya (north-west parts of Jammu & Kashmir and Himachal Pradesh and Uttarakhand on west) and Eastern & North-East India (Sikkim, Arunachal Pradesh and Darjeeling district of West Bengal and other Eastern States; Manipur, Meghalaya, Mizoram, Nagaland and Tripura).



**Figure 1 Map showing Indian Himalayan Region (IHR) with States in which IHR fall from North-Western to North-Eastern Himalayas**

According to the State of Forest Report (FSI, 2011), around 42 % 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. Around 22 % of India's total geographical area was found to be under forest cover, of which 2.99 % was under Very Dense Forest, 9.38 % under Moderately Dense Forest, and 9.18 % 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, Union Territory ; Jammu & Kashmir, Himachal Pradesh and States; 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 and Tripura had 77.69%, 76.45%, 86.27%, 75.33%, and 73.68% of their respective geographic area under forest cover (FSI, 2017).

### Forests of Himachal Pradesh

Himachal Pradesh is a mountainous state in the northernmost part of India, situated in the western Himalayas between latitude 30° 22' 40" N to 33 ° 12' 40" N and longitude 75 ° 45' 55" E to 79 ° 04' 20" E. The State's geographic landscape of Himachal Pradesh is divided into three distinct regions – Shivalik up to 1500m altitude; Mid-Himalayas between 1500-3000m and above 3000m stands the Himadris. Two-thirds of State area (55,673 sq km) falls under recorded forest area, however, only 27.12 % 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 (5.12 %), Protected (89.45 %), and Un-classed forest (2.39 %), within which certain areas are categorised for specific wildlife, flora and natural ecosystem protection (HPFD, 2012).

As per Champion and Seth (1968) classifications, Himachal Pradesh Forests are classified under 8 types:

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

Forest Type	Altitude	Mean Annual Temperature / Rainfall	Dominant Forests
Tropical Dry Deciduous Forests	>1000 m above mean sea level	24-27°C, 750-1300 mm/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	21-26°C, 1000-2000 mm/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>	1000-1800 m above mean sea level	15-22°C, 1000-3000 mm/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>Albizzia chinensis</i> , <i>Emblica sp.</i> , <i>Acacia catechu</i> , <i>Murraya spp.</i> , <i>Rosa moschata</i>
<b>Himalayan Moist Temperate Forests</b>	1500-3300 m above mean sea level	13-16°C, 1500-3300 mm/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>	>1,700 m above mean sea level	6-17°C, 80-800 mm/ 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>	2,900-3,500 m above mean sea level	2-6°C 10-55 mm/annum	Conifers – <i>Abies pindrow</i> , <i>Pinus wallichiana</i>  Deciduous trees – <i>Betula utilis</i> , <i>Querus 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	-	<i>Juniperus</i> , <i>Artemisia</i> , <i>Lonicera</i> , <i>Salix</i> , <i>Myricaria</i>

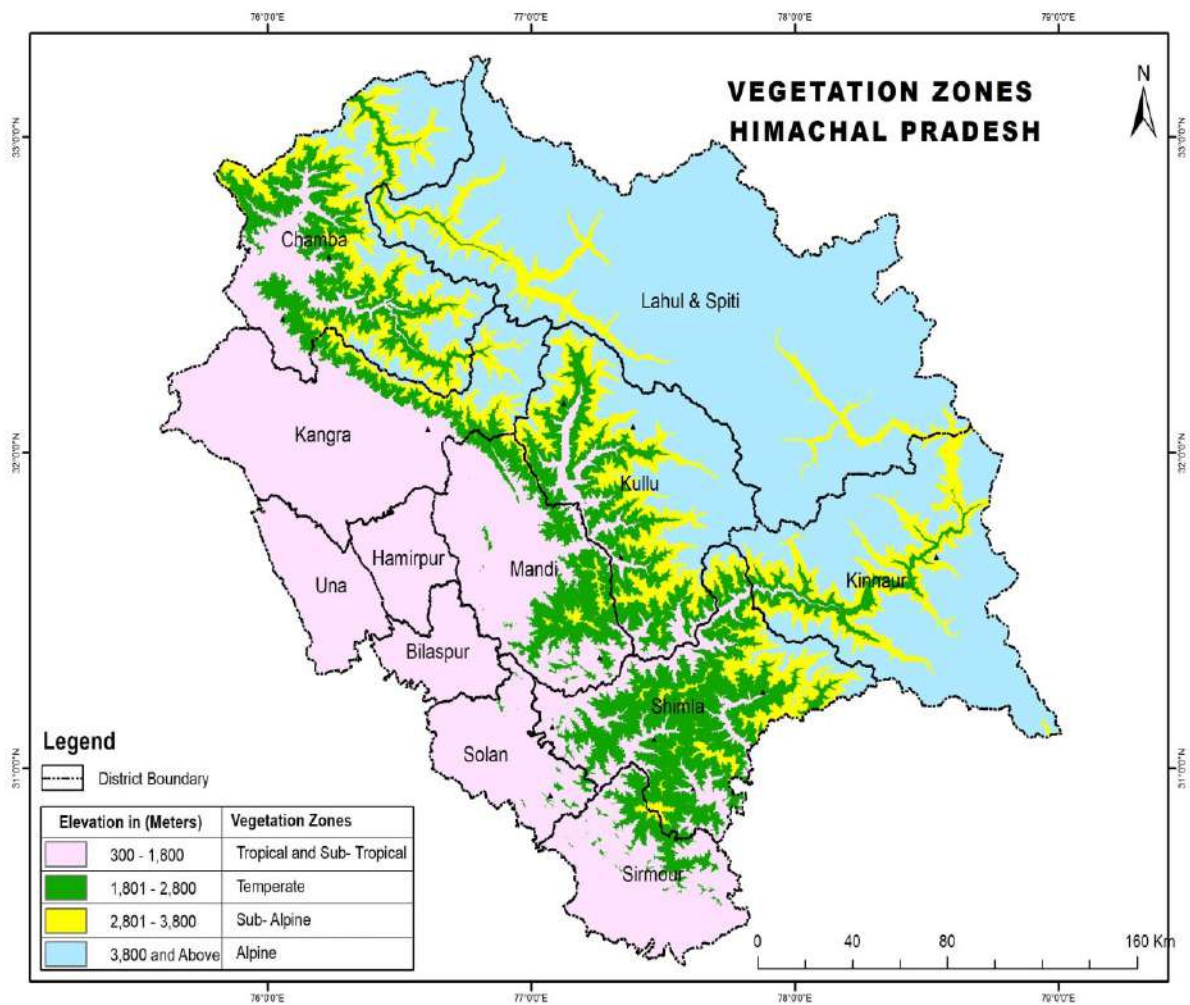
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Source: (Champion & Seth, 1968)

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 % of these species are endemic to the state and only 5 % known as exotic species have been introduced in the last 150 years. The forest ecosystem of the State 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. In the Western Himalayas, in particular, striking vegetative changes are observed where in various plant species are migrating to higher altitudes owing to warming trends (Padma, 2014), while others remain in danger of extinction. Additionally, the Hindu-Kush-Himalayan region is witnessing early trends of greening while habitat loss of around 30 % is expected for Snow Leopards owing to continuous forest losses (Panday & Ghimire, 2012) (Forrest *et al.*, 2012).

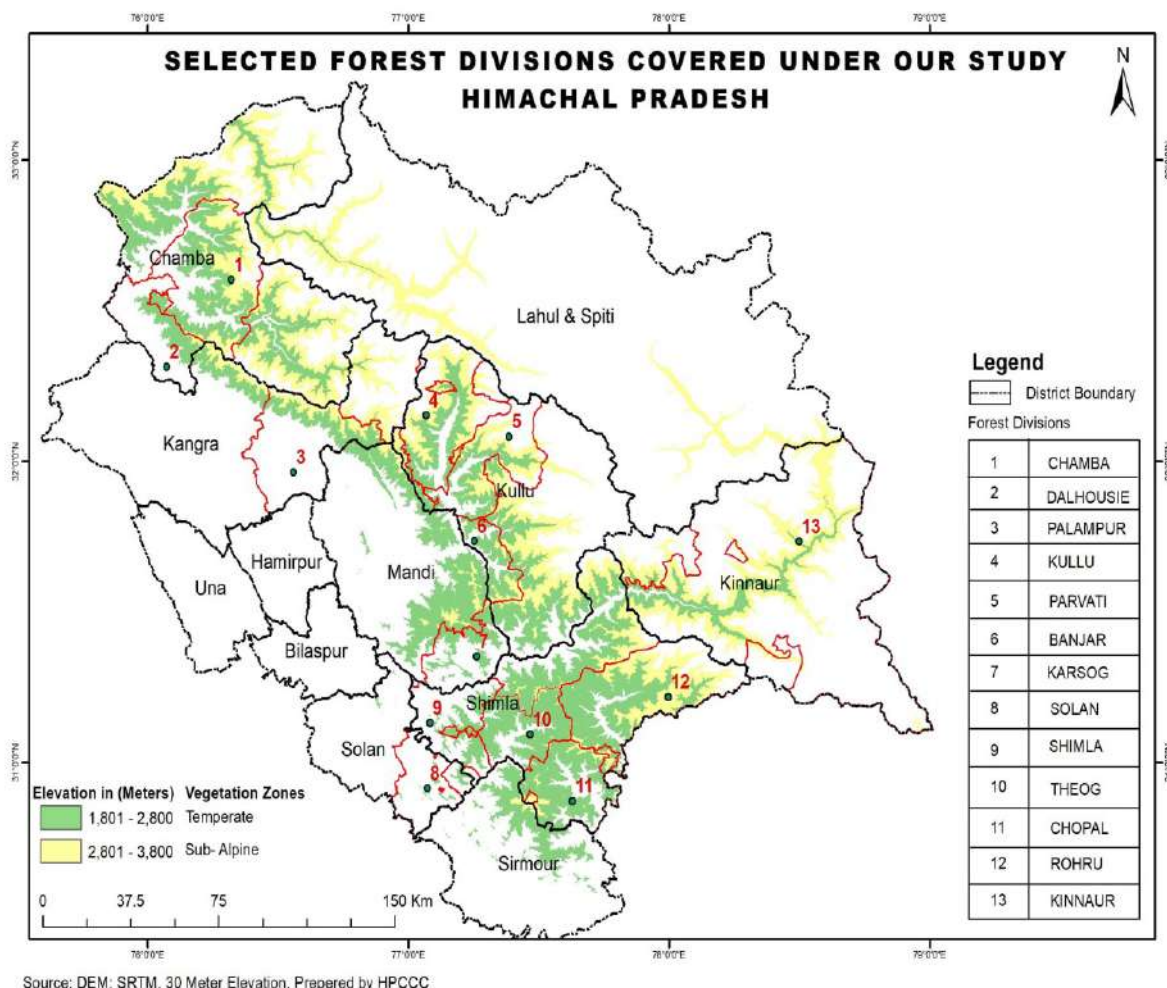
To that effect, this temporal study was designed to get a preliminary insight into the current status of vegetation, viz. species composition, in the thirteen forest divisions of Himachal Pradesh, viz. Shimla, Theog, Chopal, Rohru Forest Division (Shimla Circle); Kullu, Banjar/Seraj, Parwati Forest Division (Kullu Circle); Karsog Forest Division (Mandi Circle); Chamba, Dalhausie Forest Division (Chamba Circle); Solan Forest Division (Nahan Circle); Palampur (Dharamshala Circle); and Rampur (Rampur) Forest Division (Dharamshala Circle); and Kinnaur Forest Division (Rampur Circle). These forests were analysed to study the tree species composition (mainly conifers and oak). Most of the conifer forests of Himachal Pradesh fall under the temperate zone (as shown in Figures 2 and 3), while a few forests with *Pinus roxburghii* species are found in subtropical zones. The conifer tree species of Himachal Pradesh range from sub-tropical to sub-alpine zones. From low to high altitude, the main tree species are Chir-pine (*Pinus roxburghii*), Kail (*Pinus wallichiana*), Devdar (*Cedrus deodara*), Rai (*Picea smithiana*), Tosh (*Abies pindrow*), Rakhal (*Taxus baccata*), and Birch, Juniper, Cypress, and

Willow. Formerly, six species of conifers were considered in the status report because the forests of Himachal Pradesh are dominated by these species.



Source: DEM: SRTM, 30 Meter Elevation, Prepared by HPCCC

Figure 2. Vegetation zones of Himachal Pradesh showing elevation wise zonation from Tropical to Alpine



**Figure 3 Forest Division covered under forestry sector and green color showing temperate zone falling under selected forest division**

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 from these divisions. The report concludes with a categorised and consolidated snapshot of species composition in different Forest Divisions with information on tree community level variation with respect to altitudinal gradients.

## Study area and Methodology

### Himachal Pradesh-A Background

Himachal Pradesh is a state in the northern part of India, situated in the Western Himalayas; it is bordered by Union Territories of Jammu and Kashmir and Ladakh on the North,



Punjab State on the West, Haryana State on the Southwest, Uttarakhand State on the Southeast, and Tibet region on the East. At its Southern most point, it also touches the State of Uttar Pradesh. Predominantly a mountainous State in the Western Himalayas has a geographical area of 55,673 km<sup>2</sup>. The altitude of the State varies from 350 m to 6,975 m above mean sea level. It is located between latitude 30°45' to 33° 12'N and longitude 75°45' to 79°04'E.

It has three distinct regions viz. the Shiwaliks, middle Himalayan and Himadris, about one third of the state is permanently under snow, glaciers and cold deserts which do not support tree growth. The average annual rainfall is about 1,800 mm. The temperature varies from sub-zero to 35°C. The Satluj, Beas, Ravi, Chenab and Yamuna are the important rivers of the State. The State has 12 districts all of which are hill districts and there are three tribal districts (Chamba, Kinnaur and Lahaul & Spiti).

### **Forest Area**

The Forest Cover in the State is 15,433.52 sq km which is 27.72 % of the State's geographical area. In terms of forest canopy density classes, the State has 3,112.71 sq km under Very Dense Forest (VDF), 7,125.93 sq km under Moderately Dense Forest (MDF) and 5,194.88 sq km under Open Forest (OF). The State has reported extent of recorded forest area (RFA) 37,033 sq km which is 66.52% of its geographical area. The reserved, protected and unclassed forests are 5.13%, 89.46% and 5.41% of the recorded forest area in the State respectively. About two third of the State's geographical area is under recorded forests but a substantial part of this is not conducive for tree growth, being under permanent snow, glaciers and cold desserts.

### **Forest Zone**

Himachal Pradesh is a predominantly mountainous State. Consequently, the climate is more congenial to forests. It comprises four forests zones- sub-tropical, sub-temperate, wet-temperate and dry-temperate.

#### *Subtropical Forests:*

This zone consists of foothills and valleys up to an elevation of about 915 m above mean sea level with a subtropical climate and an annual rainfall of 70-100 cm, of which 75 % fall during

the monsoon season. The maximum temperature goes up to 40<sup>0</sup>C. It comprises dry deciduous, Chir pine, Sal (2140 sq km) and thorny forests (43 sq km) mostly of xerophytic species.

#### *Sub Temperate Forests:*

These forests extend from 916 m to about 1523 m above mean sea level, has a mild climate and an annual rainfall of 90 to 120 cm, nearly 70% of which is received during the monsoon season. Some upper hills get mild snowfall during winter, which does not stay for long. The maximum temperature in summer remains around 30<sup>0</sup>C. Various species of Pines, Oaks and broad-leaved grow in this zone and good pasturelands.

#### *Wet Temperate Forests:*

These extend from 1524 to 2472 m above mean sea level and have some major forests and pasturelands. The annual rainfall varies from 100 to 250 cm, with snowfall during winter, when temperature falls to minus 10<sup>0</sup>C. During summer, the maximum temperature ranges between 15 and 20<sup>0</sup>C. These forests have been categorized as

- (a) Lower western Himalayan temperate forests consisting of conifers, Oaks and various deciduous trees and
- (b) Western Himalayan temperate forests, which consists of Fir, Oaks and Rhododendron species found in alpine zones.

#### *Dry Temperate Forests:*

These forests extend above 2472 m from the mean sea level and the mean annual temperature is around 10<sup>0</sup>C with mean annual precipitation about 25 cm, most of which receives snow. The area contains scattered trees and bushes such as Chilgoza, Willow, *Robinia*, *Ailanthus*, Poplars and alpine pastures interspersed with bushes such as *Ephedra*.

### **Geography and Climatic Conditions**

Himachal Pradesh occurs in the western Himalayas covering an area of 55,673 sq km (21,495 sq m). Most of the State lies on the foothills of the Dhauladhar range. At 6,816 m, Reo Purgyl is the highest mountain peak in the State of Himachal Pradesh. The drainage system of State is composed both of rivers and glaciers. Himalayan rivers criss-cross the entire mountain

chain and provide water to both the Indus and Ganges basins. The drainage systems of the region are the Chandra Bhaga or the Chenab, the Ravi, the Beas, the Sutlej, and the Yamuna. These rivers are perennial and are fed by snow and rainfall. They are protected by an extensive cover of natural vegetation.

Due to extreme variation in elevation, great variation occurs in the climatic conditions of Himachal Pradesh. The climate varies from hot and sub-humid tropical in the southern tracts to, with more elevation, cold, alpine and glacial in the northern and eastern mountain ranges. The State's winter capital of State, Dharamshala receives very heavy rainfall, while areas like Lahaul and Spiti are cold and almost rainless. Broadly, Himachal Pradesh experiences three seasons: summer, winter, and rainy season. Summer lasts from mid-April till the end of June and most parts become very hot (except in the alpine zone which experiences a mild summer) with the average temperature ranging from 28 to 32 °C (82 to 90 °F). Winter lasts from late November till mid-March. Snowfall is common in alpine tracts.

## Methods

A three-tier assessment was conducted to study the temporal changes in different tree species composition in temperate forests of Shimla, Theog, Chopal, Rohru, Kullu, Banjar/Seraj, Parwati, Karsog, Chamba, Dalhausie, Solan, Palampur, and Kinnaur Forest Division.

- 1) community-based tree variation;
- 2) Altitude gradient driven variation (wherever possible)
- 3) Diameter class wise variations in tree composition (wherever possible). For each of the forest divisions, enumerated data were collected and analysed for their respective forest ranges as given below:

**Shimla Forest Division:** There are five forest ranges in this division: Mashobra, Koti, Bhajji, Tara Devi, and Dhambi. The other ranges, i.e., Tara Devi and Dhambi, were not considered as their respective working plans couldn't be procured. The total area of these forest ranges is 10,297 ha, of which 1793.2 ha were assessed in the study.

**Chopal Forest Division:** There are four forest ranges in this division: Chopal, Kanda, Nerwa, and Sarain. The total forest area under this division is 13602 ha, of which 6876.3 ha were assessed in this study.

**Rohru Forest Division:** There are six forest ranges in this division: Rohru, Tikker, Khashdhar, Jubbal, Bashala, and Sarswati Nagar. The total forest area under these ranges is 25194 ha, of which 9429.74 ha were assessed in this study.

**Theog Forest Division:** There are three forest ranges in this division: Theog, Balson, and Kotkhai. The total forest area under these ranges is 31,722.4 ha, of which 1660.9 ha were assessed in this study.

**Kullu Forest Division:** There are five forest ranges in this division: Kullu, Manali, Bhutti, Patlikuhl, and Naggar. The total area of these forest ranges is 40,069.31 ha, of which 6972.59 ha were assessed in the study.

**Banjar/Seraj Forest Division:** There are three forest ranges in this division: Banjar, Sainj, and Tirthan. This division's total forest area is 104,820.24 ha, of which 28,911.12 ha were assessed in this study.

**Parvati Forest Division:** There are four forest ranges in this division: Parvati, Hurla, Jari, and Kasol. The total forest area under these ranges is 9199.98 ha, of which 4343.66 ha were assessed in this study.

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

**Chamba Forest Division:** In Chamba Forest Division, there are four forest ranges: Masrund, Lower Chamba, Upper Chamba, and Tikkari. The sample area of all forest ranges was 3509.06 ha.

**Dalhousie Forest Division:** There are four forest ranges in this division: Dalhousie, Bakloh, Chowari, and Bhattiyat. The total area of these forest ranges is 39951.22 ha (falling under 851.96

ha of reserved forest, 38558.69 ha of demarcated protected forest area, and 540.57 ha of undemarcated protected forest area), out of which 1624.80 ha was assessed in this study.

**Solan Forest Division:** There are five forest ranges in this division: Kandaghat, Solan, Subathu, Dharampur, and Parwanoo. The total area of forest ranges is 11743.8 ha, of which 2061.5 ha were assessed in the study.

**Palampur Forest Division:** There are three forest ranges in the Palampur Forest Division: Baijnath, Droh, and Palampur. The total assessed area of these forest ranges is 2861.18 ha for 190 compartments.

**Kinnaur Forest Division:** There are 47 compartments that were studied and analysed to get the status of species and their fluctuations in the Kinnaur Forest Division. These forest compartments belong to three forest ranges, namely Nichar, Katgaon, Kilba, Bhaba Nagar, Kalpa, and Moorang Forest Range, with a total area of 10409 ha.

The forest divisions listed above with ranges are those that were available with comparable enumeration records, i.e., older and newer years.

### Data Sources and Techniques

Working plans from the Himachal Pradesh Forest Department and compartment history files from the selected forest divisions were used as data sources and techniques. For selected forest divisions, the temporal changes in tree species composition during successive enumeration records according to working plans were examined. The time period for each division is different as per the enumerated information available. The enumeration records for different forest divisions in Himachal Pradesh are: Shimla Forest Division (1981-1996), Chopal Forest Division (1965-2003), Rohru Forest Division (1969-1994), Theog Forest Division (1981-1996), Kullu Forest Division (1949-1994), Banjar/Seraj Forest Division (1986-2013), Parvati Forest Division (1986-2013), Karsog Forest Division (1986-2013), Chamba Forest Division (1994-2016), Dalhousie Forest Division (1969-2013), Solan Forest Division, Palampur Forest Division (1981-96 and 2010-25) and Kinnaur Forest Division (1961-76 and 2019-35).



The data taken from the selected forest divisions was collected in the form of soft copies (photographs of compartment history files) and a working plan document procured from the State Forests Library and Forest Divisions. Only those forest divisions that have comparable enumeration records were taken into the study, and those cover the temperate region of Himachal Pradesh.

A "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, the Forest Division is the basic unit. This document is used to evaluate the status of forests and the biodiversity resources within a particular division.

For assessment purposes, the forests were classified based on the delineated communities, i.e., if the relative density of a single species is greater than 50%, the tree community was identified as a single-species dominant community. For cases where more than one species collectively accounted for 50% of the relative density, the tree community was referred to as a "mixed community." Forests were further classified into different altitude gradients of 1,000–1,500 m, 1,500–2,000 m, 2,000–2,500 m, and 2,500–3,000 m (wherever the data was available). The species composition was assessed for changes in the tree density, where individuals per hectare (Ind/ha) were calculated for the two-time period, i.e., two different years of enumerations. The area under the assessed forest compartments for respective divisions was taken to be more than 10% of the total forest area, but in the status report only a tree community-based study was chosen because this was common in all forest divisions. The total area in the selected forests is 57447.45 ha, which was used as a sample area in the study. The details of the forest divisions used in the study covering Himachal Pradesh's temperate forests are provided below. These divisions have tree communities (having dominant tree species) and mixed tree communities (having two co-dominant tree species) listed with the number of forest compartments to which the species belong and the area falling under selected compartments.

Shimla Forest Division (1981-1996)		
Tree community	Forest Compartment	Area assessed (ha)
<i>Cedrus deodara</i>	16	627.2

<i>Pinus roxburghii</i>	6	327.8
<i>Pinus wallichiana</i>	7	280.8
<i>Quercus leucotrichophora</i>	5	268.8
<i>Cedrus deodara-Quercus floribunda</i> mixed	1	38.4
<i>Cedrus deodara-Quercus</i> <i>leucotrichophora</i> mixed	1	98.8
<i>Pinus roxburghii-Cedrus deodara</i> mixed	1	36.4
<i>Pinus roxburghii</i> -Broad-leaved mixed	1	12.6
<i>Pinus wallichiana-Quercus floribunda</i> mixed	1	102.4
<b>Total</b>	<b>39</b>	<b>1793.2</b>

**Table 2 Details on Tree Community, Forest Compartment and area assessed of Shimla Forest Division (1981-1996)**

<b>Chopal Forest Division (1965-2003)</b>		
<b>Tree community</b>	<b>Forest Compartment</b>	<b>Area assessed (ha)</b>
<i>Cedrus deodara</i>	69	2373.41
<i>Pinus wallichiana</i>	11	375.46
<i>Quercus floribunda</i>	1	60.7
<i>Picea smithiana</i>	10	478.2
<i>Abies pindrow</i>	5	353.68
Broad-leaved	4	269.51
<i>Quercus semecarpifolia</i>	2	225.81
<i>Cedrus deodara-Pinus wallichiana</i> mixed	4	118.15
<i>Cedrus deodara- Quercus floribunda</i> mixed	1	59.08
<i>Cedrus deodara-Quercus</i> <i>semecarpifolia</i> mixed	2	127.87
<i>Cedrus deodara- Abies pindrow</i> mixed	3	122.21
<i>Cedrus deodara- Broad-leaved</i> mixed	2	152.96
<i>Cedrus deodara- Picea smithiana</i> mixed	1	23.47
<i>Pinus wallichiana-Cedrus deodara</i> mixed	2	100.77
<i>Abies pindrow-Cedrus deodara</i> mixed	3	142.04
<i>Abies pindrow-Picea smithiana</i> mixed	3	101.97

Broad-leaved- <i>Taxus baccata</i> mixed	1	32.37
<i>Picea smithiana</i> - <i>Abies pindrow</i>	5	291.34
<i>Picea smithiana</i> -Broad-leaved	1	37.23
<i>Picea smithiana</i> <i>Cedrus deodara</i>	1	73.65
<i>Picea smithiana</i> - <i>Taxus baccata</i> mixed	2	193.43
<i>Picea smithiana</i> - <i>Quercus semecarpifolia</i> mixed	2	207.22
<i>Pinus wallichiana</i> -Broad-leaved mixed	1	56.65
<i>Pinus wallichiana</i> - <i>Quercus leucotrichophora</i> mixed	2	73.64
Broad-leaved- <i>Pinus wallichiana</i> mixed	1	75.27
Broad-leaved- <i>Abies pindrow</i> mixed	1	50.18
<i>Taxus baccata</i> - <i>Abies pindrow</i> mixed	1	54.63
<i>Quercus semecarpifolia</i> - <i>Taxus baccata</i> mixed	4	491.68
<i>Quercus semecarpifolia</i> - <i>Picea smithiana</i> mixed	1	153.73
<b>Total</b>	<b>146</b>	<b>6876.31</b>

**Table 3 Details on Tree Community, Forest Compartment and area assessed of Chopal Forest Division (1965-2003)**

<b>Rohru Division (1969-1994)</b>		
<b>Tree community</b>	<b>Forest Compartment</b>	<b>Area assessed (ha)</b>
<i>Cedrus deodara</i>	19	1365.82
<i>Pinus wallichiana</i>	45	4551.71
<i>Abies pindrow</i>	9	1150.54
<i>Pinus roxburghii</i>	6	399.02
Broad-leaved	3	335.08
<i>Quercus leucotrichophora</i>	2	121
<i>Picea smithiana</i>	1	66.37
<i>Abies pindrow</i> -Broad-leaved mixed	1	117.36
<i>Pinus smithiana</i> - <i>Cedrus deodara</i> mixed	4	346.01
<i>Abies pindrow</i> - <i>Picea smithiana</i> mixed	3	309.17
<i>Cedrus deodara</i> - <i>Pinus wallichiana</i> mixed	1	84.58
<i>Pinus wallichiana</i> - <i>Cedrus deodara</i> mixed	1	212.4
Broad-leaved- <i>Pinus wallichiana</i> mixed	1	82.55
<i>Picea smithiana</i> - <i>Abies pindrow</i> mixed	2	288.13

<b>Total</b>	<b>98</b>	<b>9429.74</b>
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**Table 4 Details on Tree Community, Forest Compartment and area assessed of Rohru Forest Division (1969-1994)**

<b>Theog Forest Division (1981-1996)</b>		
<b>Tree community</b>	<b>Forest Compartment</b>	<b>Area assessed (ha)</b>
<i>Cedrus deodara</i>	15	517.7
<i>Pinus wallichiana</i>	10	501
<i>Abies pindrow</i>	1	75
Broad-leaved	1	25
<i>Pinus wallichiana</i> -Broad-leaved mixed	2	120.6
<i>Cedrus deodara</i> - <i>Pinus wallichiana</i> mixed	1	16.6
<i>Cedrus deodara</i> - <i>Picea smithiana</i> mixed	2	158.6
<i>Quercus floribunda</i> -Broad-leaved mixed	2	87
<i>Pinus wallichiana</i> - <i>Picea smithiana</i> mixed	1	67.6
<i>Abies pindrow</i> - <i>Quercus floribunda</i> mixed	1	91.8
<b>Total</b>	<b>36</b>	<b>1660.9</b>

**Table 5 Details on Tree Community, Forest Compartment and area assessed of Theog Forest Division (1981-1996)**

<b>Kullu Forest Division (1949-1994)</b>		
<b>Tree community</b>	<b>Forest Compartment</b>	<b>Area assessed (ha)</b>
<i>Cedrus deodara</i>	27	870.67
<i>Pinus wallichiana</i>	12	527.27
<i>Abies pindrow</i>	11	1609.82
<i>Picea smithiana</i>	53	2395.31
<i>Quercus semecarpifolia</i>	6	366.55
Broad leaved	12	959.99
<i>Cedrus deodara</i> - <i>Picea smithiana</i> mixed	4	135.7
<i>Pinus wallichiana</i> - <i>Cedrus deodara</i> mixed	4	107.28
<b>Total</b>	<b>129</b>	<b>6972.59</b>

**Table 6 Details on Tree Community, Forest Compartment and area assessed of Kullu Forest Division (1949-1994)**

<b>Banjar/ Seraj Division (1986-2013)</b>
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Tree community	Forest Compartment	Area assessed (ha)
<i>Cedrus deodara</i>	22	454.47
<i>Pinus wallichiana</i>	15	486.8
<i>Pinus roxburghii</i>	5	178.47
<i>Picea smithiana</i>	10	266.68
<i>Abies pindrow</i>	3	120.08
<i>Quercus leucotrichophora</i>	2	79.27
<i>Cedrus deodara</i> - <i>Pinus wallichiana</i> mixed	4	74.87
<i>Abies pindrow</i> - <i>Taxus baccata</i> mixed	6	275.02
<i>Abies pindrow</i> - <i>Picea smithiana</i> mixed	6	232.62
<i>Abies pindrow</i> -Broad-leaved mixed	2	106.59
<i>Taxus baccata</i> - <i>Abies pindrow</i> mixed	2	73.64
<i>Quercus leucotrichophora</i> - <i>Pinus wallichiana</i> mixed	1	116.59
<i>Quercus semecarpifolia</i> - <i>Quercus leucotrichophora</i> mixed	1	92.68
<i>Picea smithiana</i> - <i>Taxus baccata</i> mixed	1	28.81
<i>Taxus baccata</i> - <i>Picea smithiana</i> mixed	1	37.49
<i>Quercus semecarpifolia</i> - <i>Taxus baccata</i> mixed	1	86.5
<i>Broad-leaved</i> - <i>Picea smithiana</i> mixed	1	91.11
<i>Quercus semecarpifolia</i> - <i>Taxus baccata</i> - <i>Abies pindrow</i> mixed	1	36.02
<i>Picea smithiana</i> - <i>Abies pindrow</i> - <i>Pinus wallichiana</i> mixed	1	53.41
<b>Total</b>	<b>85</b>	<b>2891.12</b>

Table 7 Details on Tree Community, Forest Compartment and area assessed of Banjar/Seraj Forest Division 1986-2013

Parvati Forest Division		
Tree community	Forest Compartment	Area assessed (ha)
<i>Cedrus deodara</i>	20	833.87
<i>Pinus wallichiana</i>	21	1335.14
<i>Abies pindrow</i>	12	945.12
<i>Picea smithiana</i>	3	214.28
<i>Pinus roxburghii</i>	1	12.95
<i>Broad-Leaved</i>	4	275.58
<i>Abies pindrow</i> - <i>Picea smithiana</i> mixed	2	153.75
<i>Picea smithiana</i> - <i>Cedrus deodara</i> mixed	2	143.48



<i>Picea smithiana</i> - <i>Pinus wallichiana</i> mixed	1	29.5
<i>Pinus wallichiana</i> - <i>Cedrus deodara</i> mixed	2	103.19
<i>Broad-leaved</i> - <i>Picea smithiana</i> mixed	1	112.09
<i>Pinus wallichiana</i> - <i>Pinus roxburghii</i> mixed	1	48.97
<i>Cedrus deodara</i> - <i>Picea smithiana</i> mixed	2	135.74
<b>Total</b>	<b>72</b>	<b>4343.66</b>

**Table 8 Details on Tree Community, Forest Compartment and area assessed of Parvati Forest Division (1948-1996)**

<b>Karsog Forest Division (1986-2013)</b>		
<b>Tree community</b>	<b>Forest Compartment</b>	<b>Area assessed (ha)</b>
<i>Pinus roxburghii</i>	84	3973.9
<i>Pinus wallichiana</i>	11	394.96
<i>Cedrus deodara</i>	19	902.33
<i>Picea smithiana</i>	5	300.02
<i>Abies pindrow</i>	4	152.38
<i>Quercus leucotrichophora</i>	3	168.95
<i>Pinus roxburghii</i> - <i>Pinus wallichiana</i>	5	336.55
<i>Pinus roxburghii</i> - Broad leaved	2	45.17
<i>Pinus wallichiana</i> - <i>Quercus leucotrichophora</i>	1	38.52
<i>Quercus leucotrichophora</i> -Broad leaved	1	27.37
<i>Cedrus deodara</i> - Broad leaved	1	44.15
<i>Cedrus deodara</i> - <i>Pinus wallichiana</i>	4	131.02
<i>Pinus wallichiana</i> - Broad leaved	1	31.19
<b>Total</b>	<b>141</b>	<b>6523.46</b>

**Table 9 Details on Tree Community, Forest Compartment and area assessed of Karsog Forest Division (1986-2013)**

<b>Chamba Forest Division (1994-2016)</b>		
<b>Tree community</b>	<b>Forest Compartment</b>	<b>Area assessed (ha)</b>
<i>Cedrus deodara</i>	11	450.5
<i>Picea smithiana</i>	5	401.19
<i>Pinus roxburghii</i>	9	382.64
<i>Pinus wallichiana</i>	3	154.89
<i>Quercus leucotrichophora</i>	5	295.82

<i>Quercus semecarpifolia</i>	2	112.51
Other Broad Leaved	13	840.77
<i>Cedrus deodara-Quercus leucotrichophora</i>	3	185.35
<i>Pinus roxburghii-Quercus leucotrichophora</i>	1	30.35
<i>Abies pindrow-Quercus floribunda</i>	1	56.66
<i>Quercus leucotrichophora</i> -Other Broad Leaved	1	72.7
<i>Pinus wallichiana</i> -Other Broad Leaved	1	26.71
<i>Abies pindrow</i> -Other Broad Leaved	2	321.81
<i>Cedrus deodara-Picea smithiana</i>	1	38.04
<i>Picea smithiana</i> -Other Broad Leaved	2	139.12
<b>Total</b>	<b>60</b>	<b>3509.06</b>

**Table 10 Details on Tree Community, Forest Compartment and area assessed of Chamba Forest Division (1994-2016)**

<b>Dalhousie Forest Division (1969-2013)</b>		
<b>Tree community</b>	<b>Forest Compartment</b>	<b>Area assessed (ha)</b>
<i>Cedrus deodara</i> (CD)	14	483.29
<i>Picea smithiana</i> (PS)	2	32
<i>Pinus roxburghii</i> (PR)	32	1035.08
<i>Quercus leucotrichophora</i> (QL)	1	12.54
<i>Abies pindrow</i> (AP)	1	42.9
<b>Total</b>	<b>50</b>	<b>1605.81</b>

**Table 11 Details on Tree Community, Forest Compartment and area assessed of Dalhousie Forest Division (1969-2013)**

<b>Solan Forest Division (1983 to 2017)</b>		
<b>Tree community</b>	<b>Forest Compartment</b>	<b>Area assessed (ha)</b>
<i>Cedrus deodara</i> (CD)	11	450.5
<i>Picea smithiana</i> (PS)	5	401.19
<i>Pinus roxburghii</i> (PR)	9	382.64
<i>Pinus wallichiana</i> (PW)	3	154.89
<i>Quercus leucotrichophora</i> (QL)	5	295.82
<i>Quercus semecarpifolia</i> (QS)	2	112.51
Other Broad Leaved	13	840.77
<i>Cedrus deodara-Quercus leucotrichophora</i> (CD-QL)	3	185.35
<i>Pinus roxburghii-Quercus leucotrichophora</i> (PR-QL)	1	30.35

<i>Abies pindrow-Quercus floribunda</i> (AP-QF)	1	56.66
<i>Quercus leucotrichophora</i> -Other Broad Leaved (QL-OBL)	1	72.7
<i>Pinus wallichiana</i> -Other Broad Leaved (PW-OBL)	1	26.71
<i>Abies pindrow</i> -Other Broad Leaved (AP-OBL)	2	321.81
<i>Cedrus deodara-Picea smithiana</i> (CD- PS)	1	38.04
<i>Picea smithiana</i> -Other Broad Leaved (PS-OBL)	2	139.12
<b>Total</b>	<b>60</b>	<b>3509.06</b>

Table 12 Details on Tree Community, Forest Compartment and area assessed of Solan Forest Division ((1983 to 2017)

Palampur Forest Division (1981-82 to 1995-96 and 2010-11 to 2024-25)		
Tree community	Forest Compartment	Area assessed (ha)
<i>Pinus roxburghii</i>	173	2396.18
Ban Oak	17	465.07
<b>Total</b>	<b>190</b>	<b>2861.25</b>

Table 13 Details on Tree Community, Forest Compartment, and Area Assessed of Palampur Forest Division ((1981 to 2025)

Kinnaur Forest Division (1961-62 to 1975-76 and 2019-20 to 2034-35)		
Tree community	Forest Compartment	Area assessed (ha)
<i>Cedrus deodara</i>	39	9327.9
<i>Pinus wallichiana</i>	5	891.98
<i>Picea smithiana</i>	3	189
<b>Total</b>	<b>47</b>	<b>10409</b>

Table 14 Details on Tree Community, Forest Compartment and area assessed of Solan Forest Division ((1961 to 2035)

## Assessment Techniques

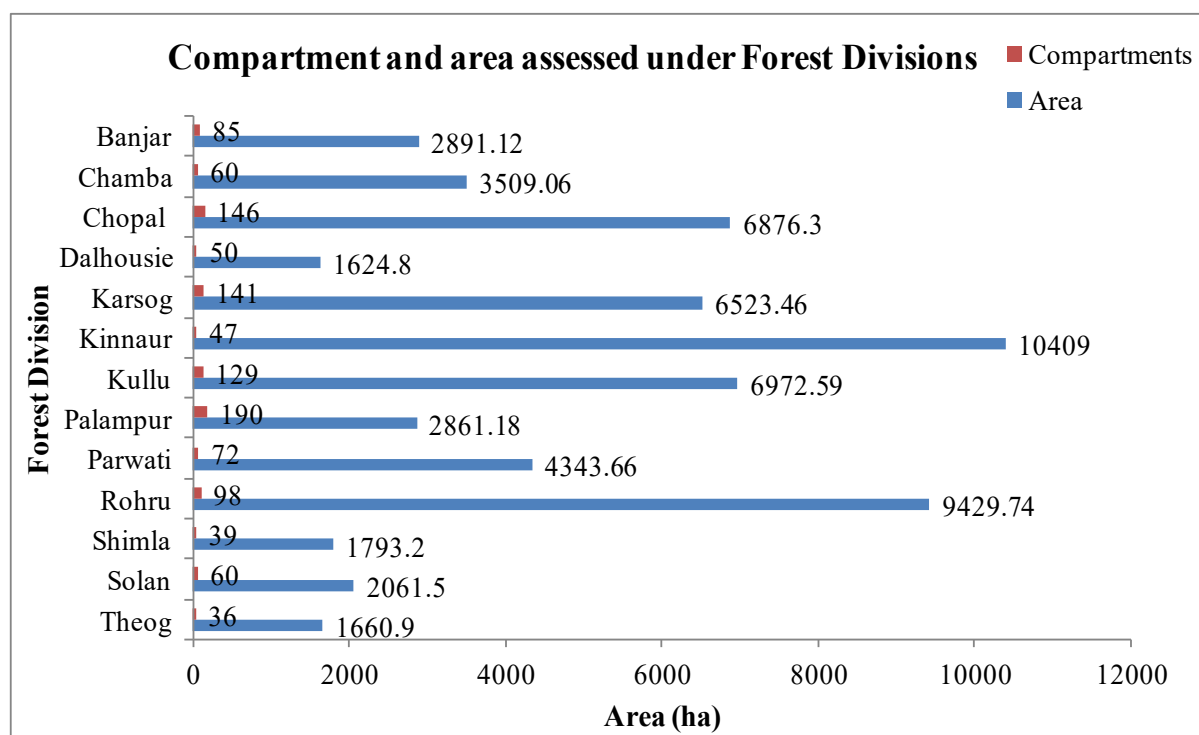
### Tree communities-based variation:

Each forest division constitutes different tree communities where dominant species is identified based on its relative density (more than 50 % categorized as dominant community and

a collective majority as mixed community). For each of the identified pure species in each forest division i.e. Shimla Forest Division (1981-1996), Chopal Forest Division (1965-2003), Rohru Forest Division (1969-1994), Theog Forest Division (1981-1996), Kullu Forest Division (1949-1994), Banjar/ Seraj Forest Division (1986-2013), Parvati Forest Division (1986-2013), Karsog Forest Division (1986-2013), Chamba Forest Division (1994-2016), Dalhousie Forest Division (1969-2013), Solan Forest Division, Palampur Forest Division (1981-96 and 2010-25) and Kinnaur Forest Division (1961-76 and 2019-35).

## Results and Discussions

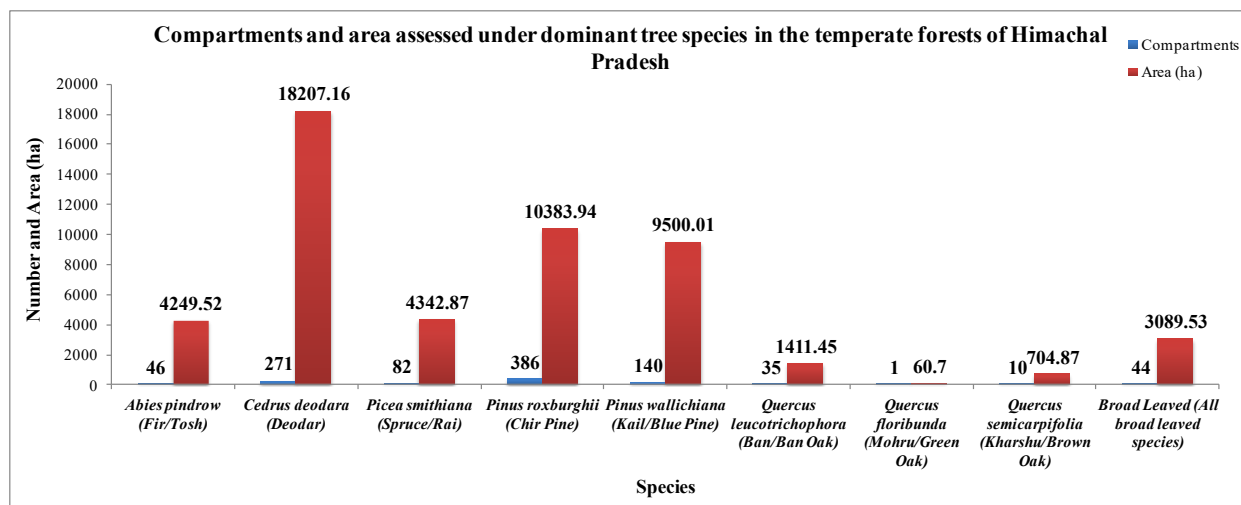
This section presents the findings or results from the assessment of the tree community, its species composition in the pure tree communities as well as in mixed tree communities in the above-mentioned forest divisions. It also highlighted the visual change in density of tree species composition in the respective years of enumerations. This analysis of the temperate forests of Himachal Pradesh revealed the status of tree species in the forests so as to observe the change in density (Ind/ha). The study provides primary insight into species composition and status, which aids in the improvement of forest management for biodiversity conservation (flora and fauna). One of the most important aspects of this study is that it highlighted the particular area where a particular species is decreasing or increasing. Such information regarding species change will help in maintaining, improving, and conserving the tree species in their natural habitat. Previously, the status of tree species was hypothetical or theoretical and defined for some particular area, but this study provides a wide view of species occurrence and locations. Therefore, if any conservation and management practices exist, we can choose the particular region where these activities can be performed.



**Table 15 Forests Divisions of Himachal Pradesh showing number of compartments analyzed and area (ha) covered.**

The tree communities identified with respect to the dominant species under different forest divisions are listed below, with forest ranges and total forest area assessed. Based on the assessment of working plans and compartment history files from the Himachal Pradesh Forest Department, a total of 1153 compartments were assessed, which covers almost all aspects and elevation ranges of Himachal Pradesh (Figure 15). Out of the total compartments assessed in the study, 1015 compartments (see Figure 3) fall under dominant tree species. These forests are complete representations of the state and include all of the important tree species that serve as the dominant flora of the temperate Himalaya. The study's findings are listed species by species, as well as the change in density over time in various parts of Himachal Pradesh.





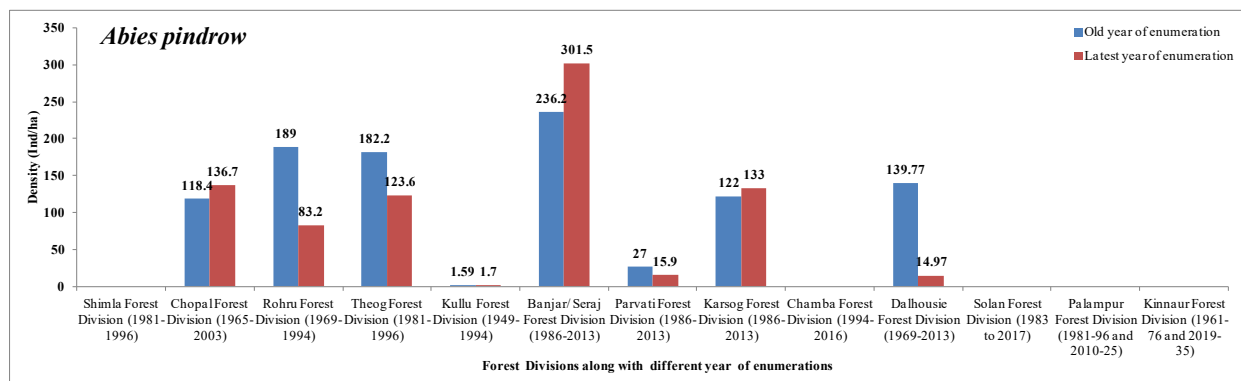
**Figure 4** Figure showed the number of compartment and area assessed under dominant tree species over a period of time in Himachal Pradesh

This report will first explain the dominant tree species, followed by the mixed ones. However, this should be kept in mind because not all species form dominant tree communities but will appear in the mixed forest. The important tree species that are not discussed in the finding part may be present in the respective forests, but due to a lack of enumeration records, they are not considered. The outcome of the study is discussed species-wise with respect to the temperate forests of Himachal Pradesh.

### 1) *Abies pindrow* (Fir/Tosh):

Data was collected from 46 compartments (see Figure 3) covering an area of 4249.52 ha in eight forest divisions (Figure 4). *Abies pindrow* was also present in other divisions, but due to a lack of comparable enumeration records, she was not considered. However, in some forests, Fir/Tosh occurs in mixed communities. Observations showed that the density of *Abies pindrow* was increased in Chopal, Kullu, Banjar/Seraj and Karsog Forests from 118.4 to 136.7 Ind/ha, 1.59 to 1.7 Ind/ha, 236.2 to 301.5 Ind/ha, and 122 to 133 Ind/ha, respectively. In other forest divisions like Rohru, Theog Parvati, and Dalhousie Forest Division, the species showed decreased density (Figure 4). The extent of the decrease in density was more pronounced in the forests of Rohru Theog and Dalhousie as compared to Parvati Forest Division (27 to 15.9 Ind/ha). In Chamba Forest Division, *Abies pindrow* was found in two mixed communities, viz., *Abies pindrow-Quercus floribunda* and *Abies pindrow*-Other broad-leaved community, where observations

showed increased densities (i.e., 185.1 to 202.5 Ind/ha and 113.2 to 122.5 Ind/ha, respectively). The combinations of this species with other species are rare, as *Abies pindrow* occurs in only a few compartments of forest. *Cedrus deodara*, *Picea smithiana*, Broadleaf, *Taxus baccata*, and *Quercus floribunda* are the other species that grow with *Abies pindrow*.



**Figure 5 Status of *Abies pindrow* (Fir/Tosh) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations**

### 1) *Cedrus deodara* (Himalayan Cedar/Devdar):

*Cedrus deodara* is the most important dominant tree species in the temperate forest of Himachal Pradesh. There are 11 Forest Divisions that showed comparable enumeration records for a maximum of 271 compartments with an area of 18,207.16 ha. Findings showed that the density of *Cedrus deodara* is increasing in five forest divisions: Chopal, Rohru, Kullu, Parvati, and Dalhousie Forest Division (from 218.9 to 234 Ind/ha, 98.5 to 107.6 Ind/ha, 101 to 132.2 Ind/ha, 89.7 to 92.7 Ind/ha, and 139.47 to 186.05 Ind/ha, respectively). Shimla, Theog, Banjar/Seraj, Karsog, Chamba, and Solan Forest Divisions have decreased in density over time (338.7 to 316.2 Ind/ha, 332.7 to 286.2 Ind/ha, 159.5 to 98.5 Ind/ha, 259 to 173 Ind/ha, 224.2 to 198.1 Ind/ha, and 29.82 to 0.08 Ind/ha, respectively). Despite its decline, the population of *Cedrus deodara* was good in the above divisions, with the exception of Kinnaur Forest Division. For the Solan and Palampur Forest Division, the enumeration records were not available. Each species' status or results are for a specific time period, i.e., the enumeration records mentioned in each figure with the respective forest division (Figure 5). The *Cedrus deodara* fluctuation in Figure 5 is for pure compartments with this species as the dominant species; however, this *Cedrus deodara* also occurs in mixed combinations with *Quercus floribunda*, *Quercus*

*leucotrichophora*, *Pinus roxburghii*, *Pinus wallichiana*, *Quercus semicarpifolia*, *Abies pindrow*, *Picea smithiana*, and Broadleaved.

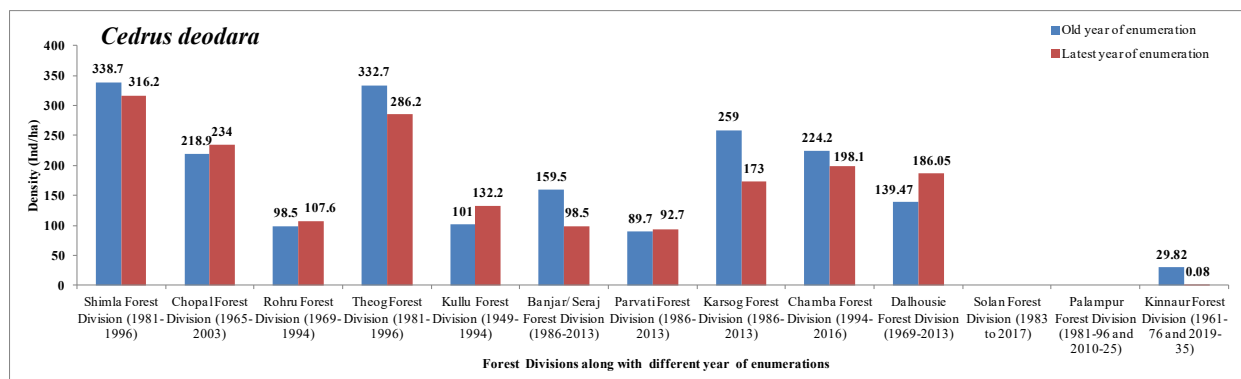
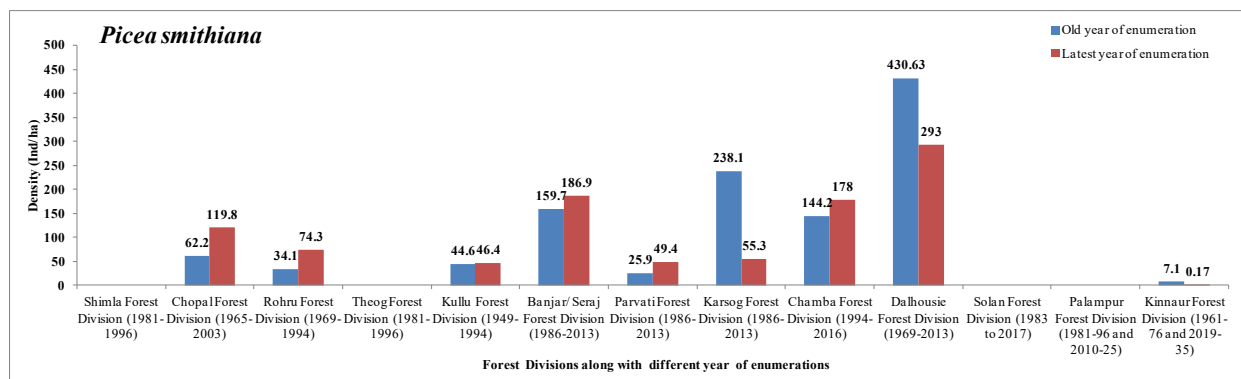


Figure 6 Status of *Cedrus deodara* (Deodar/Devdar) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

## 2) *Picea smithiana* (Spruce/Rai):

*Picea smithiana* which is commonly known as Spruce and Rai is a high-altitude temperate species and only few forest compartments represent this as dominant species. Under this species 82 forest compartments were selected with an area of 4342.87 ha in 9 divisions viz., Chopal, Rohru, Kullu, Banjar/Seraj, Parvati, Karsog, Chamba, Dalhousie and Kinnaur Forest Division to study the change over a define period of time. The maximum density of *Picea smithiana* was observed in Dalhousie Forest Division i.e., 430.63 Ind/ha and lowest in Kinnaur Forest Division i.e., 7 Ind/ha. The density was increased in six forest divisions named Chopal, Rohru, Kullu, Banjar, Parvati and Chamba Forest Division from 62.2 to 119.8 Ind/ha, 34.1 to 74.3 Ind/ha, 44.6 to 46.4 Ind/ha, 159.7 to 186.9 Ind/ha, 25.9 to 49.4 Ind/ha and 144.2 to 178 Ind/ha respectively. The maximum decrease in density was observed in Karsog Forest Division i.e., from 238.1 to 55.3 Ind/ha followed by Dalhousie Forest Division from 430.63 to 293 Ind/ha and the lowest number of individuals was observed in the Kinnaur Forest Division as shown in Figure 6 below. This status is in pure communities however, this species also occurs in mixed form with other tree species. The examples of some mixed communities are: *Cedrus deodara*-*Picea smithiana*, *Abies pindrow*-*Picea smithiana*, *Picea smithiana*-Broad leaved, *Picea smithiana*-*Taxus baccata*, *Picea smithiana*- *Quercus semicarpifolia* and *Picea smithiana*-*Pinus wallichiana* mixed community. Almost all mixed communities stated above showed increased density except two

combinations with *Abies pindrow* (Rohru Forest Division) and *Pinus wallichiana* (Theog Forest Division).



**Figure 7 Status of *Picea smithiana* (Spruce/Rai) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations**

### 3) *Pinus roxburghii* (Chir pine/Chil):

The most important temperate species, *Pinus roxburghii*, is found in the lower belts of all forest divisions. The maximum number of forest compartments were found in the Palampur Forest Division (173 compartments), followed by the Karsog Forest Division (84 compartments). The total compartments under this species were 386, the most of any dominant tree species, covering an area of 10383.94 ha in nine forest divisions. Finding revealed that maximum number of individual or density were found in the Chamba Forest Division (712 Ind/ha) and minimum density were reported in Parvati Forest Division (60.2 Ind/ha). The *Pinus roxburghii* showed marginal increase in density at Shimla (187.8 to 193.5 Ind/ha) and Parvati Forest Division (60.2 to 86.6 Ind/ha) but the change was more pronounced in Karsog (210.3 to 321.9 Ind/ha), Dalhousie (61.34 to 227.57 Ind/ha), Solan (129 to 359 Ind/ha) and Palampur Forest Division (215 to 285 Ind/ha). The density observed decreased in Rohru (105.5 to 74.4 Ind/ha), Banjar/Seraj (88.9 to 30.4 Ind/ha) and sharp drop was observed in Chamba Forest Division i.e., 712 to 200.4 Ind/ha shown in Figure 7. This density fluctuation was seen in the pure community however, the mixed combinations are also there viz., *Pinus roxburghii* - *Cedrus deodara*, *Pinus roxburghii* - *Broad leaved*, *Pinus roxburghii* - *Pinus wallichiana* and *Pinus roxburghii* - *Quercus leucotrichophora*.

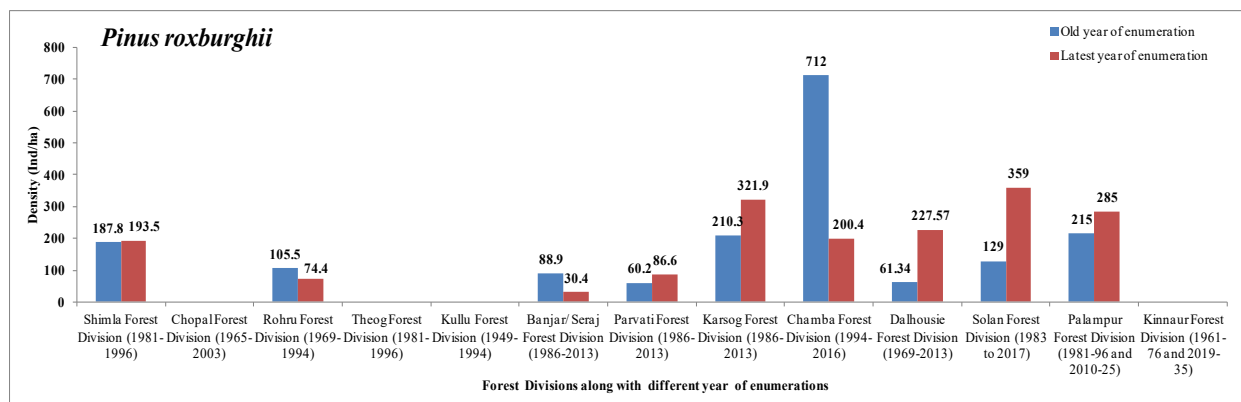
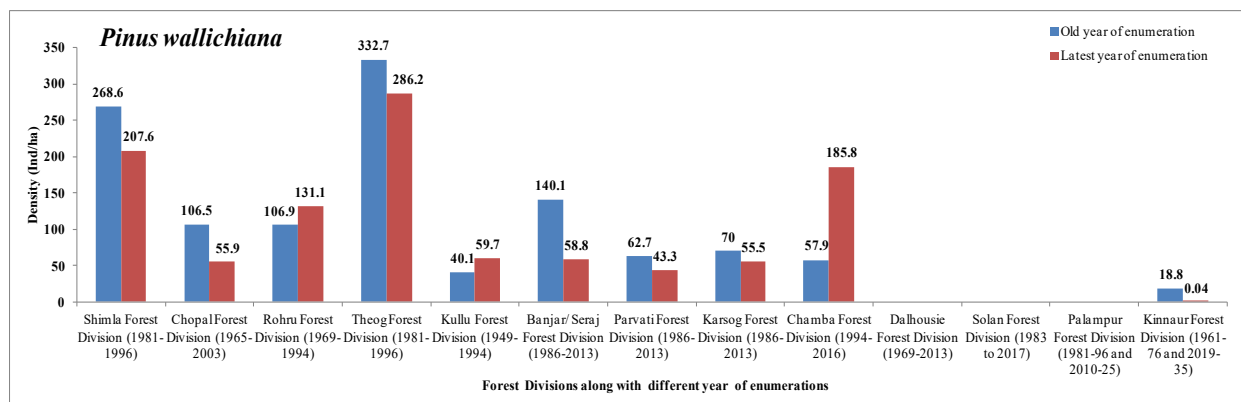


Figure 8 Status of *Pinus roxburghii* (Chir/Chirpine) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

#### 4) *Pinus wallichiana* (Blue Pine/Kail):

*Pinus wallichiana* is the most important temperate tree species in Himachal Pradesh. There are 140 compartments considered in this study covering an area of 9500.01 ha in ten forest division viz., Shimla, Chopal, Rohru, Theog, Kullu, Banjar/Seraj, Parvati, Karsog, Chamba and Kinnaur Forest Division. Studies revealed that tree density was significantly increased in Chamba Forest Division from 57.9 to 185.8 Ind/ha, Kullu Forest Division (40.1 to 59.7 Ind/ha) and Rohru Forest Division (106.5 to 55.9 Ind/ha). But the density of *Pinus wallichiana* was decreased in Shimla, Chopal, Theog, Banjar, Parvati, Karsog and Kinnaur Forest Division from 268.6 to 207.6 Ind/ha, 106.5 to 55.9 Ind/ha, 332.7 to 286.2 Ind/ha, 140.1 to 58.8 Ind/ha, 62.7 to 43.3 Ind/ha, 70 to 55.5 Ind/ha and 18.8 to 0.04 Ind/ha respectively (Figure 8). Beside the decreased density, *Pinus wallichiana* still maintain good population in the forests. Other species which formed the mixed communities in combinations are *Pinus wallichiana* - *Quercus floribunda*, *Pinus wallichiana* - *Cedrus deodara*, *Pinus wallichiana* - Broad leaved, *Pinus wallichiana* - *Quercus leucotrichophora*, *Pinus wallichiana* - *Picea smithiana* and *Pinus wallichiana* - *Pinus roxburghii* mixed community. In the above mixed tree communities *Pinus wallichiana* showed slight increase but some of the communities showed decreased density.



**Figure 9 Status of *Pinus wallichiana* (Blue pine/Kail) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations**

All of the tree species mentioned above are conifers, and they were the dominant flora of Himachal Pradesh's temperate forests. These species generally form dominant tree communities where a single species is dominant over other species in the respective compartments and also form mixed communities with other co-dominant species. Except for conifers, only three tree species, *Quercus leucotrichophora*, *Quercus floribunda*, and *Quercus semicarpifolia*, are broad-leaved species that form dominant tree communities in Himachal Pradesh's selected forest divisions. The broad-leaved species, which do not form a pure community but are an important part of temperate tree species, are grouped as Broad Leaved or other broad leaved below:

##### **5) *Quercus leucotrichophora* (Ban oak/Ban):**

The number of compartments under *Quercus leucotrichophora* was 35 with an area of 1411.45 ha in seven forest divisions named; Shimla, Rohru, Banjar, Karsog, Chamba, Dalhousie and Palampur Forest Division. The density of *Quercus leucotrichophora* was increased in four forest divisions viz., Shimla, Rohru, Karsog and Dalhousie Forest Division from 132.5 to 218.7 Ind/ha, 34.1 to 74.3 Ind/ha, 41.9 to 46.4 Ind/ha and 19.86 to 107.02 Ind/ha respectively. A sharp drop was observed in the density of *Quercus leucotrichophora* for Banjar/Seraj Forest Division i.e., 327.8 to 90 Ind/ha as shown in Figure 9. Other forests where density was decreased are; Chamba and Palampur Forest Division from 89.9 to 81.7 Ind/ha and 93 to 55 Ind/ha respectively for the selective year of enumerations. Other species which form combination with *Quercus leucotrichophora* are *Cedrus deodara*, *Pinus wallichiana*, *Pinus roxburghii* and Other Broad



leaved. The mixed tree communities of *Quercus* with above mentioned species slight change were observed.

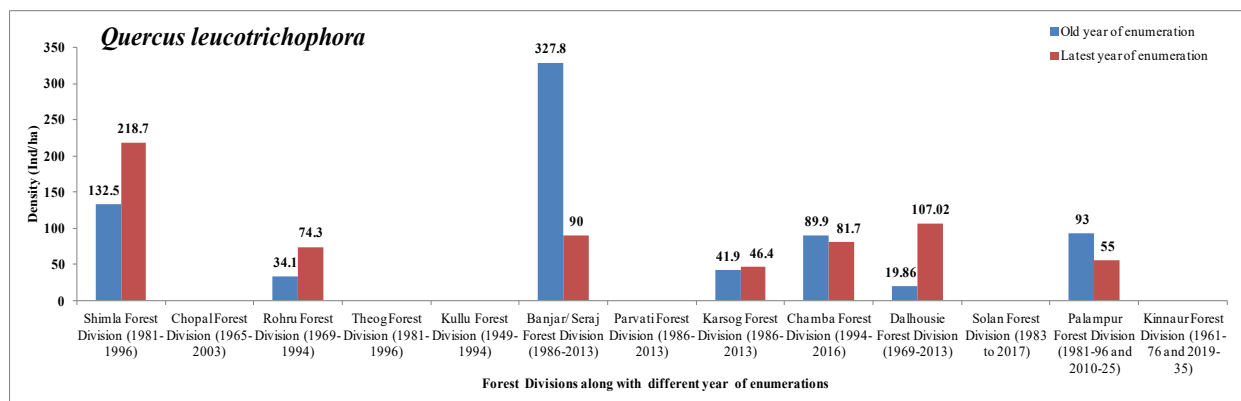


Figure 10 Status of *Quercus leucotrichophora* (Oak/Ban) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

#### 6) *Quercus floribunda* (Green Oak/Mohru):

There is only one forest division (Chopal Forest Division) where a pure tree community of *Quercus floribunda* was found among the selected thirteen forest divisions. The density of *Quercus floribunda* was decreased from 80.7 to 68.2 Ind/ha from 1965 to 2003 year of enumeration (Figure 10). However, this species was also present in other forests not in pure form but in mixed form with other species. The tree species which form mixed combinations are *Pinus wallichiana*, *Cedrus deodara*, broad leaved and *Abies pindrow* where *Quercus* showed slight change in density.

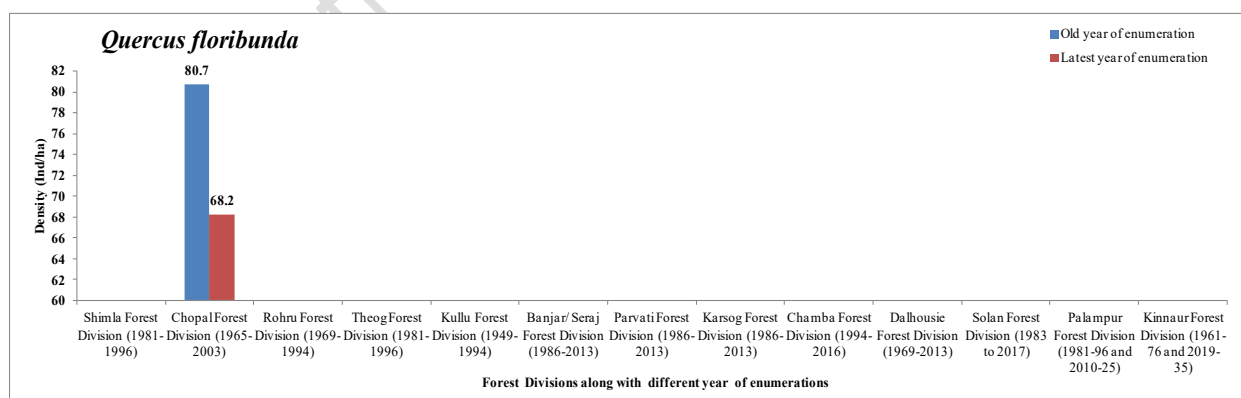


Figure 11 Status of *Quercus floribunda* (Green Oak/Mohru) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

### 7) *Quercus semicarpifolia* (Brown Oak/Kharshu):

Under this species there are only 10 forest compartments covering an area of about 704.87 ha in three forest divisions viz. Chopal, Kullu and Chamba Forest Division. The density of *Quercus semicarpifolia* increased significantly from 177.1 to 255.5 in Chopal Forest Division and 2.2 to 2.3 Ind/ha in Kullu Forest Division. In Chamba Forest Division the density decreases from 85.7 to 62.4 Ind/ha as shown in Figure 11 however, in other forest divisions the pure community of *Quercus semicarpifolia* was lacking. The reason behind this is that this species occurs in mixed communities in combination as *Cedrus deodara* - *Quercus semicarpifolia*, *Picea-smithiana* - *Quercus semicarpifolia*, *Quercus semicarpifolia* - *Taxus baccata*, *Quercus semicarpifolia* - *Quercus leucotrichophora*, *Quercus semicarpifolia* - *Taxus baccata* - *Abies pindrow*. The status of this species in all mixed communities showed increased density for particular year of enumerations.

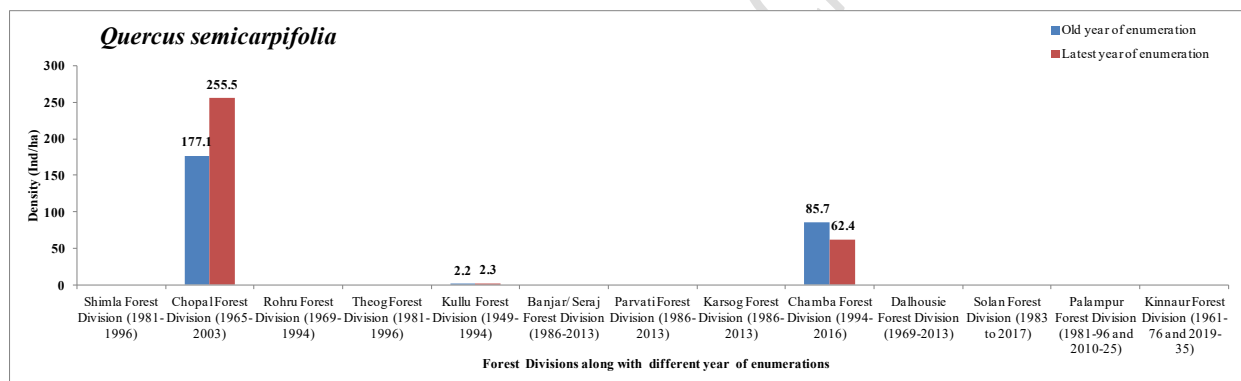


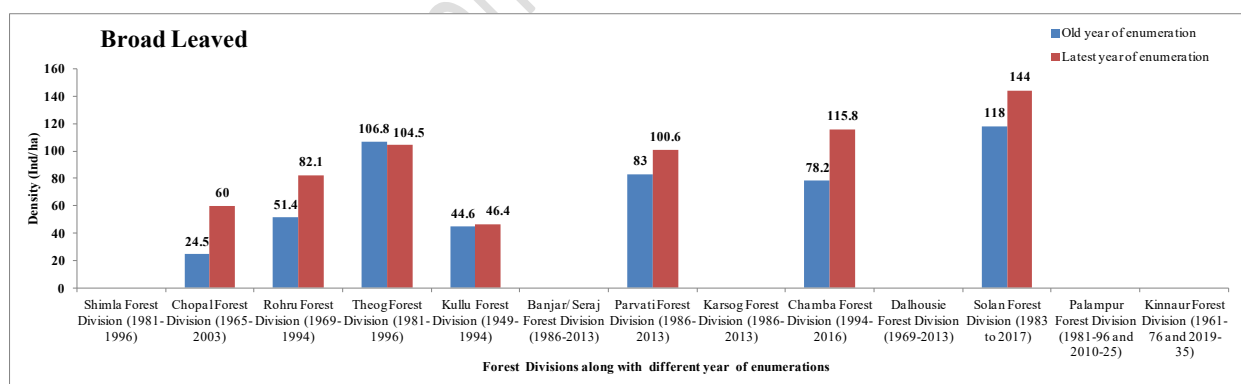
Figure 12 Status of *Quercus semicarpifolia* (Brown Oak/Kharshu) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

### 8) Broad Leaved:

As the name indicate Broad leaved means all the tree species which have broad leaves are grouped in this category. Some examples are: *Acacia catechu*, *Acer oblongum*, *Acer pictum*, *Aegle marmelos*, *Aesculus indica*, *Albizzia chinensis*, *Albizzia lebbek*, *Albizzia procera*, *Alnus nepalensis*, *Alnus nitida*, *Azadirachata indica*, *Bauhinia variegata*, *Bombax ceiba*, *Butea monosperma*, *Carpinus sp*, *Cassia fistula*, *Cedrela serrata*, *Cedrela toona*, *Celtis australis*, *Cornus capitata*, *Dalbergia sissoo*, *Emblia officinalis*, *Ficus bengalensis*, *Ficus glomerata*, *Ficus palmata*, *Ficus auriculata*, *Ficus religiosa*, *Flacortia indica*, *Grewia oppositifolia*, *Juglans regia*, *Juniperus macropoda*, *Juniperus recurva*, *Lyonia ovalifolia*, *Mallotus philipinensis*,

*Mangifera indica*, *Melia azadirachta*, *Morus alba*, *Morus serrata*, *Myrica esculenta*, *Nictanthes arbortristis*, *Olea cuspidata*, *Phoenix sylvestris*, *Pistacia integririma*, *Populus ciliata*, *Prunus armeniaca*, *Prunus communis*, *Prunus cornuta*, *Prunus persica*, *Punica granatum*, *Pyrus pashia*, *Quercus glauca*, *Quecus incana*, *Rhododendron arboreum*, *Rhus punjabensis*, *Rhus wallichiana*, *Rubinia pseudoacacia*, *Salix alba*, *Salix tetrasperma*, *Sapindus indica*, *Spondias pinnata*, *Sterculia villosa*, *Syzygium cumini*, *Terminalia belerica*, *Terminalia chabula*, *Terminalia tomentosa* etc.

These species enlisted above ranging from sub-tropical to temperate region of Himachal Pradesh but broad-leaved species belong to temperate part are considered and analyzed in this study. There are total of 44 compartments with an area of 3089.53 ha in seven forest division of Himachal Pradesh. All broad-leaved species showed increased density (except for Theog Forest Division) in Chopal, Rohru, Kullu, Parvati, Chamba and Solan Forest Division from 24.5 to 60 Ind/ha, 51.4 to 82.1 Ind/ha, 44.6 to 46.4 Ind/ha, 83 to 100.6 Ind/ha, 78.2 to 115.8 Ind/ha and 118 to 144 Ind/ha respectively. There was very slight decrease observed for broad leaved in Theog Forest Division from 106.8 to 104.5 Ind/ha as shown in Figure 12. The species which form mixed combination with broad leaved are *Pinus roxburghii*, *Picea smithiana*, *Cedrus deodara*, *Taxus baccata*, *Pinus wallichiana*, *Abies pindrow*, *Quercus floribunda* and *Quercus leucotrichophora*.



**Figure 13 Status of Broad Leaved (All broad-leaved species) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations**

## Conclusion

The temporal study was designed to get a preliminary insight into the current status of tree species in the selected forest divisions of Himachal Pradesh. To achieve the objective, tree communities were constituted (pure and mixed communities), and densities (Ind/ha) were calculated for each dominant tree species. The total area under the selected forests was 57447.45 ha, which was used as a sample area in the study. The temperate forests falling under seven districts (Shimla, Kullu, Mandi, Kinnaur, Solan, Kangra, and Chamba) covered most of the temperate area of the state. The status of each species (dominant tree species) was not only seen in one or two forests but throughout the selected forests of Himachal Pradesh, which cover all aspects, elevation ranges, and tree species important to the temperate region. The observed change in species density was not uniform in the selected forests because most of the forests had different years of enumeration. However, the data as per availability with comparable enumeration records revealed the following results:

Findings revealed that *Abies pindrow* maintained a healthy population in the Chopal, Kullu, Banjar, and Karsog Forest Divisions, but declined in the Rohru, Theog, Parvati, and Dalhousie Forest Divisions. Studies showed that this species showed a lower regeneration rate in the forests. If this species decreases for certain reasons, it will take a very long time to achieve tree height. *Cedrus deodara* is one of the important temperate conifer species, having good density in the forests, however, the decrease might be due to its great demand for timber. This species has strong wood and is commonly used for timber in the state. Plantation measures have also been implemented by various organizations, including the forest department and non-governmental organizations. Enumeration records of *Picea smithiana* showed that population density was increased in all selected forests except Karsog, Dalhousie and Kinnaur (due to localized anthropogenic activities). One observed reason during the report's compilation for its increase is that the compartment with *Abies pindrow* is far from people community or villages.

For *Pinus wallichiana*, the tree density was greatly reduced in all the selected forests except three: Rohru, Kullu, and Chamba. Because *Pinus wallichiana* is the second most common timber and fuel wood alternative in Himachal Pradesh after *Cedrus deodara*, it is more commonly used by local stakeholders. Therefore, people's dependency on this species may be one of the possible reasons for its decrease. The other reason behind the deceased populations of

*Abies pindrow*, *Cedrus deodara*, *Picea smithiana*, and *Pinus wallichiana* is the moisture regime. The places where these species were present had a good moisture regime and fertile soil; therefore, the local stakeholders or people tried to encroach on these places for apple orchards and agricultural practices. Beside these species, *Pinus roxburghii* is an important, fire-resistant, and temperature resistant tree species in Himachal Pradesh. Most of the people in the community or villages depend on this species for fuel, timber, and resins. The density of this species decreases, but due to its great regeneration power and ability to adapt to changing environments, it still maintains a good density in the forests. However, more research is needed to determine the possible causes of the aforementioned temperate species so that we can improve management practices and conservation methods.

Along with conifers, oak also serves as an important broad-leaved species in the temperate forest. There were three oak species documented as per the enumeration records available; these are: *Quercus leucotrichophora*, *Quercus floribunda*, and *Quercus semicarpifolia*. There were only a few compartments that formed a pure oak community, but in most cases these species occur in mixed form (with conifers). These species are overutilized by the local people and community for fuel, fodder, and timber. Species other than broadleaved showed a great and visible increase in density in all selected forests of Himachal Pradesh, which showed good results. In conclusion, this report provides:

- Temperate tree species composition (conifers and broadleaved) of temperate forests
- General status of species dominance, community structure (pure and mixed), and density variations
- provides a baseline finding that can be used to improve future management and conservation strategies.
- Also, open scope and inputs for future forestry research, such as species-wise studies throughout Himachal Pradesh's temperate forests with ground proofing and the possible reasons for their increase or decrease,

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