

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

Status Report (March, 2020)

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Contents

Introduction	7
The Indian Himalayan Region	7
Forests of Himachal Pradesh	9
Study area and Methodology	13
Himachal Pradesh-A Background	13
Forest Area	13
Forest Zone	14
Geography and Climatic Conditions	15
Methods.....	15
Data Sources and Techniques.....	17
Assessment Techniques	25
Results and Discussions	26
Conclusion	37
Bibliography	39

Table of Figure

Figure 1 Map showing Indian Himalayan Region (IHR) with States in which IHR fall from North-Western to North-Eastern Himalayas	8
Figure 2 Highlighted districts covered under forestry sector with respect to selected forest divisions of Himachal Pradesh.....	12
Figure 3 Figure showed the number of compartment and area assessed under dominant tree species over a period of time in Himachal Pradesh	28
Figure 4 Status of <i>Abies pindrow</i> (Fir/Tosh) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations	29
Figure 5 Status of <i>Cedrus deodara</i> (Deodar/Devdar) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations	30
Figure 6 Status of <i>Picea smithiana</i> (Spruce/Rai) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations	31
Figure 7 Status of <i>Pinus roxburghii</i> (Chir/Chirpine) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations	32
Figure 8 Status of <i>Pinus wallichiana</i> (Blue pine/Kail) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations	33
Figure 9 Status of <i>Quercus leucotrichophora</i> (Oak/Ban) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations.....	34
Figure 10 Status of <i>Quercus floribunda</i> (Green Oak/Mohru) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations.....	34
Figure 11 Status of <i>Quercus semicarpifolia</i> (Brown Oak/Kharshu) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations	35
Figure 12 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.....	36

Table of Tables

Table 1: Forest Classifications of Himachal Pradesh	9
Table 2 Details on Tree Community, Forest Compartment and area assessed of Shimla Forest Division (1981-1996).....	19
Table 3 Details on Tree Community, Forest Compartment and area assessed of Chopal Forest Division (1965-2003).....	20
Table 4 Details on Tree Community, Forest Compartment and area assessed of Rohru Forest Division (1969-1994).....	20
Table 5 Details on Tree Community, Forest Compartment and area assessed of Theog Forest Division (1981-1996).....	21
Table 6 Details on Tree Community, Forest Compartment and area assessed of Kullu Forest Division (1949-1994).....	21
Table 7 Details on Tree Community, Forest Compartment and area assessed of Banjar/Seraj Forest Division 1986-2013	22
Table 8 Details on Tree Community, Forest Compartment and area assessed of Parvati Forest Division (1948-1996).....	23
Table 9 Details on Tree Community, Forest Compartment and area assessed of Karsog Forest Division (1986-2013).....	23
Table 10 Details on Tree Community, Forest Compartment and area assessed of Chamba Forest Division (1994-2016).....	24
Table 11 Details on Tree Community, Forest Compartment and area assessed of Dalhousie Forest Division (1969-2013).....	24
Table 12 Details on Tree Community, Forest Compartment and area assessed of Solan Forest Division ((1983 to 2017)	25
Table 13 Details on Tree Community, Forest Compartment, and Area Assessed of Palampur Forest Division ((1981 to 2025)	25
Table 14 Details on Tree Community, Forest Compartment and area assessed of Solan Forest Division ((1961 to 2035)	25
Table 15 Forests Divisions of Himachal Pradesh showing number of compartments analyzed and area (ha) covered.	27

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 72⁰-91⁰ E Longitudes and 27⁰-36⁰ 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).

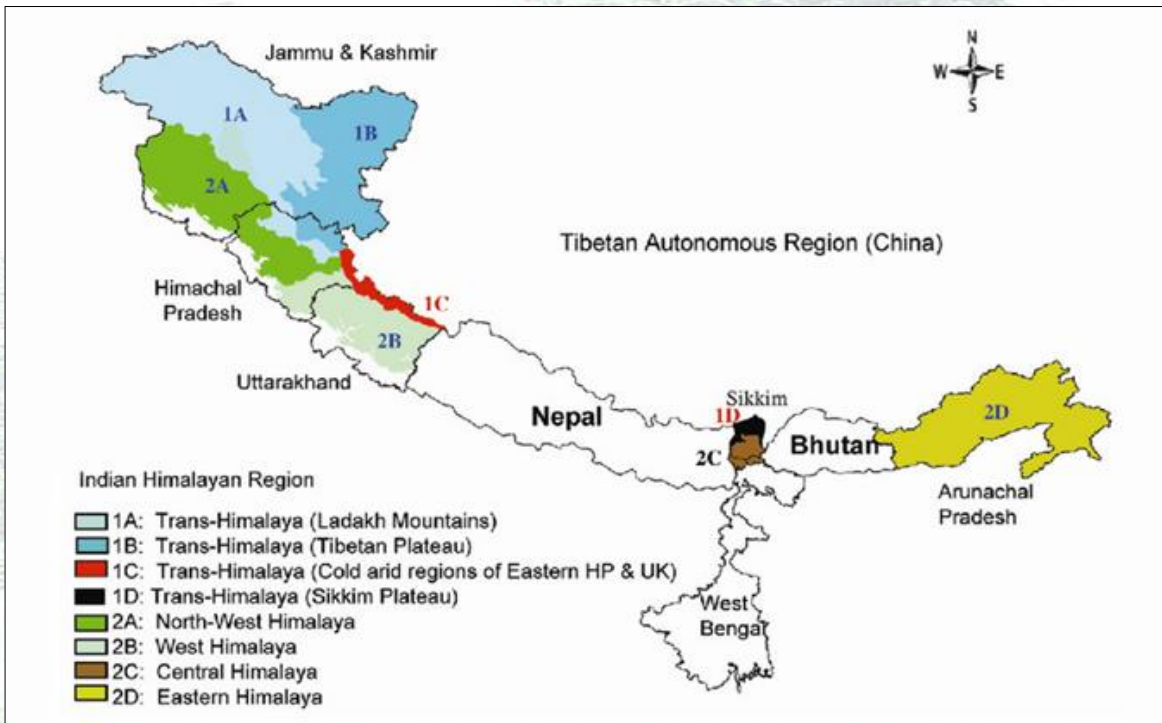


Figure 1 Map showing Indian Himalayan Region (IHR) with States in which IHR fall from North-Western to North-Eastern Himalayas

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>
Tropical Moist Deciduous forests	>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>
Subtropical Pine Forests	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>Albizia chinensis</i> , <i>Emblica sp.</i> , <i>Acacia catechu</i> , <i>Murraya spp.</i> , <i>Rosa moschata</i>
Himalayan Moist Temperate Forests	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>
Himalayan Dry Temperate Forests	>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>
Sub-Alpine Forests	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>
Moist Alpine Scrub	>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>
Dry Alpine Scrub	>6,000 m above mean sea level	-	<i>Juniperus</i> , <i>Artemisia</i> , <i>Lonicera</i> , <i>Salix</i> , <i>Myricaria</i>

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 other 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 Forest Division (Dharamshala Circle) and Kinnaur Forest Division (Rampur Circle).

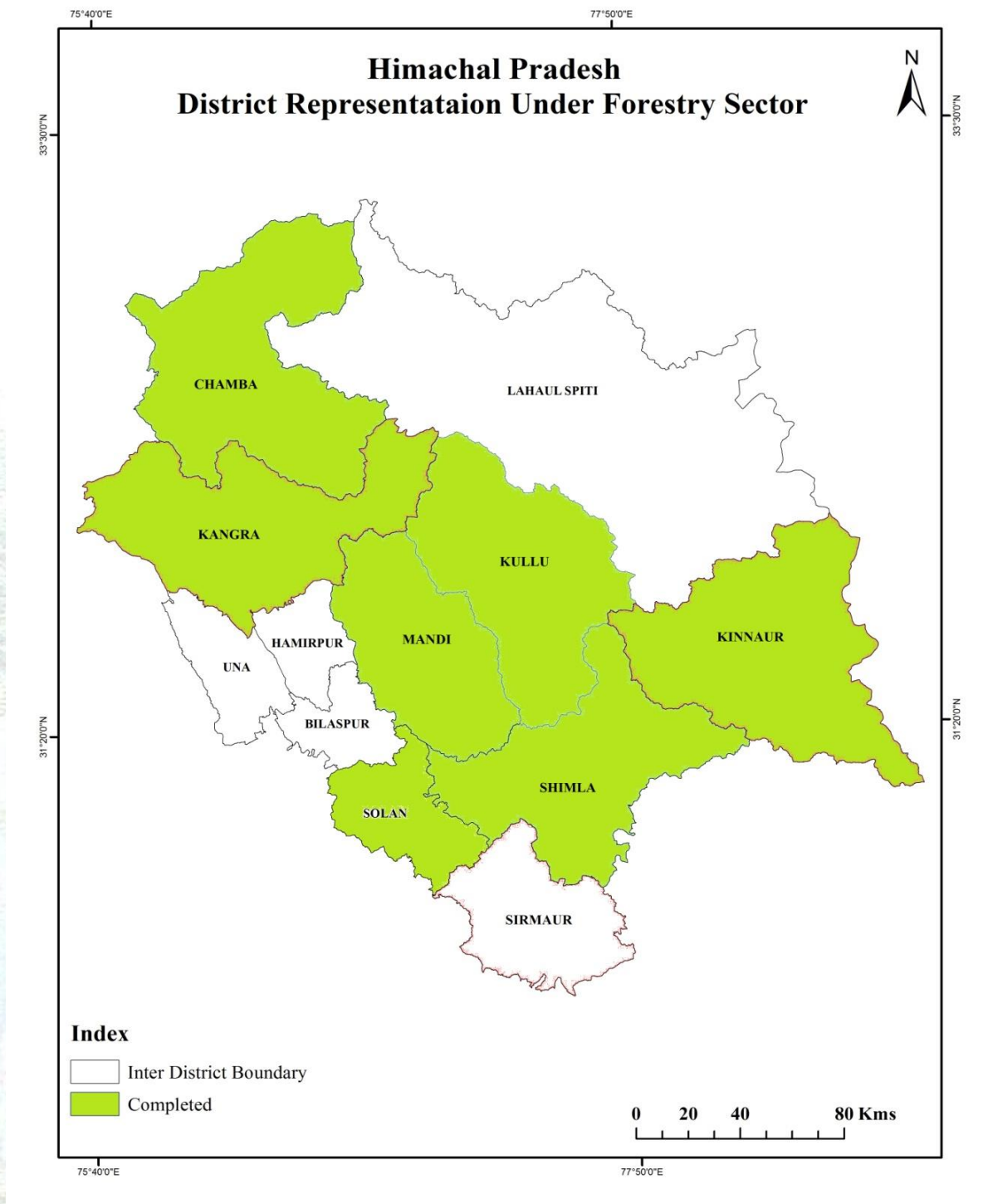


Figure 2 Highlighted districts covered under forestry sector with respect to selected forest divisions of Himachal Pradesh

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 km². The altitude of the State varies from 350 m to 6,975 m above mean sea level. It is located between latitude 30⁰45' to 33⁰ 12'N and longitude 75⁰45' to 79⁰04'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 deserts.

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 upto 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 40⁰C. 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 extends 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 30⁰C. 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 10⁰C. During summer, the maximum temperature ranges between 15 and 20⁰C. 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 form the mean sea level and the mean annual temperature is around 10⁰C 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 Bhabha 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

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, Kinnaur Forest Division three-tier assessment was conducted, covering:

- 1) Tree community based 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:

1. **Shimla Forest Division**- There are five forest ranges in this division viz. Mashobra, Koti, Bhajji, Tara Devi and Dhama. The other ranges i.e. Tara Devi and Dhama were not considered as their respective working plans couldn't be procured. The total area of these forest ranges is 10,297 ha out of which 1793.2 ha was assessed in the study.
2. **Chopal Forest Division**- There are four forest ranges in this division viz. Chopal, Kanda, Nerwa, and Sarain. Total forest area under this division is 13602ha out of which 6876.3 ha was assessed in this study.
3. **Rohru Forest Division**- There are six forest ranges in this division viz. Rohru, Tikker, Khashdhar, Jubbal, Bashala and Sarwati Nagar. Total forest area under these ranges is 25194ha, of which 9429.74 ha was assessed in this study.
4. **Theog Forest Division**- There are three forest ranges in this division viz. Theog, Balson and Kotkhai. Total forest area under these ranges is 31,722.4 ha, of which 1660.9ha was assessed in this study.
5. **Kullu Forest Division** – There are five forest ranges in this division viz., Kullu, Manali, Bhutti, Patlikuhl and Naggar. The total area of these forest ranges is 40,069.31 ha out of which 6972.59 ha was assessed in the study.
6. **Banjar/Seraj Forest Division** – There are three forest ranges in this division viz. Banjar, Sainj and Tirthan. Total forest area under this division is 104,820.24 ha out of which 2891.12 ha was assessed in this study.
7. **Parvati Forest Division** – There are four forest ranges in this division viz. Parvati, Hurla, Jari and Kasol. Total forest area under these ranges is 9199.98 ha, of which 4343.66 ha was assessed in this study.
8. **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.
9. **Chamba Forest Division**- In Chamba Forest Division there are four forests ranges viz., Masrund, Lower Chamba, Upper Chamba and Tikkari. The sample area of all forest ranges were 3509.06 ha.

10. ***Dalhousie Forest Division*** – There are four forest ranges in this division viz. Dalhousie, Bakloh, Chowari and Bhattiyat. The total area of these forest ranges is 39951.22 ha (fall under 851.96 ha reserved forest, 38558.69 ha demarcated protected forest area and 540.57ha un-demarcated area) out of which 1624.80 ha was assessed in this study.
11. ***Solan Forest Division*** – There are five forest ranges in this division viz., kandaghat, Solan, Subathu, Dharampur and Parwanoo. The total area of forest ranges are 11743.8 ha out of which 2061.5 ha were assessed in the study.
12. ***Palampur Forest Division***- There are three forest ranges in the Palampur Forest Division viz. Baijnath, Droh, and Palampur forest range. The total assessed area of these forest ranges is 2861.18 ha for 190 compartments.
13. ***Kinnaur Forest Division***- There are 47 compartments which were studied and analyzed 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 which were available with comparable enumeration records i.e. older and newer years.

Data Sources and Techniques

In data source and techniques, Working Plans from the Himachal Pradesh Forest Department and Compartment History files were consulted from the selected forest divisions. The temporal changes in tree species composition during the successive enumeration record as per Working Plans were analyzed for selected forest divisions. The time period for each division is different as per 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 forests divisions was collected in the form of soft copy (photographs of compartment history files) and Working Plan document procured from the State Forests Library and Forest Divisions. Only those forest divisions were taken in the study which has comparable enumeration records and those covers the temperate region of Himachal Pradesh.

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 %, then the tree community was identified as *single species dominant community*. For cases where more than one species collectively accounted for 50 % of the relative density, the tree community was referred as *mixed community*. Forests were further classified into different altitude gradients of 1,000-1,500m; 1,500-2,000m; 2,000-2,500m and 2,500-3,000m (wherever the data was available). 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 the status report only tree communities' based study was opted 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 forests divisions which were used in the study covering the temperate forests of Himachal Pradesh are given below. These divisions have tree communities (having dominant tree species) and mixed tree communities (having two co-dominant tree species) listed with number of forests compartments from which species belong and the area falling under selected compartments.

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.

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>	1	38.4

mixed		
<i>Cedrus deodara-Quercus 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
Total	39	1793.2

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

Chopal Forest Division (1965-2003)		
Tree community	Forest Compartment	Area assessed (ha)
<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 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-Abies pindrow</i>	5	291.34
<i>Picea smithiana</i> -Broad-leaved	1	37.23
<i>Picea smithiana 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
Total	146	6876.31

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

Rohru Division (1969-1994)		
Tree community	Forest Compartment	Area assessed (ha)
<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
Total	98	9429.74

Table 4 Details on Tree Community, Forest Compartment and area assessed of Rohru Forest Division (1969-1994)

Theog Forest Division (1981-1996)		
Tree community	Forest Compartment	Area assessed (ha)
<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
Total	36	1660.9

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

Kullu Forest Division (1949-1994)		
Tree community	Forest Compartment	Area assessed (ha)
<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
Total	129	6972.59

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

Banjar/ Seraj Division (1986-2013)		
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-Pinus wallichiana</i> mixed	4	74.87
<i>Abies pindrow-Taxus baccata</i> mixed	6	275.02
<i>Abies pindrow-Picea smithiana</i> mixed	6	232.62
<i>Abies pindrow</i> -Broad-leaved mixed	2	106.59
<i>Taxus baccata-Abies pindrow</i> mixed	2	73.64
<i>Quercus leucotrichophora-Pinus wallichiana</i> mixed	1	116.59
<i>Quercus semecarpifolia- Quercus leucotrichophora</i> mixed	1	92.68
<i>Picea smithiana-Taxus baccata</i> mixed	1	28.81
<i>Taxus baccata-Picea smithiana</i> mixed	1	37.49
<i>Quercus semecarpifolia- Taxus baccata</i> mixed	1	86.5
<i>Broad-leaved-Picea smithiana</i> mixed	1	91.11
<i>Quercus semecarpifolia- Taxus baccata-Abies pindrow</i> mixed	1	36.02
<i>Picea smithiana-Abies pindrow - Pinus wallichiana</i> mixed	1	53.41
Total	85	2891.12

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-Picea smithiana</i> mixed	2	153.75
<i>Picea smithiana - Cedrus deodara</i> mixed	2	143.48
<i>Picea smithiana-Pinus wallichiana</i> mixed	1	29.5
<i>Pinus wallichiana- Cedrus deodara</i> mixed	2	103.19
<i>Broad-leaved -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
Total	72	4343.66

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

Karsog Forest Division (1986-2013)		
Tree community	Forest Compartment	Area assessed (ha)
<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
Total	141	6523.46

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

Chamba Forest Division (1994-2016)		
Tree community	Forest Compartment	Area assessed (ha)
<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</i> - <i>Quercus leucotrichophora</i>	3	185.35
<i>Pinus roxburghii</i> - <i>Quercus</i>	1	30.35

<i>leucotrichophora</i>		
<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
Total	60	3509.06

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

Dalhousie Forest Division (1969-2013)		
Tree community	Forest Compartment	Area assessed (ha)
<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
Total	50	1605.81

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

Solan Forest Division (1983 to 2017)		
Tree community	Forest Compartment	Area assessed (ha)
<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</i> - <i>Picea smithiana</i> (CD-PS)	1	38.04
<i>Picea smithiana</i> -Other Broad Leaved (PS-OBL)	2	139.12
Total	60	3509.06

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
Total	190	2861.25

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
Total	47	10409

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 tree community, its species composition in the pure tree communities as well as in mixed tree communities in above mentioned forest divisions. It also highlighted the visual change in density of tree species composition in respective year of enumerations. This analysis on 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 the primary insight of species composition, status and helps in improving the forest management in biodiversity conservations (Flora and Fauna). One of the most important coverage of this study is that it highlighted the particular area where a particular species is decreasing or increasing. Such information regarding species change will helps in maintaining, improving and conserving the tree species at its natural habitat. Previously, the status of tree species was hypothetical or theoretical and defined to some particular area but this study provides wide view of species occurrence and locations. Therefore, if any conservation and management practices are there, then we can choose the particular region where these activities can be performed.

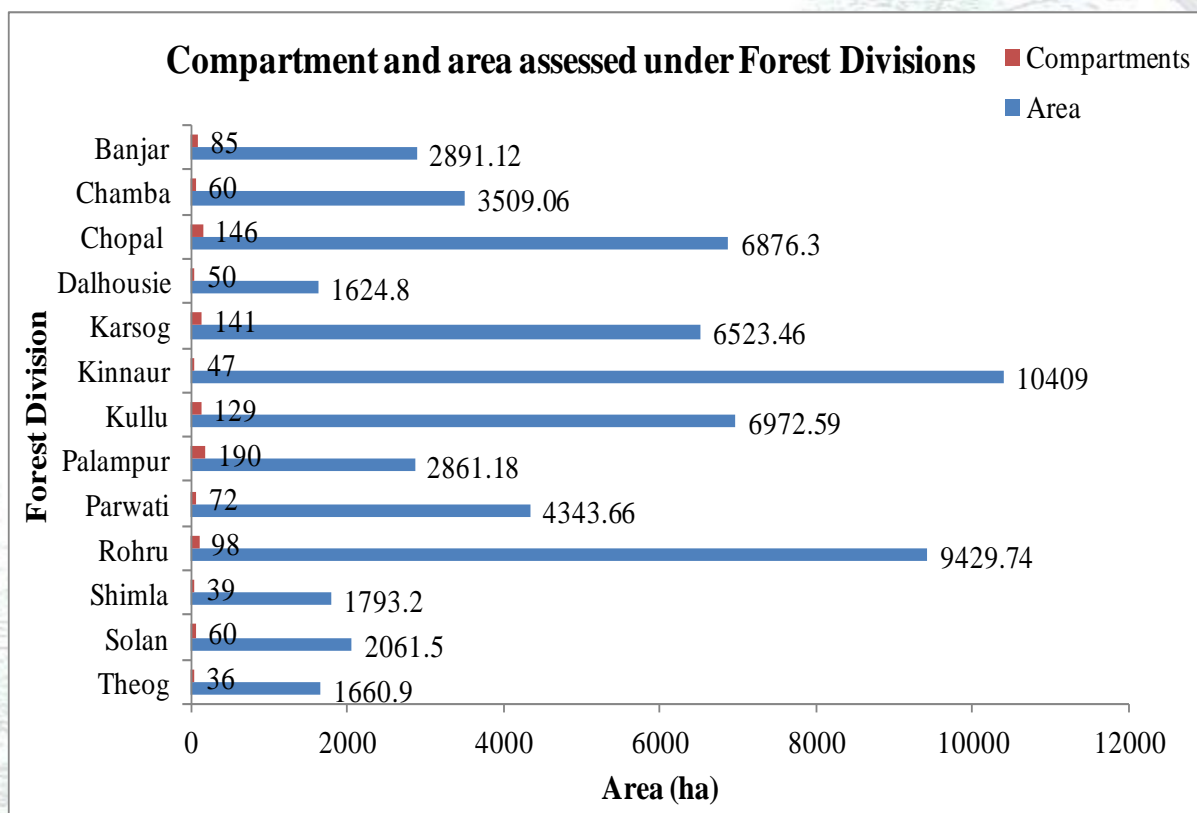


Table 15 Forests Divisions of Himachal Pradesh showing number of compartments analyzed and area (ha) covered.

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 total of 1153 compartments were assessed which covers 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 have full representations of the state and have covered all important tree species which serves as dominant flora of the temperate Himalaya. The results or outcome from the study is written species wise and its change in density over a long time period in different part of Himachal Pradesh.

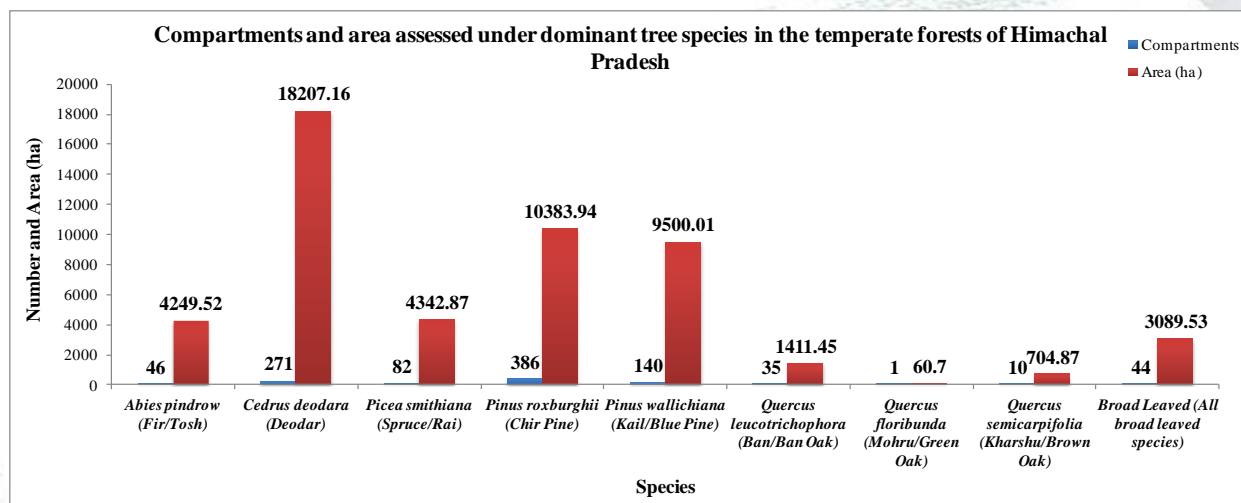


Figure 3 Figure showed the number of compartment and area assessed under dominant tree species over a period of time in Himachal Pradesh

This report will explain about the dominant tree species primarily and then about the mixed ones. However, this should be in mind that not all species forms dominant tree community but will appear in the mixed forest. The important tree species which is not discussed in the finding part may be present in the respective forests but due to lack of enumeration records is 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 lack of comparable enumeration records is 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 decrease in density were pronounced more in Forests of Rohru Theog and Dalhousie as compared to Parvati Forest Division (27 to 15.9 Ind/ha). In Chamba Forest Division *Abies pindrow* found in two mixed communities viz. *Abies pindrow-Quercus floribunda* and *Abies pindrow-Other broad leaved* community where observations showed increased density

(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 few compartments of particular forest. The other species in combination with *Abies pindrow* are *Cedrus deodara*, *Picea smthiana*, Broad leaved, *Taxus baccata* and *Quercus floribunda*.

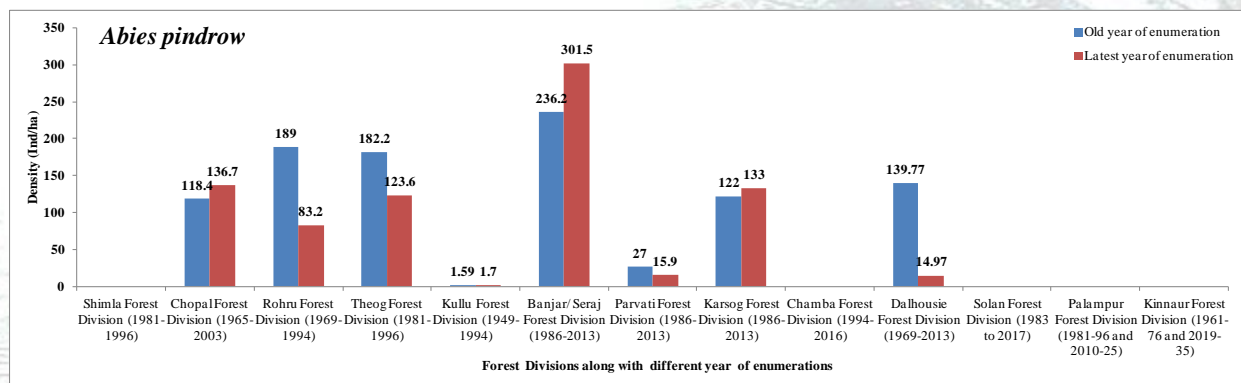


Figure 4 Status of *Abies pindrow* (Fir/Tosh) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

2) *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 which showed comparable enumeration records for maximum of 271 compartments with an area of 18207.16 ha. Finding showed that the density of *Cedrus deodara* is increased in five forest divisions viz. 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). The forests where density is decreased are Shimla, Theog, Banjar/Seraj, Karsog, Chamba and Solan Forests Division (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) over a period of time. However, the population of *Cedrus deodara* was good in the above divisions beside its decrease, Devdar still maintain in good condition except Kinnaur Forest Division. For Solan and Palampur Forest Division the enumeration records were not available. The status or results for every species is for a particular period of time i.e. the enumeration records mentioned in each figure with respective forest division (Figure 5). The fluctuation shown in the figure 5 for *Cedrus deodara* is for pure compartments which have this species as 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 .

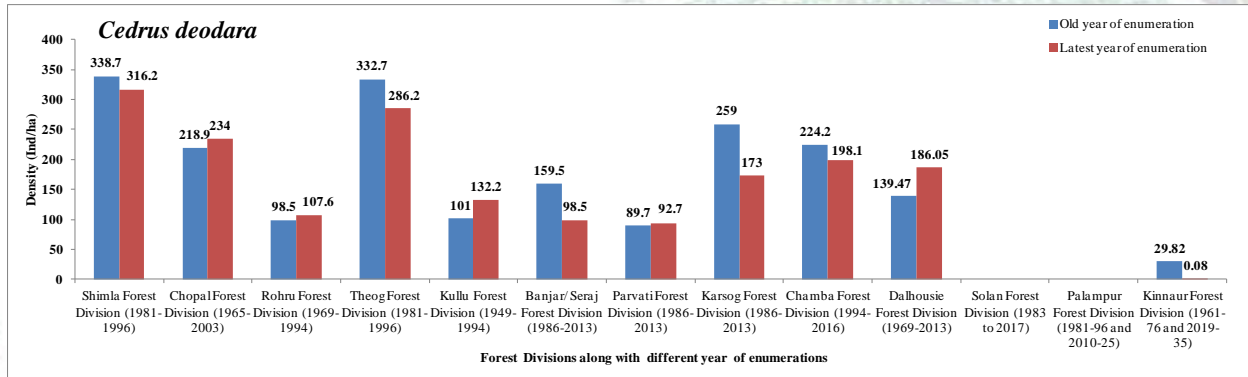


Figure 5 Status of *Cedrus deodara* (Deodar/Devdar) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

3) *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 individual 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).

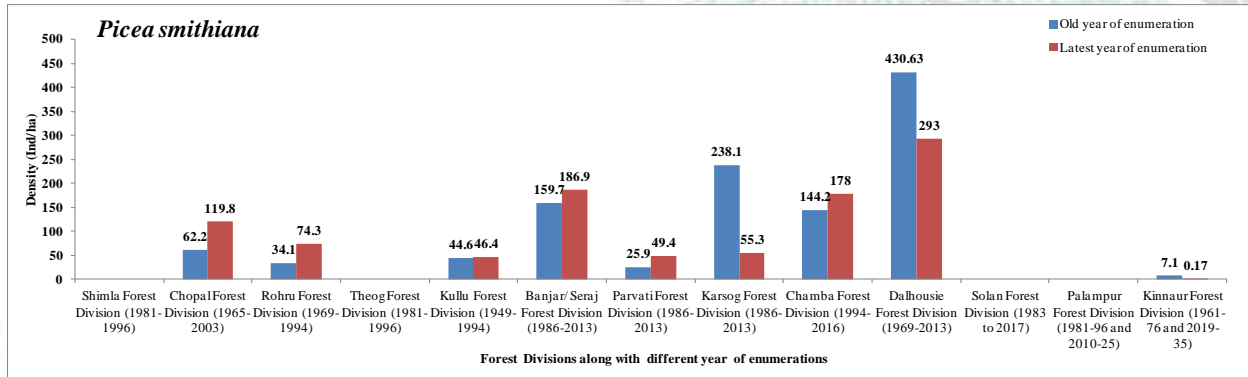


Figure 6 Status of *Picea smithiana* (Spruce/Rai) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

4) *Pinus roxburghii* (Chir pine/Chil):

Pinus roxburghii is the most important temperate species which occurs in the lower belt of all forest divisions. The maximum number forest compartments were found in the Palampur Forest Division (173 compartments) then Karsog Forest Division (84 compartments). Total compartments under this species were 386 which is maximum among all dominant tree species covering an area of 10383.94 ha in selected 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 were 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*.

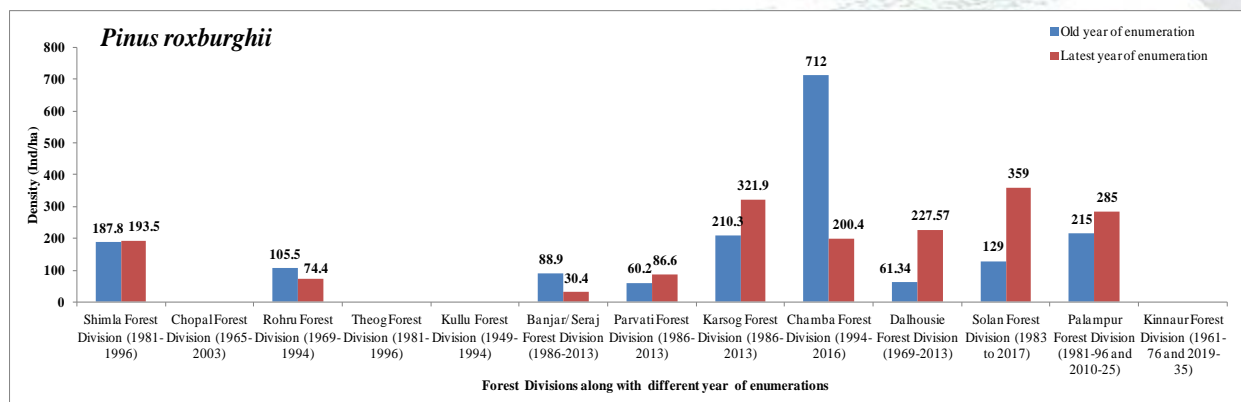


Figure 7 Status of *Pinus roxburghii* (Chir/Chirpine) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

5) *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.

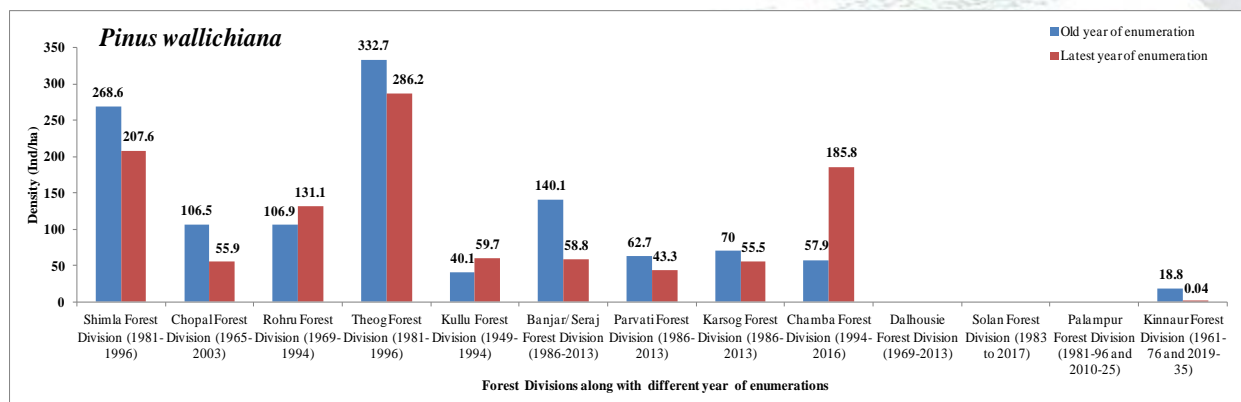


Figure 8 Status of *Pinus wallichiana* (Blue pine/Kail) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

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

6) *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 was observed.

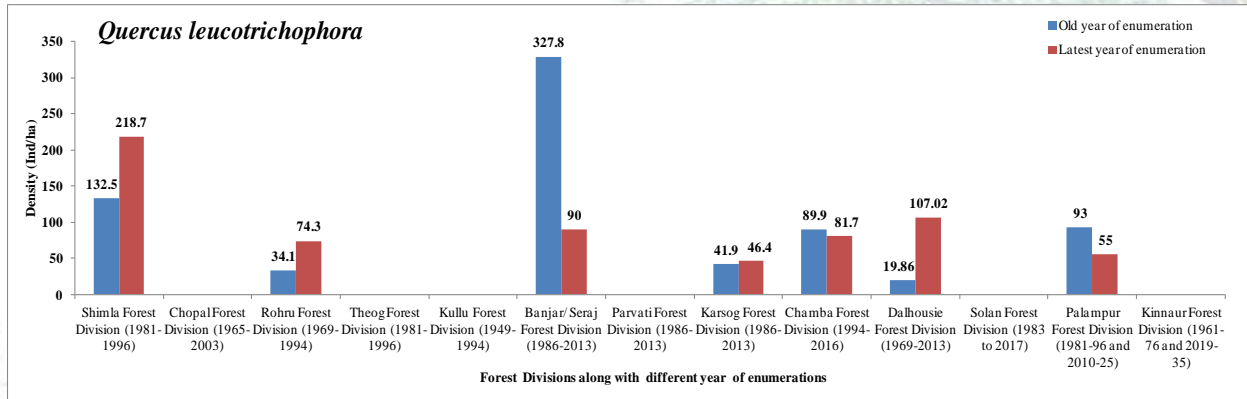


Figure 9 Status of *Quercus leucotrichophora* (Oak/Ban) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

7) *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.

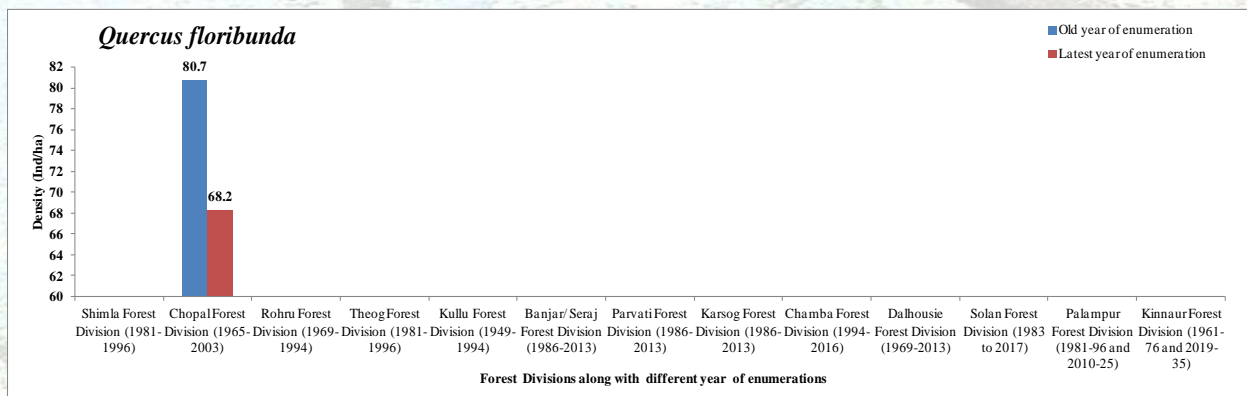


Figure 10 Status of *Quercus floribunda* (Green Oak/Mohru) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

8) *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.

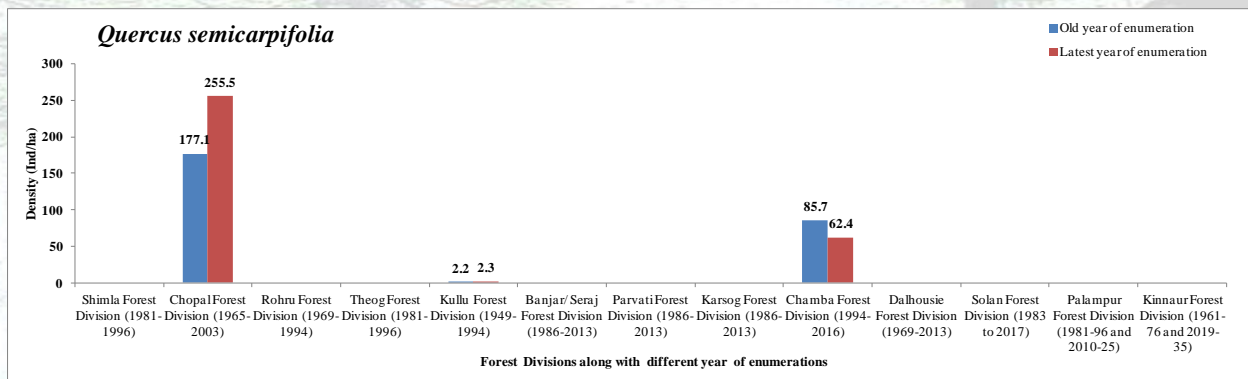


Figure 11 Status of *Quercus semicarpifolia* (Brown Oak/Kharshu) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

9) 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*, *Albizia chinensis*, *Albizia lebbek*, *Albizia procera*, *Alnus nepalensis*, *Alnus nitida*, *Azadirachat indica*, *Bauhinia variegata*, *Bombax ceiba*, *Butea monosperma*, *Carpinus sp*, *Cassia fistula*, *Cedrela serrata*, *Cedrela toona*, *Celtis australis*, *Cornus capitata*, *Dalbergia sissoo*, *Emblica 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, Nectanthes arbortristis, Olea cuspidata, Phoenix sylvestris, Pistacia integririma, Populus ciliata, Prunus armeniaca, Prunus communis, Prunus cornuta, Prunus persica, Punica granatum, Pyrus pashia, Quercus glauca, Quercus 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 consider 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*.

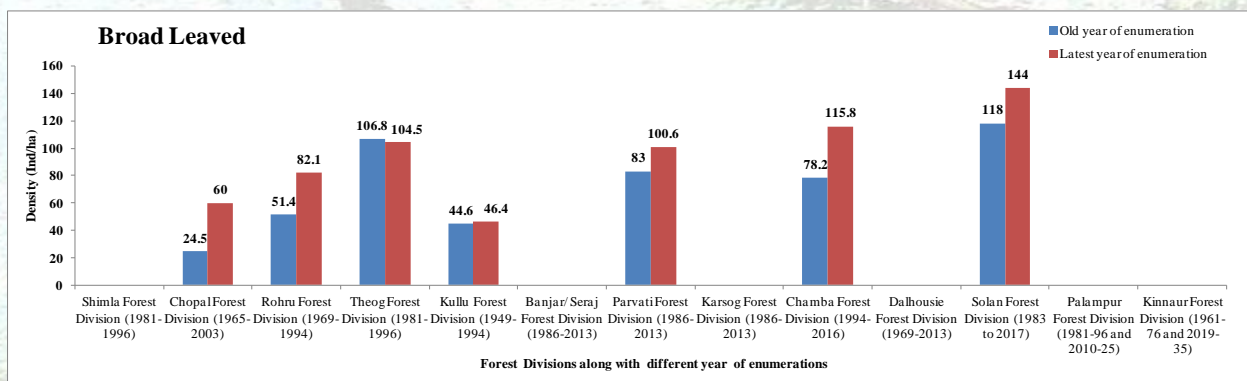


Figure 12 Status of Broad Leaved (All broad leaved species) in the temperate forests of Himachal Pradesh and change in density along two different years of enumerations

Conclusion

The temporal study was designed to get a preliminary insight in to 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 density (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 fallen under seven districts (Shimla, Kullu, Mandi, Kinnaur, Solan, Kangra and Chamba) covered most of the temperate area of the State. 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. Observed change in species density was not uniform in the selected forests because most of the forests have different year of enumerations. However, the data as per availability with comparable enumeration records revealed the following results:

Finding revealed that *Abies pindrow* maintained good population in Chopal, Kullu, Banjar and Karsog Forest Division while this species showed decreased in trends in Rohru, Theog, Parvati and Dalhousie Forest Division. Studied showed that this species showed less regeneration rate in the forests if this species decreases by certain reasons it will take very long time to achieve tree height. *Cedrus deodara* 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. As this species have durable wood and generally recommended for the timber purpose in State. Plantation measure has also being done be different organizations, forest department and NGO's. Enumeration records of *Picea smithiana* showed that population density was increased in all selected forests except Karsog, Dalhousie and Kinnaur (due to localized anthropogenic activates). One observed reason during the report compilation for its increase is that 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 forests viz., Rohru, Kullu and Chamba. As *Pinus wallichiana* is the second most alternative for timber wood and fuel wood after *Cedrus deodara* in Himachal Pradesh, that's why it is more used by the local stakeholders. Therefore, people dependency on this species may be one of the possible reasons for its decrease. The other reason behind the deceased population

of *Abies pindrow*, *Cedrus deodara*, *Picea smithiana* and *Pinus wallichiana* is the moisture regime. The place where these species were present have good moisture regime and fertile soil therefore, the local stakeholders or people tried to encroach these places for apple orchards and agriculture practices.

Beside these species, *Pinus roxburghii* is an important, fire hardy and temperature resistant tree species of Himachal Pradesh. Most of the people 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 acclimatizing (with changing environment) it still maintain good density in the forests. However, there is more need to find out the possible reason for above stated temperate species so that we can improve the management practices and conservation methods.

Along conifers, oak also serves as 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*. Only few compartments were there which forms pure oak community but in most of cases these species occurs in mixed form (with conifers). These species are over utilized by the local people/community for fuel, fodder and timber. Species other than broad leaved 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 broad leaved) of temperate forests
- ✓ General status of species dominance, community structure (pure and mixed) and density variations
- ✓ Provides baseline finding which can help to improve the management and conservation strategies in future.
- ✓ Also open scope and inputs of further research in forestry sector like, species wise studies throughout the temperate forests of Himachal Pradesh with ground proofing and the possible reason for their increase or decrease.

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