Chapter-I

Introduction
INTRODUCTION

The Himalaya is the largest mountain system in India and it shields the north-western part of the country. It supports sub tropical, temperate and alpine vegetation types. The Himalayan landscape reflects the overall combined picture of various factors such as physiographic, faunal, climatic and floral elements. The entire belt of the Himalaya has been grouped into four divisions Kashmir Himalaya, Karakoram including Ladhak, central Himalaya and eastern Himalaya. From the botanical point of view entire Himalaya are divided into western and eastern Himalaya, these two Himalayan range support contrasting plant cover. The eastern Himalaya is characterized by the occurrence of rich vegetation of broad leaf species while the conifers are restricted to only few species. On the other hand several conifer species occur in the eastern Himalaya region with a mix of few broad leaf species. Only a few species of *Quercus* are found in the western Himalaya as against the numerous species of oak in the eastern Himalaya (Champion and Seth 1968).

Timberline, forest the natural vegetation of subalpine belt in North West and Western Himalaya generally occur between 3000 meter to 4000 meter in Himalaya and primarily consist of coniferous (*Abies pindrow,*
Pinus wallichiana, Picea smithiana) and birch forest (Betula utilis). The birch is dominant constitutional of the upper subalpine forest belt on north facing slopes, where coniferous forest already have a considerable proportion of birch and finally turn into a narrow belt of pure birch stand. Rhododendron campanulatum and salix spp. are principal understory species. Further upslope, Betula utilis grows scattered in a crippled growth form and merges into a Rhododendron and/or Salix Krummholz belt.

Evergreen trees and large shrubs of genus Rhododendron (R. Campanulatum, R. Barbatim, R. Wightii, R. Fulgens, R. Lanatum a.o) replace the birch belt under less severe winter cold increasing influence from tropical monsoon moisture in the eastern Himalaya. Uppermost Rhododendron forest are interspersed with single coniferous species (Abies spp., Picea spp., Larix griffithiana), ascending from dense forest stand in the lower subalpine and upper montane belt.

The Krummholz belt higher up is often formed by the same Rhododendron species, frequently associated with Salix species. Several Juniper species (Juniperous excels, Juniperous turkestanica, Juniperous recurva, Juniperous wallichiana, Juniperous indica, Juniperous tibetica a.o.) are characteristic for the uppermost tree growth
on south facing slopes along the entire mountain arc. Occurring from fairly dense stand to very open woodland and finally to single isolated individuals. South facing slopes are often lacking a distinct and easily recognizable sequence of altitudinal belts, especially in the drier north west of the Hindu Kush Himalaya region, due to homogenizing effect of irradiation exposure.

Scattered junipers may change their growth form from tree to shrub (e.g. *Juniperus indica, Juniperus recurva*) at higher altitude and often ascend up to elevation, which correspond to alpine belt of shady slopes. As long as it is not clear, weather they indicate potentially forested altitudinal belt, they are less suitable for the delimitation of the upper timberline ecotone and the sub alpine belt, considerable research deficits, however, still remains as far as timberlines on other continents especially in sub tropical and tropical high mountain and Himalayan regions. Recent overviews of upper timberline in the tropics were provided by Miehe and Miehe (1994; 1996; 2000), for tropical/subtropical oceanic islands, Leuschner(1996), for South and East Asia Ohsawa (1990), for Middle Asia Zimina (1973), for north Asia Ohsawa (1990), for Middle Asia Zimina (1973), for North Asia Malyshev (1993).
Holtmeier (1995; 2000) showed that the timberline ecotone has to be seen as space time related phenomenon that does not respond linearly to an altitudinal shift of any isotherms, and that the actual position of upper timberline reflects site history (extreme events, fire, insect pest, human impact, inertia of tree population, biotic interactions etc) rather than present climate. He concluded that a synchronous adjustment of environmental conditions and timberline elevations to changing climate is not to be expected.

Considerable uncertainties still exist as far as our knowledge of upper timberline conditions in Himalaya is concerned. This holds true for both basic and applied aspect of timberline research.
Timberline in Himachal Pradesh

Timberline in Himachal Pradesh makes a cross section from the mountains around Beas River and Dhaola Dhar Range across Chamba and Lahul into Zanskar shows an upper timberline increase of 400 meter along a distance of ca. 100 km North exposed timberline of *Betula utilis*, *Rhododendron campanulatum*, *Sorbus aucuparia* and *Salix spp.* develops at 3500-3600 meter in the outer ranges, e.g. at Beas River (32°01’N/77°25’E; Bruce 1914; Gorrie 1933), and in (Dhaola Dhar Range; 32°19’N/76°51’E) (Chandra 1949). Wynter-Blyth (1951) encountered the upper timberline at ca. 3700 m in Kulu V. (32°12’N/77°09’E). According to Rau, (1974), upper timberline *Betula utilis*, *Rhododendron campanulatum*, *Juniperus spp.*) even attains an altitude of 4200 meter in Brahmaur (Chamba; 32°40’N/77° E), a figure which has to be verified since it seems to be very exceptional. Nevertheless, towards the inner ranges timberline elevations considerably increase to 3800-4000 meter as observed in inner Sutlej, (Thomson 1852; Gorrie 1933; Schweinfurth 1957a), where locally *Pinus wallichiana* or *Quercus semecarpifolia* may form an upper forest belt.

However, *Betula utilis* and *Rhododendron campanulatum* usually dominate the uppermost forest and Krummholz belts. Drew (1875)
encountered uppermost birch stands at ca. 3800 meter in upper Bhutna. (33°30'N/76°15'E). Seybold and Kull (1985) found uppermost Juniperus excelsa trees on both sides of Shingo La (pass between Lahul and Zanskar; 32°58'N/77°02'E) at about 3900 meter. The same altitude is given by Gupta (1994) for Junipers in Zanskar and Ladakh. Further north at Khardung (Ladakh; 34°23'N/77°40'E), Thomson (1852) still saw uppermost Junipers at 4250 meter in northern aspect.
Timberline in Uttarakhand

Timberline elevations in the outer Himalayan ranges of Uttarakhal differ broadly between 3500 and 3700 meter (Singh and Singh 1992) and tend to be slightly higher compared to the regions further northwest due to moister, warmer summer conditions.

Timberline observations are almost exclusively restricted to north-facing slopes and include the mountains in outer Tehri Garhwal (Heske 1932), around Nainital (Meusel and Schubert 1971), Pindari/Sarju, at the southern slopes of Nanda Devi massif (7816m) (30°07'-10°N/79°48'-80°04'E; Kalakoti et al. 1986; Rawal and Pangtey 1993, 1994; Rawal and Dhar 1997; Maikhuri et al. 1998), and Tunghath (30°30'N/79°15'E; Sundriyal 1994). Principal timberline species are again *Betula utilis* and *Rhododendron campanulatum*, sometimes associated with *Abies pindrow*, *Juniperus recurva*, *Pyrus foliolosa*, *Betula alnoides*, *Rhododendron arboreum*, *Rhododendron barbatum*, *Sorbus* spp. and/or *Quercus semecarpifolia*.

A more or less continuous and quite steep increase in elevation towards the inner ranges and the Great Himalaya can be observed. Timberline lies around 3700-3800 meter in upper Yamuna, (31°15'N/78°19'E; Heske 1932, 1937; Tyson 1954; Puri et al. 1989), Yumnotri
(31°03'N/78°28'E; Gupta 1983), in the valley of flowers national park (30°41'-48'N/79°33'-79°46'E; Kala et al. 2002), and in the nanda devi biosphere reserve (30°17'- 41°N/79°40'-80°50'E; Longstaff 1907; 1908; 1928; Champion 1936; Garkoti and Singh 1994). In the latter, it may occasionally ascend to 3900-4000 m, e.g. in Kuhti Yankti V. (Schmid 1938; Heim and Gansser 1939), or in Bishanganga and Dhauliganga V. (Osmaston 1922). Even higher timberlines were found at Gangotri mountain (Betula utilis at 4100 m; N-exp.; 30°55'N/78°52'E; Dudgeon and Kenoyer 1925; Heske 1932), in Tons, (Betula utilis and Rhododendron campanulatum at 4000-4100 meter; N-exp.; 31°11'N/78°13'E; Gupta and Singh 1962), and at southern aspects in upper Bhagirathi, (Juniperus spp. at 4250 meter; 31°06'N/78°58'E; Gupta 1983).

Beyond the Indian Tibetan border in this region (upper catchment of Sutlej River/Langchen Zangbo), humidity considerably decreases in the rain shadow of the Great Himalaya and is no longer sufficient to support forest growth. Along this cross-section, the increase in timberline elevations amounts to ca. 500 meter in northern aspects and 500-600 meter in southern aspects at a horizontal distance of ca. 100 km.
Regeneration of Tree Species at Treeline

There is virtually no information on the effects of environmental conditions on natural regeneration of Himalayan timberline tree species. As stated above, forest degradation and altering site conditions especially on south-facing slopes may prevent regeneration at all in drier regions (Schickhoff 2000a; 2002). Likewise, only very few observations on regeneration strategies (seed produced regeneration, seed banks, seed dispersal, vegetative reproduction) are documented. For instance, Junipers are able to regenerate from tree stumps (Miehe and Miehe 2000). Recently, Pinus wallichiana seedlings have been observed to occur 250 m above the current upper timberline, and this was attributed to climate change (Dubey et al. 2003). More detailed studies on regeneration at timberline elevations are strongly needed.

We are still at the very beginning of the way to better understand timberline ecotones in the Himalayan mountain system. Whereas information on altitudinal position, physiognomy, and floristic is more or less sufficiently documented in the widely scattered literature, studies on ecological interrelationships are very rare. If carried out, such studies quite often focus on single aspects of the ecological complexity of upper timberlines rather than on ecological interactions of varied factors. More
systematic, interdisciplinary research is strongly needed to get further insights into the many abiotic, biotic, and anthropogenic factors, to understand how these factors are interrelated and how complex ecological and socio-economic processes at various spatial and temporal scales are finally expressed in present spatial and physiognomic timberline structures.

A complex landscape ecological approach as advocated by Holtmeier (2003) seems to be most promising in order to encompass the ecological complexity and great heterogeneity of timberline ecotones. Timberlines have always been fluctuating due to either slow or abruptly changing environmental conditions. Recently, two agents of change have the upper timberline in the Himalayas, Hindu Kush and Karakorum 335 been emerging that might exert a comparatively strong influence on timberline dynamics in the Hindu Kush mountain system) accelerating socio-economic transformation processes in a globalizing world, and ii) climate change. As a rule, socio-economic change is connected with changing land use patterns and land use intensities.

As exemplified above by the decline of high pasturing in the Karakorum, strategies of resource utilization that directly influence timberline ecotones are being adapted within the framework of overall changing livelihood strategies. Negative effects on timberline structures may be
weakened by decreasing grazing pressure, but can be reinforced by other developments. Apart from pastoral use, forest use in the upper subalpine belt and tourism are present human impacts that may rapidly change in intensity in response to socio-economic change and thus influence timberline dynamics. Likewise, timberline structures are presently supposed to be modified under the influence of ongoing warming trends. Most of the regions within the Himalaya mountain system experienced an increase of mean annual temperatures in recent decades that amount to up to 0.9°C (Böhner 1996). Glaciers have retreated on a large scale in the past 30 years (e.g. Qin et al. 2000; Karma et al. 2003), monsoon rainfall is supposed to decrease in vast regions (Duan et al. 2002), and an upward shift of timberline tree species (*Pinus wallichiana*) was already observed and attributed to climatic changes (Dubey et al. 2003).

The present investigation deals with the impact of climate change and present warming trend on treeline tree species in western Himalaya. The thesis has been divided into five chapters which deal with Introduction (Chapter I), Methodology (Chapter II), Literature review (Chapter III), Results (Chapter IV) and Discussion (Chapter V). The Thesis ends with summary and literature cited and relevant appendices.