



# **Habitat Assessment and Regeneration Pattern of Himalayan Birch (*Betula utilis*) in Royal Botanical Park, Lampelri**

**Bhagat Suberi <sup>a</sup>, Kinzang Wangchuk <sup>b\*</sup> and Karma Sherub <sup>a</sup>**

<sup>a</sup> Department of Forestry, College of Natural Resources, Royal University of Bhutan, Bhutan.

<sup>b</sup> Department of Forest and Park Services, Royal Government of Bhutan, Bhutan.

## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

The Himalayan Birch (*Betula utilis* D. Don) an essential tree species due to its ecological and social importance in the himalayan region. The study assessed the effect of environmental factors on habitat, growth, and regeneration patterns of the Himalayan Birch at the Royal Botanical Park, Lampelri, Bhutan. Two vertical transects with a spacing of 75 m were laid across the altitudinal gradient. A total of 10 circular sample plots were laid on each transect with a plot size of 12.62 m for trees, 3.57 m for regeneration, and 0.57 m for ground cover vegetation. A total of 119 vascular plant species under 45 families were recorded in 20 survey plots. The Spearman rho's correlation showed strong negative correlation between the species abundance and temperature ( $r_s = -.83$ ) and positive correlation with the species count and altitude ( $r_s = .83$ ). The species richness in the study area showed an initial increase up to certain with elevation and then decreased with further increase in elevation. The importance value index (IVI) of tree species showed *Tsuga dumosa* as the most dominant species. *Betula utilis* indicated an increasing density with an increase in elevation. The regeneration of *Betula utilis* was poor as it was mostly found in a sapling stage. From a total of 43 tree species regenerating, 13.95% showed good regeneration, 34.88% fair, 23.25% poor, and 4.65% without regeneration. The remaining 23.25% seems to be either reappearing or immigrating.

**Keywords:** Dominance; Environmental variables Regeneration; Species; Temperature; Vegetation.

\*Corresponding author: E-mail: kinzangmb97@gmail.com;

## 1. INTRODUCTION

The birch belongs to the Betulaceae family, with an approximately 50 species across the world. These species mostly occur in the temperate zone of the Northern Hemisphere [1]. The Himalayan birch (*Betula utilis* D. Don), is also popularly known as Bhojpatra in Indian sub-continent, [2]. The birch is a medium sized tree which can grow up to a height of 20 m [3]. The bark is shining reddish in color, with white horizontal smooth lenticels. The bark constitutes many layers, which can be peeled into individual layers in horizontal flakes. The inner cortex of *B. utilis* is red in color, which looks attractive [4,5]. *B. utilis* is the only broadleaved tree and the dominant birch species growing across the Himalayas. *B. utilis* forms the tree line vegetation all along the Himalayas as it extensively stands on the northern shady slopes and ravines [6].

In Indian sub-continent, *B. utilis* plays a significant ecological and social role the Himalayan Birches maintains the fragile ecosystem of the northern region such as watershed protection, bio-shield for other forest, and soil stabilization in high altitude area [7,2]. The species is known to contain a wide variety of medicinal and ethnobotanical uses [1,2]. For instance.

However, due to anthropogenic pressure, *B. utilis* is critically endangered species [8]. About 85% of its population has decreased in Mankial Valley of Hindukush Range and only a small population thrives in the locality [9]. Moreover, the population of this species is reported to be declining in other parts of its habitat range. Moreover, a scanty study on *B. utilis* due to its inaccessibility to habitat range, as it grows in the high altitude tree line zone, has received less attention for its conservation significance [2]. According to Shaw et al. [7], limited knowledge and information on the least explored species, mainly from less studied parts of the globe, is a major concern of conservation. Therefore, this study addresses on how environmental variables affect the habitat and regeneration of *B. utilis*. The study will be helpful for proper management and conservation of *B. utilis*.

## 2. MATERIALS AND METHODS

### 2.1 Study Site

The study was carried out in the Royal Botanical Park, Lampelri (Fig. 1), Bhutan. The park is

situated between an within an elevation range of 2,100- 3,750 masl and covers an area of 120 km<sup>2</sup>. The park covers the biological corridor of Jigme Dorji National Park and Jigme SingyeWangchuck National Park. The park forms the heart of the “tri-junction” of the hill ranges of Sinchula, Helela and Dochula. The mean annual temperature and rainfall are 11.25°C and 946.64 mm, respectively. The vegetation types includes warm broadleaved forest in the lower valleys, cool broadleaved forest, followed by mixed conifer and fir forest and alpine scrub and alpine meadows at higher elevations.

### 2.2 Materials

During data collection, following materials were used: Measuring tape, Diameter tape, Clinometer, Global Positioning System (GPS), Compass, Soil auger, data collection sheet, GPS logger, Camera and s containers for soil sample collection.

### 2.3 Sampling Method and Plot Design

Two transects were laid over varying altitudes ranging from 2,100 m at valley bottom to the upper most accessible area at 3,500 m. The first transect was laid between an elevation range of 3,500 to 2,825 m and the second transect from 2,750 to 2,100 m. Each transect was of 10 circular plots covering different aspects with a counter interval of 75 m between plots in the study area.

The study used circular plots designed by Amatya et al. [10] for the National Forest Inventory of Bhutan with a slight modification. A circular plot of radius 12.62 m was used for tree samples, 3.57 m for understory vegetation, and 0.57 m for groundcover. Soil samples were collected from the center of the plots at a depth of 15 cm.

### 2.4 Data Collection

#### 2.4.1 Vegetation survey

In the tree plots all tree species with DBH (diameter at breast height)  $\geq 10$  cm and height  $\geq 1.3$  m were enumerated. In understory plots, all tree seedlings, saplings (DBH  $\leq 10$  m and height  $\leq 1.3$  m) count and shrubs count were taken to compute relative density. In the groundcover plot, all herbaceous species count and coverage was recorded. The association *B. utilis* with its vegetation was determined using species DBH,

height and individual counts to understand the biotic factors determining the growth of *B. utilis*. The basal area (BA), DBH class distribution and height class were calculated from DBH data and height data of individual tree species. Relative basal area (RBA) of each species was used to denote the abundance of species.

## 2.5 Climatic and Topographic Data Collection

The topographic factors having significant relation with the growth of *B. utilis* such as location, altitude, aspect and slope were recorded using a GPS, Compass and clinometer, respectively. The climatic variables such as mean rainfall and temperature, were obtained using the model developed by Dorji et al. [11].

## 2.6 Soil Sample Collection

The soil samples were collected with the help of a soil auger from the center of circular plot which

falls inside every herb plots measuring with 0.57 in diameter. Soil samples were then analyzed for pH, N, P, K, soil organic carbon and moisture content in the laboratory of the College of Natural Resources.

## 2.7 Data Processing and Analysis

The Microsoft Excel was used for sorting and cleaning the generated data. The floristic composition was also prepared using Microsoft Excel. The data was then analyzed using a PC-ORD for cluster analysis to determine the associate species of *B. utilis*. The Statistical Package for the Social Sciences (SPSS) (version....) was used for spearman correlation to determine the association between *B. utilis* and environmental variables.

## 2.8 Regeneration Analysis

Regeneration status of tree species was determined based on total numbers (population) of seedlings and saplings [12,13,14].

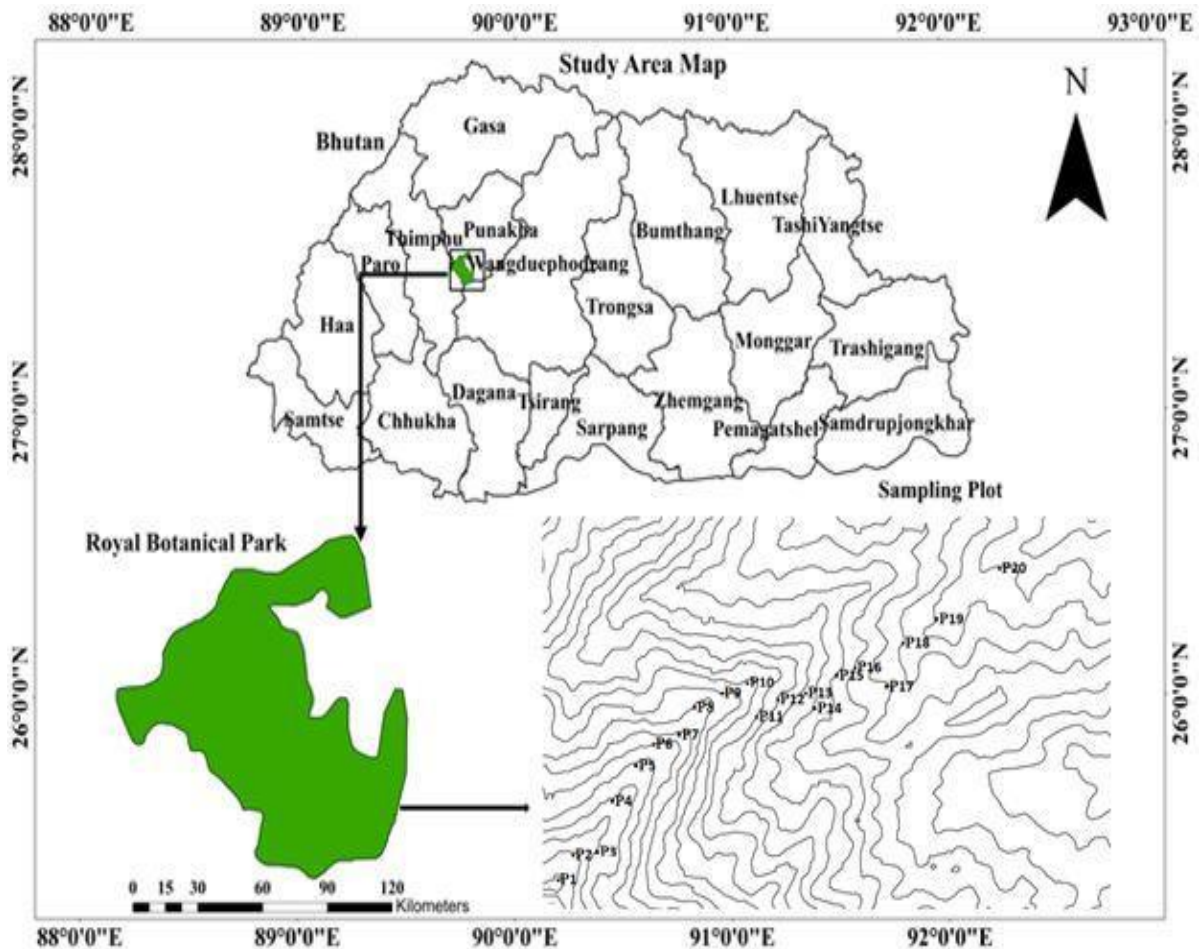


Fig. 1. Map of study area

- (I) Considered good regeneration, if seedlings > saplings > adults
- (II) Considered fair regeneration, if seedlings ≥ saplings = adults
- (III) Considered poor regeneration, if the particular species survives only in sapling stage, but no seedlings (saplings <, ≥ adults)
- (IV) Considered no regeneration, if a species is present only in adult form
- (V) Considered new regeneration, if the species has no adults but only seedlings or saplings.

## 2.9 Species Dominance Analysis

The IVI was calculated to determine the dominant species. The IVI of tree species was calculated by summing up the relative values of frequency, density, and basal area. These values were derived as the value for a species expressed as a percentage of the sum of those values for all the species of the community. Those species having the maximum IVI were considered as dominant species [15,16]. To determine the biotic factors affecting the growth of *B. utilis*, the association or correlation among species was determined by calculating the most dominant associated tree species with *B. utilis*.

(Important Value Index = Relative Frequency + Relative Density + Relative Dominance)

## 2.10 Cluster Analysis for Forest Type

PC-ORD software [17] was used for cluster analysis. Cluster analysis was performed using distance measure of Relative Sorenson (Bray-Curtis method) to determine the forest types. Qualitative similarity among sample groups was determined using Sorenson's index [18].

## 3. RESULTS AND DISCUSSION

### 3.1 Forest Composition

The forest vegetation was classified under three growth forms: matured tree, regeneration/understory, and ground cover vegetation. A total of 119 vascular plant species under 45 families were recorded in 20 survey plots.

### 3.2 Floristic Composition by Vegetation Types

The study recorded 33 tree species belonging to 13 families. out of 33 tree species, 49.07% were evergreen trees, 33.28% deciduous and 17.64%

conifers. Most of the plots had evergreen trees with different percent coverage. In the lower altitude (2,075-2,600 m), was dominated by evergreen trees, the mid-altitude (2,600-3,125 m) by deciduous trees and the higher altitudes (3,125-3,500 m) by conifer species (Fig. 2).

### 3.3 Understory Vegetation

The understory vegetation consisted of seven sub-categories of growth forms such as evergreen saplings, deciduous saplings, conifer sapling, evergreen shrubs, deciduous shrubs, climbing shrubs and bamboo (Fig. 3). A total of 52 species from 20 families were recorded from the understory vegetation. The evergreen shrubs constituted the maximum portion of understory vegetation composition with 55.18%, while climbing shrubs constituted the least portion of only 0.38%. Theaceae family (*Eurya acuminata* A.DC) dominated the the understory vegetation.

### 3.4 Ground Vegetation

The ground vegetation was classified into four growth forms such as perennial herbs, annual herbs, ferns and climber-herbs (Fig. 4). Ground cover vegetation comprised of 25 families with 51 species,. Perennial herbs dominated the ground cover with 63.51% and the annual herbs was recorded with the least ground cover of 7.29%. The Dryopteridaceae family (*Dryopsis nidus* (Baker) Holttum & P.J. Edwards) dominated the ground vegetation

### 3.5 Dominant Tree Species

The important value index (IVI) indicated that the *Tsuga dumosa* D. Don the overall tree species (IVI = 41.6) followed by *Rhododendron arboretum* Smith (IVI = 22.4) and *Lyonia ovalifolia* Wall. (IVI = 18.5). The *Alnus nepalensis* D. Don was the least dominant tree species (IVI = 2.8) (Table 1).

From the 33 seedling species with DBH ≥ 10 cm, 10 species were found regenerating. These species are *Engelhardtia spicata*, *Exbucklandia populnea*, *Micheliadoltsopa*, *Dodecadenia grandiflora*, *Larixgriffithii*, *Myrsine semiserrata*, *Symplocos sumuntia*, *Symplocos cochinchinensis*, *Symplocosand* *Symplocossp.* Out of 43 species, 13.95% showed good 34.88% fair, 23.25% poor regeneration, and 4.65% without regeneration. The remaining

23.25% seems to be either reappearing or immigrating.

The overall regeneration of *B. utilis* was found to be 30%, mostly in the form of saplings. However, natural regeneration of seedlings was totally absent. A maximum of two saplings was recorded from plot two at an altitude of 3,425 masl on a slope facing north. The highest seedling count was found from plot four with ( $n=9$ ) including all the species from the plot, while least was recorded from plot 16 ( $n=4$ ). The highest sapling count was recorded from plot 6 and 20 with  $n=9$  count each and that of least from plot 4,5,10 and 11 with ( $n=5$ ) count each (Fig. 5). Regeneration of *B. utilis* was very low due to unfavorable microhabitat for its seed germination. Most of the sites were under thick

vegetation cover which restricted access to sunlight for seed germination. According to Mir et al. (1), germination of *B. utilis* takes place under low temperature with fully imbibed state and it is regulated by temperature and interaction of photoperiod, which contradicts down the gradient in present study site. Rana et al. [16] also reported that regeneration of *B. utilis* is affected by the thick vegetation, which is least favored by light demanding species hence leading to replacement by shade tolerant species. Zhu et al. [19] also reported that open area favors the regeneration of the tree species. Lack of enough moisture content of the soil affects the germination of seeds which hinders the regeneration (Tiwari et al. [20]. analysis of soil moisture from the study site also indicated low moisture content (mean=2.44%).

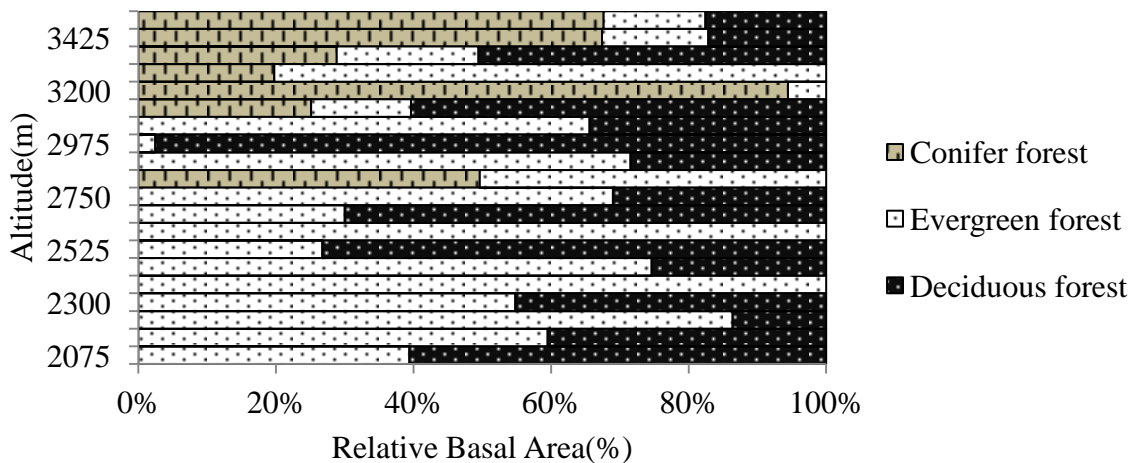


Fig. 2. Tree vegetation composition using relative basal area (%)

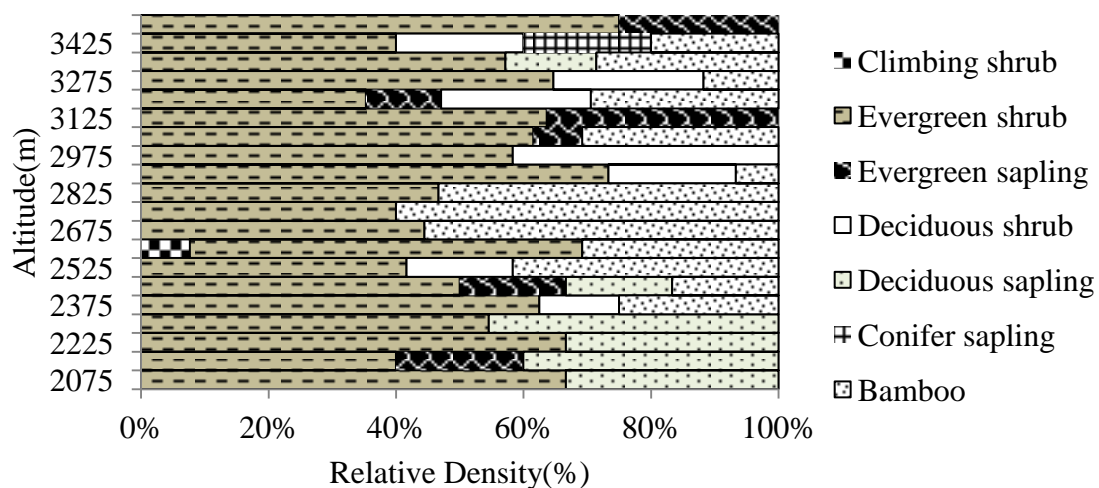


Fig. 3. Regeneration/Understory using relative density (%)

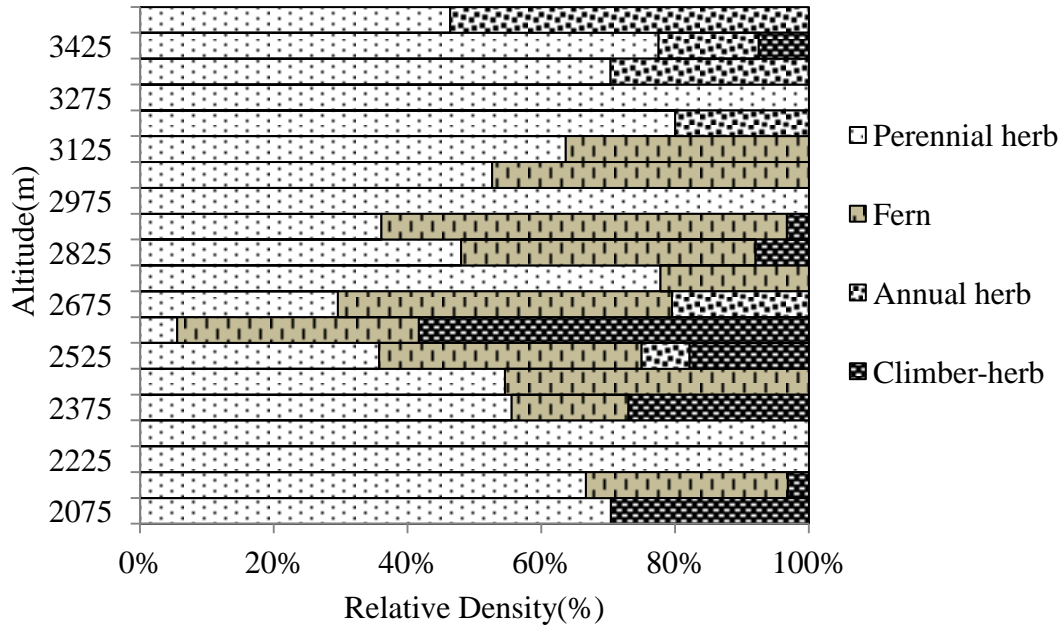
**Table 1. Important value index (IVI) of tree species**

Species	Individuals	RD	R Do	RF	IVI	Remarks
<i>Tsugadumosa</i> (D. Don)	8	8.42	26.89	6.25	41.57	Highest
<i>Alnusnepalensis</i> (D. Don)	1	1.05	0.19	1.5625	2.80	Lowest

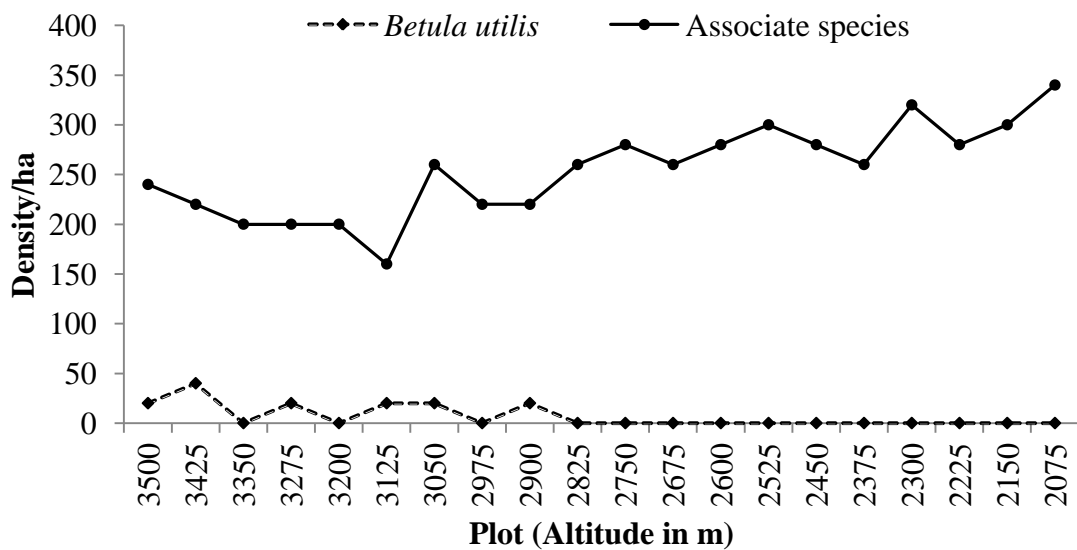
**Note:** RD= Relative density, RF=Relative frequency, R Do=Relative dominance

Regeneration of *B. utilis* and associated species

The study area constituted 27.40% seedlings, 31.14% saplings, and 41.45% of shrubs/matured trees



**Fig. 4. Ground cover vegetation using relative density (%)**



**Fig. 5. Regeneration status of species**

The dominance (RBA) of all the species in each plot was used to run cluster analysis in PC-ORD for classifying the forest types by the species similarity index with dendrogram. Three different forest types (Type I = Cool conifer forest, Type II = Evergreen broad-leaved forest and Type III = Mixed broad-leaved forest) were classified with arbitrary at 65% similarity threshold (Fig. 6) following Wangda [21]. The forests types were defined by their dominance and natural habitats and their descriptions are as follows:

**3.5.1 Type I (Cool conifer forest)**

Plots one to five were clustered in type I Cool conifer forest based on dominant species and natural habitat. The altitude ranges from 3,200 to 3,500 m and the dominant species are *Tsugadumosa* (D. Don) Eichler, *Piceaspinulosa* (Griffith), *Taxuswallichiana*(Zucc), *Betulautilis* (D. Don) and *Rhododendron arboreum* (Smith).

**3.5.2 Type II (Evergreen broad-leaved forest)**

The altitude ranging from 2,600 to 3125 m was classified as evergreen broad-leaved forest based on the dominance of *Quercus*

*semiserrata*(Roxb.), *Litsea cubeba* (Lour.), *Quercus oxyodon* (Miq.), *Acer campbellii*(Hooker & Thomson ex Hiern) and *Quercus glauca*(Thunb.). According to Wangda and Ohsawa [22], evergreen broad-leaved forest constitutes species such as *Quercus semiserrata*, *Quercus glauca*(Thunb.) and *Quercus oxyodon* (Miq.), which corresponds to species present in the Type-II.

**3.5.3 Type III (Mixed broad-leaved forest)**

The Forest Type III consisted of plots 14, 15, 16,17,18,19 and 20 with altitude range of 2,075 to 2,525 m. This category of forest is the mixed broad-leaved owing to the mixture of broad-leaved species. Dominant species in Type-III forest comprised of *Castanopsis tribuloides* (Smith),*Castanopsis hystrix* (A.DC), *Quercus griffithii* (Hook.f. & Thomson ex Miq.), *Symplocos theifolia* (D.Don), and *Quercus lanata*(Smith). The mixed broad-leaved forest constitutes *Quercus lanata* (evergreen), *Quercus griffithii*, (deciduous), and *Rhododendron arboreum* (evergreen) as major canopy species Wangda and Ohsawa [22].

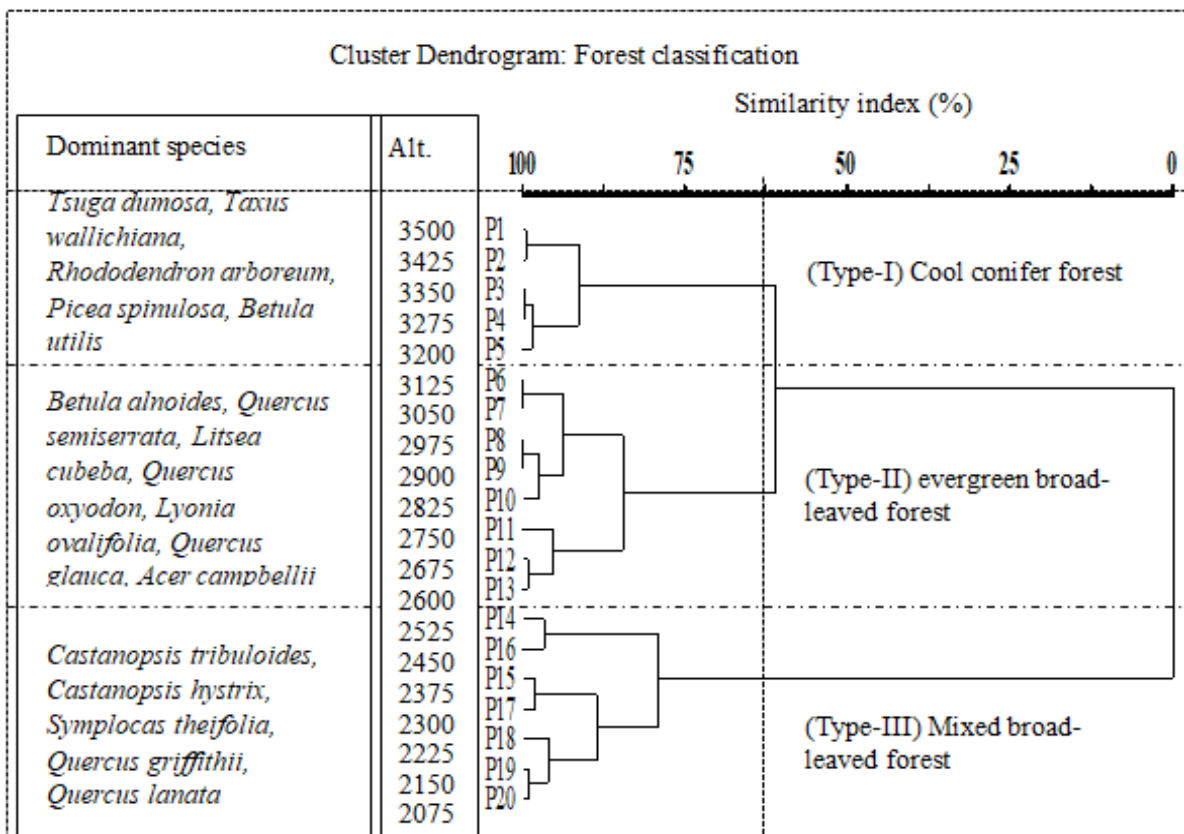


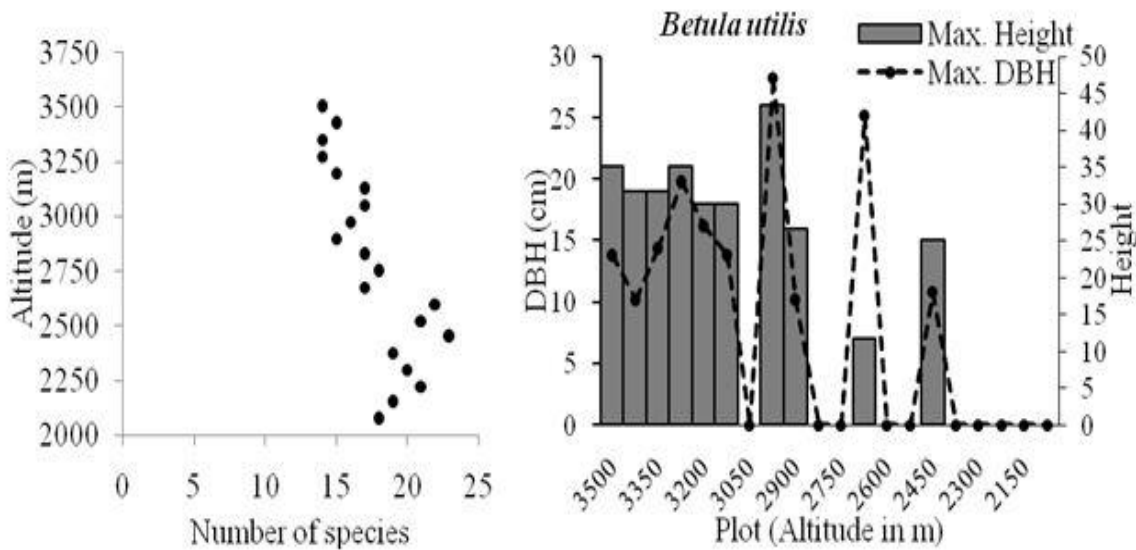
Fig. 6. Forest type classification using dendrogram

**Table 2. Association with environmental variables**

	<i>B. utilis</i> Count	Altitude (m)	Temp (°C)	Ppt (mm)	Soil pH	Soil MC (%)	OC	N	P	K
<i>Betula utilis</i> Count	1									
Altitude (m)	.835**	1								
Temp (°C)	-.835**	-1.00**	1							
Ppt (mm)	-.292	-.305	.305	1						
Soil pH	-.120	-.139	.139	-.047	1					
SoilMC	-.105	.220	-.220	.298	.312	1				
OC	-.011	.110	-.110	.188	-.543*	.167	1			
N	-.011	.110	-.110	.188	-.543*	.167	1.00**	1		
P	-.105	-.184	.184	.429	-.385	-.001	.243	.243	1	
K	.075	.229	-.229	.447*	-.298	.420	.646**	.646**	.534*	1

\*. Correlation is significant at the 0.05 level (1-tailed)

\*\* . Correlation is significant at the 0.01 level (2-tailed)



**Fig. 7. Species richness and *B. utilis* DBH & Ht**

**3.5.4 Assessment of environmental factors**

The environmental factors such as soil pH, soil moisture content, soil organic carbon and soil NPK were analyzed. The finding indicated that the soil pH ranges between 5.18 – 6.65 with a mean pH value of 5.74 (*SD* ± 0.44) indicating slightly acidic nature of soil. The soil organic carbon ranges from 0.89% - 4.41%. average soil moisture content was 2.44%, owing to data collection in dry season (December month). According to Kala [2], the species is distributed sporadically in lower altitude (<3,400 m), but in higher elevation, it has dense and gregarious stands either in pure masses or in mixed stands,

which the current study also revealed typical similarity.

The *B. utilis* count (Table: 2) shows a strong correlation with environmental factors such as altitude ( $r_s = .83, p = .00$ ) and temperature; ( $r_s = -.83, p = .00$ ). Density of *B. utilis* was found more at higher altitude than lower altitude. Kumaraswamy et al. [3] also stated that its density increases with increase in altitude. However, a temperature indicated a strong negative association with *B. utilis* count low temperature favored the growth of *B. utilis* seedlings, which governed its regeneration and distribution. According to Junttila and Hanninen



[23], temperature range below 10-15°C is vital to budburst of birch in the boreal regions. Such a response has been shown in seeds of several species, including *Betula*, particularly during the release of dormancy. However, soil moisture content and pH; ( $r_s = -.105$ ,  $p > .05$ ) and ( $r_s = -.12$ ,  $p > .05$ ) had no effect on the species which contradicted the finding of Shrestha et al. [24]

Spearman's rho correlation coefficient indicated no significant relationship between precipitation and *B. utilis* count ( $r_s = .292$ ,  $p > .05$ ). *B. utilis* forest depends on snow melt instead of monsoon rain, therefore, it grows in precipitation scarce areas Safdar et al. [25]. Moreover, Farooq et al. [5], stated that *B. utilis* is adapted to exposed areas that are covered with snow for five to six months as well as in areas where precipitation level is low.

### 3.5.5 Structural features along the elevation gradient

The features such as basal area, diameter at breast height, density diameter curve, species richness and maximum height (Fig. 7) were used in describing structural organization and forest communities along the elevation gradient. The *Castanopsis hystrix* (A.DC.) with maximum DBH of 98 cm was recorded from Plot 19 (2,150 m), and *Rhododendron falconeri* (Hook.f.) with minimum DBH of 10 cm was recorded from Plot One (3,500 m). *Tsuga dumosa* (D. Don.) with a maximum height of 42 m was recorded from Plot 10 (2,825 m) and *Lyonia valifolia* (Wall.) recorded the least with 4 m, from Plot Seven (3,050 m).

The highest basal area was recorded at an altitude of 2,825 m with 17,054.92 m<sup>2</sup>. Overall BA was higher in the second transect compared to the first transect, however, it did not show definite pattern of change along elevation gradient. The difference in change of basal area along the elevation could be attributed to varying environmental factors, which affect the growth. The species richness was found higher in lower elevation which increased up to an elevation of 2,600 m and decreased upon further increase in elevation. The maximum number of species was recorded from Plot 15 (2,450 m) with ( $S = 23$ ) (Fig. 7). The result supports the findings of Numata [26], who stated that species composition increases with increase in elevation up to a certain level and decreases with a further increase in elevation.

Density-diameter curve plotted for all tree species shows inverse J-shape (Fig. 8) indicating that overall regeneration was good in the study plot. However, the density-diameter curve plotted for tree population of *B. utilis* shows sporadic shape, which represents poor regeneration. The result indicated that, tree species having high diameter class have less density as compared to tree species having less diameter class. This could be due to more space coverage by larger tree, which then prevents and suppresses the growth of other species in an area. Saha et al. [27] also reported that increase in diameter reduces the value of tree density.

## 4. CONCLUSION

A total of 119 vascular plant species under 45 families were recorded in 20 survey plots from the study area. *Tsuga dumosa* was the most dominating tree species (IVI = 41.5) indicating a strong association with *B. utilis*, while *Alnus nepalensis* was the least (IVI = 2.8) signifying low association with *B. utilis*. This species showed higher adaptability towards low temperature and its density increased with increase in altitude. Other environmental variables such as pH, soil moisture, soil organic content NPK and Ppt were not significantly related to its density. But *B. utilis* observed in the site were moisture content was relatively high as compared to site with low moisture content despite showing statistically not significant. From these findings, it can be concluded that *B. utilis* requires minimum temperature and higher altitude site for proper establishment and also should consider moisture content of soil as factors determining its growth and establishment.

The overall regeneration of *B. utilis* was found to be 30%, mostly in the form of sapling. However, natural regeneration of *B. utilis* in seedling form was totally absent. But generally community as a whole showed good regeneration. These findings highlight the need for proper management and conservation strategies that will help in future conservation of this species. Since this study was conducted for a limited period (?? months), a further study on the topic for a longer duration is recommended to obtain a more holistic data on this species in the country.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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