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Floristic Diversity and Important Value Indices of Tree Species in Lower Kanchenjunga Singhalila Ridge Eastern Nepal

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Abstract

The present paper is based on the finding of floristic diversity inventory research work conducted in Lower Kanchenjungha Singhalila Ridge, in Nepal side of Eastern Himalaya. Knowledge on floristic diversity of an area can reflect the total resources, their use patterns and conservation status which have a key role for making conservation strategies and policies. Analysis of vegetation helps to develop detailed picture of plant communities of that region. A total of 299 plant species belonging to 184 genera and 86 families were found in the Lower Kanchenjungha Singhalila Ridge. Dicotyledonous flora includes 69 families, 150 genera and 229 species whereas Monocotyledonous flora includes 15 families, 32 genera and 39 species. On the basis of floristic analysis Rosaceae was found to be the largest family with 23 species followed by Ericaceae 17, and Lauraceae 9 species. Current study furnishes three new addition to the flora of Nepal viz. *Begonia flaviflora* H. Hara (Begoniaceae), *Carex cruciata* Wahlenberg var. *argocarpa* C. B. Clarke (Cyperaceae), and *Strobilanthes helicta* Anderson (Acanthaceae). Of this total, 30 woody tree species with 551 individuals and 23 genera were recorded from the altitudinal range of 2100 - 3000 m of study area. The highest relative frequency was recorded by *Lithocarpus pachyphylla* (18.48%), *Symplocos ramosissima* (16.30%), *Rhododendron falconeri* (13.95%), *Symplocos dryophylla* (10.20%). *Eurya acuminata* and *Symplocos* species were found to be dominant in lower elevation whereas *Lithocarpus pachyphylla* and *Rhododendron* species were found to be dominant in upper elevation.

Keywords

Eastern Himalaya, Inventory, Plant Specimens, Species Richness, Conservation

1. Introduction

Flora refers to the brief taxonomic treatment of all plants occurring in a geographical location which generates a comprehensive account. A complete flora of country is necessary to reflect the whole plant diversity of that country. Absence of flora severely hinders any scientific inquiry into plants [1]. The Eastern Himalaya is recognized as a global center of species diversity [2] [3]. The high floristic diversity of this area is due to the presence of diverse ecological habitats as well as climatic variations. It is also interesting phytogeographically because of Sino-Japanese and Sino-Himalayan elements. Species richness and endemism are very high in Eastern Himalaya due to the presence two biological niches viz. Indomalayan and Palaeartic realms [4]. The Kanchenjungha complex mostly covers the Taplejung district, the northeastern part of the Nepal, bordered by Sikkim (India) in the east and Tibet (China) in the north. The climate ranges from upper subtropical to alpine. Out of 6500 species of higher plants in Nepal flora, about two-third of the species are expected to occur in this area and the number of species are generally decreased from Central to Western Nepal [5].

Vegetation is an overall expression of various environmental factors which operates gradually or in a cyclic manner. Analysis of vegetation helps to develop detailed picture of plant communities of geographical location. More deliberatively vegetation refers to the expression of total plants cover in an area which may be made up of one or more plant communities or aggregation of plants usually forming a mosaic or complex [6]. The structure of tree species diversity in hill forest varies greatly from place to place due to variation of altitude, orientation of slope, nature of soil and type and intensity of disturbance [7].

Change in vegetation type occurs not only with respect to altitude, latitude, slope and soil but also with respect to rainfall pattern and human impacts such as natural disturbances like forest fire, soil erosion, landslide, volcanic activity etc. The climatic change determines forest dynamics and tree diversity [8]. Disturbance may increase species richness in old growth forest and may maintain species diversity [9]. Higher species richness is maintained in intermediate level of disturbance [10].

2. Materials and Methods

2.1. Study Area

Ilam is a small hilly district located in Eastern Development Region of Nepal with an area of 1703 sq. km. extending from 26˚4'N - 27˚8'N latitude and 87˚40 E - 88˚10'E longitude. The present study area Lower Kanchenjungha Singhalila Ridge covers the four eastern VDCs of Ilam district viz. Maimajuwa, Mabu, Jamuna, and Jogmai. This region enjoys a temperate climate characterized by the monsoon, which deposits most of the annual precipitation between June and October. The mountain sides are steep, and landslides are not uncommon during the monsoon season. Because of the extreme topography, because clouds and fog commonly block the sky throughout the year, so direct sunlight is limited.

The climate of this area is characterized by high rainfall, cool and humid atmosphere. Figure 1 reveals the map of the study area.

2.2. Data Collection

Two extensive field visits were conducted from June to July, 2007 as pre-monsoon and during September to October 2007 as post-monsoon. Pre-monsoon collection was focused for collection of specimens in flowering stages and other collection was focused in fruiting stages. Plants specimens were collected by two botanical expeditions. Triplicate specimens of each species were collected as far as possible. The route of collection and area has been shown in the GIS map. The collected voucher specimens were properly tagged in the field during collection with appropriate field notes. The collected specimens were dried and mounted on herbarium sheets of (28 × 44 cm). The specimens were prepared and managed using techniques mentioned in the Herbarium handbook [11]. The identification of collected plant specimens were done by using relevant literatures such as [12] [13] [14]. Similarly, plants were identified in the field by consulting the books [15] [16] under the supervision of senior taxonomist Professor Doctor Krishna Kumar Shrestha Central Department of Botany Tribhuvan University Nepal. The specimens were further confirmed by cross tallying with the specimens deposited at National Herbarium and Plant Laboratories (KATH), Godawari and Tribhuvan University Central Herbarium, Kirtipur (TUCH). The dried plant specimens were mounted in (28 × 44 cm) sheet. The process of herbarium preparation is based on the herbarium technique developed by Bridson. The

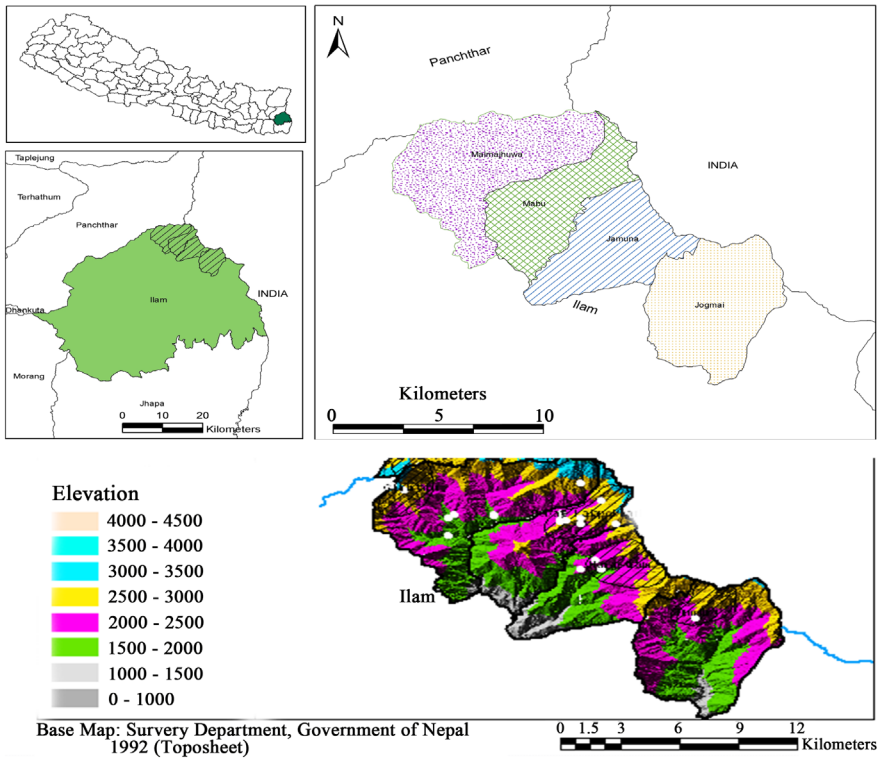

Figure 1. Map of study area.

dried specimens were deposited at National Herbarium and Plant Laboratories (KATH), Godavari, and Tribhuvan University Central Herbarium, Kirtipur (TUCH).

A total of 50 macro plots of 10 m × 10 m were laid down in three different altitudinal ranges. Altogether 30 tree species were recorded from three elevation ranges, 19 from lower elevation, 20 from middle elevation and 22 from upper elevation. The whole temperate forest of the study area was resolved into three sub zones [17] [18] to carry the quantitative vegetation analysis of the plant communities along an altitudinal gradient.

- Lower Temperate Zone (LTZ): It ranges from the elevation 2100 - 2400 m.
- Middle Temperate Zone (MTZ): It ranges from the elevation of 2400 - 2700 m.
- Upper Temperate Zone (UTZ): It ranges from the elevation of 2700 - 3000 m.

2.3. Data Analysis

Vegetation analysis of the selected forest stands along an altitudinal gradient was carried out by using square quadrats by following stratified-random sampling method [19]. The quadrat of 10 m × 10 m sized were laid down for sampling of trees. In each 10 m × 10 m quadrats the number of individual trees DBH [diameter at breast height-1.37 m, dbh ≥ 10 cm] of each species was noted. The height of each tree was estimated with the help of Clinometer. Herbarium specimens were prepared for collected plants. Quantitative data were gathered with the help of field data sheet and quantitatively analyzed for abundance, density and frequency according to the formulae given by Mishra [20]. The relative values were summed up to represent importance value index (IVI) as reported by Curtis [21]. The diversity index (H') was computed by using Shannon-Wiener information Index [22]. The concentration of dominance (CD) was computed by Simpson's Index [23]. For prediction of regeneration behavior of tree species size class distribution was developed. All the trees were divided into dbh classes of 10 cm interval and density of tees in each diameter class was calculated and size class distribution diagram was developed.

3. Results

3.1. Floristic Composition

Present study recorded 299 species among them seven species were identified only family level, 22 species only generic level rest of them to species level falling under 184 genera and 86 families. Dicots belong to 69 families, 150 genera and 229 species whereas Monocots include 15 families with 32 genera and 39 species. Similarly, Gymnosperms represented two families, two genera and two species. **Figure 2** shows the complete picture of the result.

Floristic analysis showed that Rosaceae as the largest family having 23 (8.24%) species and followed by Ericaceae 17 (6.09%), Lauraceae 9 (2.90%), Urticaceae, Labiateae, Scrophulariaceae, Asteraceae 8 (2.87%) of species. Similarly, Ranunculaceae,

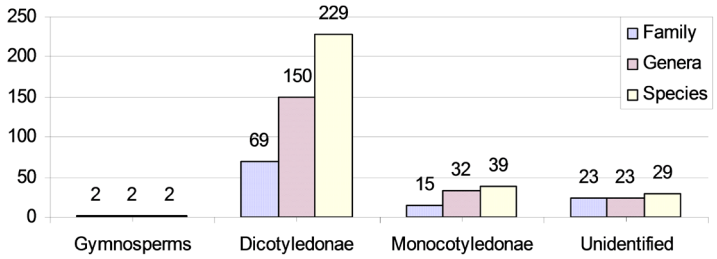

Figure 2. Number of family, genera and species recorded from study area.

Orchidaceae, Convallariaceae, Urticaceae 7 (2.51%) species and so on. The two genera *Rhododendron* and *Rubus* were found to be largest genera constituting 8 species in each. Present study has three additional new records of species to flora of Nepal. The newly recorded species are not published in available Nepali literatures till now (Table 1). Eleven threatened and one endemic plant species mentioned (Table 2).

The study includes 11 threatened species as follows: *Taxus wallichiana* (IUCN-V, CITES-II, GoN-II), *Swertia chirayita* (IUCN-V), *Podophyllum hexandrum* (IUCN-V), *Paris polyphylla* subsp *polyphylla* (IUCN-V), *Paris polyphylla* subsp *marmorata* (IUCN-V), *Michelia velutina* (CITES-II), *Michelia champaca* (IUCN-E, CITES II, GoN-III), *Magnolia globosa* (IUCN-R, CITES-II), *Magnolia campbelli* (IUCN-R, CITES II), *Dioscorea deltoidea* (IUCN-CT, CITES-II), *Aconitum spicatum* (IUCN-CT). Due to the anti-cancer properties of *Taxus*, it is highly exploited similarly the *Michelia* species are also exploited in natural forest due to the high timber value. Shrestha (2002) assessed floral diversity of Kanchenjungha conservation area at landscape level was for resource management strategy.

3.2. Community Structure in Three Zones

The whole study side was site which includes temperate Zone was resolved in three sub zones on the basis of elevation ranges.

Lower temperate zone (2100 - 2400 m)

In this range *Symplocos ramosissima*showed the highest frequency (63.64%) and relative frequency 14.29%. The lowest frequency and relative frequency were 9.09% and 2.04% respectively. Likewise, the density of individual tree species ranged from 263.64 plant/ha - 9.09 plant/ha. The total density of all tree species was 1109.09 plant/ha. The dominance of the individual tree species ranged from 15.31 m^2/ha - 0.07 m^2/ha. Similarly the important value index was found to be highest for *Eurya acuminate* (39.72) and followed by *Symplocos. ramosissima* (38.72), while the other species likes *Lindera*, *Rhus* showed least IVI (2.94). In this range canopy was dominated *Quercus lamellosa*, *Castanopsis hystrix*, *Lithocarpus pachyphylla* and *Persea odoratissima* but sub-canopy was well dominated by *Eurya acuminata* and *Symlocos* species. Altogether 19 tree species were recorded from this zone. Table 3 shows the quantitative vegetation analysis of lower temperate zone.

Table 1. New addition to flora of Nepal recorded from LKSR, eastern Nepal.

Call No.	Family	Species Name	Coll. date	Alt. (m)	Lat	Long	Locality
B 157	Begoniaceae	*Begonia flaviflora* H. Hara	06/07	2245	27.04	88.00	Jamuna 2, Hangetham, Ilam
C 240	Cyperaceae	*Carex cruciata* Wahlenberg var. *argocarpa* C. B. Clarke	09/12	3210	27 18	88.01	Bie-Chitre,
C 191	Acanthaceae	*Strobilanthes helicta* Anderson	09/05	2656	27˚40'7	87˚59'37	Dobate, Hangetham, Ilam

Table 2. List of threatened and endemic plant species recorded from LKSR.

S. N.	Record		Species Name with threatened category	Alt. (m)	Locality
1	Threatened	Ranunculaceae	*Aconitum spicatum* (IUCN-CT)	3170	Chhintapu, Maimajuwa 7
2	Threatened	Dioscoreaceae	*Dioscorea deltoidea* (IUCN-CT, CITES-II)	2005	Hangetham, Jamuna-1
3	Threatened	Magnoliaceae	*Magnolia campbelli* (IUCN-R, CITES II)	3220	Chhintapu, Maimajuwa 7
4	Threatened	Magnoliaceae	*Magnolia globosa* (IUCN-R, CITES-II)	2040	Maimajuwa 7, Naule Gaun, Ilam
5	Threatened	Magnoliaceae	*Michelia champaca* (IUCN-E, CITES II, GoN-III)	2050	Newa khola, Mai majhuwa
6	Threatened	Magnoliaceae	*Michelia velutina* (CITES-II)	1870	Newa khola, Mai majhuwa, Ilam
7	Threatened	Trilliaceae	*Paris polyphylla* subsp *marmorata* (IUCN-V)	2665	Dobate, Mabu-8
8	Threatened	Trilliaceae	*Paris polyphylla* subsp *polyphylla* (IUCN-V)	3060	Mabu, Near Mai khola, Chauri chowk, Ilam
9	Threatened	Podophyllaceae	*Podophyllum hexandrum* (IUCN-V)	3225	Mabu, Bikhe Bhanjyang, Ilam
10	Threatened	Gentianaceae	*Swertia chirayita* (IUCN-V)	2042	Maimajuwa 7, Naule Gaun
11	Threatened	Taxaceae	*Taxus wallichiana* (IUCN-V, CITES-II, GoN-II)	3220	Chhintapu,Maimajuwa 7
12	Endemic	Umbelliferae	*Heracleum lallii*	1974	Sisne, Mai majhuwa

Source: IUCN. 1987/CITES. 1995.

Table 3. Frequency (F%), Relative Frequency (RF), Density (D), Relative Density (RD), Basal area (BA), Relative Basal Area (RBA) and Importance Value Index (IVI) of Tree species in lower temperate zone.

Species name	F%	RF%	D·ha^{-1}	RD %	BAm^2·ha^{-1}	RBA %	IVI
Acer campbellii	14.29	4.35	17.86	1.48	5.64	5.22	11.05
Alangium alpinum	3.57	1.09	3.57	0.30	0.03	0.03	1.41
Daphniphyllum himalense	14.29	4.35	139.29	11.57	0.41	0.38	16.30
Eurya acuminata	17.86	5.43	53.57	4.45	2.92	2.70	12.59
Lindera neesiana	3.57	1.09	3.57	0.30	0.06	0.06	1.44
Lithocarpus pachyphylla	60.71	18.48	289.29	24.04	56.28	52.09	94.60
Lindera neesiana (Siltimur)	3.57	1.09	3.57	0.30	0.07	0.07	1.45
Lyonia ovalifolia	42.86	13.04	210.71	17.51	8.15	7.55	38.10
Magnolia campbellii	17.86	5.43	17.86	1.48	5.17	4.79	11.70
Michelia dltlsopa	3.57	1.09	3.57	0.30	0.29	0.27	1.65
Myrsine semiserata	10.71	3.26	25.00	2.08	1.87	1.73	7.07
Neolitsea cuipala	3.57	1.09	3.57	0.30	2.27	2.10	3.49
Patpate	10.71	3.26	21.43	1.78	1.32	1.22	6.26
Persea odoratissima	14.29	4.35	14.29	1.19	0.56	0.51	6.05
Quercus glauca	7.14	2.17	7.14	0.59	0.99	0.92	3.68
Quercus lamellosa	14.29	4.35	35.71	2.97	3.22	2.98	10.29
Rhododendron falconeri	14.29	4.35	42.86	3.56	1.53	1.42	9.33
Symplocos glomerata	10.71	3.26	64.29	5.34	4.30	3.98	12.58
Symplocos ramosissima	53.57	16.30	232.14	19.29	12.69	11.74	47.33
Taxus wallichiana	7.14	2.17	14.29	1.19	0.28	0.26	3.62
Total	328.57	100.00	1203.57	100.00	108.06	100.00	300.00

Middle temperate zone (2400 - 2700 m)

Lithocarpus pachyphylla was the highest frequency was achieved as 60.71% and relative frequency 8.48%. Similarly, the lowest frequency and relative frequency achieved as 3.57% and 1.09% respectively. Middle temperate forest is well dominated by *Lithocarpus pachyphylla* with its highest IVI value 94.60 and codominated by *Symplocos ramosissima* (47.33) and the species such as *Magnolia* and *Michelia* showed very scanty presence with least IVI values. In this site the density of individual tree species ranged from 289.29 plant/ha - 3.75 plant/ha. While total density of all tree was found to be 1203.57 plant/ha. Likewise the dominance of tree species ranged from 56.28 m^2/ha - 0.03 m^2/ha. In this zone *Lithocarpus* (Bante) formed the very well canopy up to 25 m. Consequently *Symplocos* sp, *Lyonia ovalifolia*, *Rhododendron falconerii* made the sub canopy. Altogether 20 tree species were recorded from this site. Table 4 shows quantitative vegetation analysis of middle temperate zones.

Table 4. Frequency (F%), Relative Frequency (RF), Density (D), Relative Density (RD), Basal area (BA), Relative Basal Area (RBA) and Importance Value Index (IVI) of Tree species in lower temperate zone.

Name of species	F%	RF%	D·ha^{-1}	RD %	BAm^2·ha^{-1}	RBA %	IVI
Acer pectinatum	27.27	6.12	54.55	4.92	15.31	15.99	27.03
Alangium alpinum	9.09	2.04	9.09	0.82	0.12	0.13	2.99
Bhadrase	9.09	2.04	9.09	0.82	5.16	5.39	8.25
Castanopsis hystrix	36.36	8.16	109.09	9.84	3.10	3.23	21.23
Castanopsis tribuloides	9.09	2.04	72.73	6.56	5.23	5.46	14.06
Cryptomeria japonica	9.09	2.04	9.09	0.82	0.14	0.15	3.01
Daphniphyllum himalaynse	9.09	2.04	9.09	0.82	5.41	5.65	8.51
Eurya acuminata	45.45	10.20	263.64	23.77	5.42	5.66	39.64
Lindera neesiana	9.09	2.04	9.09	0.82	0.07	0.07	2.94
Lithocarpus pachyphylla	27.27	6.12	45.45	4.10	9.88	10.32	20.55
Lyonia ovalifolia	36.36	8.16	100.00	9.02	3.71	3.88	21.06
Myrsine semiserata	18.18	4.08	18.18	1.64	1.00	1.05	6.77
Neolitsea cuipala	18.18	4.08	18.18	1.64	4.97	5.20	10.92
Persea odoratissima	27.27	6.12	54.55	4.92	6.80	7.11	18.15
Quercus glauca	9.09	2.04	9.09	0.82	0.45	0.47	3.33
Quercus lamellosa	27.27	6.12	45.45	4.10	15.37	16.06	26.28
Rhus succedanea	9.09	2.04	9.09	0.82	0.12	0.13	2.99
Symplocos dryophila	45.45	10.20	90.91	8.20	4.98	5.20	23.60
Symplocos ramasissima	63.64	14.29	172.73	15.57	8.49	8.86	38.72
Total	445.45	100.00	1109.09	100.00	95.74	100.00	300.00

Upper temperate zone (2700 - 3000 m)

Lithocarpus pachyphylla showed the highest frequency and relative frequency achieved as 63.64% and 16.28%. Likewise, the lowest frequency and relative frequency as 9.09% and 2.33% respectively. *Lithocarpus pachyphylla* was well canopy dominating species in this range with maximum IVI 78.8 and codominated by *Rhododendron falconerii* with IVI value 40.14 and *Quercus lamellosa.* Other species like *Taxus wallichiana*, *Michelia* and *Magnolia* showed scanty in distribution. The density of individual tree species ranged from 245.45 plant/ha - 9.09 plants/ha, while total tree density for all tree species was found to be 1009.09 plant/ha. Consequently, the dominance ranged from 68.48 m^2/ha - 0.3 m^2/ha for individual tree species. In this site *Lithocarpus pachyphylla* was monodomianat canopy forming plant up to 30 m. Altogether 22 tree species were recorded from this site. Table 5 shows quantitative vegetation analysis of upper temperate zone.

Table 5. Frequency (F%), Relative Frequency (RF), Density (D), Relative Density (RD), Basal area (BA), Relative Basal Area (RBA) and Importance Value Index (IVI) of Tree species in lower temperate zone.

Species name	F%	RF%	D·ha^{-1}	RD %	BAm^2·ha^{-1}	RBA %	IVI
Castanopsis tribuloides	9.09	2.33	9.09	0.90	0.10	0.07	3.30
Daphniphyllum himalaynse	9.09	2.33	245.45	24.32	0.20	0.14	26.79
Eurya acuminata	18.18	4.65	27.27	2.70	0.11	0.08	7.43
Ilex fragilis	18.18	4.65	18.18	1.80	0.38	0.27	6.72
Lindera neesiana (Siltimur)	9.09	2.33	9.09	0.90	3.81	2.71	5.94
Lithocarpus pachyphylla	63.64	16.28	136.36	13.51	68.48	48.73	78.53
Litsea sericea	9.09	2.33	9.09	0.90	0.14	0.10	3.33
Litsea cubela	9.09	2.33	9.09	0.90	0.14	0.10	3.33
Lyonia ovalifolia	9.09	2.33	18.18	1.80	15.23	10.84	14.97
Magnolia campbellii	18.18	4.65	27.27	2.70	3.26	2.32	9.67
Michelia velutina	9.09	2.33	18.18	1.80	1.56	1.11	5.23
Neolitsea cuipala	27.27	6.98	27.27	2.70	0.15	0.11	9.79
Persea odoratissima	9.09	2.33	9.09	0.90	0.14	0.10	3.33
Quercus glauca	18.18	4.65	18.18	1.80	0.54	0.39	6.84
Quercus lamellosa	9.09	2.33	9.09	0.90	34.27	24.39	27.61
Rhododendron arboreum	9.09	2.33	90.91	9.01	0.24	0.17	11.51
Rhododendron falconeri	54.55	13.95	190.91	18.92	10.22	7.27	40.14
Symplocos glomerata	18.18	4.65	27.27	2.70	0.03	0.02	7.38
Symplocos ramosissima	27.27	6.98	63.64	6.31	1.19	0.85	14.13
Taxus wallichiana	18.18	4.65	18.18	1.80	0.05	0.04	6.49
Viburnum cylindricum	9.09	2.33	18.18	1.80	0.18	0.13	4.26
Viburnum erubescens	9.09	2.33	9.09	0.90	0.09	0.06	3.29
Total	390.91	100.00	1009.09	100.00	140.52	100.00	300.00

3.3. Species Richness and Diversity Indices

The combined form of species richness and species evenness is simply meant the Species diversity and the number of individuals per sampling units. Species richness while the distribution of individuals among the species called Species evenness. Evenness becomes maximum when all the species have same or nearly equal number of individuals. Species diversity can be expressed in single index number. Among the several indices most commonly used two indices are Simpson's index and Shannon-Wiener's index [22]. Simpson's index (C) reflects the dominance because it is more sensitive to the most abundant species than the rare species. Following relations were used to calculate Simpson's and Shannon-Weiner indices following Barbour *et al.* [24].

$$\text{Simpson's index of dominance } (C) = \sum_{i=1}^{s} (p_i)^2$$

$$\text{Shannon -Wiener's index } (H') = -\sum_{i=1}^{s} (p_i)(\ln p_i)$$

where s = total number of species

p_i = proportion of all individuals in the sample that belongs to species i.

Beta (β) Diversity and Similarity Index

The calculation of Beta (β) diversity helps to know the extent of species turn over between the sites. The Whittaker's β diversity (β_w) was calculated using the following formula [25].

$$\beta_w = s/\overline{\alpha} - 1$$

where s = Total number of species recorded in both sites.

$\overline{\alpha}$ = average of total number of species recorded in two sites.

The value of β diversity ranges from 0 (complete similarity) to 1 (complete dissimilarity) for two sites.

Similarity Index (%)

Degree of similarity between any two stands can be determined through the use of community coefficient (similarity index) which depends on the quantitative phytosociological characters of species common to both stands. Higher the index value more similar will be the stands to each other. Following are the formula for calculating similarity index.

$$\text{Sorensen's Similarity Index } (IS_S) = \frac{2C}{A+B} \times 100$$

where IS = index of similarity

A = Total number of species in one community

B = Total number of species in another community

C = the number of species which occur in both community

The similarity index ranges from 0% to 100% to quantify the range from no similarity to complete. It is mentioned in Table 6.

Similarity, the value for tree species richness was achieved highest for lower temperate zone (5.27) and lowest in middle temperate zone (3.29) while upper

Table 6. Species richness (S), Simpson's index of Dominance (C), Shanon-weiner's index (*H*'). and Beta diversity (Bw).

Diversity Indices	LTZ	MTZ	UTZ	Beta diversity (Bw)	MTZ	UTZ
Simpson's index of Dominance (C)	0.12	0.15	0.13	LTZ	0.28	0.37
Shanon-Weiner's index (*H*')	3.50	3.22	3.68	MTZ		0.24
Species richness (S)/100 m^2	5.27	3.29	3.45			

temperate zone showed (3.45) per 100 m^2. Similarly, the Simpson's index of Dominance (*C*) was highest for stand MTZ (0.15) followed by stand UTZ (0.13) and LTZ (0.12). Shanon-Weiner's index (*H*') was maximum for UTZ (3.68) followed by LTZ (3.50) and MTF (3.22). The Whittaker's beta diversity value shows maximum between LTZ and UTF (0.37) followed by LTZ and MTZ (0.28) and (0.24) between MTZ and UTZ. Similarity index between MTZ & site UTZ was highest 76.19% while it was least between site LTF & site UTF 63.41% and 71.79% in between LTZ and MTZ. Similarity index between MTZ & site UTZ was highest 76.19% while it was least between site LTF& site UTF 63.41% and 71.79% in between LTZ and MTZ. It is expressed in Table 7.

Size class distribution

In each sites the tree species were classified into ten size classes with an interval of 10 cm dbh. Then the density diameter curves were developed to assess the general population structure of tree in three study sites. As shown in the given Figures 3-5 respectively.

4. Discussion

4.1. Floristic Composition

Flora governs the key position among the natural resources of any geographical area. Study on floristic composition of any region gives the clear picture of floristic content, which in turn can be useful for developing strategy for conservation and management of biodiversity. Eastern Nepal is unique in species diversity as it as the supplementary zone for Eastern Himalaya. The Eastern Himalaya stands out as being one of the globally important sites representing the important hotspot of South Asia. Eastern Himalaya of Nepal has been identified as one of the rich biodiversity hot spot in the world with high species diversity and high level of endemism. Floristic composition has been carried out to enumerate and prepare the comprehensive description of the vascular plants from the Lower Kanchenjungha Singhalila Ridge Ilam district east, Nepal. The variation in altitudinal range and climatic conditions favours the diversity of flora. The genera *Rhododendron* and *Rubus* both consisted of 8 species were found to be largest genera and *Begonia* with 6 species followed by *Sorbus, Hypericum*, and *Berberis* with 5 species in each. The floristic analysis showed that the dicotyledonae was dominant in comprision to the monocotyledoneae. The ratio of Monocotyledoneae to Dicotyledoneae was found to be 1:5.95 for species, 1:4.56 for genera and 1:5 for families. Siwakoti and Varma [26] recorded 743 species of flowering

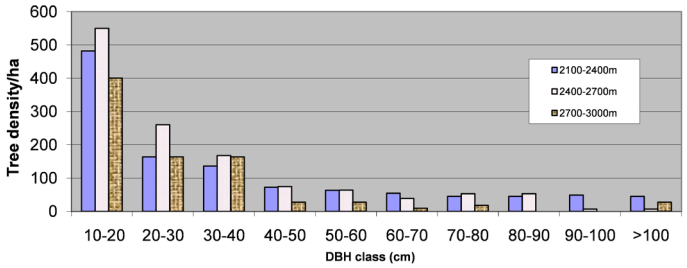

Figure 3. Size class distribution.

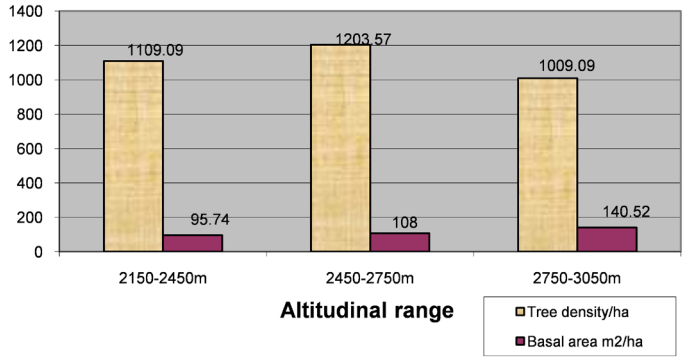

Figure 4. Density/ha and basal area in three altitudinal zone.

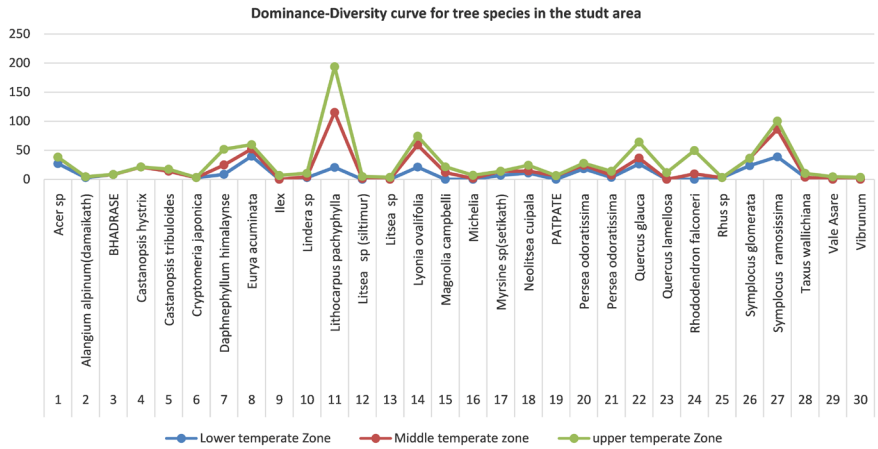

Figure 5. Dominance diversity curve for tree species.

Table 7. Similarity index among three zones.

Index of Similarity (IS)	MTZ	UTZ
LTZ	71.79	63.41
MTZ		76.19

plants belonging to 493 genera and 128 families (dicotyledons 546 species under 383 genera and 105 families of monocotyledons 197 species under 110 genera and 23 families) from eastern Terai whereas in comparison with this present result Siwakoti and Varma reported 42% of dicots and 20% of monocots respectively.

Present study has furnished some new addition to the flora of Nepal. Out of the identified 273 species, three species viz. *Begonia flaviflora* H. Hara (Begoniaceae), *Carex cruciata* Wahlenberg var. *argocarpa* C. B. Clarke (Cyperaceae), and *Strobilanthes helicta* Anderson (Acanthaceae). Several species still remaining unidentified, which is due to insufficient literature, lack of represented herbarium specimens in KATH and TUCH, etc. This proves that through deep investigation of these areas will increase the chance of new records to the flora of Nepal. The diversity of dicots is nearly five times greater than monocots it is due to the flowering and fruiting.

4.2. Structure of the Vegetation

Forest is a complex ecological system in which trees are dominant life forms. Today forest is any land managed for the diverse purposes of forestry, whether or not covered with trees, shrubs, climbers or such other vegetation. Forest represents the largest most complex and most self generating of all ecosystems.

Practices for removal of forest biomass in the form of grazing, lopping, surface burning and litter removal at a given time are a continuous disturbance affecting the stability of the ecosystem and retarding the succession processes in the area. These areas can be clearly demarcated on the basis of different phytosociological parameters of the vegetation. In the present study the tree density ranged from 1009.09 to 1203.57 individuals ha^{-1}, which is comparable to tropical forests. Higher anthropogenic disturbances in the buffer area have also led to the elimination of seedlings of most of the species. The total basal area across the sites ranged from 95.74 to 140.52 m^2/ha. The differences in basal area of tree layer among study sites may be due to difference in altitude, species composition, age of trees, and degree of disturbance and succession stages of the stands. The value obtained for basal area in the present study is comparable to the Indian tropical forests [27]. Importance value index of *Lithocarpus pachyphylla* as the present study area is located at altitude ranged from 2100 m - 3000 m. The change in IVI of *Lithocarpus pachyphylla* among the study sites is due to the change in species composition, disturbance and altitude. Other studies elsewhere have reported a similar range of species richness [28]. Importance value index (IVI) of tree species indicated that *Lithocarpus pachyphylla* and *Eurya acuminata* were the dominant species at all the study sites in the tree and sapling layers of tree serve followed by *Rhododendron, Lyonia, Acer* species, etc.

4.3. Size Class Distribution

In the study the size class distribution doesn't indicate different population structure, which may be related to differences in environment and disturbance regimes. The reverse J-shaped size class distribution of trees in a community indicates sustainable regeneration [29]. Although a clear inverse J-shaped graph is absent in present work, but the population structure of middle temperate zone shows somewhat continuous regeneration than others two range. The regenera-

tion potential of trees in the study area was somewhat in continuous. The different shape of density-diameter shows the extent of effect of disturbances on the density dbh classes [30]. In a montane rain forest in Mexico, Ramierz-Marcial *et al.* [31] found that stem density decreases with disturbance intensity. Our study also found that the stem density declined with increasing disturbance such as grazing damages sapling through trampling and browsing [32]. Dbh distribution of tree species among elevation is largely controlled by the density of over storey species and the pattern of regeneration can be described by the size distribution [33] as reported by Singh *et al.* Middle elevation sites had a lower number of species than lower and higher elevation sites. Lower elevation is easily assessable by men than others, so it is a little disturbed. Disturbed sites contained more species than undisturbed and moderately disturbed sites. Disturbances occurred either in the form of recurring soil erosion (natural) or anthropogenic disturbances such as grazing, lopping, surface burning and illegal cutting. A higher percentage of random and regular distribution reflects the greater magnitude of disturbance' such as grazing and lopping in natural forest stands. All the vegetation layers showed generally clumped type of distribution in the present study. The tree layer exhibited less clumped distribution at the disturbed sites than the undisturbed and moderately disturbed study sites. The distribution pattern of other vegetational layers did not show any distinct difference among the study sites. These findings supported the range reported by Risser and Rice [34] for temperate forests. The highest number of tree species (22) was recorded from Stand UTZ due to relatively open habitat which provided congenial environment for the growth of different species. **Figure 4** shows the total density of tree species ranged between 1009 trees/ha (UTZ) to 1203 trees/ha (MTF). Study revealed that *Quercus leucotricophora* is the most dominant species of all stands. Oak (*Qurecus* spp) forests are most extensively distributed between the altitudes 1000 m to timberline and represent the climax stage, throughout the central Himalaya [35]. The result of the present study is pronounced that as well as the altitude is increase the tree diversity is also increase which is the result of above biotic disturbance and invention by new species on these lands.

5. Conclusions

Biological resources of the area are used by local people in various ways. The loss of biodiversity and degradation of forests in many places (especially near villages) can be attributed medicinal herb collection and unregulated grazing. Many resident species are expected to be endangered or threatened. The important flora needs protection, because of their scientific interest and rarity. To prevent deforestation, alternative sources of fuel and timber should be introduced. Programs that provide conservation education, initiate the sustainable use of the forests, and propagate multipurpose indigenous trees should be initiated. Less economic tree species showed higher population and regeneration where important tree species such as *Taxus, Magnolia* and *Michelia* showed less dominated

due to the lopping and over exploitation of timber so the forest may convert into unnecessary bushy forest in near future. Higher densities of trees having less than 20 cm DBH and basal area of tree species in our study suggest that forest in each site are in stage of growing and in state of regeneration. The diversity of tree species showed hump shape relation with elevation gradient. It is recommended that biological inventories with comprehensive flora and fauna biological databases should be prepared. Detailed ecological study of vegetation is needed for the development of conservation and management programs within the study area. The study suggests conservation strategies to protect woody species against anthropogenic pressures (for example, protection from or reducing the frequency and/or intensity of disturbance, especially woodcutting and bushfires).

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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