1. INTRODUCTION

1.1 Background

Species richness is the number of species in a sampling unit, and species diversity is the species richness and evenness at local scales (Whittaker *et al*. 2001). Species diversity is the diversity within an ecological community that incorporates both species richness and the evenness (Hill 1973). Mainly, Diversity is the widely measured species richness (Stirling and Wilsey 2001, Baniya *et al*. 2010) that assumed a simple and easily interpretable indicator of biological diversity (Whittaker 1977a, Whittaker *et al.* 2001, Peet 1974). Species richness and species diversity are used to quantify the species diversity in most of the biodiversity assessment studies (Cox and Moore 2007). It is also fundamental measure of community in regional scale (Magurran 1988, Gotelli and Colwell 2001).

Whittaker (1972) distinguished three level of diversity: alpha diversity is the diversity within habitat or intracommunity diversity; beta or between diversity is defined as the change in species composition along the environmental gradients; gamma diversity is the diversity on entire landscape and can be considered as composite of alpha and beta diversity.

Species richness pattern varies with elevation which characterizes the vegetation pattern in a simple but powerful way (Baniya *et al.* 2010). However, almost without exception, species richness can be neither accurately measured nor directly estimated by observation because the observed number of species is a downward biased estimator for the total species richness of a local assemblage (Gotelli and Colwell 2001). Ecologists have found species diversity difficult to define and measure and this may in fact reflect the possibility that it is a ‘non-concept’ (Hurlbert 1971). In general, there have been an approach to measure species diversity, out of which incorporate information on the number of species (species richness) and the relative abundances of individuals within each species (species abundance) and the other involves comparing observed patterns of species abundance to theoretical species abundance models. Furthermore, the relationship between species diversity and ecosystem functioning appears to change over different spatial scales (Bond and Chase, 2002, Jonathan 2002).

Elevational gradient took as a tool for study species richness since early 1800s (Lomolino 2001). General theory of theory of the species richness says that the species richness decrease with elevational increase (Brown and Lomolino 1998, Körner 2002, Fossa 2004, Baniya *et al.* 2010). Rahbek (1995, 1997) came to the conclusion that there are three main patterns of species richness: a monotonic decline, a monotonic incline and a hump shaped pattern with a maximum richness at mid elevation (unimodal pattern) after a review of several papers. Unimodal pattern is the most dominant pattern of species richness along elevational gradient (Rahbek 1995, Brown 2001, Vetaas and Grytnes 2002, Carpenter 2005, Grau *et al.* 2007, Baniya *et al.* 2010). It has been known that species richness decrease with increase elevation (Wood ward 1987, Körner 1995, Begon *et al.* 1996, Fossa 2004) and Latitude (Wallace 1878).

The elevation represents a complex gradient along which many environmental variables change simultaneously (Austin *et al.* 1996). Species richness along elevation gradient is controlled by a series of interacting biological, climatic and historical factors (Colwell and Lees 2000). It is assumed that tree species are more influenced by climatic factors than herbaceous species. This might be due to the fact that trees are most susceptive climatic factors than herbs (Bhattarai and Vetaas 2003). Climatic factors, environmental stability and habitat heterogeneity are the factors often discussed as determinants of variability in species richness (Spies and Turner 1999). Altitudinal gradient creates varied climates along with resultant soil differentiation and promots the diversification of plant species (Brown 2001 and Lomolino 2001). Environmental stress including climatic factors, such as temperature, duration of snow cover, disturbances, light duration, competition and other factors may change with altitude that affect species richness patterns (Baniya *et al.* 2010). Species richness normally decreases with increasing elevation. However, a hump and a plateau have been documented in species richness curves in the Nepal Himalaya (Panthi *et al*. 2007).

The Himalayan elevation gradient is the sharpest bioclimatic gradient in the world. Climate changes with elevational gradients within a mountain system that results habitat differentiation and promotes the diversification among species (Brown 2001). On account of the conical shapes of the mountains, the influence of historical dispersal, extinction and speciation processes are quite different along elevational gradients on mountains than along latitudinal gradients on continents (Brown 2001). Grytnes and Vetaas (2002) analyzed plant species richness along the Himalayan altitudinal gradient in Nepal. They concluded that interpolated species richness in the Himalaya showed a hump-shaped structure. The maximum richness of flowering plants of Nepal has been found between 1500 m and 2500 m asl, but the species richness of tree species shows a significant linear pattern along the elevation gradient (Mahato 2006).

The regional pattern of species richness are consequence of many interacting factors, such as plant productivity competition, geographical area, historical or evolution development regional species pool, environmental variables and human activity (Woodward 1987, Palmer 2007, Zobel 1997).

The forest canopy modifies the availability of understory resources such as light, water, and soil nutrients (Gracia *et al.* 2006) hence affect plant growth (Antos 2002) and consequently influence the richness and composition of understory vegetation (Bartels 2010). A mature forest canopy facilitates the survival of light-intolerant understory species (Moore *et al.* 2011). Understory richness is lower when the overstory abundance is higher since the canopy has a direct effect on richness (Laughlin and Grace 2006). Canopy structure controls the quality and quantity of ecosystem differed both in spatial and temporal availability of light (Jennings *et al.* 1999). Canopy cover determines availability of light for the understory species and their composition of any ecosystem.

Scale is a very important factor to measure biodiversity (Whittaker 1977; Blake and Loiselle 2000; Rahbek and Graves 2001; Begon *et al.* 2009; Baniya 2010). Small scale measures the local influences (Blake and Loiselle 2000; Begon *et al.* 2009) whereas larger scale measures the larger temporal and spatial phenomena (Rahbek and Graves 2001). The scale also determines the size of the study area and sampling unit for the study (Wiens 1989). Smaller size studied area may cause a unimodal relationship (Lomolino 2001), whereas a larger plot size may be inappropriate for detecting local processes that cause a unimodal pattern.

The distribution and diversity of plant species in forests depend on the size of the forest or habitat area along with different factors. It is generally assumed that larger the size of the forest the more will be the number of species (Rosenzweig 1995). Hill and Curran (2001) studied species composition in fragmented forest and they proposed that large forests contain the greatest number of tree species. Due to the wide range of elevations from 60 m-8848 m Nepal is suitable place for study species richness along elevational gradient. Northern aspects are relatively moist than southern aspect, so the species richness is high in north facing slope than south facing slope (Panthi *et al.* 2007).

Forest is a complex ecological system in which trees are dominant life forms. Forest is one of the important renewable resources providing services and products to people and environment which meets the basic needs of people and a major source of world for livelihood and cash income (Vaalverde and Silvertown 1997). Still there are huge areas in Nepal yet to be explored by science. Nepal does not have a complete volume of flora up to now. Therefore this present research was done in Phulchoki area, Central Nepal based on the field sampling including all angiospermic plants. Thus, this research study will help to add some information for the study of species richness along elevation with forest types for researcher.

1.2 Justification of the study

Species richness is one of the most studied measures of plant species diversity. In the context of Nepal species richness along elevational gradient has been studied in different parts of the country. Only some empirical studies has been done with species richness along forest types. Hence, this study has been conducted to find out the current diversity and status of angiospermic species and forest types along elevational gradient in Phulchoki Area. Thus, this research work will be helpful further for conservation, management of biodiversity in the future.

1.3 Hypotheses

Species diversity varies with forest types along elevational gradient.

1.4 Objectives

General objectives of present research is to assess the vegetation pattern of forest types along elevational gradient.

Specific objectives.

- To assess the plant richness pattern along the elevational gradient.
- To access the species richness pattern with different forest types
- To assess the species composition of study area with environmental gradient.

1.5 Limitation of the study

The study area lies in the middle of the easiness and hardness, so due to limited resources the whole area couldn't be covered. The study focused only on angiospermic plant species within the quadrat. Some of the specimens were found in vegetative stage, which could not be identified up to the species. During sampling, area having slope >35° was avoided.

2. LITERATURE REVIEW

2.1 Elevation and species richness pattern

Diversity is widely measured by species richness (Stirling and Wilsey 2001, Baniya *et al.* 2010) and assumed as a simple and easily interpretable indicator of biological diversity (Whittaker 1977a). Species richness changes pattern with elevation characterizes the vegetation in simple but powerful way (Baniya *et al.* 2010). Study upon the elevation and elevation and species richness is known over a century but popular during last few decades and the knowledge about the diversity patterns is accumulating rapidly (Rahbek 1995, 2005). Several researches have been carried out in elevational gradients in various parts of the world and found specific patterns for different plants. General concept about the species richness with the elevation is gradual decrease in species richness as the elevation increases (Brown and Lomolino 1998; Körner 2002b; Fossa 2004; Baniya *et al.* 2010). Usually there are three main patterns of species richness pattern: a monotonic increase with elevation, a monotonic decrease with elevation and unimodal pattern (Rahbek 1995, 1997). Unimodal pattern is the most dominant pattern of species richness (Rahbek 1995; Brown 2001; Vetaas and Grytnes 2002; Carpenter 2005; Rowe and Lidgard 2009). Differences between organisms and between life forms of plants (Bhattarai and Vetaas 2003), geographic factors, factors correlated with latitude, biotic factors, spatially varying factors (productivity and resource richness, spatial heterogeneity and environmental harshness), temporally varying factors (climatic variation, environmental age), habitat area and remoteness (Rosenzweig 1995; Rahbek 1995, 1997; Lomolino 2001; Brown *et al.* 2004; Begon *et al.* 2009), scale (Whittaker 1997; Ricklefs *et al.*2004; Begon *et al.*2009), historical and evolutionary factors (Lomolino 2001; Bhattarai and Vetaas 2003; Grytnes 2003; Rahbek 2005), elevational gradient itself (Grytnes 2003) are responsible for species richness along the elevational gradient. Other causes of species richness are the mid-domain effect (MDE) (Colwell and Hurtt 1994; Colwell and Lees 2000) and Rapoport's elevation rules (Stevens 1992).

In Nepal, first paper on elevational species gradient was published by Yoda (1967). Second elevational species gradient pattern on animal and mammals of Nepal was published after three decades by Hunter and Yonzon (1993). Later more studies have been done based on interpolation (Vetaas and Grytnes 2002; Baniya *et al.* 2010), and empirical studies (Bhattarai and Vetaas 2003; Carpenter 2005). Interpolation studies showed hump shaped species richness pattern, peak for flowering plants of Nepal was found between 1500 m-2500 m asl and a plateau between 3000 m asl and 4000 m asl for endemic species richness. Likewise, species richness pattern for ferns peaked at 1900 m asl (Bhattarai *et al.* 2004), bryophytes and mosses at 2800 m asl and 2500 m asl respectively (Grau *et al.* 2007), lichens at 3100 m -3400 m asl (Baniya *et al.* 2010) and orchids at 1600 m asl (Acharya *et al.* 2011). An empirical study on elevational species diversity from eastern Nepal (Carpenter 2005) showed that there was a unimodal pattern for understory plants. A monotonic decrease (Paudel 2009) and a unimodal pattern (Rijal 2009) were found from eastern and central Nepal respectively.

Hump shaped species richness pattern with elevational gradient for different groups of plants was found in Nepal Himalaya (Bhattarai and Vetaas 2003, Grytnes, 2003, Bhatarai *et al.* 2004, Carpenter 2005, Grau *et al.* 2007, Baniya *et al.* 2010, Chhetri 2011). But some other researchers also found monotonic decline in species richness with elevation (Hunter and Yonzen 1992, Panthi 2012, Sharma 2012). The main cause of change in species richness along elevational gradients are climate, space, evolutionary history and biotic processes (Lomolino 2001, McCain and Grytnes 2010). Area of land decrease with elevation, lower elevation has larger area having more resources, more space for species than higher elevation. Along the elevational gradient many environmental factors including temperature, precipitation, seasonality, disturbance, soil characteristics also change (McCain and Grytnes 2010) which vary the species richness. On the other hand, in lower elevation, due to lower topographical variation, strong influence of human activity, there is also low species richness (Vetaas and Grytnes 2002).

Nepal (2001) conducted quantitative analysis of vegetation (trees and shrubs) along the altitudinal gradient on the north east slope and south west slope on Kaski district. He found variation in species composition in two different slopes of study area.

Shrestha (2001) studied species diversity and distribution along altitudinal gradient in Landruk village of Annapurna region Nepal. He found prominent variation of vegetation along altitudinal gradient.

Bhattarai and Vetaas (2003) evaluated the relation between species richness of plant in different life forms with different climatic variables such as potential evapo-transpiration (PET), mean annual rainfall (MAR) and moisture index (MI) along whole Nepal. They used empirical data of all vascular plants from eastern Nepal between 100 and 1500 m and total species (excluding ferns), shrubs and trees showed hump-shaped patterns with elevation. The woody climbers and ferns showed a positive monotonic trend with elevation. Climbers, herbaceous climbers, all herbaceous plants, grasses and forbs showed no significant relation with elevation.

Carpenter (2005) studied the species richness pattern for trees and understory plants of eastern Nepal. He also found hump-shaped trend of species richness with more species near the bottom and fewest at the top.

Bhattarai and Vetaas (2006) used 614 tree species from 100-4300 m asl of Nepal to analyze Rapoport's rule. This rule states that there is positive correlation between elevation and elevational range of species (Steven 1992). The tree species richness shows positive correlation with elevation up to 1500 m asl and then shows negative correlation beyond 1500 m. But their result does not support this rule because Nepalese vascular plants usually generally follow hump shaped pattern of species richness.

Bhatta (2006) analyzed the vegetation of alpine pasture of Manang from two sites of south facing slope. The relationship of species richness with various environmental factors like altitude, moisture and pH was carried out and species richness showed linear decreasing pattern with altitude. Subedi (2006) studied the distribution pattern of plant species of Manang along Himalayan elevation gradient of Nepal. He recorded 303 plant species using primary and secondary data, and found hump shaped distribution pattern with optimum species at 3500 m asl

Panthi *et al.* (2007) sampled species richness and composition in the north and south aspects of the dry valley of Manang between 3000 and 4000 m asl. A plateau in total species richness was observed between 3000 and 4000 m asl at the local level. Species richness was significantly higher on the north facing slope than on the south facing slope. They also determined that moisture and factors influencing evaporation (i.e. canopy and aspect) are the main environmental factors influencing species composition and richness in the dry inner valley of the trans-Himalaya.

Rijal (2009) studied the species richness along the elevation gradient in Langtang National Park from 3000 to 4700 m asl elevation. He found species richness linearly decreases for dicot and herbs whereas gentle decreases for all the life-forms with increases elevation.

Baniya *et al.* (2010) used published data of 525 species of lichens to compare the distribution pattern along elevational gradient. They found the hump-shaped species richness for lichen peaked at 3100-3400 m, and for endemic lichens peaked at 4000-4100 m. They found the species richness peak of lichen is higher than other groups of plants.

Acharya *et al.* (2011) interpolated the published data of orchids of Nepal and Bhutan (100–5200 m asl), and adjacent regions of India, i.e. Sikkim and Darjeeling. A hump-shaped relationship between orchid species richness and elevation was observed in Nepal and Bhutan, with maximum richness at 1600 m asl.

Chhetri and Bhattari (2013) studied the floristic composition pattern of Manaslu Conservation Area (MCA), Central Nepal. The DCA analysis of the floristic composition of the area showed the unimodal relationship with altitude representing more species abundance at the mid-altitudes

Thakali (2013) studied the species richness pattern for angiosperms, pteridophytes, bryophytes, mushrooms and lichens along elevational gradient in Manaslu Conservation Area, Central Nepal. In his study total species richness and angiosperms species richness showed unimodal pattern with elevation peaked at 3200 m asl. Bryophytes and lichen species showed monotonic increasing pattern while pteridophytes and mushrooms showed monotonic decreasing pattern with elevation. Similar unimodal relationship with altitude representing more species abundance at the mid-altitudes was found by Chhetri and Bhattari (2013).

Bhattarai *et al*. (2014) checked the species richness pattern with elevation gradient and compared the empirical study with regional pattern and regressed with different environmental parameter including all the habitat types and vegetation. They regressed total vascular plants along with the life forms against the altitude and between species richness and different environmental parameters. Species richness of total vascular plants and all life forms showed a unimodal pattern with altitude having a peak at an altitude of 3500 m asl.

2.2 Species richness and forest types

Nepal is nature's paradise. It’s a small attractive package of nature embracing the rich biological diversity in the tiniest area. One of the nature’s gifts to Nepal is its vegetation. The narrow band of land holds over 170 parcels of vegetation. It lies just outside of the tropics in the global climatic zonation therefore bioclimatic tropicality extends into it up to an elevation of 1000 m altitude (Shrestha, 2008). Nepal comprises around 4.27 million hectares (29% of total land area) of forest, 1.56 million hectares (10.6%) of scrubland and degraded forest, 1.7 million hectares (12%) of grassland, 3.0 million hectares (21%) of farmland, and about 1.0 million hectares (7%) of uncultivated lands (NBS 2002). The subtropical zone (1000-2000 m), the temperate zone

(2000-3000 m), the sub-alpine zone (3000-4000 m), the alpine zone (4000-5000 m) and the nival zone (5000 and above) appear juxtaposed along the mountain slopes (Shrestha, 2000)

In Nepal from tropical to alpine climatic variation and their interaction forms a diverse ecosystems. It is estimated that 6501 species of flowersing plants (Angiosperms) (Hara *et al.*, 1978, DPR, 2001), and about 534 species of Ferns (Thapa, 2002).

Stainton (1972) divided forests of Nepal in thirty five types under four major headings, tropical and subtropical, temperate and alpine broad leaved, temperate and alpine conifer and minor temperate and alpine association.

Bobo *et al.* (2006) used 4 land use types, namely near-primary forest, secondary forest, agroforestry and annual croplands in northern part of the Korup region Kamaroon. They assessed the impact of forest conversion on trees and understory plants. They have found that the tree species richness decreased significantly with increasing level of habitat modification. The tree species richness found higher in primary forest and the understory species richness found in cropland.

Shrestha (2008) classified the Nepalese forest and their distribution at protected areas based on different parameters as bioclimatic zone, geography, physignomy, life forms, floristic composition, dynamics, habitat and management.

Sharma (2012) studied the species richness pattern along the elevational gradient and different land use types in Manaslu Conservation Area and Sagarmatha National Park, Buffer zone of Nepal. She found linear decreasing pattern of species richness pattern along elevational gradient. She found higher species richness at exploited forest than other land use types, cropland, meadow and natural forest.

3. MATERIALS AND METHODS

3.1 Study Area

The Phulchoki hill is the largest peak in Kathmandu valley situated 10 km south-east of Kathmandu located in Lalitpur district. Phulchoki is located between 27°34'-27°36' N latitude to 85°22'-85°26' E longitude. Phulchoki area is a part of Sub-Himalayan Mahabharat region of with an altitudinal range of 1400-2715 m with extensive diverse forests mostly dominated by broad-leaved evergreen trees.

The general picture of the vegetation of Phulchoki is based on the altitudinal concept widely applied in the Himalayas (Stainton 1972, Hara *et al.* 1978). It covers an area of approximately 50 sq. km consisting of a vast range of Flora. The natural vegetation of Phulchoki hill is characterized into three distinct evergreen broad-leaved forests types: mixed *Schima-Castanopsis* Forest at the base (1400-1800 m), Oak-Laurel forest (1800-2400 m) and evergreen oak forests (2000 m above) (Poudyal *et al.* 2012).

The study area lies in northern slope of Phulchoki forest including community forest at the lower belt and comprising of subtropical to temperate vegetation zones with elevational range from 1600-2650 m asl altitude . The evergreen Oak forest covers area above 2000 m Conifer forest is virtually absent. A small amount of scattered species of *Pinus roxburghii* and *Pinus wallichiana* occurs side by side. The basal part of Phulchoki hill and the Godawari valley consists of mixed vegetation with a large number of shrubs and small trees. Location map of study area, showing position of Lalitpur district and studied sampling plots in Phulchoki forest is shown below (Figure 1).

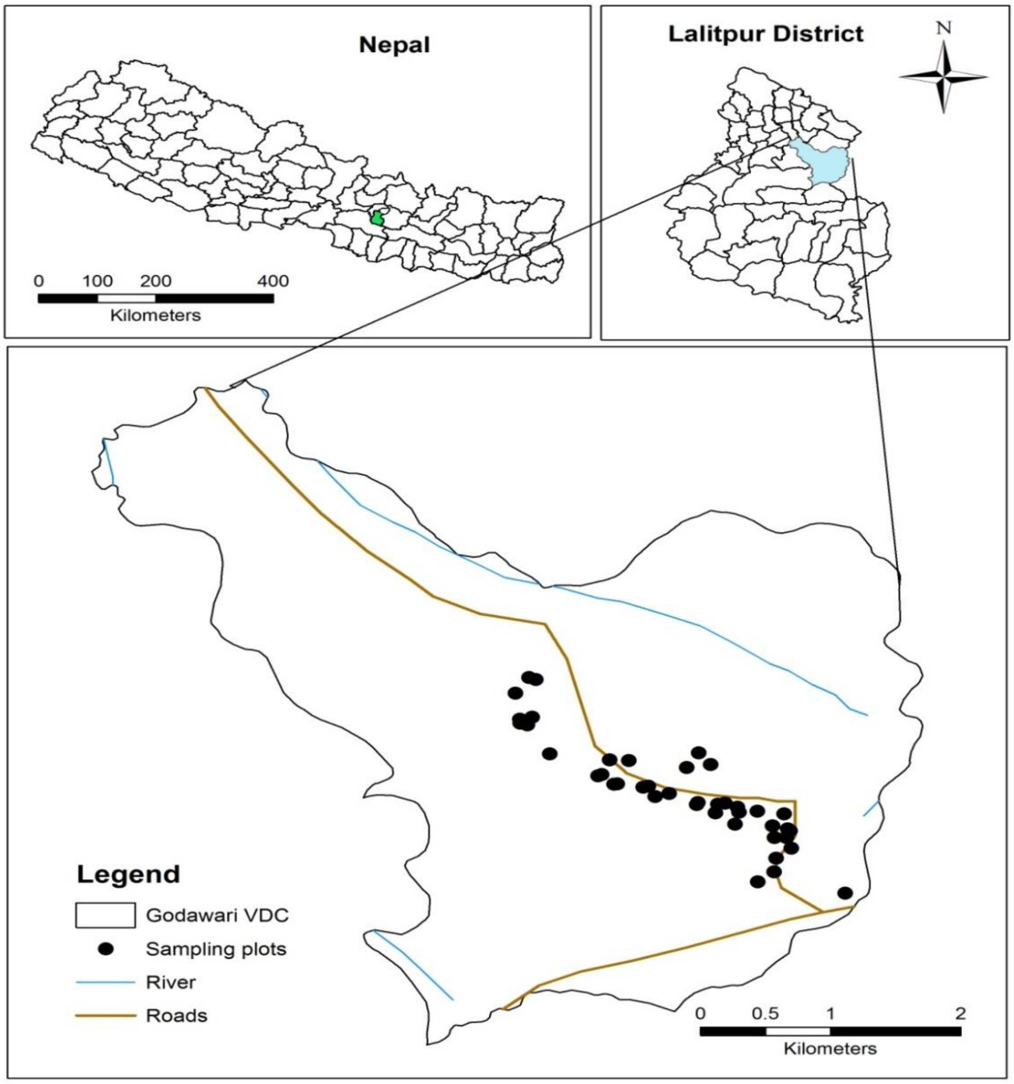


Figure 1: Map of the study area with Lalitpur district showing the sampling plots in Phulchoki forest area. (Map source: Department of Survey, Kathmandu, Nepal)

3.1.1 Climate

The study area has typical warm temperate monsoon with three seasons round the year: cold and dry winter (October to February), pre monsoon dry summer (March to May) and monsoon (June to September) (Poudyal *et al.* 2012). Climatic data from 2009 to 2013 showed the monthly average maximum and minimum temperatures to be 27.72°C and 2.06°C in the month of June and January (Figure-2). Phulchoki receives a good amount of rainfall from April/May to September/October with an annual rainfall of 1868 mm, with the highest monthly rainfall in July (411.68mm) and the lowest in November (0.24 mm) (Figure 2).

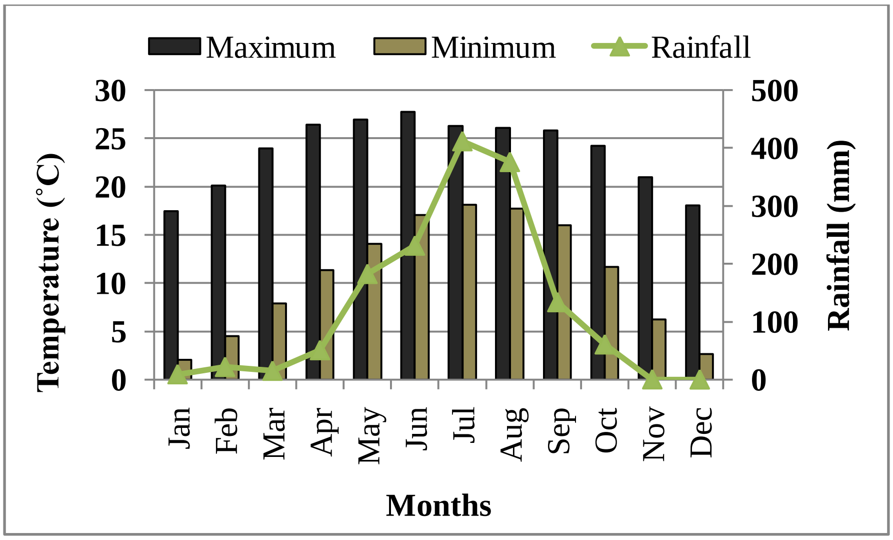


Figure 2: Five years (2009-2013) average monthly minimum, maximum temperature and rainfall recorded at Godawari weather Station (Station that is nearest from the Phulchoki area). (Source: Department of Hydrology and Meteorology, Babarmahal, Kathmandu, Nepal).

3.1.2 Biodiversity

3.1.2.1 Flora

Phulchoki area is rich in floral diversity (DPR 1997). At the lower belt it includes *Schima-Castanopsis* forest at an elevation of 1600 m. The area broadly consist of mixed broadleaved Forest (comprising *Schima wallichii, Castanopsis indica, Alnus nepalensis, Acer campbelli, Ilex dipyrena, Castanopsis tribuloides, Michelia* sp *and more* Laurels at about 1800 m. Above this altitude few hundred meter consists of Oak and Laurels with *Rhododendron* species *Lyonia* species (1900-2200 m). *Quercus glauca*, *Quercus lanata* with *Lithocarpus* species. The Oak-Laurels forest is then replaced by the Oak forest of *Quercus semecarpifolia* (2400-2650 m) where as *Rhododendron* sp and *Lyonia* are also associated with Oak. Species of *Berberis* also occur in open places. Slope with altitude of 1900-2000 m contains some extent of climbers and epiphytes, common are *Rubia, Smilax, Cissampelos* sp. etc. Phulchoki and Godavari harbors 653 species of plants, out of which 80 are Pteridophyte, 2 Gymnosperms, 571 Angiosperms. (DPR 1969).

3.1.2.2 Fauna

Phulchoki supports best places for protected, threatened and endemic faunal species. It is an abode of a wide range of vertebrates. There are more than 22 species of mammals out of which

5 species are in Protected list, Clouded Leopard (*Pardofelis nebulosa*), Leopard cat (*Prioailunus benghalensis*), Asamese Monkey (*Macaca assamensis*). Furthermore, other mammal species include common Leopard (*Panthera pardus*), Himalayan Black Beer (*Ursus tibetanus*), Jungle Cat (*Felis chaus*), Barking Deer (*Muntiacus muntijak*), Rhesus Monkey (*Macaca mulata*), Jackal (*Canis aurens*), Wild Pig (*Sus scrofa*), Indian Porcupine (*Hystrix indica*). Flying Squirrel (*Funambulus pennaii*), Mongoose (*Herpestes edwardsii*), and Other avian Fauna includes Blood Pheasants (*Ithaginis cruentus*), Kalij Pheasant (*Lophura Leucomelana*), Tibetan Snow cock (*Tetragalus tibetanus*). Plumbeous Redstart (*Phyacornis fuliginous*), Brown Dipper (*Cinclus pallasii*), Snow Pigeon (*Columba leuconata*), Eurasian Kestral (*Falco tinnuculus*), Golden Eagle (*Asaquila chlysaetos*), (NPWC 2029).

3.2 Methodology

3.2.1 Sampling design and data collection

The study area was visited in the months of July 27th - August 14th 2013 to collect data. The field visit was done at first at 27th July to 29th July. After the first visit, second visit was done in August 10th - August 14th. **S**tudy sites were selected at different elevations starting from an altitude at altitude of 1600 m. Stratified random sampling method was used for data collection. Sampling were done from the elevational range of 1600 m to 2650 m altitude. The forest area was horizontally divided into eleven bands, at each elevation band of 100 m four quadrat were laid down with the difference of 100 m apart (Figure 3). The areas having slope >35° was avoided during sampling. The process of sampling was based on Kershaw & Looney (1985) and Krebs (1999).

On each four quadrats, with the help of iron peg and nylon rope the sampling size 10 m ×10 m was selected for trees, in same quadrat 5 m× 5 m sub quadrat was used for shrubs and for herbs 1 m ×1 m plots were laid down following species-area curve method as described by Zobel *et al.* (1987). All the species within the quadrat were recorded. Plants having diameter more than 10 cm at breast height 137 cm were considered as trees and other woody plants were considered as understory shrubs. Diameter tape was used to measure diameter at breast height (DBH) for all individual tree. The slopes, aspects and height of the each tree were measured with the help of clinometer compass. Geographic location i.e., latitude, longitude and elevation of each quadrat (10 m × 10 m) was recorded using Global Poisoning System (GPS, *eTrex* Garmin) from the centre of the quadrat. Canopy cover of the tree species was visually estimated.

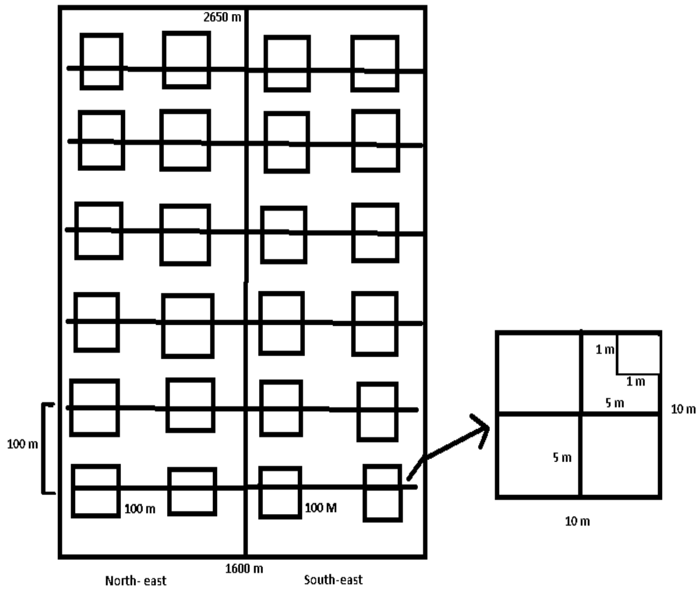


Figure 3: Study design showing the sampling point at 1600 m altitude and the last transect point at 2650 m altitude. The table in the right side shows the sampling design of the single quadrat.

3.2.2 Forest Vegetation

The distribution of forest types depend on site specific physiography (Kunwar *et al.*2008). On the basis of dominant tree species and group of species the Phulchoki forest was categorized as follows following Stainton (1972).

a. Castanopsis Broadleaved Forest: This forest extends from an altitude range of 100 m asl. This forest is tall and dark with trees of 20-35 m forming a close canopy. The understory beneath is composed largely of species of *Symplocos* and of the family Lauraceae. Associated species are *Lindera pulcherima*, *Neolitsea umbrosa*, *Neolitsea pallens*, *Eurya acuminata*, *Persea odoratissima*, *Symplocos ramosissima*, *Castanopsis tribuloides* and *Schima wallichii*.

b. Mixed Broadleaved Forests: This type of forest occurs in midlands between 2000-2300 m asl, mostly on slopes that face north and west. Canopy is mostly formed by *Schima wallichi, Lyonia ovalifolia, Rhododendron arboreum, Pyrus pachia and Myrica esculenta*. This forest is predominantly broad and rather less predominantly deciduous. In some places, *Rhododendron* forest may replace this forest. Associated species in this region are *Magnolia campbelli*, *Ilex* *dipyrena*, *Sorbus cuspidata*, *Corylus ferox*, *Betula utilis*, *Prunus cornuta*, *Symplocos ramosissima*, *Lyonia ovalifolia*,

c. Quercus semecarpifolia Forest: This type of forest is characterized by dominant species of *Quercus semecarpifolia*. It forms pure stands above 2300 m asl. Sometimes this may be overlap between *Quercus semecarpifolia* forest and upper temperate broadleaved forests. So the oak may be found growing with the *Acer campbelli*. Associated species are *Betula alnoides*, *Lithocarpus* sp., *Arundinella nepaleensis*, *Cyclobelanopsis glauca*.

3.2.3 Plant Collection, Herbarium preparation and Identification.

Collected plant species were identified in the field with the help of *Flowers of the Himalaya* and its supplement (Polunin and Stainton 1984; Stainton 1988) and the *Orchids of Nepal* (Raskoti 2009). Species that could not be identified in the field were collected, tagged, dried and brought to the Central Department of Botany for further identification. The unidentified specimens were identified by consulting literature, Flora of Bhutan (Grierson and Long 1981-2000), Flora of Kathmandu valley (Malla *et al.* 1986) Flora of Phulchoki and Godawari (DPR 1997) and comparing the specimens with relevant specimens deposited at Tribhuvan University Central Herbarium (TUCH) and National Herbarium and Plant Laboratory (KATH) Godawari. The Voucher specimens are housed at TUCH, Kathmandu, Nepal.

3.3 Data Analysis

3.3.1 Community Structure

The field data was used to calculate frequency, density, basal area, and importance value index (IVI) of tree species following the method described in Zobel *et al.* (1987). The formula used for the calculation of these attributes is given below:

$$\text{Frequency (\%)} = \frac{\text{Number of Quadrats in which individual species occured}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Density (trees ha}^{-1}\text{)} = \frac{\text{Total number of individual of a species}}{\text{Total number of quadrats studied} \times \text{Area of quadrat}} \times 10000$$

Basal area (BA) of a tree was calculated by the following formula

$$\text{Basal Area (m}^2\text{)} = \frac{\pi}{4} \times d^2$$

$$\text{Basal Area (m}^2\text{ha}^{-1}\text{)} = \frac{\text{Total Basal Area of a species}}{\text{Total number of quadrats studied} \times \text{Area of a quadrat}} \times 10000$$

Basal area of a species in each sampling plot was obtained by the summation of BA of all individuals of a species.

$$\text{Relative Frequency (\%)} = \frac{\text{Frequency of individual species}}{\text{Sum of the frequencies for all species}} \times 100$$

$$\text{Relative Density (\%)} = \frac{\text{Density of individual species}}{\text{Total Density of all trees}} \times 100$$

$$\text{Relative Basal Area (\%)} = \frac{\text{Basal area of individual species}}{\text{Total Basal area of all trees}} \times 100$$

Importance value index (IVI) gives the overall importance of each species in the community structures. It was calculated as the sum of relative values of density, frequency and basal area for trees. Relative values were obtained by the following relations.

Importance Value Index (IVI) = Relative frequency +Relative density +Relative basal area

3.4 Relative Radiation Index (RRI)

Relative radiation index (RRI) was calculated from the values of aspect (Ω), slope (β) and latitude (θ). RRI was calculated following the formula given by Ôke (1987).

$$RRI = \text{Cos}\,(180-\Omega).\text{Sin}\beta.\text{Sin}\theta + \text{Cos}\beta.\text{Cos}\theta$$

3.5 Statistical analysis

All the data were entered in the data matrix tools. The value of forest stand characteristics viz. diameter, height, canopy of tree species were compared with the forest types for species richness. The mean value of different vegetation layer (herb, shrub and total species richness were compared among three categories of forest classified by one way analysis of variance (ANOVA) followed by multiple comparison using Tukey's test. Prior to ANOVA, the data were tested for homogeneity of variance.

The total species richness data of all angiospermic plant was found normal. So, One-way Analysis of Variance (ANOVA) and Tukey's test was performed to elucidate the difference in mean species richness with altitude among the forest types. Linear regression was done to access the total (Sum of herbs, shrubs and trees) species richness with altitude.

3.5.2 Ordination

Detrended Correspondence Analysis (DCA)

Detrended Correspondence Analysis (DCA), an indirect gradient analysis (Hill and Gauch 1980) was used to analyze the species composition to test the turnover rate or axis length. The SD units of first two ordination axes (axis I and axis II) together with the eigen values were used to evaluate the dispersion/variation pattern with the species composition which. Eigen values are the shrinkage values in weighted averages (Oksanen 1996). The axes explain percentages of the variance in the species data and eigen values are good measurement of the main variation in samples and species along the ordination axes (Jongman *et al.* 1995).

The set of data sample was used for analyzing species composition. Floristic composition of the study area was analyzed through the Detrended Correspondence Analysis (DCA) using different variables. The elevation, Cover and Relative Radiation Index (RRI) was taken as continuous variable and forest types as nominal variables.

3.5.3 Software's used

R version 2.15.1 (R Core Team 2013) was used for ordination analyses. *SPSS* 16.0 (Statistical Package for Social Science) (SPSS Inc. 2007) was used for ANOVA and Tukey's Test. The graphical presentation was performed in Microsoft *Excel* 2007, *SPSS* and *R*.

4. RESULT

4.1 Species diversity

A total of 230 species of plants were recorded from the study (Table 1, Appendix 3), they belonged to 84 families and 185 genera (Table 1). Among all 84 families Asteraceae was the largest family having 14 genera and 16 species followed by Rosaceae (10 genera and 17 species), Lamiaceae (8 genera and 8 species), (Table 1, Appendix 3).

Table 1: Families with number of genera and species. (The details of families, genera and species name are given in appendix 3).

S. N.	Family	Genera	Species
1	Asteraceae	14	16
2	Rosaceae	10	17
3	Lamiaceae, Leguminosae, Rubiaceae	8 each (24)	24
4	Lauraceae, Urticaceae,	6 each (12)	19
5	Apiaceae, Euphorbiaceae, Fagaceae, Gramineae, Liliaceae, Polygonaceae, Ranunculaceae	4 each (28)	38
6	Acanthaceae, Ericaceae, Gesneriaceae, Myrsinaceae, Oleacece, Rutaceae, Zingiberaceae	3 each (21)	25
7	Anacardiaceae, Araliaceae, Berberidaceae, Betulaceae, Boraginaceae, Campanulaceae, Cucurbitaceae, Cyperaceae, Melastomataceae, Orchidaceae, Pinaceae, Scrophulariaceae, Theaceae, Verbenaceae	2 each (28)	32
8	Other remaining 48 families	1 each (48)	59
Total	84	185	230

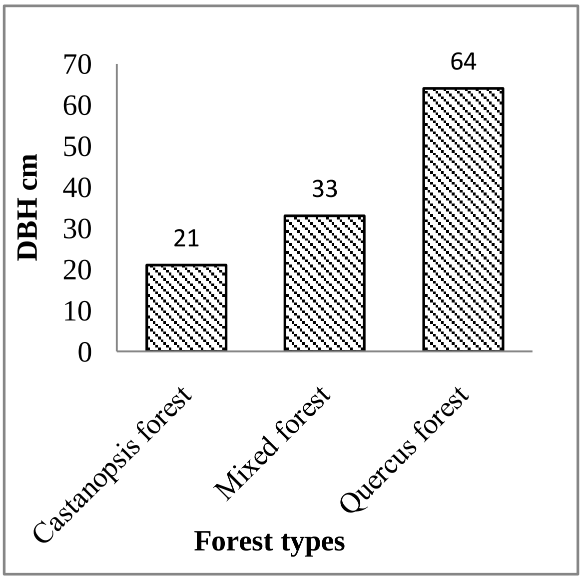
Among 185 genera of plant species, *Quercus* and *Rubus* were dominant genera having six and four species each. These were followed by *Ilex, Berberis, Anaphalis, Swertia, Lindera, Myrsine, Persicaria*, *Boehmeria* and *Pilea* having (3 species each). *Rhus* and 18 others genera having (2 species each) and *Acer* and remaining 154 genera contain single species in each genus.

4.2 Characteristics of Forests Stands

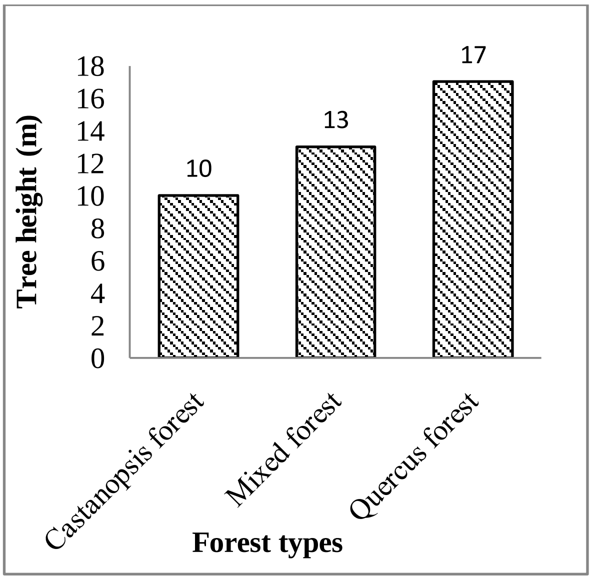
4.2.1 General characteristic of Forest

The diameter at breast height (DBH) and height of tree species compared between three categories of forest types represents the highest height and more diameter in *Quercus semecarpifolia* forest than that of other two categories of forests, this is due to distribution of large old trees in that area. Canopy cover was higher in *Castanopsis* Broadleaved Forest (Figure 4).

(a)



(b)



(c)

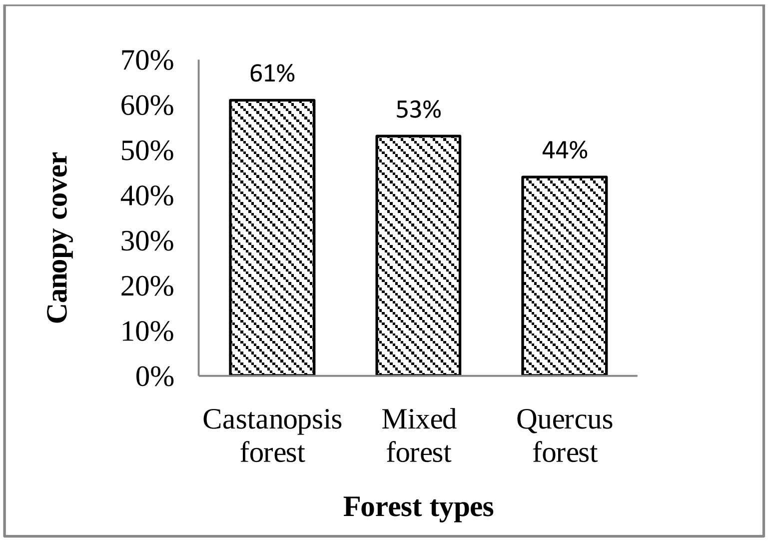


Figure 4: Diameter (a), height (b) and canopy (c) of species in three types of forest in the study area.

4.2.2 Importance Value Index (IVI) of tree species

A total of 30 species of tree were recorded from inside quadrats from all types of forests. The density was ranged from 1 to 36 trees ha^{-1} and basal area from 0.03 to 14.63 m^2ha^{-1} respectively. The Important Value Index of overall tree species of all forest shows that *Quercus semecarpifolia* was the dominant tree species with highest IVI (51.53) followed by *Castanopsis tribuloides* (34.38), *Cyclobalanopsis glauca* (27.21) (Figure 5). Canopy is formed by species of *Quercus semecarpifolia*, *Castanopsis tribuloides* and *Schima wallichii* etc.

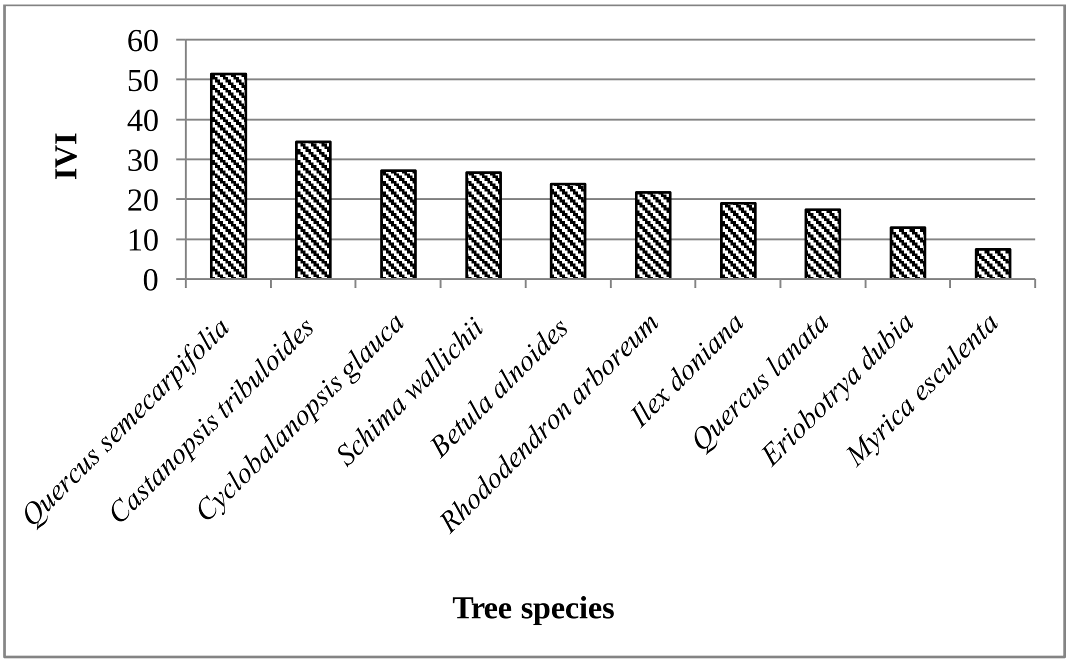


Figure 5: Importance Value Index (IVI) of top ten tree species showing highest values. The detailed of IVI chart is shown in Appendix 1.

4.2.3 Species richness and forest type

The total species richness of herbs, shrubs and trees varied according to forest type. The highest species richness was found in *Quercus semecarpifolia* forest (23.52) and mixed broadleaved forest (23.49) forests per plot ($p<0.05$) (Figure 6).

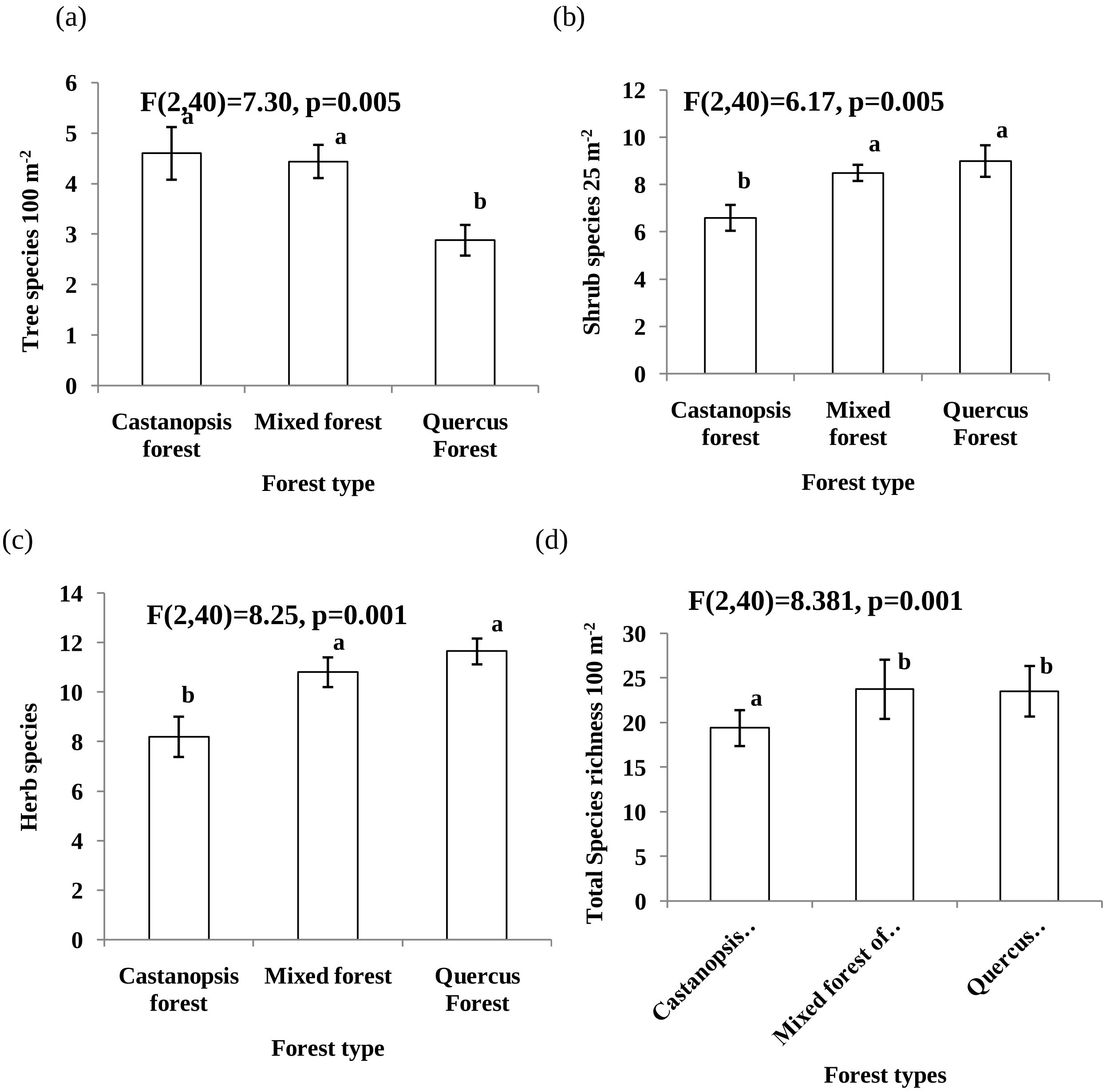


Figure 6: Relationship between total species richness and forest types. Tree layer (a), Shrub Layer (b), Herb layer (c) and total species richness (d). The bar sharing same letters on the top are not significantly different (Tukey's multi-range test).

Similarly, the species richness among different life form for both herbaceous (11.7 species per plot) and shrubs (9.1 species per plot), was found maximum at *Quercus semecarpifolia* forest, where as Tree species show maximum richness (4.8 species per plot) at *Castanopsis* broadleaved forest.

4.2.4 Variation of species richness along elevation

The total species richness of all the life forms shows increasing trends along the elevational gradient of species, overall species started to decline first and then started to increase which shows increasing pattern along elevation ($p<0.05$).

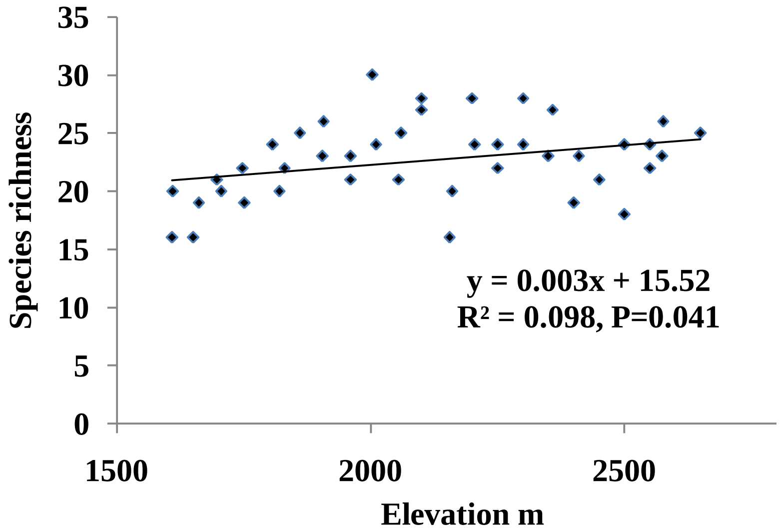


Figure 7: Relationship between variations of total species richness along elevation.

4.3 Species composition

The detailed summary of Detrended Correspondence Analysis (DCA) showed quite strong Eigen value along the axis I. The axis length in terms of standard deviation (SD) units for first and second axis were 4.05 SD unit and 3.45 SD units respectively (Table 2).

Table 2: Summary of Detrended Correspondence Analysis

Axes	DCA1	DCA2	DCA3	DCA4
Eigen Values	0.55	0.31	0.21	0.22
Length of axis	4.05	3.45	2.26	2.27

Table 3: Environmental relationship among different environmental variables with 1st and 2nd DCA axes after permutations.

Variables		DCA1	DCA2	r^2	Pr(>r)
Elevation		0.94	0.35	0.89	**0.001*** **
Cover		-0.57	0.82	0.21	**0.013***
RRI		0.69	-0.73	0.07	0.267
Forest type	**CF**	-1.22	0.01	0.63	**0.001*** **
	MF	-0.59	0.05		
	QF	1.14	-0.05		

Significance codes '***'= 0.001, '**'= 0.01, '*'= 0.05, '.'= 0.1, ''= 1 (p value is based on 999 permutations). Where, NE= north-east, NW= north-west, CF= *Castanopsis* Broadleaved Forest, MF= Mixed Broadleaved Forest, QF= *Quercus semecarpifolia* forest, RRI= Relative Radiation Index. It has been revealed that the species composition was found significantly influenced ($p \leq 0.05$) by elevation, cover, and forest types (Table 3).

The DCA analysis shows that the axis I and axis II represents altitude (elevation) and forest types respectively. (Table 3, Figure 8). The positive end of the DCA axis I represents species abundant at high altitude like, *Anaphalis busua, Colquhounia coccinea, Anemone vitifolia, Bupleurum hamiltonii, Rubus foliolosus, Phoebe* sp., *Quercus semecarpifolia* etc.

Species which are found towards the negative end of the DCA axis I are the species which forms a cluster in lower elevation i.e., *Osbeckia nepalensis, Myrsine semiserrata, Garuga pinnata, Wendlandia puberula, Randia tetrasperma, Persea odoratissima, Betula alnoides, Hydrangea macrophylla* etc.

Similarly, towards the positive end of the DCA axis II represents the species that forms a close canopy e.g., *Garuga pinnata, Myrsine semiserrata, Eurya acuminata, Mahonia nepaulensis, Betula alnoides, Ficus* sp., *Xylosma sp., Viburnum mullah etc.* and at the negative end of the DCA axis II shows that species of high altitude as in *Quercus semecarpifolia* forest which includes species like, *Pyrus pachia, Ilex fragilis, Thallictrum sp., Sarcococca coriacea, Ilex dipyrena, Rubus rugosus, Cochlianthus gracilis, Bupleurum* sp., *Selinum wallichiianum, Thallictrum* sp., *Quercus* sp., *Valeriana* sp. (Figure 8).

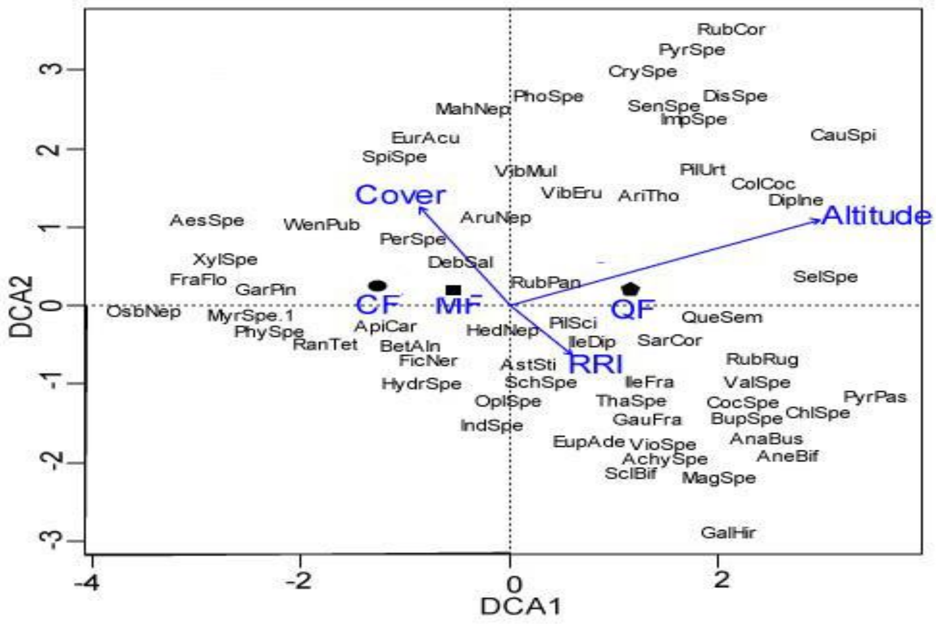


Figure 8: DCA diagram. Environmental variables (elevation, cover and RRI represented by arrows, and nominal variable (forest types) were represented by capital letters, where,●CF= *Castanopsis* broadleaved forest,■MF= mixed broadleaved forest,⬟QF= *Quercus semecarpifolia* forest (Detailed of full name of species is given in Appendix 3).

5. DISCUSSION

5.1 Species richness

5.1.1 Species richness and elevational gradient

General concept about the species richness with the elevation is gradual decrease in species richness as the elevation increases (Brown and Lomolino 1999; Körner 2002; Fossa 2004; Baniya *et al.* 2010)**.** There are three main patterns of species richness: a monotonic increase with elevation, a monotonic decrease with elevation and unimodal pattern (Rahbek 1995, 1997). The most dominant pattern of species richness along elevation is the unimodal pattern (Rahbek 1995; Brown 2001; Vetaas and Grytnes 2002; Carpenter 2005; Rowe and Lidgard 2009). This pattern applies well along the Nepalese Himalayan elevational gradient (Bhattarai and Vetaas 2003; Grytnes 2003; Bhatarai *et al*. 2004; Carpenter 2005). In this study, it was found that monotonic increasing pattern of species richness along the elevational gradient. This pattern of species richness also found by different researchers as like Grytnes and Vetaas (2002), Vetaas and Grytnes (2002), Carpenter (2005), Rijal (2009) and Sharma (2012) above an elevation 2,500 m asl in Nepalese Himalayas. This decreasing species richness along elevation in upper elevation of Himalayas may be due to decrease in temperature, rate of evapo-transpiration (Bhattarai and Vetaas 2003),

Unimodal relationship for species richness along altitude gradient was found at upper Manaslu conservation area central Nepal, which represents more species mid altitude shows that the area is rich in terms of flora (Chhetri and Bhattarai 2013).The gradual decreasing trend of herbaceous species richness along elevational gradient in this study is similar with the findings of Paudel (2009). Paudel (2009) reported a monotonic pattern in herbaceous species richness in the Imja valley of Sagarmatha National Park. Panthi (2012) also found same pattern of herbaceous species in mixed *Rhododendron* forests of Kanchenjunga Conservation Area, Eastern Nepal.

Canopy has a great significant role on diversity. It can also be translated indirectly as disturbance (Vetaas 1997). High percentage of above canopies such as trees and shrubs lead less under beneath biodiversity. Hence lower species richness under the dark tree and shrub canopies. In this study more canopy was found in *Castanopsis* Broadleaved forest at the lower elevation which represent less number of species, therefore species richness increase above this line.

The species richness pattern depends upon the scale of elevation taken. In whole range of Himalayas, species richness started to increase from low elevation then becomes saturation at mid elevation and decrease further up and formed unimodal pattern (Bhattarai and Vetaas 2003, Grau *et al.* 2007, Baniya *et al.* 2010, Acharya *et al.* 2011 and others). But this study carried out in short range of upper elevational gradient, so the species richness started to decline from first elevational band and increases towards the elevation (Sharma 2012) and it represents monotonic pattern of species richness with elevation.

5.1.2 Species richness and forest types

On the basis of the types of forest species richness was found to be more in Mixed broadleaved forest and *Quercus semecarpifolia* forest which reveals the same result as that of Khatri (2009). Due to the presence of grasses as well as shrubs species richness was found higher in Mixed Broadleaved forest and in *Quercus semecarpifolia* forest. On the other hand due to the regular use, cleaned up vegetation and other anthropogenic human disturbances the *Castanopsis* broadleaved forest may lower richness.

Angiosperms species richness follows the usual pattern of total species richness along different forest types. Angiosperm comprises all the life forms of plants. The angiospermic species richness was found to be nearly equal in Mixed broadleaved forest and *Quercus semecarpifolia* forest. In Mixed broadleaved forest, herbaceous as well as shrub species found high due to high canopy openness (Bhattarai and Vetaas 2013). Shrub species richness was found higher in *Quercus semecarpifolia* and Mixed broadleaved forest. It also followed the usual result of total species richness because shrubs are understory vegetation of forests (Bobo *et al.* 2006).

The tree species richness was found higher in *Castanopsis* Broadleaved and Mixed forest which resembles with finding of Bobo *et al*. (2006) and Lalfkawma *et al.* (2009). Kessler *et al.* (2005) also reported highest tree species richness in the primary forest of Central Sulawesi, Indonesia. The nearly equal tree species richness was found in both *Caststanopsis* and Mixed forest supported by result of Zapfack *et al.* (2002). The other cause of change in species richness in different forest types may be due to the changes in different environmental factors. These environmental factors are temperature, moisture, soil pH, soil nutrients, and soil organic matter, canopy cover (Maitima *et al.* 2009, Arya and Ram 2013). The *Quercus semecarpifolia* forest has low canopy coverage due to which maximum intensity of light reaches to ground, so it has low moisture content in soil. So species richness of both life form herbs and shrubs increaese towards the *Quercus semecarpifolia* forest.

Canopy is significant factor which influence the light intensity reaching the ground (Panthi *et al*. 2007). Radiation is one of the primary influences on vegetation composition (Kenneth *et al.* 2005). Higher value of relative radiation index (RRI) indicates that the site receives more radiation. Present study showed that the RRI was not found significant for any changes with the species composition of the study area. The DCA axes II towards the positive side shows lower species richness then the negative side of the DCA II axes. It is due to the fact that north facing slope receives low amount of solar radiation (Panthi *et al.* 2007). The north-west facing slope also holds more species then south-east facing slopes.

The importance value index provides clear picture of the forests. The value of IVI for any species did not exceed 45% of the total IVI. The total IVI shows that highest IVI was recorded for *Quercus semecarpifolia* (51.53) followed by *Castanopsis tribuloides* indicating the ecological importance and most successful tree species in that particular environment. Similarly the lowest IVI was recorded for *Cinamomum glauscens* (1.17). The overall IVI of tree species shows that *Quercus semecarpifolia* is the most dominant species. The species is mostly distributed between the altitudes of 1700-2700 m which represents the climax stage throughout the area (Pandey, 2009).

5.2 Species Composition

DCA analysis shows the eigen value of first axis found greater than 0.5 which means the complete turnover of species along the environmental variable. The complete turnover of species along the environmental variable was found to be similar as Baniya *et al.* (2009), Panthi (2012), Sharma (2012), Katuwal (2013). The length of gradient for first axis was found greater than (4 SD) units that indicate the area is highly heterogeneous and rich in species diversity which is also similar as Baniya *et al.* (2009) and Panthi (2012). The species found at one end of the gradient are different from another end of gradient (DCA diagram). The length of gradient was found greater than 1.5 which indicates the increasing pattern of species with the elevation as well as different forests types.

The elevation along the different forests types are highly significant for change in composition of species. DCA diagram indicates the species richness found lower at lower elevation and increased towards higher elevational gradients and also found maximum at mid elevation, which was found similar as (Grytnes 2003, Bhattarai and Vetaas 2003, and Sharma 2012).

The different forest type shows that the species richness show increasing pattern in response to elevation the higher species to both of the forest i.ge., Mixed broadleaved forest and *Quercus semecarpifolia* forest. The *Castanopsis* broadleaved forest showed lower number of species, it may be due to human settlement in that area and the impact of disturbances (Bobo *et al* 2009).

6. CONCLUSION

The total species richness along the elevational gradient with the forest types shows the monotonic increasing pattern of species richness at study area. While moving from lower elevation to higher elevation it can be concluded that the species richness is increased. The highest species richness is found higher in mixed broadleaved forest and *Quercus semecarpifolia* forest. Overall importance value index for tree species indicates the ecological importance and most successful tree species in particular environment.

The overall species composition shows heterogeneous mixture at all the forest types while the richness with life forms shows the herbaceous and shrubs species is maximum at high elevation, and trees were found maximum at the lower elevation, this was also showed by the Detrended correspondence analysis (DCA) analysis. Therefore the study area at range shows high species richness pattern at mixed broadleaved forest and *Quercus semecarpifolia* forest. Thus it can be concluded that study area can be considered as rich area in plant diversity.

REFERENCES

Acharya K.P., Vetaas O.R. and Birks H.J.B. 2011. Orchid species richness along Himalayan elevation gradients. *Journal of Biogeography* **38**: 1821-1833.

Antos J.A. 2002. Understory plants in temperate forests. *Forest and Forest plants*, Vol. I. Encyclopedia of Life Support System (EOLSS).

Arya N. and Ram J. 2013. Effect of canopy opening on species richness in *Pinus roxburghii* Sarg (Chir-pine) forests in Uttarakhand Himalaya. *Indian Journal of Research* **2**(4): 206-210.

Austin M.P., Pausas J.G. and Nicholls A.O. 1996. Patterns of Tree Species Richness in Relation to Environment in South-Eastern New South Wales, Australia.*Australian journal of Ecology* **21**: 35 -47.

Baniya C.B. 2010. *Species Richness Patterns in Space and Time in the Himalayan Area.* The University of Bergen, Norway.

Baniya C.B., Solhøy T., Gauslaa Y. and Palmer M.W. 2010. The elevation gradient of lichen species richness in Nepal. *The lichenologist **42**: 83 -96.*

Baniya C.B., Solhɸy T. and Vetaas O.R. 2009. Temporal changes in species diversity and composition in abandoned fields in trans-Himalayan landscape, Nepal. *Plant Ecol*ogy **201**: 383-399.

Basnet K 1989-92. Temperature variation in Nepal. The Himalayan Review, Nepal Geographical Society **20**: 25-34.

Begon M., Harper J.L. and Townsend C.R. 1996. *Ecology: individuals, populations and communities*, 2nd edn. Blackwell Scientific, Oxford.

Begon M., Townsend C.R. and Harper J.L. 2009. *Ecology: from individuals to ecosystems.* Wiley.com.

Bhatta K.P. and Chaudhary R.P. 2009. Species diversity and distribution pattern of grassland and cultivated land species in upper Manang, Nepal trans-Himalayas. *Scientific World* **7**(7): 76-79.

Bhatta, S.C. 2006. Quantitative analysis of alpine grassland in trans-himalayan region of Manang. M.Sc. Dissertation, Central Department of Botany, T.U., Kirtipur, Kathmandu.

Bhattarai K.R. and Vetaas O.R. 2003. Variation in plant species richness of different life forms along a subtropical elevation gradient in the Himalayas, east Nepal. *Global Ecology and Biogeography* **12**: 327-340.

Bhattarai K.R. and Vetaas O.R. 2006. Can Rapoport's rule explain tree-species richness along the Himalayan elevation gradient, Nepal? *Diversity and Distributions* **12**: 373-378.

Bhattarai K.R., Vetaas O.R. and Grytnes J.A. 2004. Fern species richness along a central Himalayan elevation gradient, Nepal. *Journal of Biogeography* **31**: 389-400.

Bhattarai P., Bhatta K.P., Chhetri R. and Chaudhary R.P. 2014. Vascular Plant Species Richness along Elevation Gradient of The Karnali River Valley, Nepal Himalaya. *International Journal of Plant, Animal and Environmental Sciences* **4**(3): 114 -126.

Blake J.G. and Loiselle B.A. 2000. Diversity of birds along an elevational gradient in the Cordillera Central, Costa Rica. *The Auk* **117**: 663 -686.

Bobo K.S., Waltert M., Sainge N.M., Njokagbor J., Ferman H. and Muhlenberg M. 2006. From forest to farmland : Species richness pattern of trees and understory plants along a gradient of forest conversion in southern Cameroon. *Biodiversity and Conservation* **15**: 4097-4117.

Bond, E.M., Chase, J.M., 2002. Biodiversity and ecosystem functioning at local and regional spatial scales. Ecology Letters **5**: 467–470.

Brown J.H. 1988. Species diversity. In: *Analytical biogeography: An integrated approach to the study of animal and plant distribution* (A.A. Myers and P.S. Giller, eds.), pp. 57–89. Chapman and Hall, New York.

Brown J.H. 2001. Mammals on mountainsides: elevational patterns of diversity. *Global Ecology and Biogeography* **10**: 101-109.

Brown J.H. and M.V. Lomolino 1998. *Biogeography*. Sinauer. Sunderland, MA: 1-624.

Carpenter C. 2005. The environmental control of plant species density on a Himalayan elevation gradient. *Journal of Biogeography* **32**: 999-1018.

Chaudhary R.P. 1998. *Biodiversity in Nepal* (status and conservation). Craftman Press, Bangkok, Thailand.

Chhetri R. 2011. *Species richness pattern along elevational gradients in Manaslu Conservation Area, Central Nepal*. M Sc. Thesis. Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Chhetri R. and Bhattarai P. 2013. Floristic composition and diversity in Upper Manaslu Conservation Area, Central Nepal. *Asian Journal of Conservation Biology* **2**(2): 111–121.

Colwell R.K. 2009. *Biodiversity: Concepts, Patterns and Measurement.* (In: Simon A. Levin. The Princeton Guide to Ecology). Princeton University Press. pp 257-263.

Colwell R.K. and Hurtt G.C. 1994. Nonbiological gradients in species richness and a spurious Rapoport effect. *American Naturalist* 570 -595.

Connell J.H. 1978. Diversity in tropical rain forests and coral reefs. *Science* **199**:1302-1310.

Cox. C.B. and Moore P.D. 2007. An Ecological and Evolutionary approach. Biogeography.

DNPWC. 2011. Shivapuri Nagarjun National Park. The brochure published by Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

Eklund A.M., Gardelin and Lindroth A. 2000. Simulated and measured winter evaporation in aboreal forest: Assessment of the HBV model. Upsala: The XXI Nordic Hydrological Conference. NHP Report No. **46**: 332-338.

Ellenberg H., Weeber H.E., Dull R., Rith V. and Werner W. 1974. *Zeigerwerte von Pflanzen in Mitteleurpa*. Verlag Erich Goltze GmbH and Co, Gottingen.

Etisa A.T. 2010. *Diversity of vascular epiphytes along disturbance gradient in Yayu Forest, Southwest Oromia, Ethiopia.* M.Sc. Thesis. School of Graduate Studies of Addis Ababa University, Ethiopia.

Fosaa A.M. 2004. Biodiversity pattern of vascular plant species in mountain vegetation in the Faroe Islands. *Diversity and Distributions* **10**: 217-223.

Ghimire S.K., Sapkota I.B., Oli B.R. and Parajuli-Rai R. 2008. *Non-Timber Forest Products of Nepal Himalaya: Database of Some Important Species Found in the Mountain Protected Areas and Surrounding Regions*. WWF Nepal, Kathmandu, Nepal.

Gotelli N.J. and R.K. Colwell 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparision of species richness. *Ecology Letters* **4:** 379-391

Grau O., Grytnes J.A. and Birks H.J.B. 2007. A comparison of elevational species richness pattern of bryophytes with other plant groups in Nepal, Central Himalaya. *Journal of Biogeography* **34**: 1907-1915.

Grierson A.J.C. and Long D.G. 1981-2000. *Flora of Bhutan.* Vol 1-3. Royal Botanic Garden, Edinburgh, U.K.

Grime J. P. 1973. Control of species density in herbaceous vegetation. *Journal of Environmental Management* **1**: 151-167.

Grytnes J.A. 2003. Species richness of vascular plants along seven elevational transects in Norway. *Ecography* **26**: 291-300.

Grytnes J.A. and Vetaas O.R. 2002. Species richness and altitude, a comparison between simulation modals and interpolated plant species richness along the Himalayn altitudinal gradient, Nepal. *The American Naturalist* **159**: 294-304.

Hill J. and Curran L. 2001. Species composition in fragmented forest: conservation implications of changing forest area. *Applied Geography* **21**: 157-174.

Hill M.O. 1973. Diversity and evenness: a unifying notation and its consequences. *Ecology* **54**: 427–432.

Hill M.O. and Gauch H.G. 1980. Detrended Correspondance Analysis: an improved Ordination Technique. *Vegetation* **42**: 47-58.

HMG DPR 1997. *Flora of Phulchoki and Godawari*, Ministry of Forest and Soil Conservation, Department of Plant Resources, Kathmnadu, Nepal.

HMG DPR 1997. *Supplement to the Flora of Phulchoki and Godawari*, Ministry of Forest and Soil Conservation, Department of Plant Resources, Kathmnadu, Nepal.

HMG DPR 2003. *Flora of Royal Botanical Garden*, Ministry of Forest and Soil Conservation, Department of Plant Resources, Kathmandu, Nepal.

Hunter M.L. and Yonzen P. 1992. Elevational distributions of birds, mammals, people, forests and parks in Nepal. *Conservation Biology* **7**: 420-423.

Hurlbert S.H. 1971. The nonconcept of species diversity: a critique and alternative parameters. Ecology **52**: 577–586.

Jennings S.B., Brown N.D. and Sheil D. 1999. Assessing forest canopies and understorey illumination: canopy closure, canopy cover and other measures. *Forestry* **72**(1): 1-15.

Jonathan, C.M., 2002. Spatial scale dictates the productivity–biodiversity relationship. Nature **416**: 427–430.

Kershaw, KA and JHH Looney. 1985. *Quantitative and Dynamic Plant Ecology* (3rd ed.). Oxford and IBH Publishing Co. New Delhi.

Kessler M., Kebler P.J.A., Gradstein S.R., Bach K., Schmull M. and Pitopang R. 2005. Tree diversity in primary forest and different land use systems in Central Sulawesi, Indonesia. *Biodiversity and Conservation* **14**: 547-560.

Khatri Chhetri N.B. 2009. *Floristic diversity and elevational variation of tree species in lower Kanchenjunga-Singhalila Ridge, Eastern Nepal*. M.Sc. Thesis. Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Koba H., Akiyama S., Endo Y. and Obha H. 1994. *Name List of Flowering Plants and Gymnosperms of Nepal.* Vol 1. The University Museum, University of Tokyo, Report No. 32, Japan.

Körner C. 1995. *Alpine plant diversity*: a global survey and functional interpretation. Arctic and alpine biodiversity, pattern, causes and ecosystem consequences (eds. S.F. Chapin and C. Körner), pp. 45–60. Ecological studies 113. Springer, Berlin.

Körner C. 1999. *Alpine plant life.* Functional Plant Ecology of High Mountain Ecosystem. Springer, Berlin.

Körner C. 2000. Why are there global gradients in species richness? Mountains might hold the answer. *Trends in Ecology and Evolution* **15**: 513–514.

Körner C. 2002. Mountain biodiversity, its causes and function: an overview. *Mountain biodiversity: a global assessment* 3-20.

Krebs, CJ. 1999. *Ecological Methodology* (2nd ed.). Addition- Welsey Education Publishers USA. 581p.

Kunwar R.M., Duwadee N.P.S., Shrestha K., Bhandari G.S., Gupta V.N.P., Vetaas O.R. and Chaudhary R.P. 2008. Plant diversity and soil characteristics of *Shorea robusta* and *Castanopsis hystrix* forest and Slash and burn habitats of Arun Valley, Eastern Nepal. *Pleione* **2**(1): 87 -97.

Kunwar R.M., Shrestha K., Dhungana S.K., Shrestha P. R. and Shrestha K.K. 2010. Floral Biodiversity of Nepal: An update, *Journal of Natural History Museum* **25**: 295-311.

Lalfkawma U.K., Sahoo S., Roy K. and Vanlalhriatpuia P.C. 2009. Community composition and tree population structure in undisturbed and disturbed tropical semi-evergreen forest stands of North-East India. *Applied Ecology and Environmental research* **7**: 303-318.

Lomolino M.V. 2001. Elevation gradients of species- density historical and prospective view. *Global Ecology and Biogeography* **10**: 3-13.

Magurran, A.E. (1988) *Ecological diversity and its measurement* . Princeton University Press., Princeton.

Mahato R.B. 2006. Diversity, Use and conservation of Plants in palpa district, Nepal. Ph.D. Thesis, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Malla S.B., Rajbhandari S.B., Shrestha T.B., Adhikari P.M., Adhikari S.R. and Shakya P.R. 1986. *Flora of Kathmandu Valley*. Bull. Dept. Med. Plants Nepal No. 11. Department of Medicinal Plants, Thapathali, Kathmandu, Nepal.

Matima J.M., Mugatha S.M., Redi S.R., Gachimbi L.N., Majule A., Lyaruu H., Pomery D., Mathai S. and Mugisha S. 2009. The linkages between land use changes, land degradation and biodiversity across East Africa. *African Journal of Environmental Science and Technology* **3**(10): 310-325.

McCain C.M. 2009. Global analysis of bird elevational diversity. *Global Ecology and Biogeography* **18**: 346–360.

McCain C.M. and Grytnes J.A. 2010. Elevational gradients in species richness. In: Encyclopedia of Life Sciences (ELS). John Wiley and Sons, Ltd: Chichester.

NBS. 2002. *Nepal Biodiversity Strategy*. HMG / MoFSC, Kathmandu, Nepal.

Nepal B.K. 2001. *Quantitative analysis of Vegetation (trees and shrubs) along an altitudinal gradient in Annapurna Conservation Area*. M.Sc. Dissertation, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Nuzzo V.A. 1996. Structure of cliff vegetation on exposed cliffs and the effect of rock climbing. *Canadian Journal of Botany* **74**: 607-617.

Oke T.R. 1987. *Boundary Layer Climates*. Metheuen and Co., New York, 339-348.

Oksanen J. 2011. *Multivariate analysis of ecological communities in R*: vegan tutorial (http://*www.R-project.org*).

Palmer M.W. 2007. Species-area curves and the geometry of nature. In: *Scaling Biodiversity* (D. Storch, P.A. Marquet and J.H. Brown, eds.) Cambridge University Press, Cambridge.

Pandey J. 2009. *Floristic Study and Vegetational Analysis in Lower Kangchenjungha Singhalila Ridge, Panchthar District, Eastern Nepal*. M.Sc. Thesis. Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal.

Panthi M.P, Chaudhary R.P. and Vetaas O.R. 2007. Plant species richness and composition in a trans-Himalayan inner valley of Manang district, central Nepal. *Himalayan Journal of Sciences* **4**(6): 57-64.

Panthi S. 2012. *Diversity of Herbaceous Species in Mixed Rhododendron Forests of Kanchenjunga Conservation Area, Eastern Nepal*. M.Sc. Thesis. Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Paudel E.N. 2009. *Herbaceous Flora in High elevation Imja Valley, Sagarmatha National Park, Nepal Himalaya*. M.Sc. Thesis. Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Paudyal K., Jha P.K. and Zobel D.B. 2012. Role of wood water properties and leafdynamics in phenology and response to drought in evergreen Himalayan tree species. Ecoprint **19**: 71-84.

Pavon, N.P., Hernandez – Trejo, H., and Rico-Gray, V. 2000. Distribution of plant life forms along an altitudinal gradients in the semi-arid valley of Zapotitlan, Mexico. *Journal of Vegetation Science* **11**: 39-42.

Peet R.K. 1974. The measurement of species diversity. *Annual Review of Ecology and Systematics* **5**: 285-307.

Pierson F.B. and Wight J.R. 1991. Variability of near-surface soil temperature on sagebrush rangeland. *J. Range. Manage* **44**: 491–497.

Pitchairamu C., Muthuchelian K. and Siva N. 2008. Floristic inventory and Quantitative vegetation Analysis of Tropical dry deciduous forest in Piranmalai forest, Eastern Ghats, Tamil Nadu, India. *Ethnobotanical leaflets* **12**: 204-216.

Polunin O. and Stainton A. 1984. *Flowers of the Himalaya*. Oxford University Press, New Delhi, India.

Pook E.W. and Moore W.E. 1966. The influence of aspect on the composition and structure of dry sclerophyll forest on Black Mountain, Canberra. *ACT Australian Journal of Botany* **14**(2): 223 – 242.

Poudyal K., Jha P.K., Zobel D. B., 2012. Role of wood water properties and leaf dynamics in Phenology and response to drought in evergreen Himalayan tree species. *Ecoprint. Ecological Society (ECOS)* Nepal. **19**: 71-84.

Press J.R., Shrestha K.K. and Sutton D.A. 2000. *Annotated Checklist of the Flowering Plants of Nepal*. The Natural History Museum, London, UK.

R Development Core Team. 2012. R: A language and environment for statistical computing. R foundation for Statistical Computing, Vienna, Austria.

Rahbek C. 1985. The elevational gradient of species richness: a uniform pattern? *Ecography* **18**(2): 200-205.

Rahbek C. 1995. The elevation gradient of species richness: A uniform pattern? *Ecography* **18**: 200–205.

Rahbek C. 1997. The relationship among area, elevation, and regional species richness in Neotropical birds. *American Naturalist* **149**: 875–902.

Rahbek C. and Graves G.R. 2001. Multiscale assessment of patterns of avian species richness. *Proceedings of the National Academy of Sciences* **98**: 4534 -4539

Raskoti B.B. 2009. *The Orchids of Nepal*. Quality Printers, Kathmandu, Nepal.

Ricklefs E.R., Qian H. and White S.P. 2004. The region effect on mesoscale plant species richness between eastern Asia and eastern North America. *Ecography* **27**: 129 -136.

Rijal D.P. 2009. *Species richness and elevation: searching for patterns at a local scale (Langtang National Park), Central Nepal*. M.Sc. Thesis. Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Rosenzweig M.L. 1995. *Species Diversity in space and time.*Cambridge University Press.

Rowe R.J. and Lidgard S. 2009. Elevational gradients and species richness: do methods change pattern perception? *Global Ecology and Biogeeography* 18: 163 -177.

Rowe R.J. and Lidgard S. 2009. Elevational gradients and species richness: do methods change pattern perception? *Global Ecology and Biogeeography* **18**: 163 -177.

Sagar R., Raghubansi A. S. and Singh J. S. 2003. Tree species composition, dispersion and diversity along a disturbance gradient in a dry tropical forest region of India. *Forest Ecology and Management* **186**: 61-71.

Sharma S. 2012. Vascular Plant Species Diversity Patterns along Different Land Use and Altitudinal Gradients in Nepal. M Sc. Thesis, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Shrestha S.K. 2001. *An ecological study on species diversity along disturbance and altitudinal gradient in Landruk village of Annapurna Region.* M.Sc. Dissertation, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Shrestha T. B. 1985. Indigenous Gymnosperms. In: *Nepal Natures Paradise* (Majpuria T. C.,ed). 252-260. Craftman Press, Bangkok.

Shrestha T. B. 2008. *Classification of Nepalese Forests and Their Distribution in Protected Areas*. The Initiation. 1-9.

Spies T.A. and Turner M.G. 1999. Dynamics forest mosaics. In: *Maintaining biodiversity in forest ecosystems* (M.L. Hunter Jr., ed.), pp. 95 -160. Cambridge University Press, Cambridge.

Stainton A. 1988. *Flowers of the Himalaya. A Supplement*. Oxford University Press, New Delhi, India.

Stainton J.D.A. 1972. Forests of Nepal. John Murray Publishers Ltd., London.

Stevens G.C. 1992. The elevational gradient in elevational range, an extension of Rapoport's latitudinal rule to elevation. *American Naturalist* **140**: 893-911.

Stirling G. and Wisley B. 2001. Emperical relation between Species Richness, Evenness and Propotional Diversity. *American Naturalist* **158**(3): 286-299.

Subedi S.C. 2006. *Distribution pattern of plant species of Manang along whole Himalayan elevation gradient of Nepal*. M.Sc. Dissertation, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

ter Braak C.J.F. 2002. CANOCO- A FORTAN Program for canonical community ordination by (partial) (detrended) (canonical) correspondence analysis, principal component analysis and redundancy analysis.Version 4.5, Wageningen.

Thakali A. 2013. *Elevational Species Richness Pattern in Manaslu Conservation Area, Central Nepal*. M.Sc. Dissertation, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Vaalverde T. and Silvertown J. 1997. Canopy Closure Rate and Forest Structure. *Ecology* **78**(5): 21 -28.

Vetaas O.R. 1997. The effect of canopy disturbance on species richness in a central Himalayan Oak forest. *Plant Ecology* **132**: 29-38.

Vetaas O.R. 2000. Comparing species temperature responses curves: Population density versus second hand data. *Journal of Vegetation Science* **11**: 659-666.

Vetaas O.R. and Grytnes J. A. 2002. Distribution of vascular plant species richness and endemic richness along the Himalayan elevation gradient in Nepal. *Global Ecology and Biogeography* **11**: 291-301.

Walker M.D. 1995. *Patterns and causes of arctic plant community diversity*. Arctic and Alpine Biodiversity (Eds. III, Chapin F.S. and Körner, C.), pp 1-20. Springer-Verlag, New York, NY.

Wallace A.R. 1878. *Tropical nature and other essays*. Macmillan, New York.

Whittaker R.H. 1960. Vegetation of the Siskiyou Mountains, Oregon and California. *Ecological Monographs* **30**: 279–338.

Whittaker R.H. 1972. Evolution and Measurement of Species Diversity. *Taxon* **21**: 231 -251.

Whittaker R.H. 1977. Evolution of species diversity in land plant communities. *Evolutionary Biology* **10**: 1-67.

Whittaker R.H. 1977a. Evolution of species diversity in land communities [Birds and vascular plants]. *Evolutionary Biology*. **10.**

Whittaker R.H. and Niering W.A. 1968. Vegetation of the Sant Catalina Mountains Arizoma III. Species distribution and floristic relations of the north slope. *J.Ariz.Acad.Sci*. **5**: 3-21.

Whittaker R.H. and Niering W.A. 1975. Vegetation of the Santa Carolina Mountains, Arizoma. V. Biomass production, and diversity along the elevational gradient. *Ecology* **56**: 771–790.

Whittaker, R.J., Willis, K.J. & Field, R. (2001) Scale and species richness: towards a general, hierarchical theory of species diversity. *Journal of Biogeography* **28**: 453-470.

Wiens J.A. 1989. Spatial scaling in ecology. *Functional ecology* **3**: 385 -397

Wilkinson D. M. 1999. The disturbing history of intermediate disturbance. *Oikos* **84**: 145-147.

Woodward F.I. 1987. *Climate and plant distribution*. Cambridge studies in ecology. Cambridge University Press, Cambridge.

Yoda K. 1967. A preliminary survey of the forest vegetation of eastern Nepal II. *Journal of the College of Arts and Sciences,Chiba University National Science series* **5**: 99 -140.

Zapfack L., Engwald S., Sonke B., Achoundong G. and Madong B.A. 2002. The impact of land conversion on plant divrsity in the forest zone of Cameroon. *Biodiversity Conservation* **11**: 2047-2061.

Zobel D.B., Behan M.J., Jha P.K. and Yadav U.K.R. 1987. *A practical manual for ecology*. Ratna Books Distributors, Kathmandu, Nepal.

Online Resources:

http://www.theplantlist.org/browse/A/ (accesed on June, 2014).

http://www.tropicos.org/browse/A/ (accesed on June, 2014).

APPENDICES

Appendix 1: Frequency, RF, Density, RD, Basal Area, RBA and Importance Value Index (IVI) of tree species.

Name of Species	F	RF	D ha^{-1}	RD	BA m^2ha^{-1}	RBA	IVI
Quercus semecarpifolia	14	10.53	36	12.95	14.63	28.05	51.53
Castanopsis tribuloides	10	7.52	48	17.27	5.01	9.59	34.38
Cyclobalanopsis glauca	14	10.53	31	11.15	2.88	5.53	27.21
Schima wallichii	12	9.02	19	6.83	5.69	10.90	26.75
Betula alnoides	11	8.27	25	8.99	3.41	6.53	23.79
Rhododendron arboreum	12	9.02	23	8.27	2.32	4.44	21.74
Ilex doniana	9	6.77	11	3.96	4.37	8.39	19.11
Quercus lanata	8	6.02	20	7.19	2.20	4.21	17.42
Eriobotrya dubia	4	3.01	14	5.04	2.59	4.96	13.00
Myrica esculenta	4	3.01	7	2.52	1.02	1.95	7.47
Persea odoratissima	3	2.26	4	1.44	1.82	3.49	7.18
Actinodaphne sp.	4	3.01	5	1.80	0.36	0.69	5.50
Garuga pinnata	3	2.26	4	1.44	0.77	1.47	5.16
Myrsine semiserrata	4	3.01	4	1.44	0.35	0.67	5.12
Lithocarpus grandifolius	3	2.26	5	1.80	0.27	0.52	4.57
Quercus spicata	1	0.75	2	0.72	1.14	2.18	3.65
Wendlandia puberula	2	1.50	2	0.72	0.71	1.35	3.58
Quercus lanuginosa	2	1.50	2	0.72	0.36	0.68	2.91
Lyonia ovalifolia	2	1.50	3	1.08	0.08	0.16	2.75
Mahonia napaulensis	1	0.75	3	1.08	0.44	0.84	2.67
Aesculus sp.	1	0.75	1	0.36	0.71	1.35	2.47
Magnolia campbelli.	1	0.75	1	0.36	0.28	0.54	1.65
Eurya acuminata	1	0.75	1	0.36	0.24	0.46	1.57
Phoebe sp.	1	0.75	1	0.36	0.16	0.30	1.42
Fraxinus floribunda	1	0.75	1	0.36	0.13	0.25	1.37
Prunus cerasoides	1	0.75	1	0.36	0.07	0.14	1.25
Lindera pulcherima	1	0.75	1	0.36	0.06	0.11	1.22
Ilex dipyrena	1	0.75	1	0.36	0.05	0.10	1.21
Ficus nerifolia	1	0.75	1	0.36	0.04	0.07	1.18
Cinnamomum glaucescens	1	0.75	1	0.36	0.03	0.06	1.17
Total	**133.00**	**100.00**	**278.00**	**100.00**	**52.17**	**100.00**	**300.00**

Appendix 2: Relative Radiation Index of each plots where Ω= Aspect, β= Slope, θ= Latitude Ôke (1987).

Plot No.	Aspect (Ω)	Slope (β)	Latitude(θ)	RRI
1	250	30	27.59	0.85
2	325	20	27.59	0.70
3	330	20	27.59	0.70
4	250	25	27.59	0.87
5	343	25	27.59	0.62
6	39	35	27.59	0.52
7	86	25	27.59	0.79
8	347	30	27.59	0.54
9	345	25	27.58	0.61
10	300	20	27.58	0.75
11	334	30	27.58	0.56
12	16	20	27.58	0.68
13	265	25	27.58	0.82
14	350	25	27.58	0.61
15	238	20	27.58	0.92
16	345	20	27.58	0.68
17	240	20	27.58	0.91
18	210	20	27.58	0.97
19	215	20	27.58	0.96
20	330	20	27.58	0.70
21	210	20	27.58	0.97
22	30	20	27.58	0.70
23	285	15	27.58	0.83
24	342	30	27.58	0.55
25	235	20	27.58	0.92
26	335	20	27.58	0.69
27	220	20	27.58	0.95
28	55	35	27.58	0.57
29	28	35	27.58	0.49
30	225	20	27.58	0.94
31	14	30	27.58	0.54
32	230	15	27.58	0.93
33	335	35	27.58	0.49
34	60	30	27.58	0.65
35	90	25	27.58	0.80
36	10	15	27.58	0.74
37	82	25	27.58	0.78
38	290	15	27.58	0.82
39	33	28	27.57	0.60
40	295	25	27.57	0.72
41	22	35	27.57	0.48
42	90	25	27.57	0.80
43	275	20	27.57	0.82

Appendix 3: Name of the plants with abbreviated name, family, life forms, and altitude of occurrence of those species (where, AbNames= Abbreviated Names). (The first three letters of abbreviated names indicate generic and last three letters indicate specific epithet)

S. No.	Family	Names	AbNames	Altitude (m)	Life Forms
1	Acanthaceae	*Aechmanthera gossypina* (Wall.) Nees	AchGos	300-2400	Shrub
2	Acanthaceae	*Justicia procumbens* var. *simplex* (D. Don) T.Yamaz.	JusPro	700-2500	Herb
3	Acanthaceae	*Strobilanthes glutinosa* Nees	StrGlu	1000-2800	Herb
4	Aceraceae	*Acer campbelli* Hook. f. & Thomson ex Hiern	AceCam	2100-3600	Tree
5	Amaranthaceae	*Achyranthes bidentata* Blume	AchBid	1200-2100	Herb
6	Anacardiaceae	*Dobinea vulgaris* Buch.-Ham. ex D. Don	DobRug	1500-2300	Shrub
7	Anacardiaceae	*Rhus javanica* L.	RhuJav	1300-2400	Tree
8	Anacardiaceae	*Rhus succedanea* L.	RhuSuc	1300-2400	Tree
9	Apiaceae	*Bupleurum hamiltonii* N.P. Balakr.	BupHam	1300-3900	Herb
10	Apiaceae	*Hydrocotyl himalaica* P. K. Mukh.	HydHim	1500-2500	Herb
11	Apiaceae	*Pleurospermum apiolens* C.B. Clarke	PleApi	3600-4500	Herb
12	Apiaceae	*Selinum wallichiianum* (DC.) Raizada & Saxena	SelWal	2700-4800	Herb
13	Aquifoliaceae	*Ilex dipyrena* Wall	IleDip	2500-3000	Tree
14	Aquifoliaceae	*Ilex excelsa* (Wall.) Hook. f.	IleExc	600-2100	Tree
15	Aquifoliaceae	*Ilex fragilis* Hook. f.	IleFra	2200-3000	Tree
16	Araceae	*Arisaema erubescens* (Wall.) Schott	AriEru	1900-2600	Herb
17	Araliaceae	*Hedera nepalensis* K. Koch	HedNep	2000-3200	Shrub
18	Araliaceae	*Schefflera* sp.	SchSpe	-	Tree
19	Asteraceae	*Ainsliaea latifolia* (D. Don) Sch. Bip.	AinLat	1700-3500	Herb
20	Asteraceae	*Anaphalis busua* (Buch.-Ham. ex D. Don) DC.	AnaBus	1500-2900	Herb
21	Asteraceae	*Anaphalis margaritacea* (L.) Benth.	AnaMar	1800-3100	Herb
22	Asteraceae	*Anaphalis triplinervis* (Sims) C. B. Clarke	AnaTri	1800-3300	Herb
23	Asteraceae	*Artemisia indica* Willd.	ArtInd	300-2400	Herb
24	Asteraceae	*Aster tricephalus* C. B. Clarke	AstTri	2900-4600	Herb
25	Asteraceae	*Bidens pilosa* (Blume) Sherff	BidPil	700-2100	Herb
26	Asteraceae	*Crassocephalum crepidiodes* (Benth.) S. Moore	CraCre	400-1900	Herb
27	Asteraceae	*Dichrocephala integrifolia* (Lef.) Kuntze	DicInt	800-3000	Herb
28	Asteraceae	*Galinsoga parviflora* Cav.	GalPar	850-3000	Herb
29	Asteraceae	*Gnaphalium affine* D. Don	GnaAff	600-3700	Herb
30	Asteraceae	*Inula cappa* (Buch.-Ham. ex D. Don) DC.	InuCap	150-2500	Shrub
31	Asteraceae	*Ligularia fischeri* (Ledeb)	LigFis	2200-4600	Herb
32	Asteraceae	*Senecio wallichii* DC.	SenWal	2400-3300	Shrub
33	Asteraceae	*Siegesbeckia orientalis* L.	SieOri	400-2700	Herb
34	Asteraceae	*Xanthium strumarium* L.	XanStr	100-2500	Herb
35	Balsaminaceae	*Impatiens puberula* DC.	ImpPub	1500-2700	Herb
36	Begoniaceae	*Begonia picta* Sm.	BegPic	600-2800	Herb
37	Berberidaceae	*Berberis aristata* DC.	BerAri	1800-3000	Shrub
38	Berberidaceae	*Berberis asiatica* Roxb. ex DC.	BerAsi	1200-2500	Shrub
39	Berberidaceae	*Berberis wallichiiana* DC.	BerWal	1900-3300	Shrub

40	Berberidaceae	*Mahonia nepaulensis* DC.	MahNep	2000-2900	Shrub
41	Betulaceae	*Alnus nepalensis* D. Don	AlnNep	500-2600	Tree
42	Betulaceae	*Betula alnoides* Buch.-Ham. Ex D. Don	BetAln	1200-2600	Tree
43	Bignoniaceae	*Jacaranda* sp.	JacSpe	-	Tree
44	Boraginaceae	*Cynoglossum zeylanicum* (Vahl) Thunb. ex Lehm.	CynZey	1200-4100	Herb
45	Boraginaceae	*Hackelia sp.*	HacSpe	-	Herb
46	Burseraceae	*Garuga pinnata* Roxb.	GarPin	300-1200	Tree
47	Buxaceae	*Sarcococca coriacea* (Hook.) Sweet	SarCor	600-1600	Shrub
48	Buxaceae	*Sarcococca seligna* (D.Don) Mull. Arg	SarSel	1900-2300	Herb
49	Campanulaceae	*Campanula pallida* Wall.	CamSpe	1000-4500	Herb
50	Campanulaceae	*Lobelia pyramydalis* Wall.	LobPyr	1100-2300	Herb
51	Cannabaceae	*Cannabis sativa* L.	CanSat	200-2700	Herb
52	Caryophyllaceae	*Drymaria diandra* Blume	DryDia	700-2000	Herb
53	Commelinaceae	*Commelina benghalensis* L.	ComSpe	900-1800	Herb
54	Convolvulaceae	*Ipomea purpurea* (L.) Roth	IpoPur	910-2400	Herb
55	Corylaceae	*Carpinus* sp.	CarpSpe	-	Tree
56	Cucurbitaceae	*Coccinia grandis* (L.) Vioget.	CocGra	200-900	Herb
57	Cucurbitaceae	*Trichosanthes sp.*	TriSpe	-	Herb
58	Cyperaceae	*Carex nubigena* D. Don	CarRub	1500-4000	Herb
59	Cyperaceae	*Cyperus* sp.	CypSpe	-	Herb
60	Dioscoreaceae	*Dioscorea bulbifera* L.	DioBul	150-2100	Herb
61	Dioscoreaceae	*Dioscorea deltoidea* Wall.	DioDel	450-3100	Herb
62	Dipsacaceae	*Dipsacus inermis* Wall.	DipIne	1500	Herb
63	Ebenaceae	*Diospyros* sp.	DioSpe	-	Tree
64	Ericaceae	*Gaultheria fragrantissima* Wall.	GauFra	1200-2600	Shrub
65	Ericaceae	*Lyonia ovalifolia* (Wall.) Drude	LyoOva	1300-3300	Shrub
66	Ericaceae	*Rhododendron arboreum* Sm.	RhoArb	1500-3300	Tree
67	Euphorbiaceae	*Glochidion* sp.	GloSpe	-	Herb
68	Euphorbiaceae	*Macaranga* sp.	MacSpe	-	Tree
69	Euphorbiaceae	*Phyllanthus* sp.	PhySpe	-	Shrub
70	Euphorbiaceae	*Sapium insigne* (Royle) Benth. ex Hook.	SapIns	500-1800	Tree
71	Fagaceae	*Castanopsis indica* (Roxb.) Miq.	CasInd	1200-2900	Tree
72	Fagaceae	*Castanopsis tribuloides* (Sm.) A. DC.	CasTri	450-2300	Tree
73	Fagaceae	*Cyclobelanopsis glauca* (Thunb.) Oersted	CycGla	450-3100	Tree
74	Fagaceae	*Lithocarpus grandifolius* (DC.) S. N. Biswas	QueGra	1400-2000	Tree
75	Fagaceae	*Lithocarpus pachyphylla* (Kurz) Rehder	LitPac	2100-2800	Tree
76	Fagaceae	*Lithocarpus* sp.	LitSpe	-	Tree
77	Fagaceae	*Quercus floribunda* Lindl. ex A. Camus	QueFlo	2100-2700	Tree
78	Fagaceae	*Quercus lanata* Sm.	QueLan	460-2600	Tree
79	Fagaceae	*Quercus semecarpifolia* J.E. Smith.	QueSem	1700-3800	Tree
80	Flacourtiaceae	*Xylosma controversum* Clos	XylCon	1300-1700	Shrub
81	Gentianaceae	*Swertia angustifolia* Buch.-Ham. ex D. Don	SweAng	600-2600	Herb
82	Gentianaceae	*Swertia chirayita*(Roxb. ex Fleming) Karsten	SweChi	1500-2500	Herb
83	Gentianaceae	*Swertia nervosa* (G. Don) C. B. Clarke	SweNer	700-3000	Herb

84	Geraniaceae	*Geranium nepalense* Sweet	GerNep	1500-4000	Herb
85	Gesneriaceae	*Chirita urticifolia* Buch.-Ham. Ex D. Don	ChiUrt	900-2300	Herb
86	Gesneriaceae	*Didymocarpus aromaticus* Wall ex. D. Don	DidAro	1600-3000	Herb
87	Gesneriaceae	*Lysionotus serratus* D. Don	LysSer	1000-2400	Shrub
88	Gramineae	*Arundinella nepalensis* Trin.	AruNep	500-2500	Herb
89	Gramineae	*Cynodon dactylon* (L.) Pers.	CynDac	100-3000	Herb
90	Gramineae	*Oplismenus compositus* (L.) Beauv.	OplCom	300-2800	Herb
91	Gramineae	*Poa annua* L.	PoaAnn	2300-3500	Herb
92	Grossulariaceae	*Ribes takare* D. Don	RibTak	2200-3300	Shrub
93	Guttiferae	*Hypericum choisianum* Wall. ex N. Robson	HypCho	2400-3600	Shrub
94	Hydrangeaceae	*Hydrangea macrophylla* (Thunb.) Ser.	HydMac	1700	Shrub
95	Juncaceae	*Juncus wallichiianus* Laharpe	JunWal	1500-2900	Herb
96	Lamiaceae	*Colquhounia coccinea* Wall.	ColCoc	1200-4200	Shrub
97	Lamiaceae	*Desmodium confertum* DC	DesCon	300-2000	Shrub
98	Lamiaceae	*Elsholtzia flava* (Benth.) Benth.	ElsFla	1900-2700	Shrub
99	Lamiaceae	*Notochaete hamosa* Benth.	NotHam	1500-2600	Herb
100	Lamiaceae	*Leucosceptrum canum* Sm.	LeuCan	1000-2800	Shrub
101	Lamiaceae	*Anisomeles indica* (L.) Kuntze	NapSpe	200-2400	Herb
102	Lamiaceae	*Salvia nubicola* Wall ex. Sweet	SalvNub	2100-3600	Herb
103	Lamiaceae	*Scutellaria discolor* Colebr.	ScuDis	700-2400	Herb
104	Lardizabalaceae	*Holboellia latifolia* Wall.	HolLat	2000-4000	Shrub
105	Lauraceae	*Cinamomum glanduliferu* (Wall.) Meisn.	CinGla	2100-2600	Tree
106	Lauraceae	*Cinamomum tamala*(Buch.-Ham.) Nees & Eberm.	CinTam	450-2000	Tree
107	Lauraceae	*Lindera nacusua* (D. Don) Merr.	LinNac	1300-1800	Tree
108	Lauraceae	*Lindera pulcherrima* (Nees) Benth.ex Hook. f.	LinPul	1400-2700	Tree
109	Lauraceae	*Lindera neesiana* (Wall. ex Nees) Kurz	LinNee	1800-2700	Tree
110	Lauraceae	*Machilus duthiei*King	MacDut	1000-2900	Tree
111	Lauraceae	*Neolitsea pallens* (D. Don) Mimy. & H. Hara ex. H. Hara	NeoPal	2000-3000	Tree
112	Lauraceae	*Persea odoratissima* (Nees) Kost.	PerOdo	1000-2000	Tree
113	Lauraceae	*Phoebe sp.*	PhoSpe	-	Tree
114	Leguminosae	*Cochlianthus gracilis* Benth.	CocGrac	1800-2000	Herb
115	Leguminosae	*Caesalpinia decapetala* (Roth) Alston	CaeDec	1000-2200	Shrub
116	Leguminosae	*Desmodium microphyllum* (Thunb.) DC.	DesMic	1500-2300	Shrub
117	Leguminosae	*Hedysarum* sp.	HedySpe	-	Herb
118	Leguminosae	*Indigofera dosua* Buch.-Ham. Ex D. Don	IndDos	1000-3000	Herb
119	Leguminosae	*Piptanthus nepalensis* (Hook.)D. Don	PiptNep	2000-3800	Shrub
120	Leguminosae	*Trifolium repens* L.	TriRep	1500-2500	Herb
121	Leguminosae	*Trigonella* sp.	TriSpe	-	Herb
122	Liliaceae	*Polygonatum cirrhifolium* (Wall.) Royle	PolCir	1700-4600	Herb
123	Liliaceae	*Polygonatum* sp.	PolSpe	-	Herb
124	Liliaceae	*Smilacina oleracea* (Baker) Hook. f.	SmilOle	2500-3400	Herb
125	Liliaceae	*Smilax aspera* L.	SmiAsp	1200-2600	Herb
126	Liliaceae	*Theropogon pallidus* (Kunth) Maxim.	ThePal	1800-2700	Herb
127	Loganiaceae	*Buddlega asiatica* Lour.	BudAsi	350-2000	Shrub

128	Magnoliaceae	*Magnolia campbelli* Hook. f. & Thomson	MagCam	2250-2700	Tree
129	Malvaceae	*Urena lobata* L.	UreLob	200-1300	Herb
130	Melastomataceae	*Melastoma normale* D. Don	MelNor	900-1800	Shrub
131	Melastomataceae	*Osbeckia stellata* Buch.-Ham. ex D. Don	OsbSte	1300-2600	Shrub
132	Meliaceae	*Toona serrata* (Royle) M. Roem.	CedToo	2100-2300	Tree
133	Menispermaceae	*Cissampelos pareira* L.	CisPar	150-2200	Shrub
134	Moraceae	*Ficus neriifolia* Sm.	FicNer	1800	Tree
135	Moraceae	*Ficus religiosa* L.	FicRel	150-1500	Tree
136	Myricaceae	*Myrica esculenta* Buch.-Ham. ex D. Don	MyrEsc	1200-2300	Tree
137	Myrsinaceae	*Ardisia macrocarpa* Wall.	ArdMac	1500-2400	Shrub
138	Myrsinaceae	*Maesa chisia* Buch.-Ham. ex D. Don	MaeChi	1200-2600	Shrub
139	Myrsinaceae	*Myrsine capitellata* Wall.	MyrCap	900-1800	Tree
140	Myrsinaceae	*Myrsine semiserrata* Wall.	MyrSem	1200-2700	Shrub
141	Myrsinaceae	*Myrsine africana* L.	MyrAfr	1200-2300	Shrub
142	Oleacece	*Fraxinus floribunda* Wall.	FraFlo	1200-2000	Tree
143	Oleacece	*Jasminum humile* L.	JasHum	1600-3400	Shrub
144	Oleacece	*Osmanthus longifolius* (DC.) H. Hara	OsmLon	2400-3300	Shrub
145	Orchidaceae	*Calanthe plantaginea* Lindl.	CalPla	1500-2100	Herb
146	Orchidaceae	*Calanthe tricarinata* Lindl.	CalTri	1500-3200	Herb
147	Orchidaceae	*Goodyera fusca* (Lindl.) Hook. f.	GooFus	3200-4700	Herb
148	Papaveraceae	*Corydalis govaniana* Wall.	CorGov	3000-4800	Herb
149	Pinaceae	*Cedrus deodara* (Roxb. ex. D. Don) G. Don	CedDeo	2000-2500	Tree
150	Pinaceae	*Pinus wallichiiana* A.B. Jackson	PinWal	1800-4100	Tree
151	Piperaceae	*Piper longum* L.	PipLon	200-800	Shrub
152	Plantaginaceae	*Plantago erosa* Wall.	PlaEro	900-4100	Herb
153	Plantaginaceae	*Plantago major* L.	PlaMaj	900-4100	Herb
154	Polygalaceae	*Polygala arillata* Buch.-Ham. ex D. Don	PolAri	1500-2700	Shrub
155	Polygonaceae	*Aconogonum molle* (D. Don) H. Hara	AcoMol	120-2400	Herb
156	Polygonaceae	*Bistorta amplexicaulis* (D. Don) Greene	BisAmp	2100-4800	Herb
157	Polygonaceae	*Persicaria capitata* (Buch.- Ham.) H. Gross	PerCap	600-2400	Herb
158	Polygonaceae	*Persicaria runcinata* (Buch.-Ham. ex D. Don) H. Gross	PerRun	1600-3800	Herb
159	Polygonaceae	*Persicaria chinensis* (L.) H. Gross	PerChi	1200-2900	Herb
160	Polygonaceae	*Rumex nepalensis* Spreng.	RumNep	1200-4200	Herb
161	Ranunculaceae	*Anemone vitifolia* Buch.-Ham. ex DC.	AneVit	1300-3300	Herb
162	Ranunculaceae	*Anemone elongata* D. Don	AneElo	1800-3700	Herb
163	Ranunculaceae	*Clematis montana* Buch.-Ham. ex DC.	CleMon	1600-4000	Herb
164	Ranunculaceae	*Ranunculus diffusus* DC.	RanDif	1500-1700	Herb
165	Ranunculaceae	*Ranunculus sceleratus* L.	RanSce	800-1700	Herb
166	Ranunculaceae	*Thalictrum foliolosum* DC.	ThaFol	1300-3400	Herb
167	Rhamnaceae	*Ziziphus incurva* Roxb.	ZizInc	900-1600	Tree
168	Rosaceae	*Cotoneaster accuminatus* Lindl.	CotAcc	2500-3700	Shrub
169	Rosaceae	*Eriobotrya dubia* (Lindl.) Decne	EriDub	1500-2000	Tree
170	Rosaceae	*Eriobotrya hookeriana* Decne.	EriHoo	1500-2500	Tree
171	Rosaceae	*Neillia thyrsiflora* D. Don	NieThy	1600-2000	Shrub

172	Rosaceae	*Potentilla kleiniana* Wight	PotKle	1000-2200	Herb
173	Rosaceae	*Potentilla fulgens* Wall. ex Hook	PotFul	1600-4800	Herb
174	Rosaceae	*Prunus cerasoides* D. Don	PruCer	1300-2400	Tree
175	Rosaceae	*Rosa brunonii* Lindl.	RosBru	1500-2400	Shrub
176	Rosaceae	*Rosa sericea* Lindl.	RosCar	2200-4600	Shrub
177	Rosaceae	*Rubus accuminatus* Sm.	RubAcc	1000-2300	Shrub
178	Rosaceae	*Rubus ellipticus* Sm.	RubEll	1700-2300	Shrub
179	Rosaceae	*Rubus foliolosus* D. Don	RubFol	2100-2900	Herb
180	Rosaceae	*Rubus paniculatus* Sm.	RubPan	2100-2900	Shrub
181	Rosaceae	*Rubus biflorus* Buch.-Ham. ex Sm.	RubBif	2100-3300	Shrub
182	Rosaceae	*Rubus rugosus* Sm.	RubRug	1500	Shrub
183	Rosaceae	*Sorbus cuspidata* (Spach) Hedl.	SorCus	2700-3700	Tree
184	Rosaceae	*Stranvaesia nussia* (D. Don) Decne	StrNau	900-2500	Shrub
185	Rubiaceae	*Galium hirtiflorum* Req. ex DC.	GalHir	1200-2200	Herb
186	Rubiaceae	*Hedyotis scandens* Roxb.	HedSca	400-1800	Herb
187	Rubiaceae	*Hymenopogon parasiticus* Waall.	HymPar	1600-2800	Shrub
188	Rubiaceae	*Luculia gratissima* (Wall.) Sweet	LucGra	1000-2100	Shrub
189	Rubiaceae	*Mussaenda macrophylla* Wall.	MusMac	-	Shrub
190	Rubiaceae	*Randia tetrasperma* (Roxb.) Benth. & Hook. f. ex Brandis	RanTet	1300-2600	Shrub
191	Rubiaceae	*Rubia manjith* Roxb. Ex Fleming	RubMan	1200-2100	Herb
192	Rubiaceae	*Wendlandia puberula* DC.	WenPub	700-2000	Tree
193	Rutaceae	*Boenninghausenia albiflora* (Hook.)	BoeAlb	600-3300	Herb
194	Rutaceae	*Murraya paniculata* (L.) Jack	MurPan	400-1050	Shrub
195	Rutaceae	*Zanthoxylum armatum* DC.	ZanArm	1100-2500	Tree
196	Rutaceae	*Zanthoxylum oxyphyllum* Edgew.	ZanOxy	2100-2800	Shrub
197	Salicaceae	*Salix denticulata* Andersson	SalDen	2400-3000	Shrub
198	Sambucaceae	*Viburnum erubescens* Wall. ex DC.	VibEru	1500-3000	Tree
199	Sambucaceae	*Viburnum mullaha* Buch.-Ham. ex D. Don	VibMul	1800-2700	Shrub
200	Santalaceae	*Osyris wightiana* Wall. ex Wight	OryWig	1100-2600	Shrub
201	Saurauiaceae	*Saurauia nepaulensis* DC.	SauNep	750-2100	Tree
202	Saxifragaceae	*Astilbe rivularis* Buch.-Ham. ex D. Don	AstRiv	2000-3600	Herb
203	Saxifragaceae	*Saxifraga diversifolia* Wall. ex Ser.	SaxDiv	2400-4800	Herb
204	Scrophulariaceae	*Hemiphragma heterophyllum* Wall.	HemHet	1800-3500	Herb
205	Scrophulariaceae	*Pedicularis bifida* (Buch.-Ham. ex D. Don) Pennell	PedBif	1000-3500	Herb
206	Solanaceae	*Solanum aculeatissimum* Jacq.	SolAcu	1600	Herb
207	Symplocaceae	*Symlocus ramosissima* Wall. ex G. Don	SymRam	1400-2600	Tree
208	Theaceae	*Eurya acuminata* DC.	EurAcu	1300-2500	Shrub
209	Theaceae	*Schima wallichii* (DC.) Korth.	SchWal	900-2100	Tree
210	Thymelaeaceae	*Daphne papyracea* Wall. ex Steud.	DapPap	1500-2300	Shrub
211	Thymelaeaceae	*Daphne bholua* Buch.-Ham. ex D. Don	DapBho	2000-2900	Shrub
212	Ulmaceae	*Celtis australis* L.	CelAus	1300-2200	Tree
213	Urticaceae	*Boehmeria glomerulifera* Miq.	BoeGlo	500-600	Herb
214	Urticaceae	*Boehmeria platyphylla* D. Don	BoePla	800-2700	Shrub
215	Urticaceae	*Boehmeria ternifolia* D. Don	BoeTer	900-2300	Herb

216	Urticaceae	*Debregessia salicifolia* (D. Don) Rendle	DebSal	1500-2400	Herb
217	Urticaceae	*Elatostema sessile* J. R. Forst.	ElaSes	1800-3000	Herb
218	Urticaceae	*Girardinia diversifolia* (Link) Friis	GirDiv	1700-3000	Herb
219	Urticaceae	*Pilea scripta* (Buch.-Ham. ex D. Don) Wedd.	PilScr	1300-2500	Herb
220	Urticaceae	*Pilea symmeria* Wedd.	PilSym	2100-3300	Herb
221	Urticaceae	*Pilea umbrosa* Blume	PilUmb	1200-2500	Herb
222	Urticaceae	*Urtica dioca* L.	UrtDio	3000-4500	Herb
223	Valerianaceae	*Valeriana hardwickii* Wall.	ValHar	1200-4000	Herb
224	Verbenaceae	*Caryopteris foetida* (D. Don) Thell.	CarFoe	1200-2200	Shrub
225	Verbenaceae	*Clerodendrum indicum* (L.) Kuntze	CleInd	200-1400	Shrub
226	Vitaceae	*Tetrastigma serrulatum* (Roxb.) Planch	TetSer	500-2400	Herb
227	Zingiberaceae	*Cautleya spicata* (Sm.) Baker	CauSpi	1800-2800	Herb
228	Zingiberaceae	*Hedychium spicatum* (Roscoe) Wall.	HedSpi	2100-2400	Herb
229	Zingiberaceae	*Roscoea nepalensis* Cowley	RosNep	2440-3050	Herb
230	Zingiberaceae	*Roscoea purpurea* Sm.	RosPur	1500-1900	Herb