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ELEVATIONAL DISTRIBUTION OF TREE DIVERSITY IN LOWER HIMALAYA: A CASE STUDY OF PHULCHOKI HILL, NEPAL

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Abstract

Changes in tree species composition with elevation have been studied at three distinct altitudinal ranges on the basis of dominance, in sub-tropical and temperate forests on south slopes of Phulchoki hill, central part of lower Himalaya, Nepal. The greatest number of tree species was found in the low altitude (1600 m), followed by intermediate altitude (1950 m). The highest altitude (2650 m) contained only one distinct tree species (Oak). Site I has higher species diversity (Shannon Index: 2.1863, Evenness Index: 0.852) and density (5575 individual per hectare) dominated by *Castonopsis indica, Quercus glauca, Myrica esculenta and myrsine capitellate*. Site II has average species diversity (Shannon Index: 1.759, Evenness Index: 0.9) and an average density (2150 individual per hectare) dominated by *Rhododendron arboretum, Castanopsis tribuloides and Quercus incana*. At site III the forest is entirely dominated by *Quercus semicarpifolia*, a high altitude Oak. A linear trend of decreasing tree species diversity and density along with elevations was seen which might be because of intense afforestation by communities at lower elevation as site I and II under community managed forest and lower altitudinal ecozone with clear zonation of elevational vegetation types.

Key words: Elevation, Diversity, Density, Lower Himalaya

Introduction

A fundamental characteristic of mountain ecosystems is the drastic change in vegetation as well as in climate from the base to the summit of mountain. Elevation gradients create varied climates, along with resultant soil differentiation; promote the diversification of plant species (Brown *et al.*, 1989). Elevation itself is not an ecological factor directly affecting plant diversity (Korner, 1998). Rather, it is factors that are either directly related to elevation (e.g., air pressure, temperature) or that have a more complex relationship with elevation (available surface area, precipitation, etc.) that affect plants growing at different elevations.

Many studies have investigated local tree species composition along elevation gradient across soil characteristics such as soil nutrient, Organic Matter, pH and moisture content of soil (Fleming, 1973, Rayachhetri, 1981, Yadav, 1984, Tuladhar, 1996 and Sigdel, 2008), as a part of efforts to understand ecosystem effects on biodiversity. Furthermore, the observable associations between species distribution and elevation bands may help to understand the possible effects of climate change, e.g., by providing baseline information from which to measure or gauge the effect of climate change and anthropogenic changes on vegetation (Sharma, 2000).

Elevational patterns of plant species composition are a consequence of many interacting factors, such as plant productivity, competition, geographical area, historical or evolutional development, regional species dynamics, regional species pool, environmental variables, and human activity (Criddle *et al.*, 2003). Yadav (1984) and Sharma (2000) studied the elevational patterns of plant species diversity in Shivapuri National Park (Baghdwar to Sundarijal) (adjoining Phulchoki hill) and observed that diversity of trees decreased with the rise in altitudes. Whereas Sigdel (2008) carried out the study on plant community structure in different altitudinal ranges of Shivapuri National Park and observed that species richness was highest in the middle range of altitude.

In the present study, influence of elevation on tree species composition was determined. It was done on the basis of change in density, evenness and species diversity of tree species with change in elevation. The study site falls within Lower Himalaya as per Dobremez classification (1973).

Methodology

Site description

The study was carried out at Phulchowki hill (27 33'N, 85 22'E), 10 km southeast of Kathmandu, Nepal. It is a part of sub-Himalayan Mahabharat region with an altitudinal range of 1400 to 2715 m with extensive diverse forests mostly dominated by broad leaved evergreen trees. It covers an area of approximately 50 square km consisting of a vast range of flora. The vegetation of Phulchowki Hill is characterized by three distinct evergreen broad leaved forest types: mixed Schima Castanopsis forest at the base (1400 m to 1800 m), Oak-Laurel forest (1800 m to 2400 m) and evergreen oak forest (2000 m above). The study area has typical warm temperate monsoon climate 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). There is no perennial source of water above 1600 m in Phulchowki Hill. Mean temperature ranges between 2.6 to 18.7 C in winter and 15.8 to 28.2 C in summer. Mean annual rainfall is 1882 mm with about more than 80 percent between mid June to mid September. Relative humidity at 6:30 am is greater than 90 percent in July, with a minimum of 63 percent in April (Poudyal, 2013).

Malla (1986) have enumerated 527 species of Angiosperms and 2 species of Gymnosperms species from Phulcoki and Godavari area. The natural climax vegetation of the hill is a mixed leaved forest (subtropical vegetation) dominated by *Schima wallichi* and *Castanopsis indica*. In the surrounding hills, Oaks-laurel forest occurs, the plantation of many deciduous species and conifers have been practiced and the pine forest can be seen in many hill locks. The upper hill consists of temperate type of vegetations.

Method of study

Floristic composition and structure of tree species with changing elevation was measured in 16 randomly placed sample plots, of 10 m × 10 m as suggested by Mishra (1968). Measurements were taken in May 2014 when species were more easily identifiable. Three different elevations (viz; 1600m, 1950m and 2650m) were selected on the basis of complete change in vegetation composition. In each selected elevation four samplings were done on around the four directions from the selected point to get the wholesome tree composition as

suggested by Kershaw (1973). The following tree species variables was recorded or measured in each of the 16 sample plots: species, number, height (to ensure tree from shrubs woody plant), diameter and number of tree cut stamps per study plot. Height and diameter of all trees were measured with the help of caliber 3 m pole and diameter with a dbh tape respectively. Ben-Shahar (1998) defined trees as woody plants with a stem diameter of 6 cm or more and higher than 3 m. Most of the tree species were identified in the field through their local names. The herbarium specimens unidentified plants were collected from the field and were identified in National Herbarium and Plant Laboratories, Godawari (Nepal).

Density was calculated to represents the numerical strength of the species in the community.

Density (ind. per hectare) = $(I / (A \times N)) \times 10000$

Where, I= Total number of individuals, A= Area of each sampling plot and N= Total number of plots

Shannon-Wiener's Index (Shannon and Weaver, 1949) was calculated to measure species diversity.

The Shannon wiener's index is; $H = - \sum pi \, Ln \, pi$

Where, H is the index number, s is the total number of species, pi is the proportion of all individuals in the sample which belongs to species i, and Ln is the natural log, 2.718.

Species Evenness of species was calculated using the Shannon evenness index to understand the relationship of species to each other. The Shannon evenness index ranges from zero (when one species is dominant) to one (when all species are equally abundant).

Shannon Evenness Index, e= H/log S.

Where, H is Shannon wiener's index of species diversity and S is number of species.

Results and Discussion

The study area had three different forests, site I was a secondary growth forest, in which stands of trees were resulting from secondary ecological succession after cutting, at this site grazing and collection of fallen branches for wood fuel were frequent. Site III contained old growth forest which were virgin (uncut) and remaining of old secondary forests that have not been seriously disturbed for several years. They contained hundreds of years old massive trees, these forest also had large number of standing dead trees (snags) and fallen logs

(boles), which are habitats for a variety of plants, animals and microorganism, and on decay returns nutrients to the soil (Krebs, 1972). Site II contained the mixture of site I and site III forest.

The variation of total tree species richness along the elevation gradient is shown in the Table 1, 2 and 3. The highest number of tree species (13) was found in site I. This may be due to the transition zone of sub-tropical and temperate zone. This site acts as ecozone. But in site III comparatively lower no. of species were reported. This may be due to the mature forest with almost closed canopy and trees were large; so the number of species was low. In case of site II, the lower number of species in comparison with site I and higher than site III, may be due to steeper slope and temperate climatic condition and higher than site III, may be due to open canopy resulting from timely collection of branches for wood fuel. The pattern of distribution of plant species was not uniform according to altitude due to variation in micro-climate.

At lower altitude (site I) *Castonopsis indica* is dominant tree species. The major associate tree species are *Quercus glauca, Myrica esculenta, myrsine capitellate* etc. Generally middle altitude are shown to have maximum diversity in hills surrounding the Kathmandu valley (Sigdel, 2008) but here higher diversity was reported at lower altitude as observed by Yadav *et al.* (1984) and Sharma (2000) in Shivapuri National Park. That may be due to influences of microclimatic conditions. *Phyllanthus parvifolius* is most dominant species among shrub species. *Melastoma malabaricum, Berberis aristata, Sarcocca coriaceae, Crotalaria cytisoides, Osyris wightiana, Antidesma acuminatium* were associated common species. *Eupatorium adenophorum* is the most dominant species among herbaceous species.

Table no.1: Site I (altitude 1600m)

S. N	Name of Species	No. of trees in different plots				Average Nos.	Density (no. per hectare)	Shannon Wiener's Index (H)
		Plot I	Plot II	Plot III	Plot IV			
1.	*Myrica esculenta*	22	2	4	5	8.25	825	
2	*Castanopsis indica*	30	10	-	-	10	1000	

3.	*Carpinus viminea*	3	-	-	-	0.75	75	
4.	*Ilex sp.*	8	2	-	-	2.5	250	
5.	*Rhododendron arboreum*	4	4	3	6	4.25	425	
6.	*Castanopsis tribuloids*	20	-	-	-	5	500	2.1863
7.	*Quercus glauca*	3	-	36	-	9.75	975	
8.	*Myrsine capitellata*	-	25	2	2	7.25	725	
9.	*Schima wallichi*	-	6	2	11	4.75	475	
10.	*Choerospndias axillaris*	-	-	1	-	0.25	25	
11.	*Eurya acuminate*	-	-	2	-	0.5	50	
12.	*Pyrus pashia*	-	-	1	-	0.25	25	
13.	*Lyonia ovolifolia*	-	-	9	-	2.25	225	

At middle altitudinal range, *Rhododendron abroreum* and *Castanopsis tribuloides* were frequently dominant among the tree species and major associated species are *Quercus incana, Quercus glauca, Castonopsis indica, Myrsine remiserata* among shrub *Melastoma malabaricum, Berberis aristata, Sarcocca coriaceae, Crotalaria cytisoides, Osyris wightiana* were associated common shrub species and *Chlorophytum nepalensis* among herbs.

Table no. 2: Site II (altitude 1950 m)

S. N	Name of species	No. of trees in different plots				Average Nos.	Density (no. per hectare)	Shannon Wiener's Index (H)
		Plot I	Plot II	Plot III	Plot IV			
1.	*Quercus incana*	8	-	-	5	3.25	325	
2.	*Quercus glauca*	4	-	5	-	2.25	225	
3.	*Rhododendron arboreum*	3	12	1	9	6.25	625	
4.	*Myrsine remiserata*	-	-	6	-	1.5	150	1.759
5.	*Castanopsis tribuloides*	-	10	7	5	5.5	550	

6.	*Schima wallichi*	-	-	-	4	1	100	
7.	*Castonopsis indica*	-	-	-	7	1.75	175	

At higher altitude, forest composed of pure Oak forest, that is the forest is entirely dominated by *Quercus semecarpifolia, a high altitude Oak*, *Daphne bholua* among shrub species. The common associated species were *Berberis asiatica, Rubus acuminatus, Rubus paniculatum, Lindera pulcherrima, Indigofera atropurpuria, Arundinaria falcata* and *Aconitum ferox* among herbaceous species.

Table no. 3: Site III (altitude 2650m)

S. N	Name of species	No. of trees in different plots				Average Nos.	Density (no. per hectare)	Shannon Wiener's Index (H)
		Plot I	Plot II	Plot III	Plot IV			
1.	*Quercus semecarpifolia*	16	21	30	21	22	550	0

Species diversity is the combination of species richness and species evenness (Krebs, 1972). Species richness is the total number of tree species. Evenness of species is expressed as relationship of species to each other. The species richness was the highest in site I (5575 number per hector) but species evenness (0.9) was higher in site II. Despite of this, site I has the highest species diversity (Shannon Index of general diversity: 2.1863) followed by site II (Shannon Index of general diversity: 1.759); this might be because of intense afforestation by communities at lower elevation as site I and II falls under community managed forest and therefore trees at lower altitude were with small basal area and may be lower altitude becoming ecozone between sub tropical and temperate zone.

Species richness and species diversity were low in site III but index of dominance was high. The evenness was low and dominance concentrated to a single species. It was because, higher the number of individuals, lower their contribution to make dominancy. Reverse type of result was recorded; in case of species diversity i.e. species diversity was directly

proportional to total number of species while index of dominance was inversely proportional to species richness.

Conclusion

A linear trend of decreasing tree species diversity and density along with elevations was seen in sub-tropical and temperate forests on south slopes of Phulchoki hill, central part of lower Himalaya, Nepal.

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