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Plant diversity indices and pedological characteristics of Ragiroom Beat, Senchal West Zone Forest Range, Darjeeling, West Bengal, India

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Abstract

The present investigation concerns the plant diversity and pedological characteristics in Ragiroom Beat under Senchal West Forest Zone, Darjeeling. Diversity indices of 50 plant species and the regulatory effects of the pedological factors on the plant diversity were assessed.

***Key words*:** Plant diversity, Pedological characteristics, Ragiroom Forest Beat

INTRODUCTION

Since the dawn of human civilization man - environment relationship has been an inseparable entity. In mountain areas this is more pronounced due to terrain inaccessibility, climatic inhospitality, soil infertility, transport scarcity, inadequacy of basic amenities and facilities, etc made the life style of these people more nature oriented (Chakraborty 1988).

The vegetation of Darjeeling shows diversity having developed in various types of microclimate and soils in different elevations extending to sub-alpine regions. The soil under the forested plant communities of the Darjeeling part of the Himalayas provides unique opportunity for studying the organic matter constituents, their characteristics and impact on pedogenesis. Vegetations of both natural and plantations have pronounced effects on soil characteristics.

Studies on soils in the Himalayan region are rather scanty (Dhir 1967; Pal *et al* 1984). Available studies on the physical and chemical characteristics and nutrient status of soils under different vegetation in different altitudes of the eastern and north–eastern Himalayas is mainly with reference to Darjeeling Himalayan region (Banerjee *et al* 1985, 1986a,b; Nath *et al* 1983, 1986, 1998, Das *et al* 1986; Chandran *et al* 1987).A noteworthy contribution in the field of phytosociology was received from Das & Lahiri (1997) which dealt with the ground covering flora in different types of vegetation in Tiger Hill, Darjeeling District.

The investigations concerning different types of forests or similar forests located in different areas have given no concrete conclusion for pinpointing the vegetation effect since site conditions are changed and it is often impossible to separate the cause from the effect (Gupta *et al* 1982). However, diversity of trees in the Darjeeling foot hill region of Eastern Himalaya was recently studied by Rai & Das (2008).

In Darjeeling hills, plantations of new species in many places are being tried after clear felling the old trees. Therefore, an opportunity to study the effect of change of vegetations on the alteration of soil properties in a contiguous area in this hill tract was availed and the results thus obtained are presented in this communication.

Objectives:

- Preparation of an inventory of different plant species of the forest and contribute towards taxonomy of forests of Darjeeling-Sikkim Himalayas.
- Assessment of diversity indices that can be used as a predictor of the ecosystem health of the region.

- Corroboration of the abundance of different species of plants and the soil parameters to comment on the regulatory effects of the pedological factors on the plant diversity of the forests of Darjeeling Hills.

Study area:

Darjeeling Himalaya forms a part of the Eastern Himalayan Ranges and is bounded by Sikkim, Nepal and Bhutan on the north, west and east respectively. The study site is located in the district of Darjeeling.

The Ragiroom Beat is a part of the Senchel Wildlife Sanctuary, Darjeeling, West Bengal. It lies between 26° and 27°N latitude and 88° and 88°20´E longitude at an elevation of 2600 m. Administration of this beat is controlled by the Head Quarters at 3rd mile.

MATERIALS AND METHODS

A field survey was conducted in the aforesaid study area covering about 5 sq km choosing sites at random in different seasons between February and December, 2006. Specific sites were selected for laying 30 quadrats (1 m^2). Importance value Index (IVI) which is an index of all relative values of frequency, density and abundance, was determined for each of the recorded species (Table 2). Simpson index (D) and Shannon index (H) Dominance indices, evenness, were determined on the basis of the species and individuals recorded from their attendance in the quadrats laid. Each of these indices is described in the following.

Determination of Species Diversity Indices

A conventional way to express and compare diversity is to calculate diversity indices based on the ratio of parts to the whole or (ni/N) where, in is the importance value of each component (for example species) and 'N' is the total importance value. There are two most common method and formulae of calculation. Simpson index (D) and Shannon index (H) and follows:

$D = \sum (ni/N)^2$ $H=\sum(ni/N)^2 \log (ni/N)$

Or, $D=\sum (pi)^2$ or, $H=\sum(Pi \log_e Pi)$

$\therefore D= (pi)^2 \times S$ $\therefore H=Pi \log_e Pi \times S$

∑(Sigma) is the summation, pi=ni/N and S=No. of species having indicated P value. The Simpson index, 'D' is an index of dominance once, since the maximum value, 1, is obtained when there is only one species i.e. complete dominance, and the values approaching 'O' are obtained when there are numerous species, each a very small fraction of the total (no dominance), when we are thinking in term of diversity it is convenient to compute the reciprocal, 1-D, so that higher the value, the greater the diversity, the Shannon index 'H' is an index of diversity in that higher the value greater the diversity & less the value the less the diversity i.e. community is dominated by one or few kinds of species. To compare the 2 indices directly it is necessary to scale the latter so that 1 is maximum and zero the minimum. This can be done by dividing H by log of S. (which is the maximum possible index value for the number of kinds present).

Dominance indices:

Dominance indices are weighted toward the abundance of the commonest species. It is known as Berger and Parker Index, as Berger & Parker (1970) first proposed this index. This index denoted by D_{BP}.

$D_{BP} =$ Nmax / N

Where Nmax = is the number of individuals in the most abundant species.

And N= is the total number of all individuals in all species.

The idea is that one species tends to dominate a community; the community will likely not be very diverse. Where as if no species dominate, the community is probably diverse.

Evenness:

All information-statistics indices are affected by both the number of species and their equitability or evenness. A higher number of species and a more even distribution both increase diversity. For any information-statistics index, the maximum diversity of a community is found when all species are equally abundant.

Community's actual diversity is measured by the formula:-

Evenness (E) = H / Hmax

E, is Constrained between 0 and 1.0.

Soil parameters:

Top 15 cm layer of soil samples were collected from upper surface and lower surface layers of forest floor. The samples were properly packed, air-dried, cleaned, crushed and then strained through 2 mm mesh sieves and analyzed. Such important parameters of the soil samples as pH, specific conductance, nitrogen, phosphorus and organic carbon were determined following standard methods as given in Black (1965), Piper (1950), Trivedy & Goel. (1992) and Jadav & Jogdan (1993).

RESULTS AND DISCUSSION

After taxonomic survey of the ground cover flora an analysis of the identified taxa was done, which reflects the dominance of dicotyledonous plants over those of monocots (Table 1). Incidentally no tree sapling/ seedling could be identified within the areas covered by the quadrats laid excepting that of *Acer campbellii*. The species diversity indices determined in the study sites is presented in Table 3.

Table 1. A synoptic account of the recorded forest flora

	Dicotyledons			Monocotyledons	
	Total	Total	Percentage	Total	Percentage
Families	28	23	82.14	5	17.85
Genera	46	42	91.30	4	8.69
Species	50	46	92.00	4	8.00

Table 2. Determination of IVI

[D = Density; A = Abundance; RF = Relative Frequency; RD = Relative Density; RA = Relative Abundance; IVI = Importance Value Index]

Plant Names	D	A	Frq. Class	RF	RD	RA	IVI
Fragaria nubicola	31.9	34.18	E	10.20	40.31	13.36	63.87
Gentiana pedicellata	5.3	14.45	B	4	6.69	5.65	16.34
Hemiphargma heterophyllum	0.23	2.33	A	1.09	0.29	0.91	2.29
Clinopodium umbrosum	6.5	11.47	C	6.2	8.21	4.48	18.89
Digitaria ciliaris	7.1	14.2	C	5.46	8.97	5.55	19.98
Galium mollugo	1.76	5.88	B	3.28	2.22	2.29	7.79
Rubus elipticus	0.1	1	A	1.09	0.12	0.39	1.6
Gnaphalium affine	2.1	5.72	B	4	2.65	2.23	8.88
Geranium nepalense	0.46	3.5	A	1.45	0.58	1.36	3.39
Stellaria sikimensis	2.46	6.72	B	4	3.10	2.62	9.72
Oxalis corniculata	1.66	6.25	B	2.91	2.09	2.44	7.44
Hydrocotyle nepalensis	0.2	3	A	0.72	0.25	1.17	2.14
Rumex nepalensis	2.1	12.6	A	1.82	2.65	4.92	9.39
Persicaria capitata	2.53	7.6	B	3.64	3.19	2.19	9.8
Swertia chirayita	0.2	2	A	1.09	0.25	0.78	2.12
Trifolium repens	1.56	15.66	A	1.09	1.97	6.12	9.18

Plant Names	D	A	Frq. Class	RF	RD	RA	IVI
Oenanthe thomsonii	0.83	5	A	1.82	1.04	1.95	4.81
Viola betonicifolia	1.03	3.44	B	3.28	1.30	1.34	5.92
Osbeckia stellta	1.43	4.3	B	3.64	1.80	1.68	7.12
Capsella bursapastoris	0.23	2.33	A	1.09	0.29	0.91	2.29
Hydrocotyle sibthopioides	0.6	2.25	B	2.91	0.75	0.87	4.53
Eupatorium adenophrum	0.1	1.5	A	0.72	0.12	0.58	1.42
Rubia wallichiana	0.46	4.66	A	1.09	0.58	1.82	3.49
Stellaria media	1.73	7.42	B	2.55	2.18	2.90	7.63
Persicaria runcinata	03	4.5	A	0.72	0.37	1.75	2.84
Pilea umbrosa	0.53	8	A	0.72	0.66	3.12	4.5
Urtica dioica	0.23	3.5	A	0.72	0.29	1.36	2.37
Impatiens urticifolia	0.03	1	A	0.36	0.03	0.39	0.78
Elsholtzia flava	0.66	3.33	A	2.18	0.83	1.30	4.31
Hydrocotyl himalaica	1.16	5	B	2.55	1.46	1.95	5.96
Commelina sikkimensis	0.13	2	A	0.72	0.16	0.78	1.66
Hypericum uralum	0.06	1	A	0.72	0.07	0.39	1.18
Ophiorrhiza nutans	0.06	2	A	0.36	0.75	0.78	1.89
Anaphalis triplinervis	0.33	5	A	0.72	041	1.95	3.08
Berberis insignis	0.03	1	A	0.36	0.03	0.39	0.78
Dichroa febrifuga	0.46	7	A	0.72	0.58	2.73	4.03
Acer campbellii	0.1	1.5	A	0.72	0.12	0.58	1.42
Plantago erosa	0.16	5	A	0.36	0.20	1.95	3.51
Pouzolzia hirta	0.33	5	A	0.72	0.41	1.95	3.08
Dioscorea bulbifera	0.03	1	A	0.36	0.03	0.39	0.70
Paris polyphylla	0.03	1	A	0.36	0.03	0.39	0.78
Isodon coetsa	0.5	5	A	1.09	0.63	1.95	3.67
Melissa axillaris	0.03	1	A	0.36	0.03	0.39	0.78
Sonchus arvensis	0.06	1	A	0.72	0.07	0.39	1.18
Lindenbergia grandifilora	0.26	2	A	1.45	0.32	0.78	2.55
Artemisia indica	0.43	3.25	A	1.45	0.54	1.27	3.26
Drymaria diandra	0.1	1.5	A	0.72	0.12	0.58	1.42
Gaultheria fragrentissima	0.26	4	A	0.72	0.32	1.56	2.6
Calceolaria mexicana	0.16	1.66	A	1.09	0.20	0.64	1.93
Crocosmia x crocosmiiflora	0.13	2	A	0.72	0.16	0.78	1.66

Table 3. Determination of Diversity Indices in the Forest Area

Plant Names	ni	$pi = \frac{ni}{N}$	Log ni	Shanon Index (Hs)	Bergar & Parker (DBP)	Evenness(E)
Fragaria nubicola	957	0.4022	2.98	-0.36	0.4022	120
Gentiana pedicellata	159	0.0668	2.20	-0.18	0.0668	60
Hemiphargma heterophyllum	7	0.0029	0.84	-0.016	0.0029	5.33
Clinopodium umbrosum	195	0.0819	2.29	-0.20	0.0819	66.66
Digitaria ciliaris	213	0.0895	2.32	-0.216	0.0895	72
Galium mollugo	53	0.0222	1.72	-0.084	0.0222	28
Rubus elipticus	3	0.0012	0.47	-0.008	0.0012	2.66
Gnaphalium affine	63	0.0264	1.79	-0.095	0.0264	31.66
Geranium nepalense	14	0.0058	1.14	-0.025	0.0058	9.66
Stellaria sikimensis	74	0.0311	1.86	-0.107	0.0311	35.66
Oxalis corniculata	50	0.0213	1.69	-0.08	0.0210	26.66
Hydrocotyle nepalensis	6	0.0025	0.77	-0.014	0.0025	4.66

Plant Names	ni	$pi = \frac{ni}{N}$	Log ni	Shanon Index (Hs)	Bergar & Parker (DBP)	Evenness(E)
Rumex nepalensis	63	0.0264	1.79	-0.09	0.0264	30
Persicaria capitata	76	0.0319	1.88	-0.10	0.0319	33.33
Swertia chirayita	6	0.0025	0.77	-0.014	0.0025	4.66
Trifolium repens	47	0.0197	1.67	-0.07	0.0197	23.33
Oenanthe thomsonii	25	0.0105	1.39	-0.04	0.0105	13.33
Viola betonicifolia	31	0.0130	1.49	-0.056	0.0130	18.66
Osbeckia stellta	43	0.0180	0.84	-0.072	0.0180	24
Capsella bursapastoris	7	0.0029	1.25	-0.016	0.0029	5.33
Hydrocotyle sibthopioides	18	0.0075	1.25	-0.036	0.0075	12
Eupatorium adenophrum	3	0.0012	0.47	-0.008	0.0012	2.66
Rubia wallichiana	14	0.0058	1.14	-0.029	0.0058	9.66
Stellaria media	52	0.0218	1.71	-0.08	0.0218	26.66
Persicaria runcinata	9	0.0037	0.95	-0.020	0.0037	6.66
Pilea umbrosa	16	0.0067	1.20	-0.033	0.0067	11
Urtica dioica	7	0.0029	0.84	-0.010	0.0029	3.33
Impatiens urticifolia	1	0.0004	0	-0.003	0.0004	1
Elsholtzia flava	20	0.0084	1.30	-0.04	0.0084	13.33
Hydrocotyl himalaica	35	0.0147	1.54	-0.06	0.0147	20
Commelina sikkimensis	4	0.0016	0.60	-0.01	0.0016	3.33
Hypericum uralum	2	0.0008	0.30	-0.005	0.0008	1.66
Ophiorrhiza nutans	2	0.0008	0.30	-0.005	0.0008	1.66
Anaphalis triplinervis	10	0.0042	1	-0.022	0.0042	7.33
Berberis insignis	1	0.0004	0	-0.003	0.0004	1
Dichroa febrifuga	14	0.0058	1.14	-0.02	0.0058	6.66
Acer campbellii	3	0.0012	0.47	-0.008	0.0012	2.66
Plantago erosa	5	0.0021	0.69	-0.01	0.0021	3.33
Pouzolzia hirta	10	0.0042	1	-0.02	0.0042	6.66
Dioscorea bulbifera	1	0.0004	0	-0.003	0.0004	1
Paris polyphylla	1	0.0004	0	-0.003	0.0004	1
Isodon coetsa	15	0.0063	1.17	-0.03	0.0063	10
Melissa axillaris	1	0.0004	0	-0.003	0.0004	1
Sonchus arvensis	2	0.0008	0.30	-0.005	0.0008	1.66
Lindenbergia grandifilora	8	0.0033	0.90	-0.018	0.0033	6
Artemisia indica	13	0.0054	1.11	-0.028	0.0054	9.33
Drymaria diandra	3	0.0012	0.47	-0.008	0.0012	2.66
Gaultheria fragrentissima	8	0.0033	0.90	-0.0018	0.0033	6
Calceolaria mexicana	5	0.0021	0.69	-0.012	0.0021	4
Crocosmia x crocosmiiflora	4	0.0016	0.60	-0.01	0.0016	3.33

DISCUSSION

Rio Earth Summit held in 1992 emphasized the need to conserve the biodiversity of the earth especially of the tropics. The meaning of conservation involves through understanding of the flora on the regional basis including those of the forests. Since, the presence of all life forms of plants is one of the characteristic features of forest and may form the bulk of the forest flora and have immense functional values, the present work keeps confined into taxonomic account of them.

The Senchal West Zone forest region deserves special mention for its rich floristic composition in one hand and the diversity of soil type on the other. It is evident from IVI scores (Table- 2) that the highest score belongs to the species *Fragaria nubicola*. The decreasing trend of IVI score was in the order of *Digitaria ciliaris, Clinopodium umbrosum* and *Gentiana pedicellata*. The highest IVI score by *Fragaria nubicola* reveals that the species was most dominant in that community and the Lowest IVI scores of *Impatiens urticifolia, Rabdosia coetsa* and *Dioscorea bulbifera* reflect as rare species of that community.

Figure I

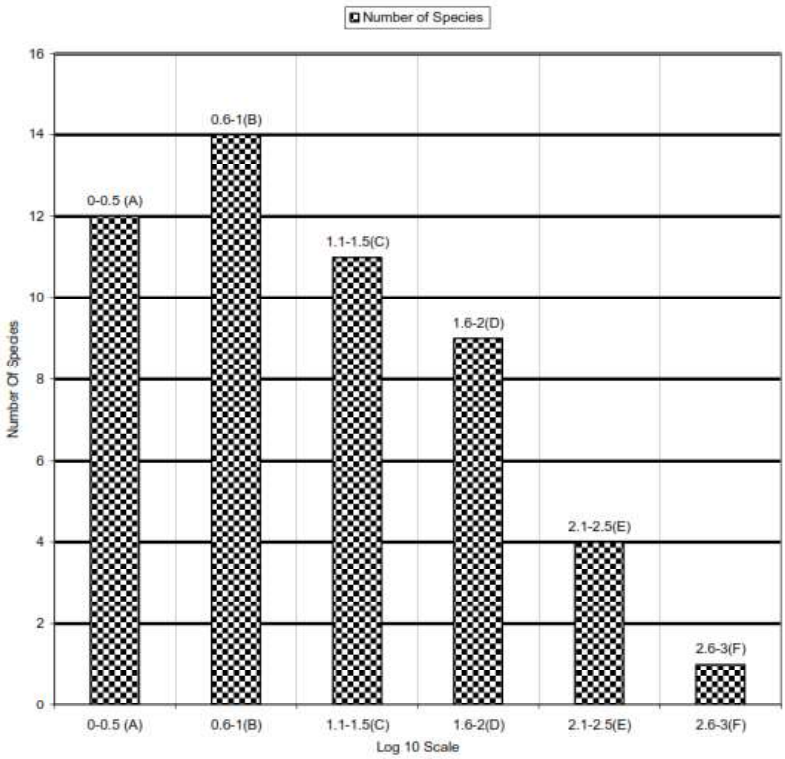

Table 3. Physico-chemical properties of soil

Pedon / Surface		P_H	Specific Conductance u.mhos.cm.	Nitrogen (g/kg)	Phosphorus (g/kg)	Organic Carbon	Carbon Nitrogen Ratio
PE DO N I	UPPER	6.84	248.85	0.39	3.02	2.69	11.87
	LOWER	8.24	156.45	0.15	2.82	2.28	26.2
PE DO N II	UPPER	7.03	194.25	0.16	2.94	2.51	27
	LOWER	6.89	178.5	0.12	1.80	2.28	32.75
PE DO N III	UPPER	6.74	285.6	0.34	2.96	2.45	12.41
	LOWER	6.76	181.65	0.11	1.72	2.18	34.09
PE DO N IV	UPPER	7.12	254.1	0.38	2.20	2.81	12.73
	LOWER	7.33	206.85	0.10	2.31	2.69	46.3
PE DO N V	UPPER	6.62	201.6	0.24	2.54	2.20	15.79
	LOWER	7.07	183.75	0.12	2.38	2.04	29.25
PE DO N VI	UPPER	6.85	175.35	0.19	2.18	2.18	19.73
	LOWER	7.02	96.6	0.10	2.01	2.32	39.9
PE DO N VII	UPPER	7.55	194.25	0.24	2.20	2.34	16.79
	LOWER	7.15	241.5	0.12	1.97	2.56	36.75
PE DO N VII I	UPPER	7.83	273	0.16	1.65	2.51	27
	LOWER	7.22	284.55	0.11	1.88	2.69	42.09
PE DO N XI	UPPER	8.00	238.35	0.08	1.73	2.38	51.25
	LOWER	7.23	136.5	0.12	1.36	2.85	40.91
PE DO N X	UPPER	7.61	254.1	0.06	1.38	2.1	60.33
	LOWER	7.11	179.55	0.16	1.42	2.37	25.5

Diversity is the index of the ratio between the number of species and the importance value of an individual. Shanon index value is highest in *Berberis insignis, Dioscorea bulbifera, Impatiens urticifolia* and lowest in *Fragaria nubicola, Gentiana pedicellata, Hemiphragma heterophylla* etc (Table 3).

The maximum value of DBP was found in case of *Fragaria nubicola* followed in decreasing order by *Clinopodium umbrosum, Digitaria ciliaris, Gentiana pedicellata* and so on. Thus, *Fragaria nubicola* is the most dominant species of the study area.

Dry matter accumulation and productivity of forests are influenced by the presence of nutrients in soils and their recycling. Nutrient element therefore limits forest productivity. Recycling of nutrients is one of the principal processes that supports organic matter production of forests. Thus, the functioning of a forest ecosystem in relation to dry matter production depends not only on the availability of nutrients but also on the pattern and rate of nutrient uptake by species occurring in the forest. Survival depends upon the availability of water. The type and age of the species is affected by climate, nutrient accumulation and the pattern of distribution in different plants. The major macronutrients limiting the production of a forest crop are N, P and K.

Data pertaining to the physicochemical characteristics of soil sample (Table 4) reveals that the highest pH value (8.24) is in Pedon-I in lower soil surface. This type of soil was collected from the substratum of *Fragaria nubicola*, and in the Pedon IX, the soil of upper surface had a pH of 8.00 where *Gallium mollugo* was present. The pH value of Pedon II, Pedon-V upper, Pedon-VI upper, Pedon III, were more or less similar being close to the neutral point. The soils became turned into alkaline in the Pedon IV, VII, VIII, IX, and X where *Digitaria ciliaris, Hydrocotyle sibthorpioides*, *Stellaria sikkimensis* and *Trifolium repens* occur respectively. On the other hand the lowest pH value was in the Pedon -III, Pedon-II lower and Pedon-I upper. The lowest pH under natural forest might be due to the acidifying effect of intense decomposition products of organic residues accumulated on the forest floor since remote past. The contents of exchangeable Ca^{++} were related to the pH of the soils and leaching of calcium under natural vegetation increased the acidity, particularly in the surface soil.

So far the specific conductance was concerned the maximum value (285.6) was observed in Pedon-III upper surface soil where the plant is *Clinopodium umbrosum.* It might be due to rapid mineralization of the decomposed material. The soil retains its minerals under the prevailing environmental condition and the overtopping vegetation has a major impact on the soil nutrient capacity. The least or minimum value were observed in the Pedon-VI, the prevailing vegetation were very thin. It might be due to low mineral content of that site.

The value of total Nitrogen was at the peak in Pedon-I. Interestingly specific conductance was also high in that Pedon. The minimum value was observed in Pedon X upper surface soil since its mineral concentration was relatively lower. A good correlation can be deduced from the observed result that where more electrolytes present, the nitrogen concentration was interestingly high.

The phosphorus concentration was maximum in Pedon-I. Concentration of electrolytes was also at the peak in Pedon-I comparison with other Pedons. From the observed result it was evident that in Pedon-I mineralization or decomposed material were more pronounced. The minimum value was observed in Pedon-IX and X.

The values of organic carbon were also at peak in Pedon-IV i.e. the soil under the plant *Digitaria ciliaris* and the minimum value was in Pedon-X i.e. under soil of *Trifolium repens*. There was an increasing trend of this parameter in Pedon-II, III, IV, and V.

The ratio of carbon and nitrogen were also measured (Table 4). Maximum C/N ratio (60.33) was noted in case of Pedon-X (upper soil surface) and minimum in Pedon-III, the value being 12.41. The intermediate values were observed in other Pedons.

The organic carbon content of the surface and subsurface soils is very high which decreases uniformly down the profile CEC showing linear relationship with the organic carbon content of soils. Values of pH show that the surface horizon has lower pH in most of the cases and it increases gradually down the profile. The high level of organic matter present in the soil is in the highly humified form produced during humification process.

It was found that *Fragaria nubicola* was most dominant species of that locality. The soil that was collected from surface and subsurface under *Fragaria nubicola* plant i.e. the soil of Pedon-I was highly acidic, well drained and rich in organic matter with very low base saturation. The colour of the dry surface soil is very pale brown and that of moist one is dark yellowish brown.

It may be inferred that acidity of soil was highest in Pedon-V upper surface soil and more alkalinity were observed under the soil of Pedon-I, lower surface. Lower acidity may be attributed to differential recycling of elements. Total nitrogen; total phosphorus and organic carbon were more pronounced in Pedon-V. This situation could perhaps be due to the exchange sites of these clay humus complexes with organic matter and high contents of mobile salts.

Most plants from low nutrient sites are low nutrient requiring plants growing on nutritionally deficient sites. These plants minimize nutrient loss by translocating a greater fraction of N and P from senescing leaves. Unscientific thinning and harvesting of trees not only degraded forest but also removed nutrients from the ecosystem. The amounts of nutrients taken up depend on the demand of the plant species and on the availability of nutrients in the soil to meet-up the demand. Thus, dry matter production is generally based on the fertility of the soil and on extra inputs provided by the management.

The differential responses of the different pedons of the forest areas under study to different parameters are possibly an outcome of their unique abiotic composition, the interactions between biotic and abiotic components and between themselves and the prevailing climatic conditions. This information can be used in future for laying out schemes optimization of forest ecosystems.

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