Forest Stand Structure of Shiwalik region of Nainital district along an Altitudinal Gradient in Indian Central Himalaya

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Abstract: The present investigation concentrates on variations of plant species diversity in three forest types in the same aspect. A pure Sal (*Shorea robusta* Gaertn.F.) forest located in foothills of Shiwaliks compares the variations in diversity with increasing altitude with Sal mixed with other broad leaved forest (800-1100m) and with its end limit (1100-1500m) when it mixes with Chir pine (*Pinus roxburghii* Sarg.). Total tree species diversity (SD) was maximum in middle elevation (4.33) while, it was minimum (1.96) in lower elevation. For shrub layer, it was maximum (3.97) at higher elevation and minimum (2.55) at lower elevation. It was found maximum (4.91) in higher elevation and minimum (4.56) at lower elevation for herbaceous growth. The tree species richness (SR) was found maximum (32) in Sal mixed with broad leaved forest while, it was minimum (7) in lower site (i.e, pure Sal forest). In case of shrubs, species richness was maximum (21) in higher altitude followed by middle (10) & lower sites (09). Herbaceous species richness was recorded maximum (50) in lower elevation while it was minimum (46) in higher elevation. The concentration of dominance (CD) was comparatively higher in pure Sal forests rather than others for tree (0.35) and shrub (0.23) layer while, it was more or less same (0.01) for herbs in all three forest types.
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Key words: Altitude, Concentration of dominance, Herbaceous, Shiwalik, Species diversity, Species richness.

1. Introduction

The Shiwalik of Kumaun region in Uttarakhand forms a very fragile and complex Himalayan ecosystem where topography, availability of resources and land use pattern differ greatly while compared to the other parts of the Indian Central Himalayas. Presently, the Shiwalik forests of Kumaun are degrading because of incessant pressure of fodder and fuel wood which is unscientific and excessive. In the present study, three forest types were taken pure Sal (500-800 m) (*Shorea robusta* Gaertn. F.), Sal mixed with broad leaved forests (800-1100 m) and Sal-pine (*Pinus roxburghii* Sarg.) mixed (1100-1500 m).

Sal and its associates generally forms pure forest mixed with the under canopy tree species i.e, *Mallotus philippinensis* in the lower range. In the middle range, it intermixed with *Terminalia* species, *Anogeissus latifolia, Adina cordifolia, Terminalia bellirica, Mallotus philippinensis, Emblica officinalis, Cassia fistula* and some other under canopy species. Towards the extreme upper limits (1100-1500 m) it mixes with chir pine.

Biodiversity can be considered as the biological capital of world. In the heart of ecological research and related conservation/management aspects, biodiversity gains significance since all types of organisms existing in nature and important both from scientific and technical point of view. Species composition of major forest types of Indian Central Himalaya is described by Saxena and Singh 1982, Bankoti et al. 1992, Tewari and Singh 1985, Rawal and others 1994, Rawal and Pangtey 1994a, b), Rikhari and others 1989, Rana and others 1989, Chaturvedi and Singh 1987a, b and Rawat and Singh 1988. Singh et al. (1994) have made detailed studies on biomass productivity, leaf longevity and forest structure from low elevation to high altitude forests of Indian Central Himalaya. The present study comprises variations in plant bio-diversity, vegetation composition and regeneration pattern along an altitudinal gradient in three forests namely pure Sal, Sal mixed with broad leaved and Sal-chir pine forest occurring between 500-1500 m elevations.

2. Material and Methods

Study area is located between 29^0 17' 39" to 29^0 30' 40" N latitude and 79^0 9' 13" to 79^0 26' 24" E longitude between 500-1500 m elevation in the Shiwalik ranges of Kumaun Himalaya where Sal and chir-pine found in lower and upper parts, respectively

and Sal mixed broad leaved forest in the middle region.

For the detailed study of plant diversity and other vegetational parameters, the area was divided into three sites. All three sites selected were on decreasing elevation on eastern aspects (Mangoli, Ghatgarh and Kaladhungi).

Climate of the study area is influenced by sub-tropical monsoon pattern of rainfall. Of the total 2076 mm rainfall, nearly more than three fourth occurs between mid-June to mid September. The mean daily temperature ranges from 13.1^{0}C in January to 32.0 ^{0}C in June. The year is divisible into three distinct seasons: (i) dry and warm summer season (mid March to mid June), (ii) wet and warm rainy season (mid June to mid September) and (iii) dry and cold winter season (October to February) with frequent frost. As far as the geology of Shiwalik Himalaya is concerned the rocks are relatively very young. They consist of sandstones conglomerate beds, quartzite and more or less unconsolidated segments made up of cobbles, shingles pebbles, gravels and boulders. The Shiwalik rocks are usually in contact with the sediments of the Indo-Gangetic plain along prominent fault zones.

The study was conducted during the year 2004-2005. From each sites, the composite soil samples were collected from 0-10 cm, 10-20 cm and 20-30 cm depths with the help of a soil corer, packed in polythene bags and brought to the laboratory for physical analysis. From each site nine samples were collected that is three samples from each depth class. Moisture content was determined on fresh weight basis in each season that is rainy, winters and summers. Soil texture was determined using the sieves of different size classes.

Vegetational analysis was made for all the three layers of the forest that is trees, shrubs and herbs. For the identification of plants, a plant taxonomist and by Osmaston 1926 and Collet 1971 were consulted. The sampling was made by using quadrats of 10 m x 10 m size. The size and number of samples was determined following Saxena and Singh 1982. Ten quadrats were placed randomly in each site for the analysis of trees, saplings and seedlings. The vegetational data were quantitatively analyzed for density, abundance and frequency (Curtis and McIntosh 1950). The values of Importance index (IVI) for the trees, shrubs and saplings were determined as a sum of the relative frequency, relative density and relative dominance (Curtis 1959). The distribution pattern of different species was studied using the ratio of abundance to frequency (Whitford 1949). Trees were considered to be individuals >30 cm circumference at breast height (cbh), saplings 10-30 cm cbh and seedlings <10 cm cbh (Saxena and others 1984 and Misra 1968). The shrub layer was analyzed by sampling ten quadrats of 5 m x 5 m randomly on each site. The circumference of shrubs was measured at 10 cm above ground level. The herbs were analyzed by placing ten quadrats of 1 m x 1 m randomly on each site during rainy season (peak growth period). The diversity index for all the three layers at each site was computed using Shannon-Wiener Information Index (Shannon-Wiener 1963) and concentration of dominance was computed by Simpson's index (Simpson 1949).

3. Results

Forest soil

There was a little variation in sand, silt and clay per cent on the studied sites. Per cent sand ranged from 32.98 to 48.25, silt 39.98 to 58.49 and clay 3.74 to 12.91. The bulk density ranged from 1.14 to 1.99 g cm^{-3} and it was comparatively higher in the higher elevation. Soil porosity varied from 25.34 to 56.11 and the higher values were observed on the lower elevation. Soil moisture content (MC %) was higher on the lower elevation in all the seasons. It varied from 13.40 to 21.16 % in rainy season within the study sites. During winters the MC ranged from 11.17 to 12.96% and during summers it was from 6.60 to 11.56%. The water holding capacity was comparatively higher on the lower elevation and varied from 37.85 to 50.58 % across the study sites (Table 1).

Plant diversity

A total of 169 species of plants were identified across all the study sites, out of which 39 were trees, 27 shrubs and 103 herbs.

I) Trees

The total density was higher (820 trees ha^{-1}) in middle elevation as compared to 600 trees ha^{-1} in higher elevation. A lowest tree density of 550 trees ha^{-1} was in lower elevation. The mean basal area (MBA) ranged between 107.66 cm^{-2} tree^{-1} to 3846.50 cm^{-2} tree^{-1}. Maximum total basal area (TBA) 44.04 m^2 /ha was in the middle elevation followed by 38.05 m^2/ha in higher elevation, while it was minimum (32.08m^2 /ha) in lower elevation. *S. robusta (*IVI of 77.96-166.40) was the dominant species in middle elevation and lower elevation respectively. *Pinus roxburghii* with an IVI of 109.43 was the most dominant species in higher elevation. The least dominant tree species were *S.oleosa, C.fistula and P.barbata* with an IVI of 11.52, 3.04 and 5.15 in lower elevation, middle elevation and higher elevation respectively (Table 2). The species diversity for the tree species were 3.37, 4.33 and 1.96 in higher elevation, middle elevation and lower elevation respectively (Table 7).

II) Saplings

The total sapling density was reported highest in middle elevation (530 inds/ha) as compared to 490 and 390 inds/ha in higher elevation and lower elevation respectively. The total basal area for saplings was maximum in both higher and middle elevation with 1.42 m^2 /ha as compared to 1.26 m^2 /ha in lower elevation.*Shorea robusta* was the dominant sapling in middle elevation and lower elevation with an IVI of 136.23 and 164.32 respectively. *P.roxburghii* with an IVI of 102.60 was the most dominant sapling in higher elevation. The least dominant saplings in middle, lower and higher elevations were *B.latifolia, M.phillippensis* and *S.insigni* with an IVI of 6.77, 59.41 and 6.7 respectively (Table 3). The sapling diversity was 1.42, 2.58 and 2.94 in lower, middle and higher elevation respectively (Table 7).

III) Seedlings

The total seedling density varied from 970 to 1800 inds /ha across the sites. It was reported maximum (1800 inds/ha) in middle elevation followed by 1600 inds/ha in lower elevation, whereas the minimum (970 inds/ha) in higher elevation. In all three elevations the maximum individual density and frequency was reported for S.robusta (390 & 50, 930 & 100 and 1210 & 100) respectively.

IV) Shrubs

The total shrub density varied from 2,600 inds/ha to 5,200 inds/ha in the present study sites. The total shrub density was comparatively higher (2,600 inds/ha) in higher elevation as compared to 3,360 inds/ha in lower elevation. It was reported minimum (2,600 inds/ha) in lower elevation. The total number of shrubs reported in the present study was 21, 10, and 9 in higher, middle and lower elevations respectively. *E. adenoforum* with an IVI of 47.18 was the most dominant species in higher elevation, while in lower and middle elevation *L.camara* with an IVI of 122.06 & 79.91 was the most dominating shrub. The least ones were *I.cappa, X.alatum* and *M.koenghii* in middle, higher and lower elevation with an IVI of 5.25, 3.04 and 12.24 respectively (Table 4). The species diversity of shrubs varied from 2.55 to 3.97. It was maximum (3.97) in higher elevation followed by middle elevation (2.36). The minimum diversity (2.02) was reported in lower elevation (Table 7).

V) Herbs

The total herb density was maximum (8, 45,000) in higher elevation followed by (4, 99,000) in middle elevational and minimum (3, 91,000 /ha) in lower elevation. The most dominant herb was *J.simplex* with a density of 1, 04,000 inds /ha in higher elevation. *C.gryllus* with a density of 69,000 inds /ha was the most dominant herb in middle elevation and *A. connyzoides* with a density of 58,000 inds/ha was the most dominant herb in lower elevation. A 100% frequency was reported for *C.gryllus* in higher elevation, 80% for *T.roehlensum* in middle elevation and 90%for *L. camara* in lower elevation (Table 6).

Species diversity

The species richness (SR), species diversity (SD) and concentration of dominance (CD) of different vegetational layers are given in Table 7. For tree layers the SR was17, 32 and 7 in higher, middle while the SD was maximum in middle elevation (4.33) and minimum (1.96) in lower elevation. The SR was maximum (50) in lower and minimum (46) in higher elevation for herbs. The SD was maximum (4.91) in higher elevation and minimum (4.56) in lower elevation for herbs. The CD for tree layers was greater (0.35) in lower elevation as compared to the higher (0.16) and middle elevation (0.09). The CD for shrubs varied from 0.07 (higher elevation) to 0.23(lower elevation) while, for herbs it was same (0.01) in all the sites (Table 7).

Regeneration

The seedling density was recorded minimum for *P.barbata* (10 inds/ha) and maximum for *S. robusta* (520 inds /ha) across the sites. The seedlings of *S.robusta* and *S. cumini* were present in all the sites. *E.officinalis* and *Cassia fistula* seedlings were present in the middle elevation only whereas, *M.phillippensis* seedlings were present in the middle and lower elevation. Seedlings of *P.roxburghii, P.pashia* and *A.lebbeck* were present in higher elevation only. The regeneration of *A.marmelos, E.officinalis* and *P.barbata* were restricted in the middle elevation.

Table 1. Different sites of Shiwalik forests of Kumaun Himalaya.

Site	Forest Types	Elevation(m)	Aspect	Dominant species
1.	Sal dominant foothill forest	500-800	NE	S.robusta, S.cumini
2.	Sal mixed broad leaved	800-1100	NE	S.robusta, S.cumini
3.	Sal mixed pine forest	1100-1500	NE	P.roxburghii, S.robusta

Table 2. Physical properties of Soil (0-30 cm depths) in different sites of Shiwalik forests of Kumaun Himalaya.

S.No	Soil parameters	Soil depth class (cm.)	Forest sites Higher elevation (1100-1500m)	Middle elevation (800-1100m)	Lower elevation (500-800m)
	Soil moisture content (%)				
I	Winters	0-10	11.99±0.31	12.14±0.39	12.28±0.28
		10-20	11.47±0.13	11.80±0.03	11.89±0.23
		20-30	11.17±0.16	11.45±0.34	11.93±0.40
Ii	Summers	0-10	6.60-0.09	7.11-0.21	9.09-0.58
		10-20	6.68-0.62	7.41-0.23	10.15-0.85
		20-30	7.18-0.65	8.26-0.0.16	11.56±0.58
Iii	Rainy	0-10	18.85±0.36	20.12±0.36	21.16±0.11
		10-20	14.17±1.11	17.62±0.27	18.77±0.29
		20-30	13.40±0.84	16.29±0.41	17.85±0.18
2	Soil texture (%)				
i	Sand	0-10	45.54±3.20	32.58±0.44	43.46±3.32
		10-20	42.95±4.03	34.84±1.09	41.18±2.72
		20-30	42.74±7.43	35.70±1.89	48.25±0.80
ii	Silt	0-10	52.92±2.77	58.49±1.62	43.72±2.93
		10-20	50.38±6.23	57.70±2.10	46.17±4.76
		20-30	52.47±4.44	57.15±1.15	39.98±0.67
iii	Clay	0-10	3.74±0.46	4.65±0.59	12.91±3.41
		10-20	3.95±0.51	4.80±0.75	9.01±1.20
		20-30	4.79±0.43	4.25±0.15	7.88±0.68
3	Water holding capacity (%)	0-10	48.82±1.58	47.82±1.17	50.58±0.46
		10-20	43.35±1.27	43.17±1.96	47.16±0.93
		20-30	37.85±1.45	38.01±2.27	44.02±1.74
4	Bulk density (g cm-3)	0-10	1.21±0.18	1.26±0.13	1.14±0.06
		10-20	1.68±0.14	1.42±0.11	1.35±0.12
		20-30	1.99±0.04	1.83±0.20	1.61±0.13
5	Porosity (%)	0-10	53.89±2.61	47.45±3.99	56.11±0.83
		10-20	37.58±5.95	41.37±6.33	52.02±0.55
		20-30	25.34±2.64	32.64±6.54	49.80±1.48

Table 3. Vegetational parameters for Trees in Shiwalik forest of Kumaun Himalaya along the altitudinal gradient.

S.No.	Name of species	Higher elevation (1100-1500m)				Middle elevation (800-1100m)				Lower elevation (500-800m)			
		D (ha-1)	MBA (cm2 ind-1)	TBA (m2 ha-1)	IVI	D (ha-1)	MBA (cm2 ind-1)	TBA (m2 ha-1)	IVI	D (ha-1)	MBA (cm2 ind-1)	TBA (m2 ha-1)	IVI
1	Acer oblangum	20	2163.65	4.32	20.76	-	-	-	-	-	-	-	-
2	Adina cordifolia	-	-	-	-	20	415.26	0.83	6.06	10	961.62	0.96	13.89
3	Aegle marmelos	-	-	-	-	10	153.86	0.15	3.30	-	-	-	-
4	Albizzia lebbeck	20	510.44	1.02	12.07	-	-	-	-	-	-	-	-
5	Albizzia procera	-	-	-	-	20	754.38	1.50	9.35	-	-	-	-
6	Alnus nepalensis	20	803.84	1.60	10.58	-	-	-	-	-	-	-	-
7	Bahunia perpuria	-	-	-	-	10	2041.78	2.04	7.59	-	-	-	-
8	Boehmeria regulosa	20	122.65	0.24	7.00	10	314.00	0.31	3.67	-	-	-	-
9	Buchanania latifolia	-	-	-	-	20	1256.00	2.51	11.63	-	-	-	-
10	Casearia graveolens	-	-	-	-	10	615.44	0.61	4.35	-	-	-	-
11	Cassia fistula	-	-	-	-	10	379.94	0.03	3.04	-	-	-	-
12	Deploknema butyracea	-	-	-	-	20	1045.81	2.09	8.92	-	-	-	-
13	Emblica officinalis	20	254.34	0.50	7.69	40	188.59	0.75	11.84	-	-	-	-
14	Engelhardtia colebrookiana	20	989.29	1.97	11.55	-	-	-	-	-	-	-	-
15	Eugenia frondosa	10	706.50	0.70	6.54	-	-	-	-	-	-	-	-
16	Ficus cunia	-	-	-	-	10	490.62	0.49	4.07	-	-	-	-
17	Ficus cuniata	-	-	-	-	20	153.86	0.30	6.62	-	-	-	-
18	Ficus regligiosa	-	-	-	-	10	706.50	0.70	4.56	-	-	-	-
19	Glochidion velutinum	-	-	-	-	10	254.34	0.25	3.53	-	-	-	-
20	Grewia hainesiana	-	-	-	-	20	254.34	0.50	7.08	-	-	-	-
21	Lagerstromia parviflora	-	-	-	-	10	1589.62	1.58	6.56	-	-	-	-
22	Mallotus philippinensis	-	-	-	-	10	314.00	0.31	3.67	20	329.89	0.65	23.86
23	Mangifera indica	-	-	-	-	20	660.18	0.66	4.45	-	-	-	-
24	Myrica esculanta	20	754.38	1.50	13.35	-	-	-	-	-	-	-	-
25	Olea glandulifera	-	-	-	-	10	907.46	0.90	5.02	-	-	-	-
26	Ougeinia oogeinensis	-	-	-	-	30	586.33	1.75	11.14	-	-	-	-
27	Phoenix humilis	-	-	-	-	20	226.86	0.45	521	-	-	-	-
28	Pinus roxburghii	260	657.00	17.08	109.43	10	254.34	0.25	3.53	-	-	-	-
29	Premna barbata	10	176.62	0.17	5.15	10	176.62	0.17	3.36	-	-	-	-
30	Pyrus pashia	20	490.62	0.98	11.96	-	-	-	-	-	-	-	-
31	Sapium insigne	20	415.26	0.83	11.57	10	94.98	0.09	3.17	-	-	-	-
32	Schleichera oliosa	-	-	-	-	10	803.84	0.80	4.78	10	200.96	0.20	11.52
33	Semecarpus anacardium	-	-	-	-	10	200.96	0.20	3.41	10	754.38	0.75	13.25
34	Shorea robusta	50	735.04	3.67	30.10	270	277.37	12.88	77.96	440	563.81	24.80	166.4
35	Syzygium cumini	40	371.35	1.48	19.65	50	326.68	1.63	16.8	40	466.20	1.86	49.44
36	Terminalia belerica	-	-	-	-	10	3846.50	3.84	11.69	-	-	-	-
37	Terminalia chebula	10	530.66	0.53	6.08	20	1256.00	2.51	11.63	-	-	-	-
38	Terminalia tomentosa	20	240.40	0.48	7.62	80	107.66	0.86	23.98	20	1417.90	2.83	21.55
39	Toona ciliate	20	452.16	0.90	8.73	10	1962.50	1.96	7.41	-	-	-	-
Total		600		38.05	299.83	820		44.04	299.53	550		32.08	299.91

D=density, MBA=mean basal area, TBA=total basal area, IVI=Importance value index

Table 4. Vegetational parameters for Saplings in Shiwalik forest of Kumaun Himalaya along the altitudinal gradient.

S.No.	Name of species	Higher elevation (1100-1500m)				Middle elevation (800-1100m)				Lower elevation (500-800m)			
		D (ha-1)	MBA (cm2 ind-1)	TBA (m2 ha-1)	IVI	D (ha-1)	MBA (cm2 ind-1)	TBA (m2 ha-1)	IVI	D (ha-1)	MBA (cm2 ind-1)	TBA (m2 ha-1)	IVI
1	Boehmeria regulosa	10	16.61	0.01	7.04	-	-	-	-	-	-	-	-
2	Bombax ceiba	10	50.24	0.05	9.40	-	-	-	-	-	-	-	-
3	Buchnania latifolia	30	19.62	0.05	13.79	10	16.61	0.01	6.77	-	-	-	-
4	Cassaria tomentosa	30	60.82	0.05	13.20	-	-	-	-	-	-	-	-
5	Cassia fistula	-	-	-	-	30	44.15	0.13	22.53	-	-	-	-
6	Deploknema butyracea	-	-	-	-	10	38.46	0.03	8.30	-	-	-	-
7	Ehretria arborescens	20	19.23	0.03	10.46	-	-	-	-	-	-	-	-
8	Emblica officinalis	-	-	-	-	20	60.10	0.12	16.07	-	-	-	-
9	Lagerstromia parviflora	-	-	-	-	20	15.89	0.03	9.87	-	-	-	-
10	Mallotus philippinensis	-	-	-	-	70	21.88	0.15	46.42	50	22.89	0.11	59.41
11	Myrica esculanta	30	16.61	0.04	13.15	-	-	-	-	-	-	-	-
12	Pinus roxburghii	150	47.75	0.71	102.60	-	-	-	-	-	-	-	-
13	Pyrus pashia	30	17.78	0.05	13.40	10	50.24	0.05	9.12	-	-	-	-
14	Sapium insigne	10	12.56	0.01	6.7	-	-	-	-	-	-	-	-
15	Semecarpus anacardium	-	-	-	-	40	22.89	0.09	25.28	-	-	-	-
16	Shorea robusta	120	20.65	0.24	60.04	250	28.26	0.70	136.23	280	36.29	1.01	164.32
17	Syzygium cumini	70	15.47	0.10	40.80	30	28.82	0.08	13.31	60	22.97	0.13	76.24
18	Terminelia tomentosa	20	10.74	0.02	9.27	-	-	-	-	-	-	-	-
Total		490		1.42	299.90	530		1.42	299.90	390		1.26	299.97

D=density, MBA=mean basal area, TBA=total basal area, IVI=Importance value index

Table 5. Vegetational parameters for Shrubs in Shiwalik forest of Kumaun Himalaya along the altitudinal gradient.

S.No.	Name of species	Higher elevation (1100-1500m)				Middle elevation (800-1100m)				Lower elevation (500-800m)			
		D (ha-1)	MBA (cm2 ind-1)	TBA (m2 ha-1)	IVI	D (ha-1)	MBA (cm2 ind-1)	TBA (m2 ha-1)	IVI	D (ha-1)	MBA (cm2 ind-1)	TBA (m2 ha-1)	IVI
1	Aechmenthera gossypina	240	0.26	0.006	9.20	400	0.09	0.003	21.14	-	-	-	-
2	Ardisia solanacea	-	-	-	-	-	-	-	-	160	2.06	0.032	18.63
3	Berberis asiatica	40	1.76	0.006	3.38	-	-	-	-	-	-	-	-
4	Boehmeria scabrella	200	0.03	0.001	8.05	-	-	-	-	-	-	-	-
5	Caryoptris fragrans	120	1.13	0.013	5.47	-	-	-	-	-	-	-	-
6	Cassia floribunda	240	13.58	0.005	34.76	-	-	-	-	-	-	-	-
7	Clerodendron viscosum	-	-	-	-	-	-	-	-	680	0.86	0.058	65.93
8	Cocculus laureifolius	200	2.37	0.047	9.95	-	-	-	-	-	-	-	-
9	Coriaria nepalensis	120	3.14	0.037	7.58	-	-	-	-	-	-	-	-
10	Desmodium pulchellum	120	0.22	0.002	6.58	80	0.63	0.004	6.36	120	0.19	0.002	13.11
11	Eupatorium adenophorum	1440	0.42	0.060	47.18	120	0.34	0.004	7.35	-	-	-	-
12	Flacortia indica	-	-	-	-	-	-	-	-	120	3.66	0.043	19.08
13	Flamengia bracteata	-	-	-	-	160	0.15	0.06	10.91	-	-	-	-
14	Fluggea microcarpa	200	0.91	0.018	9.47	-	-	-	-	-	-	-	-
15	Inula cappa	200	0.26	0.005	8.36	80	0.09	0.004	5.25	160	0.10	0.001	12.89
16	Jasminus dispermum	80	0.86	0.006	4.15	-	-	-	-	-	-	-	-
17	Lantana camara	440	1.56	0.068	26.60	760	1.83	0.138	79.91	1000	3.14	0.314	122.06
18	Lawsonia inemis	120	2.26	0.026	8.69	-	-	-	-	-	-	-	-
19	Maesa indica	440	2.26	0.099	27.22	640	1.69	0.108	65.78	-			
20	Martynia annua	280	1.13	0.031	14.22	-	-	-	-	-	-	-	-
21	Muraya Koenigii	120	4.90	0.058	13.49	560	1.00	0.056	50.25	80	1.88	0.014	12.24
22	Osbeckia stellata	80	0.33	0.002	3.77	-	-	-	-	-	-	-	-
23	Pogostemone	-	-	-	-	120	0.45	0.13	7.65	160	2.74	0.043	20.62

	banglensis												
24	Pyracantha cranulata	-	-	-	-	-	-	-	-	-	-	-	-
25	Rubus ellipticus	320	1.24	0.039	17.72	-	-	-	-	-	-	-	-
26	Woodfordia fruticosa	160	18.61	0.297	30.80	440	1.65	0.072	45.27	80	3.97	0.031	15.33
27	Zanthoxylum alatum	40	0.78	0.002	3.04	-	-	-	-	-	-	-	-
Total		5200		0.828	299.68	3360		0.579	299.87	2600		0.543	299.89

D=density, MBA=mean basal area, TBA=total basal area, IVI=Importance value index

Table 6. Vegetational parameters for Seedlings in Shiwalik forest of Kumaun Himalaya along the altitudinal gradient.

S.No.	Name of species	Higher elevation (1100-1500m)				Middle elevation (800-1100m)				Lower elevation (500-800m)			
		D (100 m-2)	F (%)	A	A/F	D (100 m-2)	F (%)	A	A/F	D (100 m-2)	F (%)	A	A/F
1	Acer oblangum	0.2	10	2.0	0.20	-	-	-	-	-	-	-	-
2	Agle marmelos	-	-	-	-	1.2	20	6.0	0.30	-	-	-	-
3	Albizia lebbeck	0.3	10	3.0	0.30	-	-	-	-	-	-	-	-
4	Cassia fistula	-	-	-	-	0.5	20	2.5	0.12	-	-	-	-
5	Elacodendron glaucum	-	-	-	-	0.1	10	1.0	0.10	-	-	-	-
6	Emblica officinalis	-	-	-	-	0.2	20	1.0	0.05	-	-	-	-
7	Glochdion velutinum	-	-	-	-	0.4	20	2.0	0.10	-	-	-	-
8	Mallotus philippinensis	-	-	-	-	2.8	50	2.8	0.05	1.8	40	4.5	0.11
9	Ougeinia oogenesis	-	-	-	-	0.3	20	1.5	0.07	-	-	-	-
10	Pinus roxburghii	3.4	50	6.8	0.13	-	-	-	-	-	-	-	-
11	Premna barbeta	-	-	-	-	0.1	10	1.0	0.10	-	-	-	-
12	Pyrus pashia	0.4	10	4.0	0.40					-	-	-	-
13	Schleichea oliosa	-	-	-	-	-	-	-	-	0.8	30	2.66	0.08
14	Semecarpus anacardium	-	-	-	-	-	-	-	-	0.3	20	1.5	0.07
15	Shorea robusta	3.9	50	7.8	0.15	9.3	100	9.3	0.09	12.1	100	12.1	0.12
16	Sygyzium cumini	1.2	20	6.0	0.30	2.6	50	2.6	0.05	1.0	60	1.66	0.02
17	Terminalia tomentosa	0.3	10	3.0	0.30	0.5	20	2.5	0.12	-	-	-	-
Total		9.7				18				16			

D=density, F=frequency, A=abundance

Table 7. Vegetational parameters for Herbs in Shiwalik forest of Kumaun Himalaya along the altitudinal gradient.

S.No.	Name of species	Higher elevation (1100-1500m)				Middle elevation (800-1100m)				Lower elevation (500-800m)			
		D (m-2)	F (%)	A	A/F	D (m-2)	F (%)	A	A/F	D (m-2)	F (%)	A	A/F
1	Acyranthus spesies	-	-	-	-	-	-	-	-	0.1	10	1.00	0.10
2	Abrus fruticosa	-	-	-	-	-	-	-	-	0.3	10	3.00	0.30
3	Acyranthus aspera	-	-	-	-	0.4	10	4.00	0.40	-	-	-	-
4	Aeginetia indica	-	-	-	-	-	-	-	-	1.0	10	10.00	1.00
5	Ageratum conyzoides	6.0	80	7.50	0.09	-	-	-	-	-	-	-	-
6	Ageratum conyzoides	-	-	-	-	-	-	-	-	5.8	80	7.25	0.90
7	Ainsliacea latifolia	-	-	-	-	0.3	20	1.50	0.07	-	-	-	-
8	Ajuga parviflora	0.9	50	1.80	0.03	-	-	-	-				
9	Anaphalis contorta	1.0	50	2.00	0.04	-	-	-	-	-	-	-	-
10	Anaphilis busua	0.9	40	2.25	0.05	-	-	-	-	-	-	-	-
11	Apluda mutica	0.7	30	2.33	0.07	-	-	-	-	0.5	20	2.50	0.12
12	Aresaema tartolum	-	-	-	-	-	-	-	-	0.1	10	1.00	0.10
13	Arthroxon lanceolatus	-	-	-	-	3.6	70	5.14	0.07	0.9	40	2.25	0.05
14	Arthroxon priomnoides	0.4	10	4.00	0.40	-	-	-	-	-	-	-	-
15	Arundinenella nepalensis	-	-	-	-	-	-	-	-	3.2	30	10.66	0.35
16	Barleria cristata	1.2	40	3.00	0.07	0.2	20	1.00	0.05	0.7	30	2.33	0.07
17	Biden biternata	1.5	30	5.00	0.16	-	-	-	-	0.2	10	2.00	0.20

18	Bidens pilosa	1.0	50	2.00	0.04	-	-	-	-	0.2	10	2.00	0.20
19	Boehmeria diffusa	-	-	-	-	-	-	-	-	0.1	10	1.00	0.10
20	Capillipedium parviflorum	0.6	30	2.00	0.06	0.6	30	2.00	0.06	-	-	-	-
21	Carex crucida	-	-	-	-	3.2	10	32.00	3.20	0.6	20	3.00	0.15
22	Carex spp	-	-	-	-	-	-	-	-	0.2	10	2.00	0.20
23	Cassia saemosoides	3.6	70	5.14	0.07	-	-	-	-	-	-	-	-
24	Cavex nubigena	0.4	10	4.00	0.40	-	-	-	-	-	-	-	-
25	Cerestium vulgatum	-	-	-	-	0.6	10	6.00	0.60	-	-	-	-
26	Chlorophytum tuberosum	0.5	30	1.66	0.05	0.2	10	2.00					
27	Chrysopogon gryllus	6.6	100	6.60	0.06	6.9	80	8.62	0.10	-	-	-	-
28	Cirsium arvensis	-	-	-	-	-	-	-	-	0.2	10	2.00	0.20
29	Cissampelos pareira	-	-	-	-	0.4	30	1.33	0.04	0.2	20	1.00	0.05
30	Clematis grata	-	-	-	-	0.5	20	2.50	0.12	-	-	-	-
31	Commelina bengalensis	1.8	60	3.00	0.05	0.6	30	2.00	0.06	0.5	10	5.00	0.50
32	Conscora diffusa	-	-	-	-	0.2	10	2.00	0.20	-	-	-	-
33	Conyza japonica	1.3	30	4.33	0.14	0.9	60	1.50	0.02	-	-	-	-
34	Crotalaria scsiflora	0.8	40	2.00	0.05	0.2	10	2.00	0.20	0.1	10	1.00	0.10
35	Crotolaria humifusa	1.4	40	3.50	0.08	-	-	-	-	-	-	-	-
36	Curcuilgo orchidioles	-	-	-	-	-	-	-	-	1.5	60	2.50	0.04
37	Cyanoglossum glochidion	-	-	-	-	1.0	50	2.00	0.04	-	-	-	-
38	Cynoglossum lanceolatus	0.9	20	4.50	0.22	0.8	50	1.60	0.03	-	-	-	-
39	Cynotis barbata	-	-	-	-	-	-	-	-	0.8	20	4.00	0.20
40	Cynotis vaga	1.2	50	2.40	0.04	-	-	-	-	0.5	10	5.00	0.50
41	Cyperus monocephala	-	-	-	-	-	-	-	-	0.3	10	3.00	0.30
42	Cyperus triceps	0.9	30	3.00	0.10	-	-	-	-	-	-	-	-
43	Desmodium species	-	-	-	-	-	-	-	-	1.2	60	2.00	0.03
44	Desmodium elegans	0.6	30	2.00	0.06	0.1	10	1.00	0.10	-	-	-	-
45	Desmodium gangiticum	-	-	-	-	0.7	40	1.75	0.04				
46	Desmodium parviflorum	0.6	30	2.00	0.06	1.3	60	2.16	0.03	1.6	60	2.66	0.04
47	Dioscorea biofila	-	-	-	-	-	-	-	-	0.2	20	1.00	0.05
48	Dioscorea bulbifera	-	-	-	-	0.4	10	4.00	0.40	-	-	-	-
49	Eclipta indica	-	-	-	-	-	-	-	-	0.2	10	2.00	0.20
50	Elephantopus scaber	-	-	-	-	0.4	30	1.33	0.04	0.5	40	1.25	0.03
51	Emilia sonchifolia	-	-	-	-	-	-	-	-	0.2	10	2.00	0.20
52	Glinus lotoides	-	-	-	-	1.2	10	12.00	1.20	-	-	-	-
53	Globba racemosa	-	-	-	-	-	-	-	-	0.2	20	2.00	0.20
54	Gonatanthus pulinus	-	-	-	-	-	-	-	-	0.3	10	3.00	0.30
55	Habeneria accuminata	0.9	30	3.00	0.10	-	-	-	-	-	-	-	-
56	Hedychium spicatum	-	-	-	-	0.2	20	1.00	0.05	1.0	50	2.00	0.40
57	Hedyotis hispida	-	-	-	-	0.4	20	2.00	0.10	-	-	-	-
58	Hydiotis prinifolia	2.5	20	12.50	0.62	-	-	-	-	-	-	-	-
59	Ipomoea nil	-	-	-	-	-	-	-	-	0.1	10	1.00	0.10
60	Isachne albens	-	-	-	-	-	-	-	-	1.0	20	5.00	0.25
61	Ixeris sagittifolia	-	-	-	-	0.2	10	2.00	0.20	-	-	-	-
62	Justicia simplex	10.4	80	13.00	0.16	5.1	50	10.20	0.20	1.2	20	6.00	0.30
63	Leucas lanata	0.5	30	1.66	0.05	0.6	20	3.00	0.20	1.9	80	2.37	0.02
64	Leucas mollissime	-	-	-	-	-	-	-	-	0.1	10	1.00	0.10
65	Lindenbergia grandiflora	-	-	-	-	2.9	80	3.62	0.04	3.6	80	4.50	0.05
66	Lindernia cordifolia	-	-	-	-	0.8	10	8.00	0.80	-	-	-	-
67	Lindernia cristata	0.7	20	3.50	0.17	-	-	-	-	-	-	-	-
68	Lindernia indica	-	-	-	-	0.2	10	2.00	0.20	-	-	-	-
69	Lindernia multiflora	-	-	-	-	0.2	10	2.00	0.20	-	-	-	-
70	Lysimachia alternefolia	-	-	-	-	-	-	-	-	0.3	10	3.00	0.30
71	Marsedenia lucida	-	-	-	-	0.2	10	2.00	0.20	-	-	-	-
72	Micromeria biflora	1.1	30	3.66	0.12	-	-	-	-	-	-	-	-
73	Microstylis wallichii	-	-	-	-	0.3	10	3.00	0.30	-	-	-	-
74	Murdania nudiflora	1.3	30	4.33	0.14	0.2	10	2.00	0.20	-	-	-	-
75	Neametis cerycima	-	-	-	-	0.2	10	2.00	0.20	-	-	-	-

76	Neotis colycina	0.6	30	2.00	0.06	-	-	-	-	-	-	-	-
77	Ophroglossum reticulatum	-	-	-	-	0.2	10	2.00	0.20	-	-	-	-
78	Oplismenus composirus	-	-	-	-	4.0	70	5.71	0.08	1.7	50	3.40	0.06
79	Oxalis corniculata	1.1	40	2.75	0.06	-	-	-	-	0.4	10	4.00	0.40
80	Paspalum dhasticum	-	-	-	-	-	-	-	-	0.1	10	1.00	0.10
81	Peperomia pellweida	-	-	-	-	-	-	-	-	0.5	10	5.00	0.50
82	Phyllanthus niurea	-	-	-	-	-	-	-	-	0.4	10	4.00	0.40
83	Phyllanthus simplex	1.5	10	15.00	1.50	0.8	10	8.00	0.80	-	-	-	-
84	Plectranthus japonicus	1.9	60	3.16	0.05	-	-	-	-	-	-	-	-
85	Polygala chinensis	0.1	10	1.00	0.10	0.4	10	4.00	0.40	-	-	-	-
86	Polygonum nepalensis	0.2	10	2.00	0.20	-	-	-	-	-	-	-	-
87	Pouzolzia hirta	3.1	50	6.20	0.12	-	-	-	-	-	-	-	-
88	Rungia pactinata	-	-	-	-	0.4	30	1.33	0.04	-	-	-	-
89	Seigesbeckia orientalis	1.7	60	2.83	0.04	-	-	-	-	-	-	-	-
90	Setaria glauca	-	-	-	-	-	-	-	-	0.2	10	2.00	0.20
91	Setaria hamonyma	5.0	80	6.25	0.07	-	-	-	-	0.2	10	2.00	0.20
92	Sida acuta	-	-	-	-	-	-	-	-	0.4	10	4.00	0.40
93	Sida cordata	-	-	-	-	0.6	50	1.20	0.02	0.8	40	2.00	0.05
94	Sida cordifolia	-	-	-	-	0.4	40	1.00	0.02	-	-	-	-
95	Smithia ciliate	3.2	30	10.66	0.35	-	-	-	-	-	-	-	-
96	Solanum spp.	-	-	-	-	-	-	-	-	0.2	10	2.00	0.20
97	Spiranthus sinensis	0.3	20	1.50	0.07	1.1	70	1.57	0.02	-	-	-	-
98	Strobilanthus alatus	3.1	20	15.50	0.77	2.9	80	3.62	0.04	-	-	-	-
99	Teucrium royleanusum	1.2	50	2.40	0.04	2.5	90	2.77	0.03	-	-	-	-
100	Themeda amethesia	0.9	30	3.00	0.10	-	-	-	-	-	-	-	-
101	Triumfetta annua	7.1	50	14.20	0.28	0.4	30	1.33	0.04	-	-	-	-
102	Triumfetta annua	-	-	-	-	-	-	-	-	1.1	40	2.75	0.06
103	Zorina diphylla	1.3	40	3.25	0.08	-	-	-	-	-	-	-	-
Total		84.50				49.90				37.60			

D=density, F=frequency, A=abundance

Table 8. Species diversity of different forest strata along the altitudinal gradients in Shiwalik forest of Kumaun Himalaya.

S.No	Altitude	Parameters	Vegetational layers				
			Trees	Saplings	Seedlings	Shrubs	Herbs
1	Higher elevation (1100-1500 m)	Species richness (SR)	17	12	7	21	46
		Species diversity(SD)	3.37	2.94	2.04	3.97	4.91
		Concentration of dominance(CD)	0.16	0.18	0.30	0.07	0.01
2	Middle elevation (800-1100 m)	Species richness (SR)	32	10	11	10	47
		Species diversity(SD)	4.33	2.58	2.08	2.78	4.75
		Concentration of dominance(CD)	0.09	0.22	0.39	0.17	0.01
3	Lower elevation (500-800 m)	Species richness (SR)	7	3	5	9	50
		Species diversity(SD)	1.96	1.42	1.23	2.55	4.56
		Concentration of dominance(CD)	0.35	0.40	0.59	0.23	0.01

4. Discussions

Shiwalik forests of Kumaun Himalaya are suffering from a tremendous pressure of human and livestock population. Due to this some of the plant species are under threat. Therefore, it is necessary to study the vegetational status of forest with respect to their site characteristics. A comparison was made for soil physical characteristics at three different elevations covering the whole study forest area that is from 500-1500m from the sea level. The soil moisture content (%) decreased with increase in elevation in each season. The maximum percentage of sand and silt was in the higher elevation whereas clay contents in lower elevation which is somewhat similar to the finds of soil characteristics as reported by Chaudhary 1989. However, due to lower soil bulk density the

water holding capacity and porosity was high in the lower elevation then others.

The species diversity of the Shiwalik forest was found in the following order; herbs (103)> trees (39)> shrubs (27). This shows a close relationship of trees to the herbs layer than shrubs because herbs play an important part in the soil characteristics as they decompose annually and take part in nutrient cycling of the ecosystem. We have observed higher seedlings and saplings in the middle elevation than other two elevations that is lower and higher, it is because of lesser tree density and basal area in the elevation. This indicates that the open canopy supports the higher recruitment of seedlings and saplings in this elevation. Total shrub and herb richness declined with an increase in tree basal area. In lower elevation the richness was maximum (50) for herbs and 21 for shrubs, respectively in Sal dominant and Sal mixed with pine forest, which is close to the findings reported by Ram and others, 2004 for pine mixed broad leaved forest in the other parts of Himalayan region. In each forest site, the most widely distributed species were *S. robusta* and *S. cumini* in tree category, *M. indica* in shrub category and *A. connyzoides, C. tuberosum, A. lanceolatus, G. pullinus, D. parvifolium, J. simplex, B. biternata, C. paniceus, C. triceps, C. bengalensis*, and *C. orchidioles* in herb category.

The present range of tree density (550-820 inds /ha) of Shiwalik forests was higher than the value (443 /ha) reported for Sal forest of similar region by Rana and others, 1988. The total basal area (TBA) ranged between by 0.03 m^2 /ha to 24.80 m^2 /ha. The present values are slightly higher than the values (56.40 m^2/ha) reported by Rana and others, 1988 for the Sal forest in foothills of Indian Central Himalaya.

In the higher elevation the present study indicates that, trees of *P.roxburghii* were present in the higher girth classes, while *S.robusta* and *S.cumini* indicate a successional trend of the forest community shown in Fig-2. In middle and lower elevation a few trees of *S.robusta* were present in higher girth classes. The seedlings and saplings *S.robusta* and *S. cumini* were reported in all the sites while in case of *P.roxburghii* they were present only in higher elevation. This indicates the regeneration of species in the respective area. The relative seedlings density was maximum for *S.robusta* in all the sites. However the proportion of saplings and lower girth classes in relation to seedlings were in lower side. This is due to non conversion of seedlings into saplings and trees of lower girth classes. Consequently seedlings either may die due to higher intensity of forest fire or due to competition for moisture, space, nutrients and sunlight for their growth and survival. This resembles with the hypothesis of vegetation mosaic across the landscape for different age and /or seral classes with time as given by Spies and Turner 1999.

The present findings indicate that the State forest department should carry out the necessary silvicultural operations such as thinning, pruning and removal of matured and dead ones so as to provide the sufficient space for the growth of seedlings so that the equilibrium between the growth and various ecological necessities would be maintained. Measures should also be taken into consideration that is control of forest fire and various other anthropogenic activities in the concerned forest area.

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References

1. Bankoti, N. S., Rawal, R. S., Samant, S. S. and Pangtey, Y. P. S. Forest vegetation of inner hill ranges in Kumaun, Indian Central Himalaya. *Tropical Ecology*; 1992. 33(1): 41-53.
2. Champion, H. G. and Seth, S. K. A revised survey of the forest types of India. Government of India Publications, New Delhi. 1968.
3. Chaturvedi, O. P. and Singh, J. S. A quantitative study of the forest floor biomass, litter fall and nutrient return in a *Pinus roxburghii* forest in Kumaun Himalaya. *Vegetatio*; 1987a. 71: 97-106
4. Chaturvedi, O. P. and Singh, J. S. The structure and function of pine forest in Indian Central Himalaya: Dry matter dynamics. *Annals of Botany*; 1987b. 60: 237-252.
5. Chaudhary, S. Ecology of certain pioneer and promising species relevant of landslide damaged forest sites in Kumaun Himalaya. Ph. D. Thesis, Kumaun University, Nainital, India. 1989.
6. Collet, H. Flora Simlensis: 3rd impression. 1971.
7. Curtis, J. T. and McIntosh, R. P. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*; 1950. 31: 434-455.
8. Curtis, J. T. The Vegetation of Wisconsin*:* An Ordination of Plant Communities. University

Wisconsin Press, Madison, Wisconsin; 1959. 87pp.
9. Misra, R. Ecology Work Book. Oxford and IBH Publishing Co., Calcutta, India. 1968.
10. Osmaston, A. E. A Forest Flora of Kumaun. International Book Distributors, Dehradun, India. 1926.
11. Ram, J, Kumar, A. and Bhatt, J. Plant diversity in six forest types of Uttarakhand Central Himalaya, India. *Current Science;* 2004. 87 (7): 975-978.
12. Rana, B. S., Singh, S. P. and Singh, R. P. Biomass and net primary productivity in Indian Central Himalayan forest along an altitudinal gradient. *Forest Ecology and Management*; 1989. 27: 199-218.
13. Rawal, R. S. and Pangtey, Y. P. S. Distribution and structural-functional attributes of trees in the high altitude zone of Indian Central Himalaya, India. *Vegetatio*; 1994a. 112: 29-34.
14. Rawal, R. S. and Pangtey, Y. P. S. Altitudinal zonation of high altitude forests in Kumaun, Indian Central Himalaya. *Indian Journal of Forestry*; 1994b. 17 (4): 332-344.
15. Rawal, R. S., Bankoti, N. S. and Pangtey, Y. P. S. Broad community identification of high altitude forest vegetation in Pindari region of Kumaun Central Himalaya. *Proceedings of Indian National Science Academy*; 1994. B 60 (6): 553-556.
16. Rawat, Y. S. and Singh, J. S. Structure and function of Oak Forest in Indian Central Himalaya: Dry matter dynamics. *Annals of Botany*; 1988. 62: 397- 402.
17. Rikhari, H. C., Chandra, R. and Singh, S. P. Patterns of species distribution and community characters along a moisture gradient with in an Oak zone of Kumaun Himalaya. *Proceedings of Indian National Science Academy*; 1989. B 55: 431-438.
18. Saxena, A. K. and Singh, J. S. Quantitative profile structure of certain forest in the Kumaun Himalaya. *Proceedings of Indian National Science Academy*; 1982. 91: 529-549.
19. Saxena, A. K., Singh, S. P. and Singh, J. S. Population structure of forests of Kumaun Himalaya: Implications for management. *Journal of Environment & Management*; 1984. 19: 307-324.
20. Shannon, C. E. and Weiner, W. The Mathematical Theory of Communication. University of Illinois Press, Urbana. 1963.
21. Simpson, E. H. Measurement of Diversity. *Nature*; 1949. 163: 688-690.
22. Singh, S. P., Adhikari, B. S. and Zobel, D. B. Biomass productivity, leaf longevity and forest structure in the Indian Central Himalaya. *Ecological Monograph*; 1994. 64: 401-421.
23. Singh, S. P. Chronic disturbance: a principal cause of environmental degradation in developing countries (ed). *Environment & Conservation*; 1998. 25: 1-2.
24. Spies, T. A. and Turner, M. G. Maintaining Biodiversity in Forest Ecosystems: Dynamics forest mosaics. Cambridge University Press, Cambridge, U.K.; 1999. 95-160.
25. Tewari, J. C. and Singh, S. P. Analysis of woody vegetation in a mixed Oak Forest of Kumaun Himalaya. *Proceedings of Indian National Science Academy*; 1985. B 51: 332-347.
26. Whitford, P. B. Distribution of Woodland plants in relation to succession and seasonal growth. *Ecology*; 1949. 30: 199-208.
27. Whittaker, R. H. Dominance and diversity in land plant communities. *Science*; 1965. 147: 250-260.
28. Whittaker, R. H. Communities and Ecosystems: 2nd Edition, Macmillan Publishing Co, New York. 1975.

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