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Altitudinal variation of woody vegetation in Tirthan valley of great Himalayan national park at Kullu, Himachal Pradesh

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Abstract
The present investigation entitled "Altitudinal variation of woody vegetation in Tirthan valley of Great Himalayan National Park at Kullu, Himachal Pradesh" was carried out in three different elevation i.e. lower zone (1500-2000 m.), mid zone (2000-2500 m.) and upper zone (2500-3000 m.) of Tirthan valley at Great Himalayan National Park. In every elevational zone, 12 quadrats of 30 m X 30 m (900 sq m) size determined by species area curve method were randomly laid to study tree species. In each quadrat, a sub-quadrat of 5m X 5m (25 sq m) size for study of shrubs was laid. The generic spectrum of vegetation in Tirthan valley of Great Himalayan National Park comprised of 113 woody elements which included 58 tree species and 98 shrub species. In Tirthan valley, number of forest species decreased periodically from lower elevation to upper elevation and mean density (Individual/ha.) of tree vegetation increased along elevation. Tree density (Individual/ha.) in Tirthan valley was 683.33, 758.34 and 816.67 for lower zone, mid zone and upper zone respectively. Whereas, shrub density (Individual/ha.) in valley was 2866.67, 1900, 1233.33 for lower, mid and upper zone respectively. In valley, *Pinus wallichiana* at lower zone (IVI 58.7), *Picea smithiana* at mid zone (IVI 50.43), *Quercus semecarpifolia* at upper zone (IVI 70.79) were the dominant tree species. In shrub layer of Tirthan forest, dominant species at lower zone was *Desmodium triflorum*, at mid zone was *Indigofera heterantha* while at upper zone it was *Rosa sericea*.

Keywords: Phytosociology, altitude, vegetation, diversity, species

Introduction
Plant species diversity is essential for human survival, economic welfare and for the ecosystem stability (Singh 2002) [26]. The Indian Himalayan Region (IHR) is well known for its unique and natural diverse flora and fauna which is socio-economically important also (Samant *et al*., 1998) [29]. Great Himalayan National Park (GHNP) is a highly diverse site of the Indian Himalayan Region (IHR), located in Western Himalaya. Undoubtedly this Protected area of Indian Himalayan Region (IHR) is rich on its vegetational composition. Study of relative important species is the best measure of the species role for the conservation and sustainable utilization, and it may be helpful for the policy makers for drafting management plans of fragile mountain ecosystems. Therefore, quantitative approaches to vegetation are fundamental for conservation of these natural areas; these patterns have frequently been the focus of ecological studies (Zhang *et al*. 2013) [40]. Quantitative information is of key significance to understand the composition, distribution, and abundance of woody species which forms the structure of a forest community and also much needed for planning and implementation of conservation strategy of the community (Malik 2014) [19]. Unfortunately during the last decade the vegetation of Tirthan area has been degraded largely because of human disturbances within the buffer area and also frequent occurrence of natural hazards like landslides during the last few years has exacerbated the degradation (Gairola *et al.* 2011) [10, 11]. Further it is also figured that mountain forests, in general, have a major problem of poor regeneration (Krauchii *et al*. 2000) [15]. This is true for Tirthan valley at Great Himalayan National Park, Kullu, Himachal Pradesh. Therefore, it needs a reliable data on vegetation cover for successful management and conservation of natural forests in Tirthan valley. Keeping in view the aforesaid facts, an investigation on "Altitudinal variation of woody vegetation in Tirthan valley of Great Himalayan National Park at Kullu, Himachal Pradesh" has been under taken with the following objective:

1. To conduct phytosociological studies of woody elements at different altitudinal zones of Tirthan Valley in Great Himalayan National Park.

Material and Methods

Study site

The study area lies in Tirthan valley which is in Kullu district of Himachal Pradesh. Tirthan valley is well known for their unique ecosystems at macro and micro-climatic levels, vastness of mountains and richness of biodiversity. The valley covers the area of 61 sq. kms and the same constitutes Tirthan wildlife sanctuary and part of Great Himalayan National Park. The entire catchment of the river is covered by deciduous, sub tropical coniferous, subalpine and alpine forest.

The present study was carried out at three different altitudes of Tirthan valley. After reconnaissance survey, three different altitudes *i.e.* lower (1500-2000 m asl), middle (2000-2500 m asl) and higher (2500-3000 m asl) were selected and from each of these sites, four forests, differing in aspect, elevation and slope were selected (Table 1). GPS and clinometers were used to determine the aspect, elevation and slope of the selected forests. Hence a total of twelve forests, four from each altitudinal range, were investigated for species composition, diversity, concentration of dominance and other phytosociological attributes of woody (trees and shrub) species.

Table 1: Details of studied area at different elevations of Tirthan valley, GHNP

Site 1 (1500-2000 m. asl)				
S No	**Forest Name**	**Elevation**	**Aspect**	**GPS Co-ordinates**
1	Rikhli	1772	NE	N 31^{0}37”863’ E 077^{0}26”238’
2	Dhar	1822	SW	N 31^{0}37”365’ E 077^{0}26”267’
3	Dhamanal	1905	NW	N 31^{0}36”247’ E 077^{0}27”584’
4	Behali	1673	S	N 31^{0}37”034’ E 077^{0}26”483’
Site 2 (2000-2500 m. asl.)				
1	Narala	2075	SW	N 31^{0}37”654’ E 077^{0}26’604’
2	Dharal	2124	NW	N 31^{0}36”104’ E 077^{0}28”471’
3	Katalcha	2207	SE	N 30^{0}35”952’ E 077^{0}28”552’
4	Ghadingcha	2389	NE	N 31^{0}36”229’ E 077^{0}30”273’
Site 3 (2500-3000 m. asl.)				
1	Kamada	2517	NE	N 31^{0}36”578’ E 077^{0}30”446’
2	Kandhi	2612	N	N 31^{0}35”552’ E 077^{0}30”403’
3	Mashyar	2743	SW	N 31^{0}36”480’ E 077^{0}30”298’
4	Dharaj	2925	S	N 31^{0}35”359’ E 077^{0}28”129’

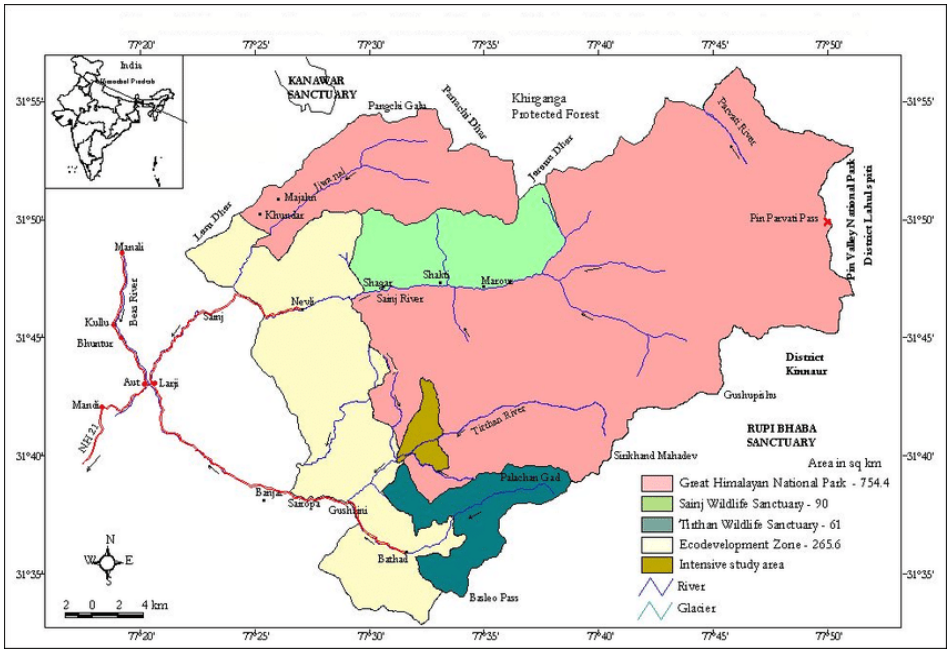

Fig 1: Map of Great Himalayan National Park, Kullu, Himachal Pradesh

Physio - Climatic Settings

The climate of the study area is typical of the western Himalaya’s front ranges. It has four distinct seasons: spring (April to June); rainy/summer (July to September); autumn (October to November) and winter (December to March). Precipitation is moderate for most of the year and abundant during the monsoon, from mid-June to mid-September. In recent years, maximum annual rainfall has been recorded 1,298 mm. The ambient temperature can vary from -10ºC in January to 40 ºC in June. Tirthan valley is characterised by deep river valleys, numerous high ridges, deep gorges, precipitous cliffs, rocky crages and steep mountain slopes. The slope-wise distribution of the area shows that more than 50% of the area lies between the slope category of 27°-45°. The topography of the area has also been influenced by avalanches and land slides. The underlying rock found in the area is largely quartzite, schist, phyllite, dolomites, limestone, shale, slate, gneiss and granites. In general, soil pH was 6.05 ± 0.90. High pH of 8.22 is recorded from temperate forest and low pH of 4.16 from alpine area of Great Himalayan National Park (Singh & Rawat 2000) [38].

Methodology

Field expeditions were made to the selected forests during 2017-18. The analysis of woody species was carried out by placing random sampling plots (quadrats) as per Mishra (1969) [21]. In every altitudinal range 12 quadrats of 30 m × 30 m size as determined by species area curve method were randomly laid to study tree species. In each quadrat, a sub-quadrat of 5m × 5m size for shrubs was randomly laid for study purpose and the size of these quadrats was determined by species area curve method. The collected plants were identified with the help of taxonomists, available literature and regional floras (Naithani 1984-1985; Gaur 1999) [22, 12]. Each species data were quantitatively analyzed for density, percent frequency and abundance following Phillips (1959)

[25], while Importance Value Index (IVI) was calculated following Curtis (1959) [9]. Alpha diversity such as Shannon-Wiener diversity index (Shannon and Weiner 1963) [31], Species richness (Menhinick 1964) [20], species equitability or evenness (Pielou 1966) Simpson's index of dominance or coefficient of dominance (Simpson 1949) [33] was calculated. A/F ratio that indicated the distribution pattern (Curtis 1956) [8] has been calculated.

Results

Species composition

A total of 113 types of woody elements were recorded in experimental sites which included 49 tree species and 64 shrub species. Recognizable difference was seen in composition of woody elements in different altitudinal range of Tirthan valley. Woody elements i.e. both tree and shrubs in lower, mid and upper zone of valley were 70, 66 and 41 respectively. It indicates that in Tirthan valley, there were 31 tree species belonging to 20 families in lower zone, 28 species belonging to 19 families in mid zone and 15 tree species belonging to 09 families in upper zone was present (Table 2). The perusal of Table 2 also indicates that there were 39 shrub species belonging to 22 families, 37 shrub species belonging to 19 families, 26 shrub species belonging to 14 families in lower, mid and upper zone of Tirthan valley.

Table 2: Diversity indices of woody vegetation in Tirthan valley, GHNP

Descriptions	Altitudinal ranges					
	1500-2000 m asl.		2000-2500 m asl.		2500-3000m. asl.	
	Trees	Shrubs	Trees	Shrubs	Trees	Shrubs
Number of species/families	31/20	39/22	28/19	37/19	15/09	26/14
Shannon's Index(H')	2.59	2.25	2.27	2.38	1.95	2.07
Species Richness (S)	1.88	1.62	1.68	1.59	1.26	1.48
Evenness (j')	2.11	1.92	1.89	2.21	2.16	2.17
Coefficient of dominance (Cd)	0.09	0.09	0.10	0.10	0.15	0.14

Phytosociological Study

Lower Altitude (1500-2000 m. asl.)

Lower altitudinal zone of Tirthan Valley i.e. 1500-3000 m. asl. was frequently occurred with 17 tree species out of the 31 existing tree species as mentioned in table 2 with a total density of 683.33 individual / ha and basal area of 37.18 m²/ ha. Maximum IVI (58.7) and IV (%) 22.7 was observed in case of tree species *Pinus wallichiana.* While minimum IVI value and IV (%) 3.94 and 0.66 respectively was observed in case of *Machillus duthiei.* (Table 3) Fifteen species of shrubs were frequently occurred out of the 39 existing shrub species in the lower elevation of Tirthan valley with a total density of 2866.67 individual / ha and basal area of 4.67 m²/ha. In the shrub layer *Desmodium triflorum* was the dominant species with IVI and IV per cent values 54.77 and 20.52 respectively While minimum IVI value 3.71 and IV (%) value 0.88 was obtained for the shrub species of *Deutzia staminea.* (Table 4)

Mid Altitude (2000-2500 m. asl.)

There were 16 frequently occurred tree species reported out of the 29 identified tree species in the mid altitudinal zone (2000–2500 m. asl) of Tirthan valley. In mid zone of Tirthan valley, Sixteen tree species were found with a total density of 758.34 individual / ha and basal area of 49.56 m² / ha. *Picea smithiana* was the dominant tree species with IVI 50.43 and IV (%) value 28 followed by *Abies pindrow* as a co-dominant tree species with IVI 38.04 and IV (%) value 21.81 respectively. While Minimum IVI 4.58 and IV (%) value 1.16 was obtained for the tree species of *Prunus cornuta.* (Table 5) Twelve species of shrubs were frequently occurred out of the 37 existing shrub species in the mid altitudinal zone of Tirthan valley with a total density of 1900.00 individual / ha and basal area of 3.82 m²/ha. Shrub layer was dominated by the species of *Indigofera heterentha* with IVI and IV per cent values 59.31 and 20.57 respectively. Whereas minimum IVI 4.58 and IV (%) value 1.16 was obtained for the shrub species of *Elaeagnus parviflora.* (Table 6)

Upper Altitude (2500-3000 m. asl.)

Upper altitude of Tirthan Valley i.e. 2500 – 3000 m. asl. was frequently occurred with 8 tree species out of the existing tree species with a total density of 816.67 individual / ha and basal area of 58.88 m²/ ha. In this zone of Tirthan valley, *Quercus semecarpifolia* was the dominant tree species with IVI and IV per cent value as 70.79 and 25.78 respectively followed by *Abies pindrow* as co-dominant tree species with IVI 51.81 and IV (%) value 18.21. Whereas minimum IVI and IV (%) value 12.88 and 2.60 was obtained for the tree species of *Prunus cornuta.* (Table 7) Nine species of shrubs were frequently occurred out of the total existing shrub species with a total density of 1233.33 individual / ha and basal area of 2.53 m²/ha. Out of which *Rosa sericea* with IVI (77.23) and IV per cent 28.62 was the dominant one and shrub species *Caragana gerardiana* with IVI and IV (%) value 8.27 and 2.14 was the suppressed one. (Table 8)

Alpha diversity

The tree species diversity ranged from 2.59 to 1.95 for Tirthan valley and for shrubs from 2.25 to 2.07. Altitudinal wise species diversity of Tirthan valley was decreasing from lower elevation to upper elevation. The tree species richness was 1.88 in Lower zone, 1.68 in mid zone and 1.26 in upper zone. Likewise values for shrubs ranged from 1.48 to 1.62. Species evenness of tree species ranged from 1.89 to 2.16. In case of Tirthan valley tree species dominance was 0.15 in upper zone, 0.10 in mid zone followed by 0.09 in lower zone similarly in case of shrub it was 0.14 in upper zone, 0.10 in mid zone and 0.09 in lower zone. (Table 2)

A/F Distribution

Abundance to frequency ratio is used as an indicator of spatial distribution of a species in the community. A close look at this study depicts that most of the tree species were contagiously distributed i.e. 77.5 per cent. Randomly distributed tree species were 22.5 per cent and None of the tree species was reported with regular distribution. Where as in Shrubs 94.25 per cent were contagiously distributed and rests were with random type of distribution.

Table 3: Diversity, Basal area, IVI and IV of trees in lower elevation of Tirthan valley

S. No.	Tree Species	Density Individual / ha.	Av. BA/ha (m^2)	IVI	IV (%)
1	*Acer acuminatm*	41.67	2.64	23.73	6.60
2	*Aesculus indica*	33.33	1.82	15.04	4.89
3	*Alnus nepalensis*	66.67	0.18	12.87	5.12
4	*Cedrus deodara*	91.67	10.44	52.02	20.75
5	*Cornus macrophylla*	25.00	1.51	12.97	3.86
6	*Grewia optiva*	16.67	1.46	9.00	3.19
7	*Juglans regia .*	25.00	1.79	16.37	4.24
8	*Lyonia ovaliifolia*	16.67	0.48	6.35	1.86
9	*Machillus duthiei*	8.33	0.03	3.94	0.66
10	*Morus serrata*	16.67	0.73	7.04	2.21
11	*Pinus wallichiana*	125.00	10.13	58.7	22.77
12	*Prunus spp*	41.67	1.80	12.55	3.65
13	*Quercus leucotrichophora*	16.67	0.30	9.53	3.45
14	*Robinia pseudoacacia*	50.00	1.40	18.97	5.54
15	*Salix wallichiana*	16.67	0.41	8.81	1.78
16	*Toona ciliata*	33.33	0.52	14.17	3.14
17	*Ulmus wallichiana*	58.33	1.54	17.93	6.34
	Total	683.33	37.18		

IVI= Importance Value Index IV= Importance Values

Table 4: Diversity, Basal area, IVI and IV of shrubs in lower elevation of Tirthan valley

S. No.	Shrub Species	Density Individual / ha.	Av. BA/ha (m^2)	IVI	IV (%)
1	*Berberis aristata*	366.67	0.61	37.67	12.96
2	*Berberis lycium*	266.67	0.37	25.01	8.59
3	*Buddleja neemda*	66.67	0.08	7.90	1.99
4	*Cotinus coggyria*	133.33	0.18	14.41	4.27
5	*Desmodium triflorum*	500.00	1.10	54.77	20.52
6	*Deberegeasia salicifolia*	233.33	0.44	23.51	8.82
7	*Deutzia staminea*	33.33	0.03	3.71	0.88
8	*Indigofera heterantha*	66.67	0.11	8.62	2.35
9	*Jasminum officinale*	166.67	0.22	18.44	5.30
10	*Myrsine aricana*	133.33	0.24	15.75	4.94
11	*Rosa brunonii*	166.67	0.26	25.77	7.99
12	*Rosa webbiana*	200.00	0.27	17.52	5.82
13	*Rhus wallichi*	133.33	0.26	20.29	6.23
14	*Prinsepia utilis*	300.00	0.36	16.22	6.15
15	*Zanthoxylum armatum*	100.00	0.14	10.37	3.23
	Total	2866.67	4.67		

Table 5: Diversity, Basal area, IVI and IV of trees in mid elevation of Tirthan valley

S. No.	Tree Species	Density Individual / ha.	Av. BA/ha (m^2)	IVI	IV (%)
1	*Abies pindrow*	108.33	7.26	38.04	21.81
2	*Acer acuminatum*	25.00	3.53	14.97	8.77
3	*Acer villosum*	16.67	1.09	8.94	3.29
4	*Aesculus indica*	50.00	5.70	24.91	14.80
5	*Betula alnoides*	41.67	2.39	14.86	7.57
6	*Cedrus deodara*	33.33	4.54	20.37	11.35
7	*Celtis tetrandra*	50.00	0.10	15.89	3.51
8	*Juglans regia*	33.33	1.77	14.8	5.78
9	*Picea smithiana*	133.33	9.52	50.43	28.00
10	*Populus ciliata*	16.67	0.93	8.62	2.97
11	*Prunus cornuta*	16.67	0.05	4.58	1.16
12	*Pyrus pashia*	16.67	0.50	7.77	1.61
13	*Quercus floribunda*	91.67	3.53	26.03	13.17
14	*Quercus glauca*	41.67	2.47	15.02	7.73
15	*Rhododendron arboreum*	58.33	4.06	20.43	12.04
16	*Taxus wallichiana*	25.00	2.12	14.40	5.93
	Total	758.34	49.56		

IVI= Importance Value Index IV= Importance Values

Table 6: Diversity, Basal area, IVI and IV of shrubs in mid elevation of Tirthan valley.

S. No.	Shrub Species	Density Individual / ha.	Av. BA/ha (m²)	IVI	IV (%)
1	*Berberis lycium*	233.33	0.47	33.59	12.25
2	*Debergeasia Salicifolia*	100.00	0.17	15.82	4.88
3	*Elaeagnus parviflora*	66.67	0.09	14.86	2.89
4	*Hypericum uralum*	133.33	0.18	20.75	5.83
5	*Indigofera heterentha*	333.33	0.90	59.31	20.57
6	*Prinsepia utilis*	100.00	0.18	16.12	5.03
7	*Rhus semialata*	166.67	0.48	30.48	10.70
8	*Rosa webbiana*	133.33	0.08	15.19	4.57
9	*Rosa sericea*	200.00	0.41	24.38	10.68
10	*Sarcococca saligna*	233.33	0.51	37.73	12.81
11	*Strobilanthus artropurpureus*	100.00	0.20	16.53	5.24
12	*Syringa emodi*	100.00	0.15	15.22	4.58

IVI= Importance Value Index IV= Importance Values

Table 7: Diversity, Basal area, IVI and IV of trees in upper elevation of Tirthan valley.

S. No.	Tree Species	Density Individual / ha.	Av. BA/ha (m²)	IVI	IV (%)
1	*Abies pindrow*	166.67	9.42	51.81	18.21
2	*Acer caesium*	50.00	4.47	21.4	6.86
3	*Betula alnoides*	50.00	13.85	41.17	14.82
4	*Cedrus deodara*	66.67	6.20	30.23	9.35
5	*Picea smithiana*	150.00	3.17	35.29	11.88
6	*Prunus cornuta*	33.33	0.66	12.88	2.60
7	*Quercus semecarpifolia*	200.00	15.94	70.79	25.78
8	*Taxus wallichiana*	100.00	5.18	36.42	10.52
	Total	816.67	58.88	299.99	100.00

IVI= Importance Value Index IV= Importance Values

Table 8: Diversity, Basal area, IVI and IV of shrubs in upper elevation of Tirthan valley.

S. No.	Shrub Species	Density Individual / ha.	Av. BA/ha (m²)	IVI	IV (%)
1	*Berberis jaeschkeana*	100.00	0.17	26.96	7.48
2	*Caragana gerardiana*	33.33	0.04	8.27	2.14
3	*Cotoneaster rosea*	133.33	0.27	33.29	10.65
4	*Deutzia compacta*	100.00	0.15	22.05	7.03
5	*Elaeagnus parviflora*	133.33	0.19	26.42	9.21
6	*Hypericum uralum*	200.00	0.31	40.6	14.30
7	*Rosa webbiana*	133.33	0.42	39.38	13.69
8	*Rosa sericea*	300.00	0.83	77.23	28.62
9	*Spiraea bella*	100.00	0.14	25.8	6.90
	Total	1233.33	2.53	300.00	100.00

IVI= Importance Value Index IV= Importance Values

Discussion

Survey on floral composition of Tirthan valleys of Great Himalayan National Park gave an account that both the valleys were enriched with woody elements. It had been reported that in Tirthan valley, number of plant species decreased periodically from lower selevation to upper elevation which was in line with Mahato (2013) [17]. The number of plant species recorded in Tirthan valley of Great Himalayan National Park comparable to the findings of Chawla *et al*. (2012) [6], Chandrasekar and Srivastava (2009) and Chawla *et al*. (2008) [5]. Various parameter of phytosociological and diversity study which is reported in the present study are best fitted within those reported earlier from different parts of Western Himalaya. In present investigation, the tree density ranged from 683.33 trees/ha in lower altitude, 758.33 trees/ha in mid altitude, 816.67 trees/ha in upper altitude for Tirthan Valley. These values of density are within the earlier values reported by various authors like Rawat and Singh (2006) [8]; Pant and Samant (2007) [24]; Semwal *et al*. (2010) [30], Gairola *et al*. (2011) [10, 11]; Raturi (2012) [27] and Bhat (2012) [3]. Shrub density in Tirthan valley varied from 2866.67 to 1233.33 ind/ha. Similar type of observation is reported by Pant and Samant (2007) [24] and Rawat and Singh (2006) [8]. The results suggests that in both of the valley tree density increases with increasing altitude in the order of upper zone>mid zone>lower zone but density of shrubs showed decreasing trend with the increase in elevation. Such trends were also reported by Rawat & Singh (2006) [8] in various forest communities elsewhere in Great Himalayan National Park (GHNP) in north western Himalaya.

The TBC (total basal cover) of trees for Tirthan valley ranged from 37.18 m²/ha in lower altitude to 49.56 m²/ha in mid altitude and 58.28 m²/ha in upper altitude. These values of TBC (m²/ha) are similar with the earlier values reported by various authors like Pant and Samant 2007 [24]; Gairola *et al*. 2011; [10, 11] Raturi 2012 [27] who reported 19-84 m²/ha,35-84 m²/ha,3-74 m²/ha respectively. The possible reason for higher value of TBC at higher altitude could be that these forests constitute the core zone of GHNP and hence are protected and mature, which seems to have reached their higher limit of productivity while the forests of lower altitude come under adjoining areas of GHNP that are not protected from anthropogenic disturbances which is in line with (Malik and Bhatt, 2016) [18].

Shannon-Wiener diversity index ranged between 2.59 to 1.95 for trees and for shrubs from 2.25 to 2.07. The higher

diversity at lower altitude may be due to interaction of different species on these sites. Higher number of species with generally overlapping niches may coexist and it may be concluded that higher diversity always give higher stability (Kharkwal 2009) [14]. These studies provide a support to the earlier investigations that species richness increases from high elevation to low elevations (Kumar and Thakur, 2008) [16], Sharma *et al*. (2009) [32], Raturi (2012) [27] and Singh (2013) [35]. Species dominance ranged from 0.09 to 0.15 in Tirthan valley. According to Baduni and Sharma (1997) [1] species dominance is strongly affected by the IVI of the first three relatively important species in a community and species dominance were inversely related with each other in the study area, which is generally the case in established forests (Zobel *et al*. 1976). Concentration of dominance has inverse relation to evenness (j'), highest value of Cd corresponds to the lowest value of j', Which is true in case of both trees and shrubs. Similar results have been obtained in the studies conducted in other parts of Himalayas by Tynsong and Tiwari (2011) [39] and Behera *et al.* (2002) [2].

The spatial distribution of plants in a population is the legacy of the spatial arrangement of parent plants and the interactions that have taken place between plants in the past. Tree species following contagious distribution in natural vegetation has also been reported by several workers (Kershaw, 1973; Singh and Yadava, 1974; Singh *et al.* 1991; Nautiyal *et al*. 1998 and Condit *et al*. 2000) [13, 34, 37, 23].

Conclusion

It can be concluded that altitudinal variation had major impact on both shrub and tree vegetation. Human disturbance, extensive grazing and other anthropogenic activities has resulted highly fragmented vegetation type on lower altitudinal zone. Thus, various vegetation indices of both tree and shrub were highest in forests of upper elevation as compared to other forests. There was a regular trend of change in these vegetational indices along the elevation which was distinctly visible in the study area.

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