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Vegetational Distribution in a Mountainous Riparian Corridor along Neeru stream, Bhaderwah, Jammu and Kashmir

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ABSTRACT: Riparian corridors are related to longitudinal and lateral patterns of plant species distribution as well as to species flows and exchanges across ecotonal and ecoclinal boundaries. The spatial distribution depends on a number of factors like physiography, hydrology, geo-morphology, climatic regime, substratum, light and temperature, etc. The present communication describes the distribution pattern of riparian vegetation along an elevational gradient of 1302 m along Neeru stream, a major left bank tributary of river Chenab. The results reveal that a large stretch of the riparian forest exhibits random followed by contagious and (negligible) regular pattern validating the better chances of species survival with adequate resource availability. When analyzed for occupancy frequency distribution, the vegetation showed homogenous distribution in the riparian and heterogeneous distribution along the upland forests. The whole corridor as a single linear unit was observed to be homogenous with high frequency of occurrence observed for class C (41-60%) and class D (61-80%) at the mid elevation. The hierarchical clustering defines the extent of similarity among the plant associations in the riparian and upland buffers with more information on patterns of distribution.

Key words: Abundance, Distribution pattern, Frequency, Heterogeneous, Homogeneous, Plant associations, Riparian, Upland

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INTRODUCTION

The riparian vegetation is quite distinctive from the upland vegetation as it comprises the plants adapted to high soil moisture (Kocher & Harris, 2007) and complex interactions among hydrology (Scott *et al.,* 1996 & 1997; Shafroth *et al.,* 1998 and Stromberg, 1993 & 1998), light and insolation (Brinson, 1990; Malanson, 1993, Nichols *et al.,* 1998; Yeakley *et al.,* 2000; Pierce *et al.,* 2005 and Suzaki *et al.,* 2005, Armesto & Martinez, 1978; Franklin *et al.,* 2000; Martinez-Yrizar *et al*., 2003 and Hietel *et al*., 2004) and elevation (Rahbek, 1995; Kappelle *et al*., 1995; Lieberman *et al.,* 1996; Lovett, 1999; Grytness & Vetaas, 2002 and Grytness & Beaman, 2006). The distribution of riparian vegetation is primarily determined by the gradients of available moisture and oxygen, and plant communities can be stratified by height above the river channel (Tickner *et al*., 2001 and Boucher, 2002). As important interfaces, the riparian areas are the biological and physical link between terrestrial and aquatic ecosystems (Youngblood et al., 1985; Gregory *et al.,* 1991; Martin *et al.,* 1999; Naiman *et al.,* 2005; Stanford *et al.,* 2005 and Malard *et al.,* 2006).

At the landscape level, riparian forest buffers support disproportionate amount of ecosystem services and species diversity compared to adjacent terrestrial ecosystems (Ward, 1998 and Brauman *et al*., 2007). Riparian ecosystems also have significant habitat functions (de Groot *et al.,* 2002) both locally and in landscapes, and tend to increase the diversity of species pools at regional scales (Sabo *et al.,* 2005 and Clarke *et al*., 2008). The landscape position however differs significantly in the mountain ecosystems, where the ecotones are sharply distinct.

Riparian plant communities along the rivers are dynamic, species rich (Salo *et al.,* 1986; Nilsson, 1991 and Kalliola & Puhakka, 1988) affected by both longitudinal (Vannotte *et al.,* 1980) and transversal (Newbold *et al.,* 198l) linkages for species recruitment and diversity. The spatial heterogeneity resulting from geomorphological processes is viewed as one of the major causes of high species richness (Hupp, 1988; Gould & Walker, 1997 and Ferreira & Stohlgren, 1999). Interestingly riparian vegetation changes continuously from the beginning of a river in the mountains up to the river mouth with the changing environmental conditions.

Riparian plant species establish in locations where there are suitable conditions for seed germination and sufficient water for seedling survival, and where the species can tolerate physical disturbance from floods (Stromberg & Patten, 1992; (Stromberg *et al.*, 1997; Hupp & Osterkamp, 1996; Scott *et al.*, 1996; Auble & Scott, 1998; Mahoney & Rood, 1998 and Shafroth *et al.*, 1998).

The physiography and topographic complexity of the Bhaderwah valley (the study area) has resulted in extreme habitat and microclimatic heterogeneity which has an obvious influence over the distribution of vegetation from near the origin of stream Neeru far south to its confluence with river Chenab towards north. The present study therefore aims to highlight the extent and pattern of vegetational distribution on the riparian corridor based on frequency distribution and population dispersion. Frequency as a measure of occurrence of particular kind of vegetation has been used as one of the important characters of phytosociology. The frequency continuously declines in the first four classes and then increase in the terminal classes thus suggesting the trend as A>B> C=D< E (Raunkiaer, 1934). The higher the value of E, the more homogenous is the stand while the value (E+D)/(B+C) less than one, suggests for heterogeneity and greater than one, homogeniety. A low frequency indicates that a species is either irregularly distributed or rare in a particular stand or forest (Kharkwal & Rawat, 2010).

METHODOLOGY

Fifteen sites were selected along the elevation gradient. Abundance frequency ratio was analyzed for riparian corridor and uplands. For the purpose of analysis the quadrat method (10m×10m, 5m×5m, 1m×1m for trees, shrubs and herbs respectively) was applied. Accordingly abundance frequency ratio was calculated. The abundance to frequency ratio (A/F) of different species was computed using the Whitford's index. This ratio indicates regular (< 0.025), random (0.025 to 0.05) and contagious (> 0.05) distribution (Whitford, 1949). The frequency classes at 20% interval are represented as A=1-20%, B=21-40%, C=41-60%, D=61-80%, and E=81-100% (Raunkiaer, 1934). The percentage of species encountered in all the five Raunkaier's frequency classes for riparian and for upland forests along the left and right banks as well as for the whole study corridor has been calculated. The frequency classes at 20% interval are represented as A=1-20%, B=21-40%, C=41-60%, D=61-80%, and E=81-100%. The statistical analysis was performed in Microsoft excel and PAST 3.0 software.

A. Study area

The study area, Neeru stream an important left bank tributary of Chenab catchment was surveyed for a linear stretch of 35 km lying between 32°55′32″ to 33°08′26″N and 75°32′41″ to 75°45′78″E along an elevational range of 837 m (Pul Doda) to 2183 m near Thanalla (Map 1).

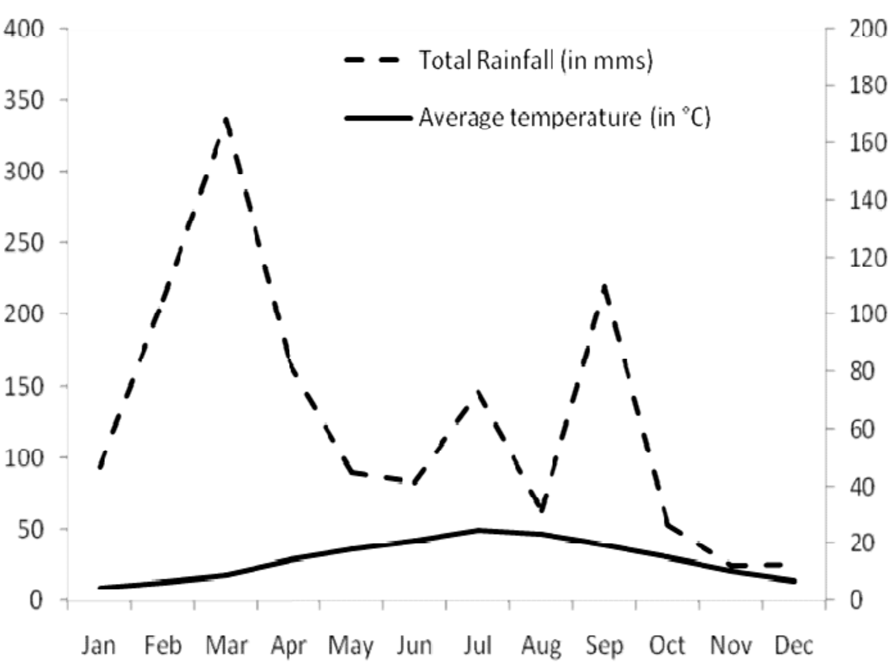
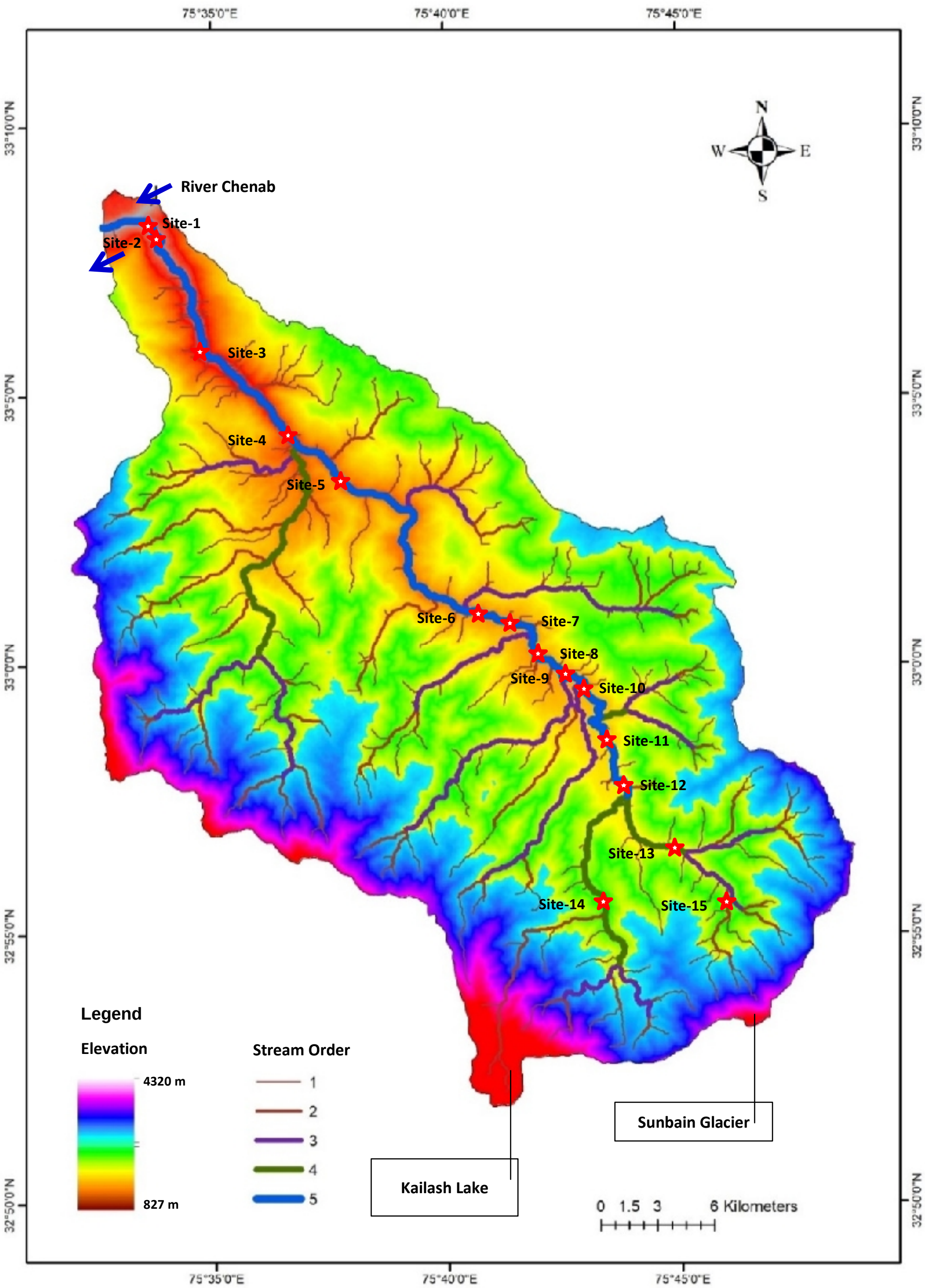


Fig. 1. Ombrothermic curve of the study area.



Map 1: Digital Elevation Map of Neeru watershed.

It is a linear hydromorphological unit from its head located near Ashapati and its confluence with River Chenab at Pul Doda as a corridor 35 km long and ~1.5 Km wide including the river bed and flood plain and the edge upslopes (~ 200 m on either sides). The area is influenced by cold arid climate with short summers and long dry winters. Temperature in the study area regularly drops as low as sub-zero in the winter, and varies primarily with elevation (Fig. 1). The area is characterized by are four major seasons.

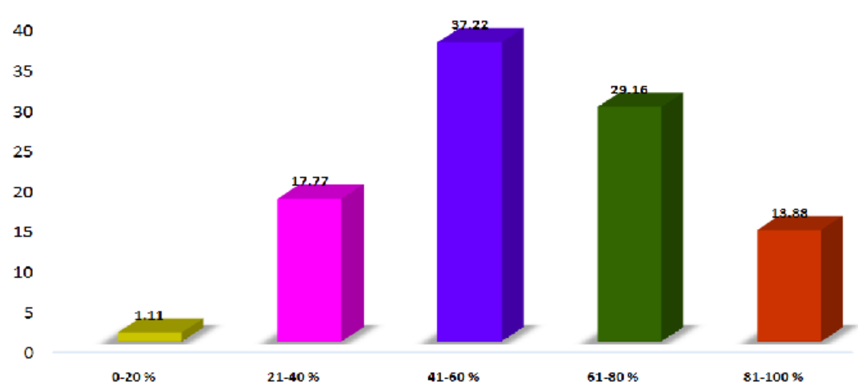
RESULTS

The study corridor is characterized by a mix of sub-tropical, sub-temperate and temperate forest types comprised of Himalayan subtropical pine forest (9/C1), Dalbergia-Melia scrub forest (10/C1a), Ban Oak forest (12/C1a), Moru oak forest (12/C1$_b$), Moist Deodar Forest (12/C1c), Upper west Himalayan temperate forest (12/C$_2$), Alder forest (12/1S$_1$), Riverine Blue pine (12/1S2), Low level blue pine (12/2S1), West Himalayan high level dry blue pine forest (13/C4) as per Champion & Seth (1968). A total of 248 plant species (39 trees, 49 shrubs and 170 herbs) contained in 193 genera and 78 families were recorded from the riparian forests of the study area during April 2014 to August 2016. The riparian forests mainly comprised of Alder while the upland buffers are represented by conifers *Pinus roxburghii*, *Pinus wallichiana*, *Cedrus deodara, Abies pindrow* and *Picea smithiana* along the rising elevation in the study corridor. The biological spectrum suggested a typical thero-hemicryptophytic type of phytoclimate in the study area. The results obtained revealed that frequency classes C and D represented maximum number of species in all the zones (Table 1). The frequency ratio between E+D and B+C showed a homogenous pattern of distribution for the riparian forest corridor ((A<B<C<D>E)) with values more than one (1.64) whereas on the upland the right bank of the channel revealed homogenous pattern (1.28, A<B<C<D>E). The vegetation along the left bank is heterogeneous (more diverse) while that along the right bank is homogenous (less diverse). When calculated for the whole corridor for all the species, the frequency classes C (33.94), D (32.66) and E (18.34) included 85 % of the total species of study area.

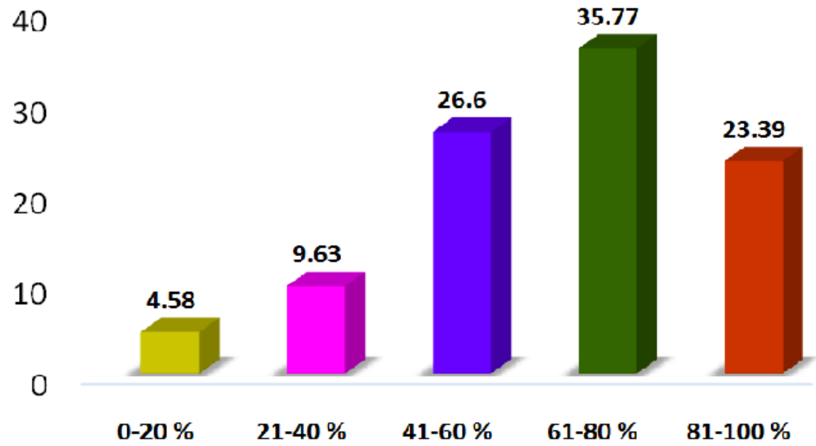
Table 1: Raunkiaer's frequency classes for the study areas.

Zones	A (1-20%)	B (21-40%)	C (41-60%)	D (61-80%)	E (81-100%)	Raunkiaer's frequency	Value (E+D/B +C)	Distribution
Riparian Forest								
Corridor	4.58 (10)	9.63 (21)	26.60 (58)	35.77 (78)	23.99 (51)	A<B<C<D>E	1.64	Homogenous
Upland Forest								
Left Bank	1.11 (07)	17.77 (64)	37.22 (134)	29.16 (105)	13.88 (50)	A<B<C>D>E	0.78	Heterogeneous
Right Bank	0.35 (01)	11.38 (32)	32.02 (90)	34.37 (98)	21.30 (60)	A<B<C<D>E	1.28	Homogenous
Whole study corridor (Riparian and upland buffers)								
Total	1.65 (18)	13.39 (146)	33.94 (370)	32.66 (356)	18.34 (200)	A<B<C>D>E	1.07	Homogenous

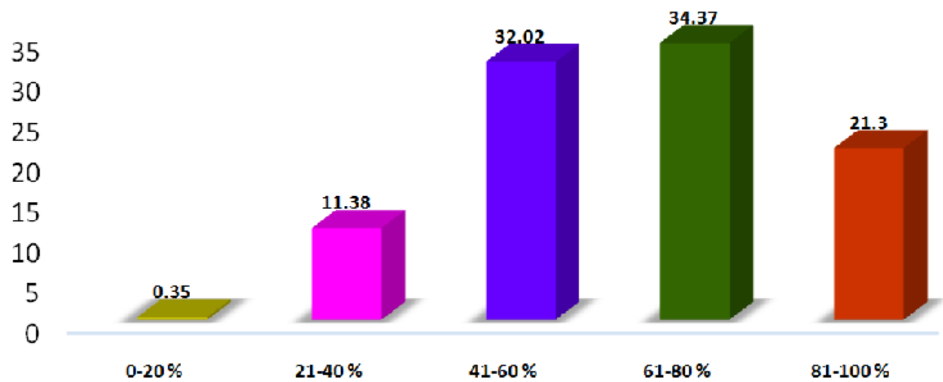
Number in parentheses is the number of species in case of riparian and upland forests, and, frequency of occurrence in case of whole study corridor.



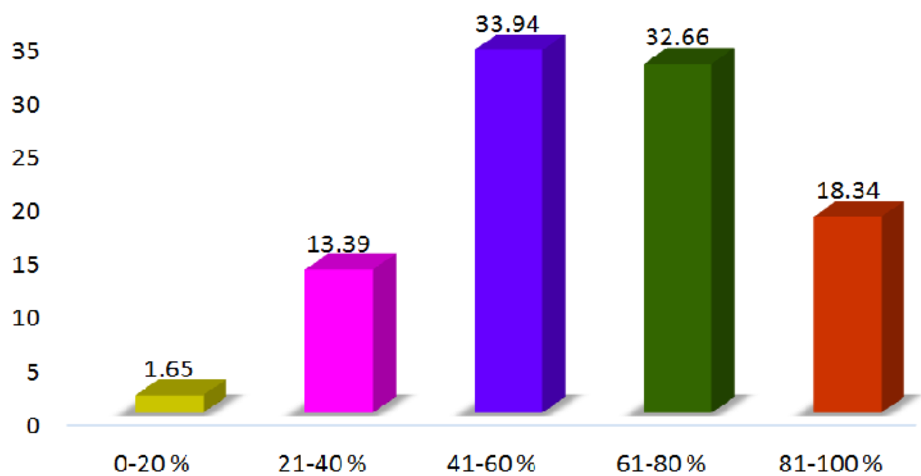
a) along left bank upland.



b) along Riparian corridor.



(c) along the right bank upland.



(d) Raunkiaer's Frequency diagram of the vegetation along the Whole corridor

Fig. 2. Raunkier's frequency diagram of the forest.

The Raunkiaer's frequency is represented as A<B<C>D>E with E+D / B+C ratio obtained larger than one (1.07) suggesting a homogenous type of distribution (Figs. 2a, b, c,d).

A. Distribution of vegetation (Vegetational dispersion)
The abundance frequency ratio was obtained for the representative species with highest Importance Value from each site for trees, shrubs and herbs respectively (Table 2). The results revealed that most of the vegetation is random or contagious in distribution with a small section showing regular distribution. *Alnus nitida* the dominant tree in the riparian zone showed more of a contagious distribution with the evidence of random distribution at the lower and moderately higher elevations. The vegetation from Pranoo (Site-3) to Bheja (Site-13) in the riparian zone represented by *Alnus nitida* showed more or less contagious distribution. The upland forests dominated by a mix of species revealed more of a random pattern followed by contagious distribution along both the banks of the stream. The right bank comprises of a mix of *Pinus roxburghii, Cedrus deodara, Pinus wallichiana* with representation of *Populus ciliata* at Guptganga (Site-11).

Table 2: The ecological dominance of species site wise and their respective A/F ratio.

Left Bank upland				**Riparian corridor**			**Right Bank upland**		
Sites	**Species - Trees / Shrubs / Herbs**	**IV**	**AFR**	**Species - Trees / Shrubs / Herbs**	**IV**	**AFR**	**Species - Trees / Shrubs / Herbs**	**IV**	**AFR**
Site-1 Pul Doda	*Pinus roxburghii*	73.42	0.03(R)	*Melia azedarach*	177.2	0.038 (R)	*Punica granatum*	56.47	0.02 (Re)
	Artemisia myriantha	62.95	0.049 (R)	*Daphne oleoides*	108.5	0.028 (R)	*Berberis lycium*	76.39	0.028 (R)
	Anthemis cotula	58.13	0.083 (C)	*Artemisia vestita*	105.20	0.046 (R)	*Artemisia vestita*	42.47	0.032 (R)
Site-2 Galgander	*Pinus roxburghii*	88.80	0.05 (R)	*Pinus roxburghii*	107.5	0.029 (R)	*Quercus baloot*	129.5	0.032 (R)
	Berberis lycium	99.63	0.035 (R)	*Daphne oleoides*	132.3	0.034 (R)	*Berberis lycium*	79.00	0.046 (R)
	Verbascum thapsus	43.33	0.037 (R)	*Cannabis sativa*	76.11	0.028 (R)	*Artemisia vestita*	50.83	0.038 (R)
Site-3 Pranoo	*Quercus baloot*	61.96	0.06 (C)	*Alnus nitida*	128.9	0.077 (C)	*Pinus roxburghii*	65.53	0.053 (C)
	Berberis lycium	64.18	0.03 (R)	*Berberis lycium*	141.9	0.034 (R)	*Berberis lycium*	110.70	0.038 (R)
	Artemisia vestita	22.9	0.038 (R)	*Artemisia vestita*	39.44	0.055 (C)	*Verbascum thapsus*	30.33	0.043 (R)
Site-4 Bhalla	*Pinus roxburghii*	89.08	0.032 (R)	*Alnus nitida*	148.6	0.055 (C)	*Pinus roxburghii*	64.86	0.035 (R)
	Berberis lycium	64.20	0.031 (R)	*Berberis lycium*	80.34	0.026 (R)	*Prinsepia utilis*	79	0.027 (R)
	Imperata cylindrica	30.15	0.032 (R)	*Artemisia vestita*	51.91	0.048 (R)	*Oenothera rosea*	34.79	0.045 (R)
Site-5 Seri	*Cedrus deodara*	43.24	0.045 (R)	*Alnus nitida*	136.2	0.09 (C)	*Pinus roxburghii*	64.74	0.04 (R)
	Prinsepia utilis	35.51	0.029 (R)	*Berberis lycium*	70.33	0.034 (R)	*Berberis lycium*	53.15	0.034 (R)
	Chrysopogon gryllus	17.64	0.035 (R)	*Cannabis sativa*	26.68	0.034 (R)	*Verbascum thapsus*	19.02	0.056 (C)
Site-6 Drudu	*Cedrus deodara*	56.63	0.053 (C)	*Alnus nitida*	134.1	0.078 (C)	*Cedrus deodara*	95.24	0.046 (R)
	Berberis lycium	66.25	0.037 (R)	*Berberis lycium*	115.2	0.032 (R)	*Berberis lycium*	98.00	0.03 (R)
	Capsella bursa-pastoris	18.99	0.072 (C)	*Artemisia vestita*	31.82	0.053 (C)	*Imperata cylindrica*	31.74	0.045 (R)
Site-7 Dranga	*Pinus wallichiana*	60.78	0.042 (R)	*Alnus nitida*	100.3	0.06 (C)	*Cydonia oblonga*	81.44	0.04 (R)
	Berberis lycium	54.91	0.03 (R)	*Prinsepia utilis*	65.38	0.028 (R)	*Berberis lycium*	81.8	0.03 (R)
	Trifolium pratense	22.95	0.077 (C)	*Cannabis sativa*	39.95	0.053 (C)	*Verbascum thapsus*	34.48	0.04 (R)

Conitinued…

Left Bank upland				Riparian corridor			Right Bank upland		
Sites	**Species - Trees / Shrubs / Herbs**	**IV**	**AFR**	**Species - Trees / Shrubs / Herbs**	**IV**	**AFR**	**Species - Trees / Shrubs / Herbs**	**IV**	**AFR**
Site-8 Amiranagar	*Cedrus deodara*	42.6	0.036 (R)	*Alnus nitida*	128.1	0.055 (C)	*Pinus wallichiana*	97.49	0.043 (R)
	Berberis lycium	69.8	0.033 (R)	*Prinsepia utilis*	70.58	0.036 (R)	*Berberis lycium*	65.93	0.028 (R)
	Cannabis sativa	21.23	0.38 (R)	*Cannabis sativa*	40.38	0.038 (R)	*Verbascum thapsus*	26.87	0.023 (Re)
Site-9 Gatha	*Ficus palmata*	57.75	0.045 (R)	*Alnus nitida*	136.8	0.047 (R)	*Cedrus deodara*	108.8	0.028 (R)
	Berberis lycium	73.82	0.025 (Re)	*Berberis lycium*	106	0.036 (R)	*Berberis lycium*	91.41	0.032 (R)
	Trifolium pratense	41.17	0.105 (C)	*Artemisia brevefolia*	47.19	0.017 (Re)	*Cannabis sativa*	53.86	0.05 (R)
Site-10 Renda	*Robinia pseudoacacia*	92.99	0.05 (R)	*Alnus nitida*	119.5	0.085 (C)	*Cedrus deodara*	50.3	0.029 (R)
	Berberis lycium	60.57	0.027 (R)	*Prinsepia utilis*	98.02	0.032 (R)	*Berberis lycium*	72.04	0.033 (R)
	Verbascum thapsus	49.77	0.043 (R)	*Cannabis sativa*	44.89	0.037 (R)	*Digitalis purpurea*	33.22	0.087 (C)
Site-11 Guptganga	*Robinia pseudoacacia*	68.36	0.06 (C)	*Alnus nitida*	88.37	0.08 (C)	*Populus ciliata*	43.36	0.032 (R)
	Berberis lycium	54.87	0.028 (R)	*Prinsepia utilis*	86.95	0.028 (R)	*Cactus* sp.	41.10	0.026 (R)
	Plantago lanceolata	25.9	0.046 (R)	*Plantago lanceolata*	34.71	0.048 (R)	*Artemisia scoparia*	31.54	0.028 (R)
Site-12 Dareja	*Populus ciliata*	59.38	0.048 (R)	*Alnus nitida*	134.5	0.068 (C)	*Pinus wallichiana*	52.63	0.034 (R)
	Berberis lycium	40.06	0.04 (R)	*Berberis lycium*	129.6	0.028 (R)	*Berberis lycium*	62.42	0.034 (R)
	Trifolium pratense	43.02	0.109 (C)	*Plantago lanceolata*	36.45	0.043 (R)	*Trifolium pratense*	29.96	0.055 (C)
Site-13 Bheja	*Cedrus deodara*	53.07	0.023 (Re)	*Alnus nitida*	110.8	0.068 (C)	*Pinus wallichiana*	57.78	0.037 (R)
	Berberis lycium	53.86	0.025 (Re)	*Berberis lycium*	130.90	0.03 (R)	*Berberis lycium*	38.30	0.049 (R)
	Trifolium pratense	17.49	0.06 (C)	*Artemisia scoparia*	30.23	0.36 (R)	*Artemisia scoparia*	25.04	0.046 (R)
Site-14 Thanthera	*Cedrus deodara*	94.57	0.052 (C)	*Alnus nitida*	94.97	0.062 (C)	*Pinus wallichiana*	97.89	0.042 (R)
	Viburnum grandiflorum	45.78	0.033 (R)	*Prinsepia utilis*	96.01	0.032 (R)	*Prinsepia utilis*	53.06	0.024 (Re)
	Trifolium pratense	19.18	0.094 (C)	*Digitalis purpurea*	34.41	0.029 (R)	*Digitalis purpurea*	33.48	0.043 (R)
Site-15 Thanalla	*Ailanthus altissima*	60.84	0.053 (C)	*Robinia pseudoacacia*	89.7	0.043 (R)	*Pinus wallichiana*	70.14	0.045 (R)
	Viburnum grandiflorum	64.31	0.055 (C)	*Berberis lycium*	81.07	0.025 (Re)	*Prinsepia utilis*	43.81	0.029 (R)
	Digitalis purpurea	24.46	0.043 (R)	*Aquilegia pubiflora*	25.22	0.038 (R)	*Taraxacum officinale*	21.61	0.037 (R)

C-contagious, R-Random, Re-Regular, IV-Importance Value, AFR-Abundance Frequency Ratio

All the species except *Pinus roxburghii* at Site-3 (contagious) and *Punica granatum* at Pul Doda (random) exhibited regular distribution. Precisely the trees exhibited the random pattern followed by contagious distribution along the upland forests while riparian corridor showed a contagious pattern for most of the sites and random in few sections.

The A/F ratio obtained for the understorey layer suggests more of a random distribution. The riparian forests showed the random distribution for the dominant *Berberis lycium* at all sites except Sites-11 (where *Cactus* sp. showed random), 14 & 15 where *Prinsepia utilis* showed random and *Berberis lycium* exhibited regular distribution. The upland forests along the left bank again showed random distribution for all the sites except Sites-14 and 15 wherein *Berberis lycium* and *Viburnum grandiflorum* exhibited regular and contagious distribution, respectively. The herbaceous layer showed a mixed trend of distribution pattern with major vegetation exhibiting random and contagious distribution mixed with few cases of regular distribution. *Artemisia brevefolia* at Site-9 (Gatha) along the riparian, and, *Verbascum thapsus* at right bank upland forest showed the regular distribution while other species exhibited random and contagious type of distribution along both the banks.

B. Plant associations

The plant associations (trees in this case) were identified for all the study sites along the riparian corridor and upland buffers (Table 3) and Hierarchical cluster analysis was performed to better understand the level of similarity among the plant associations along the study corridor.

Table 3: Major tree associations in the study corridor.

Upland Forests (Left bank)	Riparian Forests	Upland Forests (Right bank)
	Along the rising elevation	
1. *Pinus roxburghii-Quercus baloot-Robinia pseudoacacia* 2. *Pinus roxburghii-Quercus baloot-Populus ciliata* 3. *Quercus baloot-Pinus roxburghii-Melia azedarach* 4. *Pinus roxburghii-Alnus nitida-Melia azedarach* 5. *Cedrus deodara-Pinus wallichiana-Robinia pseudoacacia* 6. *Cedrus deodara-Populus ciliata-Robinia pseudoacacia* 7. *Pinus wallichiana-Cedrus deodara-Robinia pseudoacacia* 8. *Cedrus deodara-Pinus wallichiana-Alnus nitida* 9. *Ficus palmata-Robinia pseudoacacia-Alnus nitida* 10. *Robinia pseudoacacia-Pinus wallichiana-Populus ciliata* 11. *Robinia pseudoacacia-Pinus wallichiana-Quercus leucotrichophora* 12. *Populus ciliata-Robinia pseudoacacia-Alnus nitida* 13. *Cedrus deodara-Pinus wallichiana-Ailanthus altissimo* 14. *Cedrus deodara -Pinus wallichiana-Quercus leucotrichophora* 15. *Ailanthus altissima-Pinus wallichiana-Quercus baloot*	1. *Melia azedarach- Ficus palmata- Robinia pseudoacacia* 2. *Ficus palmata - Pinus roxburghii - Quercus baloot* 3. *Alnus nitida - Ficus palmata - Quercus baloot* 4. *Alnus nitida - Ficus palmata - Quercus leucotrichophora* 5. *Alnus nitida - Ficus palmata - Robinia pseudoacacia* 6. *Alnus nitida - Pinus wallichiana -Cedrus deodara* 7. *Alnus nitida - Ficus palmata - Pinus wallichiana* 8. *8. Alnus nitida - Ficus palmata -Populus ciliata*	1. *Punica granatum-Ficus palmata-Melia azedarach* 2. *Quercus baloot-Pinus roxburghii-Quercus leucotrichophora* 3. *Pinus roxburghii-Quercus baloot-Quercus leucotrichophora* 4. *Pinus roxburghii-Melia azedarach-Ficus palmata* 5. *Pinus roxburghii-Quercus leucotrichophora-Cedrus deodara* 6. *Cedrus deodara-Cydonia oblonga-Melia azedarach* 7. *Cydonia oblonga-Pinus wallichiana-Cedrus deodara* 8. *Pinus wallichiana-Cedrus deodara-Punica granatum* 9. *Cedrus deodara-Pinus wallichiana-Populus ciliata* 10. *Cedrus deodara-Ficus rumphii-Pinus wallichiana* 11. *Populus ciliata-Pinus wallichiana-Robinia pseudoacacia* 12. *Pinus wallichiana-Ficus palmata-Cedrus deodara* 13. *Pinus wallichiana-Cedrus deodara-Salix alba* 14. *Pinus wallichiana-Cedrus deodara-Quercus baloot* 15. *Pinus wallichiana-Cedrus deodara-Abies pindrow*

C. Riparian forests

The riparian forests along the study corridor are represented by eight major tree associations dominated by *Alnus nitida, Ficus palmata, Robinia pseudoacacia, Pinus roxburghii, Pinus wallichiana* and *Cedrus deodara* (Table 3).

Two boarder clades have been obtained in the dendrogram with 15 leaves represented as the sites based on the similarities of vegetation in the respective sites. Clade-1 include the sites 1, 2, 8, 9, 10, 13, 14 and 15 while Clade-2 showed clustering in Sites 3, 4, 5, 6, 7, 11 and 12 (Fig. 3b).

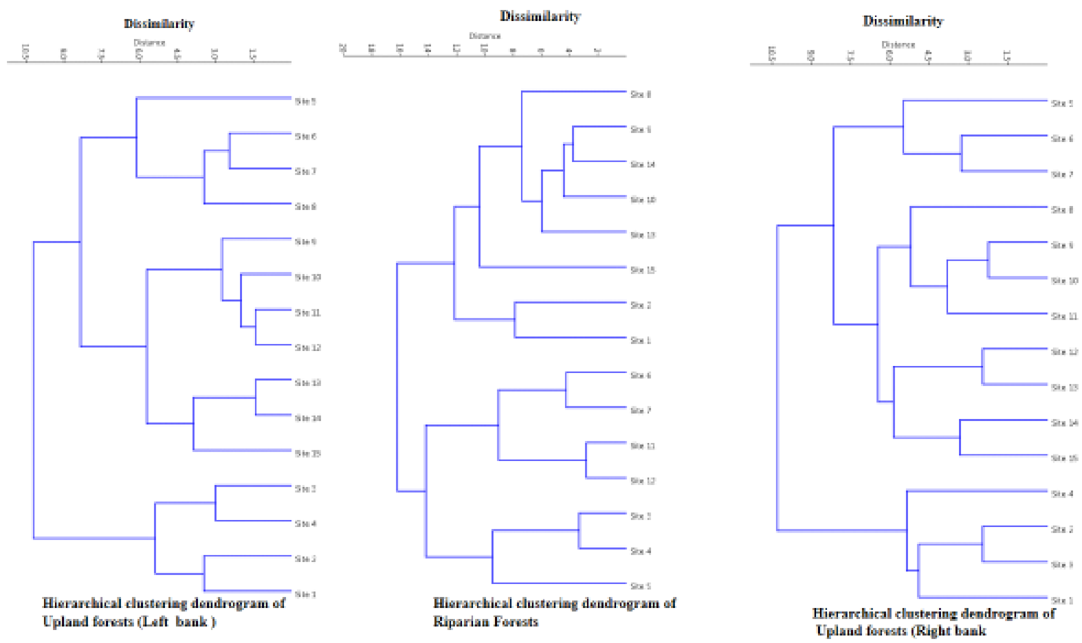


Fig. 3. Hierarchical cluster analysis a) Left bank forest b) Riparian forest c) Right bank forest.

The analysis showed that the Sites 11 & 12 are closely related to each other with similar tree associations with high abundance rates. Sites 3 & 4 and 9 & 14 also show closest similarity while Sites 6 & 7 though distantly located too reflected more or less similar vegetational elements. Sites 1 & 2 distantly located exhibited a unique similarity with sub-tropical dry deciduous vegetation mainly represented by *Melia azedarach-Ficus palmata- Robinia pseudoacacia* communities at the lower elevation. Sites 10 & 13 show a little deviation but remain closely associated with Sites 8, 9 & 14. These sites bear the pure stands of *Robinia pseudoacacia* plantations. Site-5 (Seri) represents all the tree associations run for hierarchical cluster analysis and hence forms an simplicifolius linkage while Site-15 (Thanalla) is represented mainly by *Alnus nitida - Ficus palmata - Robinia pseudoacacia* and thus appear as singleton.

D. Upland forests

The upland forests along the left banks of Neeru stream are represented by fairly good diversity of trees forming 15 associations (Table 3). The dendrogram obtained for the upland forest showed 3 main clusters containing sites (5, 6, 7 & 8, one bifolius and two simplicifolius), (9, 10, 11, 12, 13, 14 & 15, two bifolius and three simplicifolius) and (1, 2, 3 & 4, two bifolius), respectively based on the degree of similarity (Fig 3a). Sites 11 & 12 and 13 & 14 located at a shortest distance reveal maximum similarity. Sites 1 & 2 and 3 & 4 represent the respective clusters with more or less similar associations. These are the sites at the lower elevation with sparse heterogeneous vegetation. Sites 6 & 7 again form a cluster with similar tree composition mostly in the form of gregarious *Alnus nitida* stands and plantation of *Robinia pseudoacacia.* Sites 5, 8, 9, 10 and 15 form the simplicifolius structure thereby indicating moderate to high extent of dissimilarity amongst them along the left bank upland forest corridor. Site-5 (Seri) represents all possible associations and figure out as a separate entity.

Sun facing, comparatively dry upland forests along the right bank of Neeru stream are represented by 15 tree associations (Table 3). The dendrogram obtained for the upland forest showed 4 main clades containing sites (5, 6 & 7, one bifolius and one simplicifolius), (8, 9, 10 & 11, one bifolius and two simplicifolius), (12, 13, 14 & 15, two bifolius) and (1, 2, 3 & 4, one bifolius and one simplicifolius), respectively based on the degree of similarity (Fig 3c). Sites 9 & 10 are found closely related with highest degree of similarity. The major tree associations encountered in the releves included *Cedrus deodara-Pinus wallichiana-Populus ciliata, Pinus wallichiana-Cedrus deodara-Punica granatum, Cedrus deodara-Pinus wallichiana-Populus ciliata, Cedrus deodara-Ficus rumphii-Pinus wallichiana* and *Pinus wallichiana-Cedrus deodara-Quercus baloot.*

This is followed by Sites 12 & 13 with *Pinus wallichiana* sharing the mix of species together at two contagious sites. The dendrogram obtained for the right bank forests represents four simplicifolius leaves thus suggesting alienation of these locations with the rest of the sites. These include Sites 5 (Seri) with representation of all combinations, Site-1 (Pul Doda), Site-4 (Bhalla) and Site-8 (Amiranagar) with less richness and more heterogeneity.

DISCUSSION

The study reveals that *Alnus nitida* a moisture loving tree grows gregarious in whole of the riparian corridor along the elevational gradient. This is evident by its high frequency values and contagious distribution obtained among its associates along the abiotic variables. *Alnus nitida* shows a sparse distribution along the upland forests. Besides *Alnus nitida, Robinia pseudoacacia* and *Populus ciliata* have successfully acclimatized themselves over the slopes as artificially raised plantations. When compared with Raunkiaer's normal frequency class distribution our findings differed from the (normal) reverse J-shaped curve with lesser number of species obtained for class A and highest for classes C and D. This may be attributed to the difference in the physiography and climatic regime of the present study area when compared to the sub-tropics where Raunkiaer worked on.

Dangulla (2013) while working on forests of Yabo area of Sokoto state of Nigeria found *Populus ciliata* and *Robinia pseudoacacia* as most preferred plantations owing to its soil binding properties along the stream bank and agricultural land holdings. Danjuma *et al*. (2017) reported that *Fadherbia albida* and *Adansonia digitata* the preferred agro-forestry trees dominated the riparian buffers in northwestern Nigeria. They reported that these species were used as food, fodder and also enhance fertility of the soil and did not compete with the available nutrients. Similar observations have been made by Roupsard *et al*. (1999) and Cameron (2011).

In terms of vegetational distribution, the species with highest IVI exhibited the contagious pattern while the upland forest communities showed the mixed trend. High frequency of occurrence does not necessarily mean the high importance value (Sharma & Sharma, 2013). Contagious (patchy) distribution reflects the presence of multiple microhabitats in the study area (Vaghasiya *et al*., 2015). Lesser number of species in Class A (1-20%) in the study corridor indicates a homogenous nature of the forest community and similar trend was observed by Shaheen *et al*. (2011). The vegetational heterogeneity along the stream buffers is attributed to a number of abiotic factors like aspect, slope, elevation, sun exposure, availability of resources (water, nutrients, and available space), etc. Left bank on the northern aspect with moderate slopes receive optimum sunshine and support sufficient substratum for the rich and luxuriant vegetation. Elevation also plays an important role in the distribution of vegetation in the study corridor. Mid elevation sites showed high frequency of occurrence while the vegetation is moderately distributed on the higher elevation sites. Rate of recurrence also varied due to natural reasons like landslides and flash floods (Galgander and towards Pranoo) and anthropogenic reasons like construction activities, creation of tourist spots and recreation centers (Pul Doda and Gatha). A change in the distribution of species provides information about the species expansion or contraction, predictability of occurrence, effectiveness of control measures, habitat preferences, and dispersal mechanisms (Nkoa *et al*., 2015). Identifying distribution patterns of specific species or populations can provide insights into the habitat requirements and changes over the time. *Alnus nitida* for example prefers the moist environment while *Pinus roxburghii* and *Berberis lycium* tend to establish on drier habitats. The left bank of the stream indicates high species richness and diversity supporting heterogeneity and randomness in distribution. This indicates that the species present on the left bank have better chances of survival and adaptation as supported by the study of Lohani *et al*., 2013 in Kumaun Himalayas. Rawat & Chandok (2009) reported the random distribution as the most common form of distribution in Govind Pashu Vihar National Park, Uttarakhand. The present study reveals random pattern of distribution in case of trees and shrubs while the herbs depict contagious pattern. The riparian corridor is more contagious while the upland forests are more random than contagious. The regular pattern of dispersion is almost negligible. The random pattern of vegetational distribution exhibited by most of the forest types in the study area suggests a better seed dispersal (Odum 1971) on the contrary the contagious pattern and regular distribution pattern indicating high competition.

The dendrograms obtained rightly suggest the distribution of vegetation and plant associations as indicated with the level of similarity along the sites. It was observed that different forest communities are present in this stretch ranging from subtropical forest communities at Pul Doda, Galgander and Pranoo (837-1033 m), to temperate at higher elevation from Bhalla to Thanalla (1200-2163m).

CONCLUSION

Raunkiaer's frequency classes reveal the highest frequency of occurrence of majority of species in class C and D pointing towards the homogeneity in the riparian corridor while the upland forests along both the banks were observed to be heterogeneous. The whole corridor as a single unit was however found to be homogenous. In terms of dispersion, the left bank upland forest showed random and riparian the contagious pattern.

The results confirm that corridor is resource rich and there are better chances of survival and adaptation giving way to high abundance, frequency, diversity and species richness. The upland forests along the banks were heterogeneous represented by different associations. Diverse plant associations were recorded with 8 associations in the riparian zone and 15 each along the left and right bank upland. *Alnus nitida* emerged as a major dominant and *Ficus palmata* and *Robinia pseudoacacia* as co-dominants along the riparian stretch and conifers interspersed with broad-leaved species along the upland buffers.

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REFERENCE

Armesto, J. J. and Martinez, J.A. (1978). Relations between vegetation structure and slope aspect in the Mediterranean region of Chile. *Journal of Ecology*, **66**: 881-889.

Auble, G.T. and Scott, M.L (1998). Fluvial disturbance patches and cotton wood recruitment along the upper Missouri river, Montana. *Wetlands*, **18**: 546-556.

Boucher, C. (2002). Flows as determinants of riparian vegetation zonation patterns in selected southern African rivers. In: *Enviro Flows. Proceedings of the International Conference on Environmental Flows for River Systems*, incorporating the 4th International Ecohydraulics Symposium, Cape Town.

Brauman, K. A., G. C. Daily, T. K. E. Duarte, and Mooney, H. A (2007). The nature and value of ecosystem services: An overview highlighting hydrologic services. *Annual Review of Environment and Resources*, **32**: 67-98.

Brinson, M.M. (1990) Riverine forests. In (eds. Lugo, A.E., Brinson, M.M. and Brown, S) *Ecosystems of the World - 15: Forested wetlands*. Elsevier, Oxford. pp 87–141.

Cameron, E. (2011). From vulnerability to resilience: Farmer Managed Natural Regeneration (FMNR) in Niger. Climate & Development Knowledge Network.

Champion, H.G. and Seth, S.K (1968). A revised survey of the forest types of India. Government of India Publication Division, New Delhi. Changes in Arctic Vegetation. *Arctic*, **62**: 281-294.

Clarke A. R., Mac Nally, R., Bond, N. and Lake, P. S (2008). Macro invertebrate diversity in headwater streams: a review. *Fresh water Biology*, **53**: 1707–21.

Dangulla, M. (2013). The diversity and spatial variability of woody species in Yabo area, sokoto state. Thesis submitted to the school of Postgraduate studies, Ahmadu Bello University, Zaria, Nigeria.

Danjuma, M.N., Bindawa, A.A., Babankowa, I.A. and Maiwada, B. (2017). Frequency class distribution of vegetation in the dry land of Northwestern Nigeria. *American Journal of Biology and Life Sciences,* **5**(2): 7-12.

De Groot, R. S., Wilson, M. A. and Boumans, R. M. J. (2002). A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics*, **41**: 393–408.

Ferreira, L.V. and Stohlgren, T. J. (1999). Effects of river level fluctuation on plant species richness, diversity, and distribution in a flood plain forest in Central Amazonia. *Oecologia*, **120**: 582–587.

Franklin, J., McCullough, P. and Gray, C (2000). Terrain variables used for predictive mapping of vegetation communities in conservation. Taylor and Francis, Boca Raton, *Florida*, 315-342.

Gould, W. A. and Walker, M. D (1997). 'Landscape-scale patterns in plant species richness along an arctic river', *Canadian Journal of Botany–Revue Canadienne De Botanique*, **75**: 1748–1765.

Gregory, S.V., Swanson, F. J., McKee, W. A. and Cummins, K.W. (1991). An ecosystem perspective of riparian zones. *Bioscience*, **41**(8): 540-551.

Grytnes, J. A. and Vetaas, O. R (2002). Species richness and altitude: a comparison between null models and interpolated plant species richness along the Himalayan altitudinal gradient, Nepal. *The American Naturalist,* **159**: 294–304.

Grytnes, J. A. and Beaman, J. H. (2006). Elevational species richness patterns for vascular plants for Mount Kinabalu, Borneo. *Journal of Biogeography*, **33**:1838–1849.

Hietel, E., Waldhart, R. and Otte, A. (2004). Analysing land-cover changes in relation to environmental variables in Hesse, Germany. *Landscape Ecology*, **19**: 473-489.

Hupp, C. R (1988). Plant ecological aspects of flood geomorphology and paleoflood history. In: Baker, V.R., Kochel, R.C. & Patton, P.C. (Eds). Flood Geomorphology. Wiley, New York. pp. 335–356.

Hupp, C. R. and Osterkamp, W.R. (1996). Riparian vegetation and fluvial geomorphic processes. *Geomorphology,* **14**: 277–295.

Kalliola, R. and Puhakka, M. (1988). River dynamics and vegetation mosaicism: a case study of the River Kamajohka, northernmost Finland. *Journal of Biogeography*, **15**: 703–719.

Kappelle, M., Vanuffelen, J., and Cleef, A. M (1995). Altitudinal zonation of montane *Quercus* forests along two transects in the Chirripó National Park, Costa Rica. *Vegetatio*, **119**(2): 119–153.

Kharkwal, G. and Rawat, Y.S. (2010). Structure and composition of vegetation in subtropical forest of Kumaun Himalaya. *African Journal of Plant Science*, **4**(4): 116-121.

Kocher, S. and Harris, R. (2007). Forest Streams: Forest stewardship series 9 (8239): 1-10, and 10 (8240): 1-7. Division of Agricultural and Natural Resources, University of California.

Lieberman, M., Lieberman, D., Hartshorn, G.S. and Peralta, R (1996). Tropical forest structure and composition on a large-scale altitudinal gradient in Costa Rica. *Journal of Ecology*, **84**:137–152.

Lieberman, M., Lieberman, D., Hartshorn, G.S. and Peralta, R (1996). Tropical forest structure and composition on a large-scale altitudinal gradient in Costa Rica. *Journal of Ecology*, **84**:137–152.

Lohani, N., Tewari, L.M., Kumar, R., Joshi, G.C., Chandra, J., Kishore, K., Kumar, S. and Upreti, B.M. (2013). Population studies, habitat assessment and threat categorization of *Polygonatum verticillatum* (L.) Allioni in Kumaun Himalaya. *Journal of ecology and natural environment,* **5**(5): 74-82.

Lovett, J.C (1999). Tanzanian forest tree plot diversity and elevation. *Journal of Tropical Ecology*, **15**: 689–694.

Mahoney, J. M. and Rood, S. B (1998). Stream flow requirements for cottonwood seedling recruitment- an integrative model. *Wetlands*, **18**(4): 634-645.

Malanson, G.P. (1993). *Riparian landscapes*. Cambridge University Press, Cambridge, UK.

Malard, F., Vehlinger, U., Zah, R., Tockner, K (2006). Flood-pulse and river-scape dynamics in a braided glacier river. *Ecology*, **87**: 704-716.

Martin, T. L., Kaushik, N. K., Trevors, J. T. and Whiteley, H. R (1999). Review: denitrification in temperate climate riparian zones. *Water, Air, and Soil Pollution*, **111**: 171-186.

Martı´nez-Yrı´zar, A., Bu´rquez, A. and Maass, M. (2000). Structure and functioning of tropical deciduous forest in Western Mexico. In (eds.) Robichaux R.H, Yetman, D.A. The tropical deciduous forest of Alamos: biodiversity of a threatened ecosystem in Mexico. The University of Arizona Press, Tucson, 19–35.

Naiman, R. J., Decamps, H., Mclain, M. E. (2005). Riparia: Ecology, conservation and management of streamside communities. *Elsevier/Academic Press*, San Diego.

Newbold, J.D., Elwood, J.W., O'Neill, R.V. and Van Winkle, W (1981). Measuring nutrient spiralling in streams. *Canadian Journal of Fisheries and Aquatic Sciences*, **38**: 860–863.

Nichols, W.F., Killinbeck, K. T., August, P. V (1998). The influence of geomorphological heterogeneity on biodiversity II. A landscape perspective. *Conservation Biology*, **12**: 371–379.

Nilsson, C. (1991). Conservation management of riparian communities In: Hansson, L. (Ed) Ecological principles of nature conservation. *Elsevier Science, Amsterdam*, 352–372.

Nkoa, R., Micheal, D. K.O., and Swanton, C.J. (2015). Weed Abundance, Distribution, Diversity, and Community Analyses. *Weed Science*, 64-90.

Odum, E.P. (1971). *Fundamentals of Ecology*, W. B. Sounders and Co., Philadelphia.

Pierce, K. B. Jr, Lookingbill, T. and Urban, D (2005). A simple method for estimating potential relative radiation (PRR) for landscape-scale vegetation analysis. *Landscape Ecology*, **20**: 137–147.

Rahbek, C (1995). The elevational gradient of species richness: a uniform pattern? *Ecography*, **18**: 200–205.

Raunkiaer, C. (1934). *The Life forms of plants and statistical Plant Geography*, Clarendon Press, Oxford.

Rawat, V.S. and Chandhok, A (2009). Phytosociological analysis and distribution pattern of tree species: A case study of Govind Pashu Vihar, National Park, Uttarakhand. *New York Science Journal*, **2**(4): 58-63.

Roupsard, O., Ferhi, A., Granier, A., Pallo, F., Depommier, D., Mallet, B., Joly, H.I. and Dreyer, E. (1999). Reverse phenology and dry-season water uptake by *Faidherbia albida* (Del.) A Chev. In an Agroforestry Parkland of Sudanese West Africa. *Functional Ecology,* **13**(4): 460-472.

Sabo, J. L., Sponseller, R., Dixon, M., Gade, K., Harms, T., Heffernan, J., Jani, A., Katz, G., Soykan, C., Watts, J., and Welte, J (2005). Riparian zones increase regional species richness by harboring different, not more, species. *Ecology*, **86**(1): 56-62.

Salo, J., Kalliola, R., Hakkinen, I., Makinen, Y., Niemela, P., Puhakka, M. and Coley, P. D (1986). River dynamics and the diversity of amazon lowland forest, *Nature*, **322**: 254–258.

Scott, M. L., Auble, G .T. and Friedman, J. M (1997). Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. *Ecological Applications*, **7**: 677–690.

Scott, M. L., Friedman, J. M. and Auble, G.T (1996). Fluvial process and the establishment of bottomland trees. *Geomorphology*, **14**: 327-339.

Shafroth, P. B., Auble, G. T., Stroberg, J. C. and Patten, D. T (1998). Establishment of woody riparian vegetation in relation to annual patterns of streamflow, Bill Williams River, Arizona. *Wetlands*, **18**(4): 577-590.

Sharma, B. and Sharma, K. (2013). Influence of various dominant trees on phytosociology of understorey herbaceous vegetation. *Recent Research in science and Technology*, **5**(2): 41-45.

Stanford, J. A., Lorang, M. S. and Hauer, F. R (2005). The shifting mosaic of river ecosystems. *Verhandlungen der Internationalen Vereinigung fur Limnologie*, **29**: 123-136.

Stohlgren, T. J., Chong, G. W., Kalkhan, M. A. and Schell, L. D. (1997). Multiscale sampling of plant diversity: effects of minimum mapping unit size. *Ecological Application*, **7**: 1064-1074.

Stromberg, J (1998). Dynamics of Fremont cottonwood (*Populus fremontii*) and saltcedar (*Tamarix chinensis*) populations along the San Pedro River, Arizona. *Journal of Arid Environments*, **40**: 133-155.

Stromberg, J. C. (1993). Instream flow models for mixed deciduous riparian vegetation within a semi-aid region. *Regulated Rivers Research & Management*, **8**: 225- 235.

Stromberg, J. C. and Patten, D. T (1992). Mortality and age of black cottonwood stand along diverted and undiverted streams in the eastern Sierra Nevada, California. *Modrono*, **39**(3): 205-223.

Suzaki, T, Kume A, Ino Y. (2005). Effects of slope and canopy trees on light conditions and biomass of dwarf bamboo under a coppice canopy. *Journal of Forest Research*, **10**: 151–156.

Tickner, D.P., Angold, P.G., Gurnell, A.M. and Mountfold, J.O. (2001). Riparian plant invasions: hydrogeomorphological control and ecological impacts. *Progress in Physical Geography*, **25**(1): 22-52.

Vaghasiya, P.M., Dhamsaniya, S., Pardya, B.R. and Patel, R. M. (2015). Vegetation characteristics of Chapredi reserve forest of Bhuj-Kachchh, Gujarat. *eJournal of Applied Forest Ecology*, **3**(1): 65-73.

Vannote, R. L., Minshall, G.W., Cummins, K.W., Sedell, J. R. & Cushing, C.E. (1980). Theriver continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences,* **37:** 130-137.

Ward, J.V. (1998). Riverine landscapes: Biodiversity patterns, disturbance regimes, and aquatic conservation. *Biological Conservation,* **83**: 269-278.

Whitford, P.B. (1949). Distribution of woodland plants in relation to succession and clonal growth. *Ecology,* **30**: 199-208.

Yeakley, J. A., Hornberger, G.M., Swank, W.T., Bolstad, P. V. and Vose, J.M. (2000). Soil moisture modeling in humid mountainous landscapes. In (eds.) Wilson J.P, Gallant J.C, Terrain analysis: principles and applications. Wiley, New York, 205–224.

Youngblood, A.P., Padgett, W.G. Winward, A.H. (1985). *Riparian Community Type Classification of Eastern Idaho-Western Wyoming.* USDA Forest Service Intermountain Region, Ogden, UT.