Tropical Plant Research
An International Journal
© Society for Tropical Plant Research

ISSN (E): 2349 – 1183
ISSN (P): 2349 – 9265
3(1): 142–152, 2016

Research article

Biomass extraction impact on vegetation community structure in Kaimur wildlife sanctuary, Uttar Pradesh, India

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Abstract: The objective of this study was to assess the impacts of biomass extraction on vegetation community structure. The area selected for this study was Kaimur wildlife sanctuary situated in Mirzapur and Sonbhadra district of Uttar Pradesh, India. Area was stratified into high, medium and low disturbed area on the basis of presence of human induced disturbance indicators. Within each stratified area, 10 m radius circular plots were laid to record the vegetation, habitat and disturbance variables. Results showed that tree density and diversity indices were recorded highest in least disturbed area. The overall highest Importance Value Index is of Sal (116), recorded from medium disturbed area. Human trail and grazing cover was negatively correlated with density and diversity indices of tree and sapling. Canopy cover was positively correlated to herb diversity indices. Tree, shrub and herb diversity indices are positively correlated to distance from human habitation. Present study concludes that grazing and lopping are the prime disturbance factor for changes in vegetation community structure. The density of some of the sampled plant species is very low which in the coming future will face local extinction. For future and long term aspects, urgent initiatives are required to conserve and protect vegetative species.
Keywords: Vegetation composition - IVI - Canopy cover - Human induced disturbance - Grazing.

[**Cite as:** Tahoor A, Musavi A & Khan JA (2016) Biomass extraction impact on vegetation community structure in Kaimur wildlife sanctuary, Uttar Pradesh, India. *Tropical Plant Research* 3(1): 142–152]

INTRODUCTION

Protected areas (PAs) are home to variety and variability of living organisms. There are around millions of people living around these PAs and are dependent on the forest resources for their basic needs (Kothari *et al.* 1995). These nearby residing villagers extract biomass in the form of livestock grazing, lopping, fuelwood collection, extraction of NTFPs (Non Timber Forest Products). At a large scale, the extraction of forest resource exerts impact on vegetation composition (Silori & Mishra 2001, Seng *et al.* 2004, Shahabuddin & Prasad 2004, Rabha 2014). It is because of unsustainable extraction of forest and increase in human population day by day. Harvesting or extraction of forest resource from the PAs is illegal but still it is going on. Earlier studies in India and abroad found that disturbance due to biomass extraction has negative impact on vegetation (Bhuyan *et al.* 2003, Sagar *et al.* 2003, Arjunan *et al.* 2005, Raghubanshi & Tripathi 2009, Biswas & Mallik 2010, Hoang *et al.* 2011, Sutomo *et al.* 2015), diversity (Singh *et al.* 2003, Karkee 2004, Mishra *et al.* 2004, Kumar & Shahabuddin 2005, Mehta *et al.* 2008, Singh *et al.* 2008, Nagendra 2010, Sarkar & Devi 2014), richness (Mishra *et al.* 2004, Kumar & Shahabuddin 2005, Tousignant *et al.* 2010, Tripathi *et al.* 2010, Sherma *et al.* 2014) and density (Silori & Mishra 2001, Schwartz & Caro 2003, Mishra *et al.* 2004, Lalfakawma 2009, Sundarapandian & Subbiah 2015). Because on individual basis, floristic composition is considered as one of the major distinguishing feature of a community (Dansereau 1960) therefore any kind of depletion in biodiversity is bound to change community structure (Mishra *et al.* 2004).

Kaimur wildlife sanctuary (KWS) is surrounded by more than 125 villages. Out of these, 20 villages are present inside the sanctuary having human and cattle population 12,327 and 10265 respectively (Chandra 2010). Because of biomass extraction, these types of forest are being converted to dry deciduous scrub, dry savannah and dry grasslands (Champions & Seth classification 1968). This calls for an urgent need to research the background factor responsible for species depletion and change in vegetation community structure. This Sanctuary is home to a variety of wild species which are accorded different levels of protection according to the

Received: 27 December 2015 Published online: 30 April 2016

Indian Wildlife Protection Act, 1972. Changes in vegetation composition due to biomass extraction will adversely affect the wildlife also. So the main objective of this study was to assess the factors responsible for changes in vegetation community and the impacts thereof.

MATERIALS AND METHODS

Study area

Kaimur wildlife sanctuary (KWS) is situated in Kaimur hills of Mirzapur and Sonbhadra district of Uttar Pradesh (Fig. 1). It covers an area of 500 km^2 in the semi-arid zone of northern India (Rodgers *et al.* 2000) with geographical extent of 82^{o}20'15" E to 24^{o}52'00" N and 83^{o}08'23" E to 24^{o}27'51" N. For administrative purpose, sanctuary is divided into four ranges namely Halia, Ghorawal, Robertsganj and Gurma. Geologically, mostly part of the sanctuary is hilly and undulating terrains. Soil found in this area is red clay which is stiff and ferruginous in nature. This Sanctuary faces three seasons namely summer (March–June), Monsoon (June–September) and winter (November–February). The maximum/minimum temperature is 46.8 and $4^{o}C$ respectively. According to Champions & Seth (1968) sanctuary comes under dry deciduous type forest. There are four major types of forest forms in this sanctuary namely Sal forest, Bamboo, Scrub and Deciduous forest. Sal forest comes under dry peninsular and enriched by *Shorea robusta*. The Bamboo forest consists of dry Bamboo brades. The Scrub forest is accompanied by open dry scrubby vegetation. While, deciduous forest consists of dry deciduous mixed woody species.

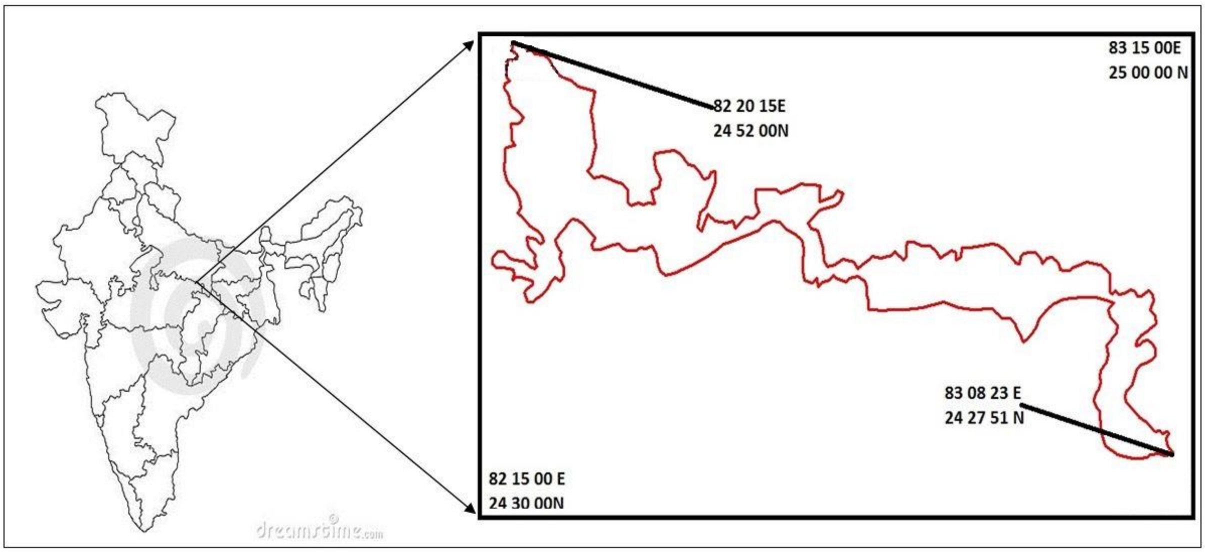

Figure 1. Map of India showing location of Kaimur wildlife sanctuary in Mirzapur and Sonbhadra districts of Uttar Pradesh.

Sampling sites

Through a reconnaissance survey, the area was stratified into high, medium and low disturbed categories on the basis of indicators reflecting biomass extraction. Highly disturbed term was used for that area which faced high biomass extraction on the basis of presence of human induced disturbance indicators namely cattle dung, lopping, fuel wood collection and extraction of NTFPs. Low disturbed area termed on the basis of fewer signs of biomass extraction. Medium disturbed term was used for that area faced neither high nor low biomass extraction. These terms (high, medium and low disturbed area) which was used in this study was only for analytical and research purpose.

Data collection

Within each stratified area (high, medium and low disturbed) line transects of 2 km was laid. On each transect a circular plot of 10 meter radius at every 200 m (statistically independent samples) was placed on the transect line. Tree layer was sampled within the 10 m radius of plot. Individuals of tree species with>30cm girth at breast height and >3m height was considered as trees (Mueller-Dombois & Ellenbergh 1974). In each plot tree species, tree individuals, girth at breast height of each tree was recorded. Canopy cover and tree height was measured by ocular estimation. A nested 5 m circular plot was used to assess shrub layer and regeneration pattern. Woody species with GBH <30cm and height <3m were considered as shrub (Mueller-Dombois & Ellenbergh 1974). Species and number of individual were recorded. Regeneration pattern was assessed by recording individuals and species of seedling and sampling. The quantification of species and individuals of herb and grass was measured by randomly laying 1m square quadrate at four locations within the larger one. Point-Intercept method was used to assess ground cover (Mueller-Dombois & Ellenbergh 1974). For that, a rod of 1m length having 20 marked points was laid randomly on the ground for five times by covering a total of 100 standard points, to record herb, grass, bare ground, litter and stone.

Data analysis

The characterization and dominance of vegetation is revealed by Importance Value Index (IVI) (Keel *et al.* 1993). The IVI was computed for each of the tree species by adding the relative values of frequency, density and dominance (basal area) or dominance (Curtis & McIntosh 1950, Krebs 1989). Sorenson's similarity index (community coefficient) for similarity of plant species in the three categories of disturbed area was calculated with the help of following formula (Jaccard 1912):

$$Cj = j(a+b-j)$$

where, Cj= Jaccard similarity coefficient, a=number of species in A area, b=number of species in B area and j=number of species common to both the area.

Index of Dissimilarity = 1-Index of Similarity

Diversity indices of vegetation like species diversity, richness and evenness was analysed using Paleontological Statistics Software Package for Education and Data Analysis (Hammer *et al* 2001, Hall 2005, Bajpai *et al*. 2012). One way Analysis of Variance (ANOVA) was applied on different categories of disturbed area (high, medium and low) to test the significant differences in community attributes of vegetation. Pearson's Product Moment Correlation was used on habitat and disturbance variables with vegetation. Principal Component Analysis (PCA) was used to reduce the dimensionality of vegetation variables by developing 2 uncorrelated Principal components. All the statistical analysis was performed on SPSS *ver*17.0 (Statistical Package for Social Sciences).

RESULTS

A total of 57 plant species were found during vegetation sampling. Out of 57, there are only 30 tree species recorded during the research period in the study area. In high, medium and low disturbed area, 28, 26 and 31 plant species were recorded including tree, shrub, herb and grass respectively. For woody species, IVI was calculated. This index gives a clear idea about the importance of tree species in any area or habitat with the help of three parameters namely dominance, frequency and density. In high disturbed area only 12 tree species were recorded with highest and lowest IVI of *Butea monosperma* and *Nyctanthes arbortristis* (74.39 and 6.125 respectively). In the same area, highest density is of *Holoptelea integrifolia* whereas *Bambusa arundinacea* was recorded highest for dominance. In medium disturbed area, the highest IVI along with dominance, frequency and density was recorded for *Shorea robusta*. While in the same area, lowest IVI was recorded for Rewa. In low disturbed area, the highest and lowest IVI were calculated for *Cassia fistula* and *Ficus religiosa* (84.19 and 5.74 respectively). On individually mentioning, *Cassia fistula* was the most dominant tree species in low disturbed area (78.48) whereas *Tectona grandis* was recorded highest on population basis. Among the tree species common to the three disturbed areas, the highest IVI is of *Shorea robusta* (116.46) from area facing medium biomass extraction. The IVI of all the woody species in all the disturbed area is given in table 1.

Table 1. Importance Value Index (IVI) of tree species in high, medium and low disturbed area of Kaimur wildlife sanctuary.

Tree species	High disturbed area				Medium disturbed area				Low disturbed area			
	Dom	Fre	Den	IVI	Dom	Fre	Den	IVI	Dom	Fre	Den	IVI
Cassia fistula	-	-	-	-	-	-	-	-	78.486	2.855	2.856	84.198
Terminalia arjuna	-	-	-	-	-	-	-	-	0.062	2.855	2.856	5.774
Terminalia elliptica	0.26	12.723	12.723	25.712	0.245	17.867	17.867	35.980	1.1198	5.711	5.713	12.544
Acacia nilotica	0.549	9.087	9.0878	18.724	-	-	-	-	-	-	-	-
Terminalia bellirica	-	-	-	-	-	-	-	-	0.156	3.426	3.427	7.011
Bambusa arundinacea	16.656	11.744	11.744	40.145	2.526	4.466	4.466	11.460	8.668	5.425	5.427	19.521
Bamboo sp.	-	-	-	-	5.883	5.955	5.955	17.794	-	-	-	-
Ficus benghalensis	8.532	2.936	2.936	14.404	2.526	4.466	4.466	11.460	0.209	2.855	2.856	5.922

Holoptelea integrifolia	0.319	14.925	14.925	30.169	-	-	-	-	-	-	-	-
Buchanania lanzan	-	-	-	-	-	-	-	-	1.188	4.2262	4.227	9.642
Delonix regia	-	-	-	-	0.556	2.977	2.977	6.512	-	-	-	-
Nyctanthes arbortristis	0.252	2.936	2.936	6.125	-	-	-	-	-	-	-	-
Abutilon indicum	-	-	-	-	-	-	-	-	0.101	3.807	3.770	7.679
Kaima#	-	-	-	-	-	-	-	-	0.204	2.855	2.856	5.916
Bauhinia purpurea	-	-	-	-	-	-	-	-	0.071	2.855	2.856	5.783
Acacia catechu	-	-	-	-	-	-	-	-	0.257	8.965	8.968	18.190
Kurayya#	-	-	-	-	-	-	-	-	0.217	4.283	4.284	8.785
Madhuca indica	3.263	4.404	4.404	12.071	4.006	2.977	2.977	9.962	0.088	2.855	2.856	5.800
Makoicha#	-	-	-	-	-	-	-	-	0.052	2.855	2.856	5.764
Azadirachta indica	-	-	-	-	-	-	-	-	0.197	2.855	2.856	5.909
Butea monosperma	53.032	10.681	10.681	74.394	0.426	10.493	10.493	21.414	0.147	5.491	5.493	11.132
Ficus religiosa	11.922	2.936	2.936	17.794	4.145	2.977	2.977	10.100	0.030	2.855	2.856	5.742
Rewa#	-	-	-	-	0.469	2.977	2.977	6.425	-	-	-	-
Rimjim#	-	-	-	-	-	-	-	-	0.210	2.855	2.856	5.922
Tectona grandis	-	-	-	-	-	-	-	-	0.187	15.229	15.235	30.651
Shorea robusta	0.448	6.850	6.850	14.149	75.517	20.473	20.473	116.463	0.124	2.855	2.856	5.836
Bombax ceiba	-	-	-	-	3.649	7.444	7.444	18.538	0.159	2.855	2.856	5.872
Cassia siamea	0.483	7.340	7.340	15.163	-	-	-	-	0.065	2.855	2.856	5.777
Albizia lebbeck	-	-	-	-	-	-	-	-	0.092	2.855	2.856	5.804
Diospyros melanoxylon	4.273	13.434	13.434	31.143	-	-	-	-	7.900	3.456	3.458	14.815

Note: Dom= Dominance, Fre= Frequency, Den= Density, IVI= Importance value index; *Values of Dominance, Frequency and Density are in percentage; # common name.

The density, diversity, richness and evenness of tree species was found to be significantly different in high, medium and low disturbed area ($F_{2,198}$=31.770,p<0.01; $F_{2,198}$=390.51,p<0.01 $F_{2,198}$=450.56,p<0.01and $F_{2,198}$=332.34,p<0.01) respectively. The density, diversity, richness and evenness of tree species were found to be highest in low disturbed area (131.48±7.777, 0.19±0.024, 0.18±0.024 and 0.12±0.015 respectively). The shrub density was calculated lowest in the low disturbed area. The density of shrub was found to be significantly in high, medium and low disturbed area ($F_{2,198}$=33.334,p<0.01). The diversity and its attribute for herb and grass layer were calculated highest in low disturbed area. The population of regeneration composition (sapling and seedling) was also calculated highest in high disturbed area. The detail of density and diversity indices of plants is provided in table 2.

Table 2. Density, diversity, richness and evenness of plants (trees, shrub, herb, grass, sapling and seedling) in high, medium and low disturbed area of Kaimur wildlife sanctuary. (Values are in Mean±Standard Error)

Area → **↓ Vegetation Variable**	**High disturbed area**	**Medium disturbed area**	**Low or minimal disturbed area**	**Overall**
Tree density	131.48±7.777	143.78±12.316	230.41±7.198	166.89±5.278
Tree diversity	0.19±0.024	0.23±0.029	1.27±0.039	0.54±0.027
Tree richness	0.18±0.024	0.22±0.032	1.75±0.062	0.69±0.038
Tree evenness	0.12±0.015	0.15±0.017	0.64±0.016	0.29±0.013
Shrub density	281.81±40.494	1.90±1.90	86.46±11.956	125.59±95.49
Shrub diversity	0±0	0.01±0.004	0.04±0.012	0.01±0.004
Shrub richness	0±0	0.01±0.006	0.05±0.0017	0.02±0.006
Shrub evenness	0±0	0±0.003	0.02±0.008	0.01±0.003
Herb diversity	0.05±0.035	0.01±0.005	0.31±0.025	0.12±0.015
Herb richness	0.05±0.035	0.01±0.002	0.17±0.012	0.007±0.013
Herb evenness	0.05±0.034	0±0.002	0.20±0.016	0.08±0.013
Grass diversity	0.22±0.021	0.10±0.018	0.03±0.007	0.12±0.010
Grass richness	0.10±0.011	0.05±0.009	0.02±0.005	0.06±0.005

Grass evenness	0.15±0.0015	0.06±0.012	0.02±0.004	0.08±0.013
Sapling density	1299.03±122.156	350.25±25	222.11±25.384	638.25±49.039
Sapling diversity	0.20±0.023	0.03±0.01	0.23±0.032	0.15±0.014
Sapling richness	0.15±0.019	0.03±0.0010	0.25±0.034	0.14±0.014
Sapling evenness	0.13±0.015	0.02±0.007	0.16±0.026	0.10±0.010
Seedling density	610.58±64.943	579.53±47.844	134.08±13.296	449.53±29.318
Seedling diversity	0.14±0.020	0.13±0.018	0.16±0.026	0.14±0.012
Seedling richness	0.16±0.025	0.13±0.019	0.23±0.033	0.17±0.015
Seedling evenness	0.09±0.014	0.08±0.012	0.12±0.016	0.10±0.008

The Sorenson's Index of dissimilarity between high-medium, medium-low and high-low disturbed areas were found to be 0.7, 0.75 and 0.8125 respectively (Table 3). A total of 9 habitat variables were selected to observe association with density and diversity attributes of vegetation layers. The density and diversity aspects of tree species showed significant negative correlation with elevation (r=-0.299, p=0.01; r=-0.724.p=0.01; r=-0.718, p=0.01 and r=-0.718, p=0.01 respectively). With increase in elevation; the density, diversity, richness, evenness and mean tree height reduced. On the other hand, density of shrub and regenerating composition (sapling and seedling) had significant positive correlation with elevation (r=0.182, p=0.01; r=0.299, p=0.01 and r=0.237, p=0.01 correspondingly). But the diversity, richness and evenness of regenerating constituents decreased as the elevation level rises. The diversity indices of ground canopy *i.e.* grass and herb showed positive and as well as negative association with the elevation respectively. The vegetation layer showed positive association with the distance from human settlements. As the distance from villages increased the population of tree increased. The diversity components of tree, shrub, herb and sapling showed significant positive association with the village distance. As the distance from water-body increased, population of tree decreased along with diversity aspects. The population of shrub was negatively associated with the canopy cover (r=-0.180, p=0.01). The grass cover showed positive association with top canopy and ground canopy (herb diversity and richness). But for regeneration component, grass showed negative association especially with population of sapling (r=-0.108, p=0.01).

Table 3. Sorenson's Index of similarity and dissimilarity of plant species among high, medium and low disturbed areas in Kaimur wildlife sanctuary.

Areas	**Index of Dissimilarity**	**Index of Similarity**
High and Medium disturbed area	0.7(70)	0.3(30)
Medium and Low disturbed area	0.75(75)	0.25(25)
High and Low disturbed area	0.8125(81.25)	0.1875(18.75)

Note: Values in parenthesis are in percentage.

The correlation between vegetation and habitat variables is given in table 4. The disturbance variables selected in the present study are human trail, cattle dung density, grazing cover, weed density, weed cover, lopping density, mean lop score and fire. Human trail showed negative association with the diversity, richness and evenness of tree species (r=-0.204, p=0.01; r=-0.208, p=0.01 and r=-0.192, p=0.01 respectively). Similarly, the density of sapling and seedling was positively associated with human trail (r=0.281, p=0.01 and r=0.210, p=0.01 respectively). The density of sapling and seedling was positively associated with human trail (r=0.281, p=0.01 and r=0.210, p=0.01 respectively). Whereas; diversity, richness and evenness of sapling species showed significant negative correlation with human trail (r=-0.096, p=0.05; r=-0.096, p=0.05 and r=-0.095, p=0.05) respectively. The grazing cover was significantly negatively associated with density, diversity, richness and evenness of tree species (r=-0.111, p=0.01; r=-0.147, p=0.001; r=-0.155, p=0.01 and r=-0.136, p=0.01 respectively). But for ground layer, grazing cover was significantly positively associated especially with the diversity, richness and evenness of grass (r=0.211, p=0.01; r=0.233, p=0.01 and r=0.200, p=0.01 respectively). A significant negative correlation was calculated between diversity, richness and evenness of sapling and livestock grazing (r=-0.85, p=0.05; r=-0.89, p=0.05 and r=-0.083, p=0.05) correspondingly. Weed cover showed a negative association with the diversity, richness and evenness grass (r=-0.011, p=0.01; r=-0.095, p=0.05 and r=-0.119, p=0.05 respectively). The lopping density showed a positive association with the population of sapling (r=-0.09, p=0.05). Fire is also another threat to fragile plants especially seedlings, grass and h erb. But in the

Table 4. Correlation of density, diversity, richness and evenness of plants (trees, shrub, herb, grass, sapling and seedling) with habitat variables in Kaimur wildlife sanctuary.

Habitat variable → / ↓Vegetation variable	Elevation (m)	DFHH (km)	DFWB (km)	Canopy cover (%)	Shrub cover (%)	Herb cover (%)	Grass cover (%)	Mean tree height (m)	Mean tree GBH (m)
Tree density	-0.299**	0.078	-0.277**	0.548**	0.007	0.214**	0.267**	0.465**	0.129**
Tree diversity	-0.724**	0.583**	-0.314**	0.637**	-0.091*	0.500**	0.450**	0.485**	0.072
Tree richness	-0.718**	0.646**	-0.315**	0.583**	-0.08**	0.524**	0.460**	0.408**	0.068
Tree evenness	-0.718**	0.530**	-0.312**	0.667**	-0.069	0.478**	0.452**	0.544**	0.072
Shrub density	0.182**	-0.065	0.288**	-0.180**	-0.319**	-0.042	-0.044	-0.131**	0.106**
Shrub diversity	-0.145**	0.126**	-0.037	0.102*	-0.037	0.023	-0.097*	0.116**	0.026
Shrub richness	-0.142**	0.126**	-0.037	0.102*	-0.036	0.023	-0.096*	0.115**	0.029
Shrub evenness	-0.150**	0.126**	-0.036	0.101	-0.038	0.028	-0.1*	0.127**	0.031
Herb diversity	-0.278**	0.124**	-0.0131**	0.185**	-0.048	0.230**	0.228**	0.041	0.037
Herb richness	-0.147**	0.323**	-0.083**	0.108**	-0.041	0.136**	0.121**	0.017	0.011
Herb evenness	-0.051	0.192**	-0.026	0.026	-0.011	0.014	0.023	0.017	0.013
Grass diversity	0.199**	-0.210**	0.261**	0.032	-0.010	-0.136**	-0.011	0.108**	-0.065
Grass richness	0.170**	-0.160**	0.204**	0.031	-0.017	-0.109**	0.001	0.078	-0.077
Grass evenness	0.214**	-0.216**	0.283**	0.030	-0.006	-0.142**	-0.015	0.119**	-0.061
Sapling density	0.299**	-0.284**	0.188**	-0.057	0.043	-0.162**	-0.108**	-0.111**	0.048
Sapling diversity	-0.104*	0.104*	0.124**	0.010	0.179**	0.023	0.043	0.031	0.050
Sapling richness	-0.182**	0.158**	0.076	0.041	0.162**	0.067	0.081*	0.050	0.049
Sapling evenness	-0.101*	0.098*	0.108**	0.011	0.166**	0.029	0.039	0.025	0.048
Seedling density	0.237**	-0.367**	0.103*	-0.037	-0.018	-0.204**	-0.092*	0.087*	-0.007
Seedling diversity	-0.085*	-0.020	-0.083*	0.063	0.030	-0.023	0.026	0.153**	0.039
Seedling richness	-0.115**	0.029	-0.059	0.64	0.026	0.004	0.069	0.143**	0.036
Seedling evenness	-0.103*	-0.001	-0.081	0.67	-0.032	-0.012	0.040	0.151**	0.034

Note: DFHH= Distance from human habitation, DFWB= Distance from water body, GBH= Girth at Breast height, km= kilometres and m= metres; ** Correlation significant at 0.001 level, *Correlation significant at 0.05 level.

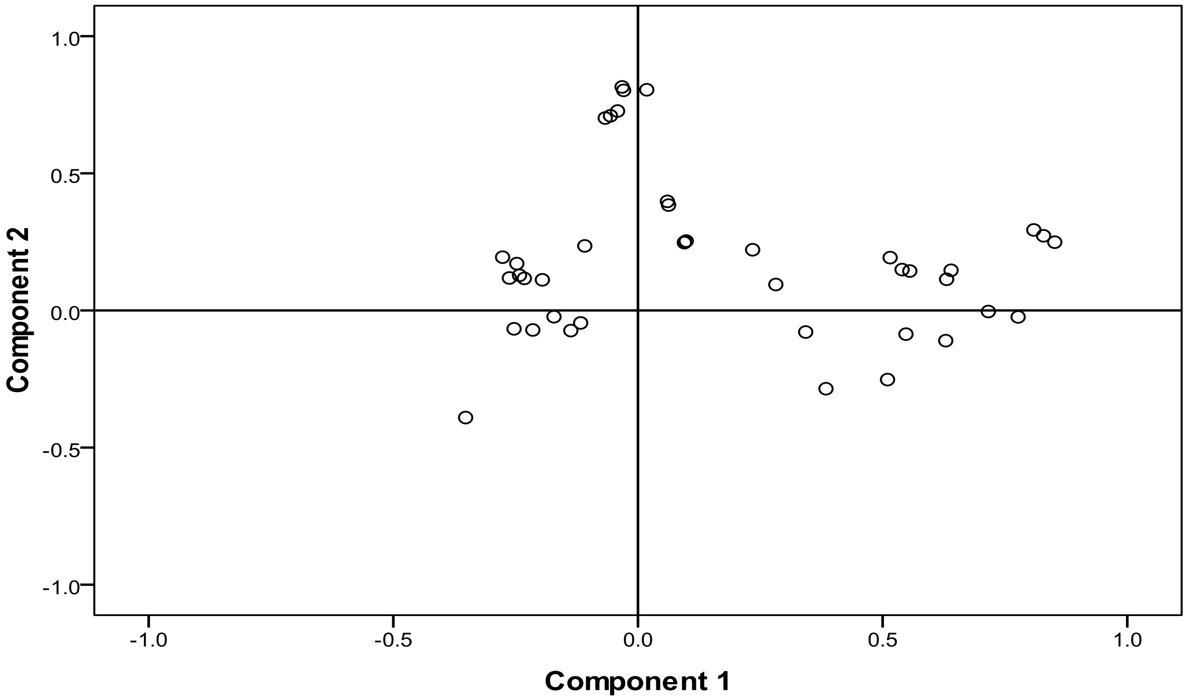

Figure 2. Presentation of habitat variables by first two components in PCA in Kaimur wildlife sanctuary. (Component Plot in Rotated Space)

present findings, fire was positively correlated with diversity indices of tree, sapling and seedling layer. The correlation between vegetation and disturbance variables is given in table 5. The outcome of PCA shows that Principal Component 1 and 2 explained 17.40% and 11.39% of variance (Fig. 2). Thus cumulatively total variance explained by first two components is 28.81%. The first component showed heavy loadings for density, diversity, richness and evenness of tree, tree height, herb density, herb diversity, herb cover, grass cover, canopy cover and distance from human habitation coupled with low lopping density and cow dung density. The component 2 showed heavy loadings for sapling diversity, sapling richness, sapling evenness, seedling diversity, seedling richness, seedling evenness together with low weed density and herb diversity (Table 6).

Table 5. Correlation of density, diversity, richness and evenness of plants (trees, shrub, herb, grass, sapling and seedling) with disturbance gradients in Kaimur wildlife sanctuary.

Disturbance gradients → / **↓ Vegetation variables**	**Human Trail**	**Cattle dung density (ha)**	**Grazing cover (%)**	**Weed density (ha)**	**Weed cover (%)**	**Lopping density (ha)**	**Mean Lopping score**	**Fire**
Tree density	-0.035	-0.069	-0.111**	0.066	0.041	0.140**	0.135**	0.007
Tree diversity	-0.204**	-0.075	-0.147**	0.166**	0.085*	-0.102*	-0.115**	0.151**
Tree richness	-0.208**	-0.070	-0.155**	0.205**	0.116**	-0.117**	-0.130**	0.179**
Tree evenness	-0.192**	-0.078	-0136**	0.149**	0.072	-0.093*	-0.104*	0.155**
Shrub density	-0.124**	-0.018	-0.089*	-0.101*	-0.081*	0.0	0.005	-0.039
Shrub diversity	-0.078	-0.016	-0.052	-0.060	-0.048	-0.058	-0.058	-0.016
Shrub richness	-0.078	-0.016	-0.051	-0.060	-0.048	-0.058	-0.057	-0.016
Shrub evenness	-0.081*	-0.016	-0.053	-0.062	-0.050	-0.060	-0.060	-0.017
Herb diversity	-0.079	-0.067	-0.058	0.134**	0.086*	-0.001	-0.069	-0.037
Herb richness	-0.011	0.032	-0.018	0.078	0.047	0.047	-0.039	-0.026
Herb evenness	-0.023	-0.005	-0.015	-0.018	-0.014	-0.017	-0.017	-0.005
Grass diversity	0.284**	0.040	0.211**	-0.0135**	-0.0115**	0.029	0.033	-0.055
Grass richness	0.262**	0.035	0.233**	-0.107**	-0.095*	0.039	0.043	-0.054
Grass evenness	0.279**	0.036	0.200**	-0.142**	-0.119**	0.029	0.033	-0.054
Sapling density	0.281**	-0.035	0.028	-0.172**	-0.135*	0.124**	0.117**	0.011
Sapling diversity	-0.096*	-0.032	-0.085*	-0.090*	-0.079	0.006	-0.011	0.239**
Sapling richness	-0.096*	-0.031	-0.089*	-0.077	-0.069	0.025	0.006	0.278**
Sapling evenness	0.095*	-0.031	-0.083*	-0.58	-0.055	-0.008	-0.021	0.193**
Seedling density	0.210**	-0.011	0.092*	-0.053	-0.046	0.127**	0.125**	0.006
Seedling diversity	0.020	0.004	0.017	-0.081*	-0.066	-0.048	-0.047	0.097*
Seedling richness	0.01	0.005	0.008	-0.096*	-0.078	-0.011	-0.010	0.100*
Seedling evenness	0.014	0.005	0.014	-0.078	-0.064	-0.042	-0.041	0099*

Note: %= Percentage, ha= Hectare; ** Correlation significant at 0.001 level, *Correlation significant at 0.05 level.

DISCUSSION AND CONCLUSION

In the present study the density and diversity of woody species in highly disturbed area were recorded lowest. The present findings are similar to the studies done previously (Bhuyan *et al.* 2003, Sagar *et al.* 2003, Arjunan *et al.* 2005, Mishra *et al.* 2008, Tripathi *et al.* 2008 Sahoo & Davidar 2013, Bajpai *et al.* 2015). Though the above authors had done their studies in different types of forests stands but the findings are similar to the present one. Like Kaimur, other studies in different PAs of same habitat had similar findings (Mueller-Dombois & Ellenbergh 1974, Pandey & Shukla 2001, Kumar & Shahabuddin 2005, Shahabuddin & Kumar 2006, Sharma & Raghubanshi 2006, Mueller-Dombois & Ellenbergh 1974, Tripathi *et al.* 2010). However some authors favors mild human disturbance for plant species richness. For example- Mishra *et al.* (2004) in their study found mild disturbance favors species richness but tree density was higher in low disturbed area. Likewise, Mishra *et al.* (2008) found higher shrub and herb in high disturb area. Whereas, Tousignant (2010) found plant species richness is negatively associated with disturbance variables. Similarly in the present study, richness of plant species was lower in areas facing disturbance. With the increase in the elevation, human disturbance increased with a simultaneous decrease in tree population and mean tree height. Several studies conclude that at lower elevation species richness is higher as compared to higher elevated areas (Rawal *et al.* 1991, Singh *et al.* 1994, Sharma *et al.* 2009). The population of shrub was negatively associated with canopy cover because dense canopy suppress the growth of lower strata by hindering sunlight (Sharma & Raghubanshi 2005). In the present study, livestock grazing individually affects trees; sapling population and composition (density, diversity, richness and evenness). But positive association with diversity, richness and evenness of grass is because due to the fact that livestock helps in immigration of new species with tangling seeds in their hooves. But impact of livestock grazing is a debate issue. Because some authors favors grazing for improvement of vegetation composition in terms of plant species richness, diversity. For example- Olff & Ritchie (1992) reported increased species diversity due to livestock grazing in grassland; Cooper (1960), Facelli (1994), Pearson (1934) and Madany & Neil (1983) concluded that grazing improves the establishment of recruiting vegetation composition; whereas Leopold (1924) found that livestock grazing would decrease the ground layer making the area naturally as fire line or breaks.

Table 6. Rotated Principal Component matrix of vegetation variables in Kaimur wildlife sanctuary.

Variables	Component 1	Component 2
Tree density	0.540	0.149
Tree richness	0.852	0.249
Tree diversity	0.829	0.272
Tree evenness	0.89	0.294
Tree height	0.515	0.193
Sapling diversity		0.815
Sapling richness		0.805
Sapling evenness		0.802
Seedling diversity		0.702
Seedling richness		0.727
Seedling evenness		0.710
Distance from human habitation	0.556	0.144
Herb density	0.777	
Herb cover	0.716	
Grass cover	0.631	0.114
Canopy cover	0.640	0.146
Herb diversity	0.629	-0.110
Herb richness	0.548	
Weed density	0.510	-0.252
Lopping density	-0.117	
Cow dung density	-0.243	

Weed presence was negatively associated with sapling and seedling because dense canopy created by vertically could reduce the receiving amount of sunlight and so suppress the growth of regenerating species (Sharma & Raghubanshi 2006). Weed was negatively associated with herbaceous vegetation because weed presence would add woody debris and more litter to ground making it less favorable for growth of herbaceous vegetation (Sharma & Raghubanshi, 2010).

Those sampling plots faced high level of tree cuts had canopy opening which may favored the growth of sapling and seedling. This is so because of canopy opening or canopy gap, species received maximum amount of sunlight and water which are important elements for growth and development of plants. Seng *et al.* (2004) favored logging for regenerating species. Similarly, in the present study sapling and seedling density was calculated highest in high disturbed area. Few literatures are also available on similar results favoring regeneration composition due to human disturbance (Pandey & Shukla 2001, Buffum *et al* 2009, Muhanguzi 2009, Sharma & Raghubanshi 2010, Tripathi *et al.* 2010). Whereas Tripathi *et al.* (2008) found lower regeneration population in disturbed area and reasoned human disturbance.

In the present study, presence of fire signs in the plot along with seedling indicates its post effects. Because some of the seeds are dormant in nature, post adverse when received favorable conditions they germinate. These disturbance variables alter the habitat and make it less favorable for growth of plant species. During the study period, some of the species with only one individual was sampled which shows vulnerability on the basis of its occurrence. And when there is very small number of population then it would have high chances of extinction locally. In the present study very low density of some of the seedling illustrates poor generation of that respective species. Some of the species occurred as only seedling and sapling which shows that these species are newly immigrants to that area. But some species were present as only woody species lacking sapling and seedling which shows nil regeneration. Bhuyan *et al.* (2003) conclude that species lacking regenerative layer are expected to face extinction locally in the coming future. In a given population, an equal or equivalent proportion of tree, sapling and seedling may help in predicting its possible future status (Saxena & Singh 1984). Whereas in the present study, none of the species was fit to the criteria given by Saxena & Singh (1984). On the basis of present findings I believe that the reason behind instability of plants species of Kaimur wildlife sanctuary is illegal biomass extraction done on larger scale by nearby villagers. Additionally, the Sorenson's Index of similarity indicates that dissimilarity of plant species increased with degree of disturbance i.e. from low to high disturbed area. This suggests that human disturbance alters the vegetation community in the study area. Similarly, the outcome of PCA in the present study conclude that livestock grazing and illegal tree lopping for fuelwood collection are the main disturbing factors responsible for changes in vegetation community structure. For example tree density, tree diversity, tree height, tree GBH, canopy cover, shrub density, shrub diversity, and sapling diversity showed negative association to disturbance gradients.

Many of the plant species don't have minimum viable populations which in the coming years may face extinction locally. Immediate actions are required in the KWS to conserve plant species facing biomass extraction. Plantation of fast growing fuelwood and fodder plant species should be encouraged. This would cover and compensate the needs of local people for forest resources. Land should be provided to these villagers where agro-forestry or agro-farming like activities can be carried out. Crop-rotation method should be implied for agricultural practices. Participation of local people along with large scale stakeholders are needed in the area. Central and State government should launch various schemes to absorb local people in small scale industries. State Forest Department and local NGOs should start awareness programs related to biodiversity conservation in the sanctuary. Animal husbandry programs should be started for best and lesser number of cattle. For livestock, stall feeding should be encouraged instead of illegal grazing inside the Sanctuary.

ACKNOWLEDGEMENT

This work was supported by grants provided by University Grants Commission, New Delhi. Authors are thankful to the Forest Department, Uttar Pradesh for providing logistic support. Authors are thankful to Siraj Mazumdar for giving valuable comments on the manuscript.

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