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An Ecological Study in the Buffer Zone of the Corbett Tiger Reserve: Prey Abundance and Habitat Conditions

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ABSTRACT

We studied prey abundance and habitat conditions in the buffer zone of the Corbett Tiger Reserve using a combination of sampling techniques based on direct and indirect evidences. langur (*Presbytes entellus*) and chital (*Axis axis*) were found to be the most abundant prey species in the buffer zone. The total prey biomass was estimated to be 2847 kg/km^2 and chital and sambar (*Cervus unicolor*) contributed 84% of it. Block-wise abundance of prey species based on the Forest Department data showed that 80% of the forest blocks had low prey biomass and these blocks were distributed in north. The density of chital estimated by line transect method appeared to be very high and was clearly an overestimate. The findings suggested that chital, nilgai and wild pig utilized areas with moderate to high levels of disturbance whereas sambar and barking deer showed clear avoidance for such areas.

The forest in buffer zone was dominated by *Shorea robusta* with an IVI value of 98.2. The mean tree density was 279.7 trees/ha and it was highest in North Jashpur forest block. The highest shrub density was recorded in Nalkatta forest block. The estimates of mean density, diversity, richness and evenness for tree, shrub, grass and herb layers differed significantly between transects. The levels of disturbance factors especially, cutting, lopping, grazing and overall biotic pressure were found to range between low to high. There were 9 blocks in low, 10 in medium and 7 blocks under high levels of biotic pressure. While attributes of tree and shrub layers showed no significant relationship with various disturbance factors except the proliferation of *Lantana camara* and other weed species in shrub layer, the attributes of grass and herb layer showed significant negative impact of disturbance factors in terms of reduction in grass and herb diversity, richness and evenness.

Key Words: Encounter Rates, Line Transect, Ungulate Densities, Weed Abundance

INTRODUCTION

Several recent studies (Karanth and Sunquist 1995, Miquelle et al. 1996b, Karanth and Nichols 1998) have found that abundance of predators, such as tiger, is influenced by the distribution and abundance of its prey species. Therefore monitoring of wild prey base is imperative for developing effective management strategies for conservation of large carnivores. On the other hand, the abundance and distribution of prey species depends on the habitat conditions, which in turn are affected by resource-dependence of the local people on the forests. Over-exploitation of forests due to livestock grazing, fuel-wood extraction, and NTFP collection results in weed proliferation and overall degradation of the habitat. This paper describes the results of assessment of prey abundance and habitat conditions in the buffer zone of the Corbett Tiger Reserve.

STUDY AREA

The study was conducted in the buffer zone and adjoining areas on the southeastern boundary of the Corbett Tiger Reserve (henceforth CTR). Depending upon the location of cattle kill, adjoining areas up to 50 km from the buffer zone boundary of the CTR were also covered for monitoring. The other details of study area appeared in Azra Musavi et al. (2006).

METHODS

Prey Abundance

The line-transect method (Burnham et al. 1980) was used for estimation of wild prey abundance in buffer zone of the CTR. Ungulates in the study area were found to collect in open areas having grasses and water. To avoid any bias, 21 permanent transects were randomly located and marked across different habitat types in the buffer zone (Figure 1a). The transect length varied between 1.75 km to 3.5 km, depending upon the terrain in which they were located. Two to three observers walked each transect in morning hours. For each sighting on a transect, the data were collected on a) species sighted, b) number of individuals in group, and c) perpendicular distance using a range finder. Twentyone line transects were walked covering a total length of 225.4 km that resulted in sightings of 107 groups of chital (*Axis axis* Erx.), 30 groups of sambar (*Cervus unicolor* Kerr), 20 groups of barking deer (*Muntiacus muntjak* Zimmermann), 9 groups of wild pigs (*Sus scrofa* Linnaeus), 3 groups of nilgai (*Boselaphus tragocamelus* Pallas), 28 groups of langur (*Presbytes entellus* Zimmermann), 19 groups of peafowl (*Pavo cristatus*), and 9 groups of rhesus monkey (*Macaca mulata* Zimmermann). Apart from line transects, which covered only 11 blocks of buffer zone, Pellet Group Count Method was also used for relative abundance estimation of different prey species using random sampling in different forest blocks. Pellet groups of different species were identified and recorded in 10 m radius circular random plots established in each block. The pellet groups of different species were identified on the basis of differences in size, shape and color of pellets. The forest department conducts regular block wise census of all ungulates. The data for year 2003 from the forest department was analysed for comparing it with that of line transect and pellet group count data collected during the current study.

Habitat Conditions and Disturbance Factors

Various habitat parameters and disturbance factors were quantified by laying sample plots, both on the permanent line transects as well as in different blocks of the buffer zone randomly.

Transect Sampling

Eleven of the 21 permanent transects were selected for collecting data on habitat structure and conditions. These 11 transects were selected on the basis of habitat type and topography. However, due to shortage of time and early start of monsoon, only nine transects could be sampled during study period. Circular plots of 10 m radius were laid at intervals of 100 m on the permanent line transects. At each sampling point, habitat type and topographical characteristics were noted. While tree layer was quantified in 10 m radius circular plots, shrubs were quantified in 3 m radius circular plots within the 10 m radius plots. All tree and shrub species and their individuals were counted for density, diversity, species richness and evenness estimation. The GBH (girth at breast height) of trees was measured for estimating basal area and Importance Value Index (IVI) for tree species. At every point tree and shrub cover was also noted. Saplings and seedlings of all species and their individuals were counted for density estimation in 1 m radius circular plots. The ground layer was quantified in four 0.50 m X0.50 m quadrates at each sampling point. All the herb and grass species and their individuals were counted for density and diversity estimation. Data on disturbance factors viz., grazing, lopping, tree cutting, cattle dung piles and weed abundance were collected at each sampling point on an ordinal scale of 0 to 4 where, 0 represented no disturbance and 4 represented very high degree of disturbance such as severe grazing, heavy lopping and tree cutting.

Random Sampling

To quantify the forest blocks of the buffer zone in terms of habitat conditions and biotic pressure, random sampling was done in all the 26 forest blocks in the buffer zone. Sampling plots were established at every 200 paces (equivalent to approximately 150 m), in a random direction in all blocks of the buffer zone. At each sampling point, vegetation type, topography, tree cover, vertical structure, number of trees cut, lopped and number of livestock dung piles were recorded in 10 m radius circular plots. Shrubs species were quantified in 3 m radius circular plots within the 10 m plots.

While counting shrubs species, a separate distinction was made between individuals of *Lantana camara,* other weed species and general shrub species, so as to differentiate between palatable and non-palatable shrub species for the ungulates. A total of 1880 sampling points were laid across the 26 forest blocks.

Analysis

As the number of sightings on individual transects were very low, transect data were pooled together to calculate the densities and encounter rates of different prey species using Program Distance (version 4.0, Thomas et al. 2002). The pellet group data collected by random sampling in forest blocks were used to calculate pellet group densities. The mean pellet group score (pellet groups/point) of a species for a particular block was calculated by dividing the total number of pellet groups sampled at all points in a block by the total number of points sampled in that particular block. The mean pellet group scores were converted into pellet group densities (number of pellet groups/ha). The mean pellet group scores were also used to categorize different forest blocks in terms of low, medium and high abundance of different prey species (Table 1). The data collected from forest department were used to calculate block wise densities of different prey species by dividing number of individuals of a species by the area of the forest block. The densities were then used to calculate block-wise biomass of different species. Average weights of prey animals were taken from Karanth and Sunquist (1995), Biswas and Sankar (2002) and Hoyo et al. (2003). On the basis of density and biomass values of prey species, blocks were ranked as low, medium and high in terms of abundance of wild prey.

The habitat data collected on the permanent transects were used to calculate species density, diversity, richness and evenness and IVI for the tree layer following Magurran (1988) and Muller-Dombois and Ellenberg (1974). For assessment of overall anthropogenic pressure on different transects, ordinal scores assigned to plots were averaged for each transect for each disturbance factor. The mean scores for each transect were calculated by dividing the sum of all scores for a particular transect by number of points sampled on a particular transect. Similarly data collected by random sampling in blocks were also used to assess anthropogenic pressure and degree of disturbance in blocks. The total number of cut trees, lopped trees and cattle dung piles for a particular block were divided by the number of points sampled in that particular block. This gave mean number of cut and lopped trees and cattle dung piles. On the basis of these mean scores, blocks were ranked in low, medium and high level of disturbance categories (Table 2).

The Kruskal-Wallis One Way ANOVA test was used to determine the differences in species density, diversity, richness and evenness between different transects. It was also used to find out differences in biotic pressure intensity and disturbance levels in different habitats and different blocks. The Pearson Product Correlation Coefficient and Spearman Rank Correlation Coefficient analysis were used to find out relationship between various habitat factors, prey abundance estimates by various methods and disturbance factors using transect and block data. These tests were performed with the help of computer software SPSS.

RESULTS AND DISCUSSION

Density, Biomass and Encounter Rates of Prey

Estimates of density and biomass of different prey species in the study area are provided in Table 3. Among all the prey species, langur was most abundant (31.18 km^{-2}). However, among the ungulates, chital was the most abundant prey species (31.08 km^{-2}), followed by sambar (3.23 km^{-2}), wild pig (2.54 km^{-2}) and barking

Table 1. Mean pellet group scores for classification of prey abundance in buffer zone of Corbett Tiger Reserve.

Prey abundance	Chital	Sambar	Barking Deer	Nilgai	Wild Pig
Low	0-1.6	0-1.3	0-0.29	0.01-0.38	0-0.17
Medium	>1.6-3.2	>1.3-2.6	>0.29-0.58	>0.38-0.75	>0.17-.34
High	>3.2-4.8	>2.6-3.9	>0.58-0.87	>0.75-1.01	>0.34-0.51

Table 2. Derived mean scores of different disturbance factors used for classification of blocks in the buffer zone of Corbett Tiger Reserve.

Category	Mean number of cut trees	Mean number of lopped trees	Mean number of dung piles	*Lantana camara* Percentage of plot under *Lantana camara*	*Lantana camara* Derived mean scorefor a block
Nil (0)	0	0	0	0	0
Low (1)	0.1-0.5	0.1-0.71	0.1-0.71	>0-20	0.006-0.6
Medium (2)	>0.5-1	>0.71-1.4	>0.71-1.4	>20-40	>0.6-1.2
High (3)	>1	>1.4-2.1	>1.4	>40	>1.2-1.8

Table 3. Density and biomass of prey species in the buffer zone of Corbett Tiger Reserve.

Species	Density/km^2	S.E.	CV (%)	Upper CI	Lower CI	Encounter Rate	Biomass (kg km^{-2})
Chital	31.1	4.8	15.4	22.9	42.0	0.48	1709.4
Sambar	3.2	0.8	24.5	1.9	5.2	0.13	684.8
Barking deer	2.0	0.6	28.9	1.1	3.7	0.08	40.6
Wild pig	2.5	1.4	53.5	0.8	7.7	0.04	96.5
Nilgai	0.1	0.6	72.1	0.04	1.3	0.01	14.5
Langur	31.2	8.4	27.1	18.3	53.2	0.12	265
Rhesus monkey	2.9	1.5	49.3	1.1	8.1	0.04	25.3
Peafowl	2.5	0.9	34.8	1.3	5.1	0.08	11

S.E. = Standard Error; CV = Coefficient of Variation; CI = Confidence Interval at 95%.

deer (2.03 km^{-2}). The overall prey biomass was 2847.1 kg km^{-2}. Chital and sambar together contributed over 84% of the available prey biomass in the area while chital alone contributed more than 60% of the total prey biomass.

The overall encounter rate (groups/km) was highest for chital (0.48) followed by sambar (0.13), barking deer (0.08), wild pig (0.04) and nilgai (0.01). The encounter rates for different prey species varied between transects. The encounter rate for chital was highest in Sawaldeh Bhabar block (0.77 groups km^{-1}) whereas the encounter rate for sambar was highest in Dumunda east and Haldgaddi blocks (0.4 groups km^{-1}). The encounter rate for barking deer was highest in Dumunda east (0.3 groups km^{-1}) and that for wild pig was highest in Sawaldeh Bhabar block (0.17 groups km^{-1}). The highest encounter rate for nilgai was recorded in Dhela Bhabar (0.28 groups km^{-1}).

Pellet Group Density of Ungulates

The overall pellet group density for chital was 36.5 pellet groups/ha and it varied significantly between different blocks (K-W One Way ANOVA χ^2 = 818, d.f. = 25, P<0.001). 69% of forest block in buffer zone (Figure 1b) had low density of chital pellet groups. These blocks were located in north and southwest of the buffer zone, except for one block, which was located in southeast of the buffer zone. Out of the remaining blocks, 19% (5) had high pellet group density while 11.5% (3) had medium density. Both high and medium density blocks were located in southeast of the buffer zone.

The overall pellet group density for sambar was 36.3 pellet groups ha^{-1} and it varied significantly between different blocks. (One Way ANOVA χ^2 = 358, d.f. = 25, P<0.001). While 61.5% of blocks had

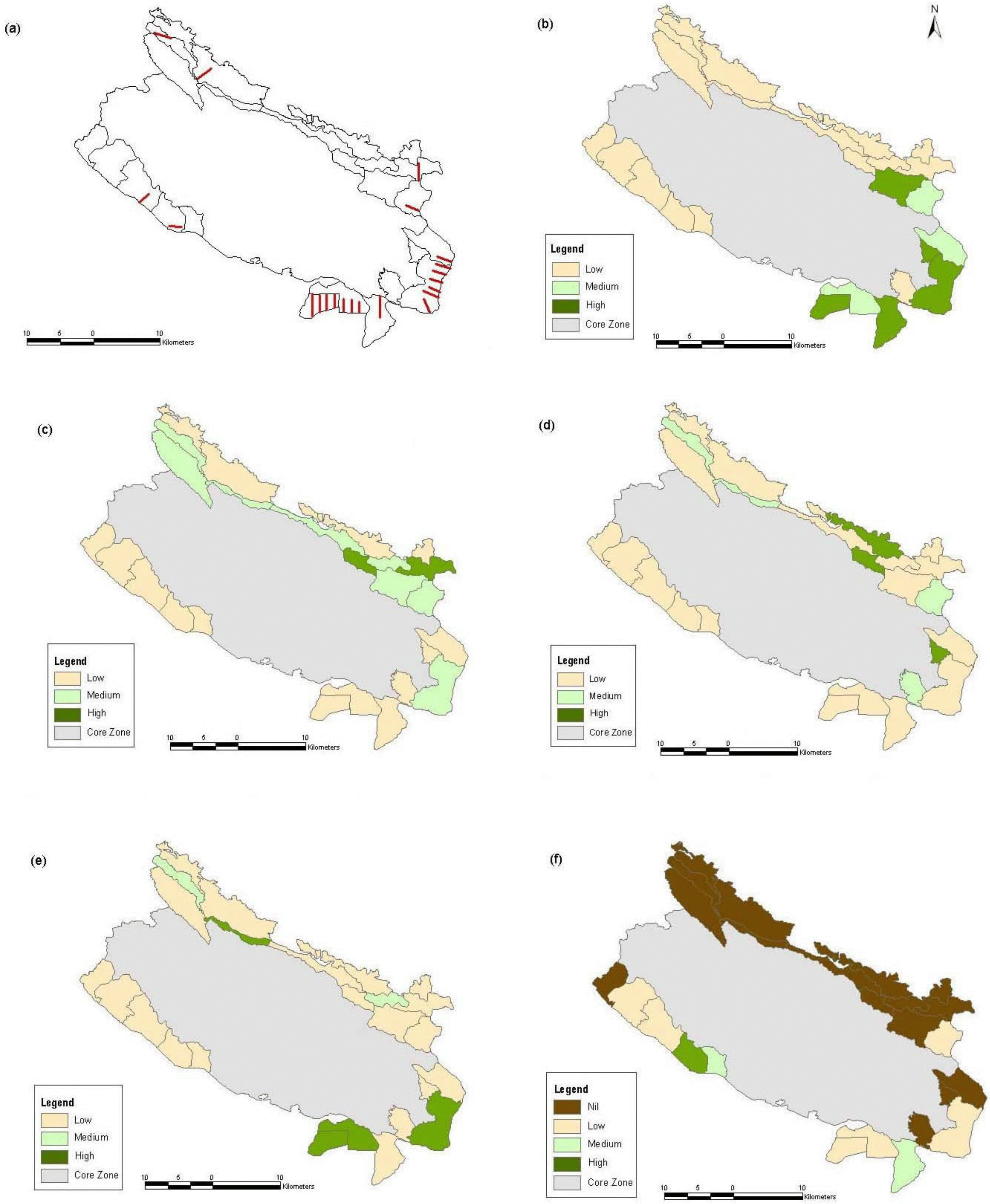

Figure 1. Location of line transects in buffer zone (a), Chital pellet group density (b), Sambar pellet group density (c), Barking deer pellet group density (d), wild pig dropping density (e) and Nilgai pellet group density (f) in different blocks of buffer zone in the CTR.

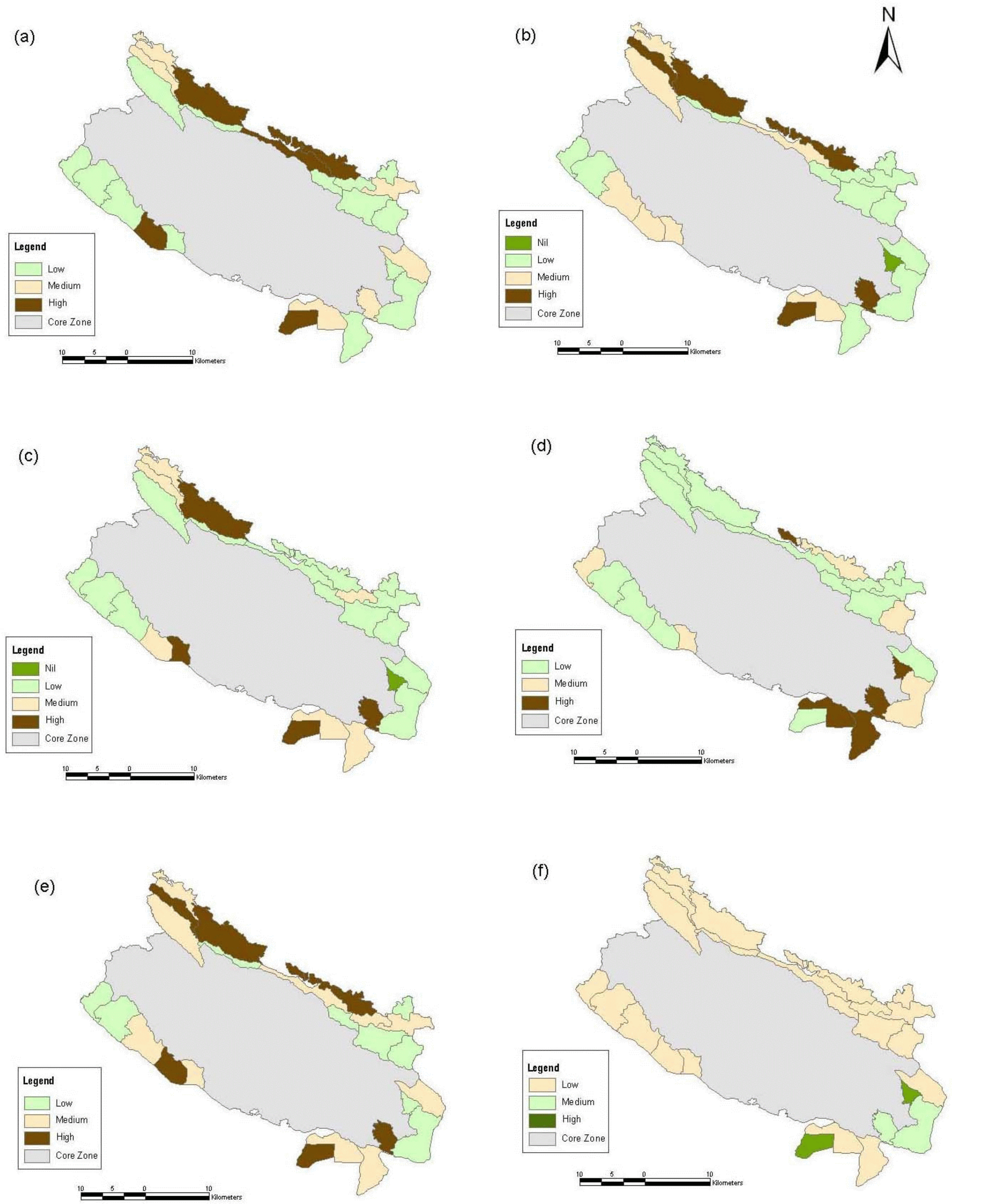

Figure 2. Cutting pressure (a), Lopping pressure (b), Grazing pressure (c), Lantana density (d), Overall biotic pressure (e) and Prey biomass (f) in different blocks of buffer zone in the CTR.

high sambar pellet group density (Figure 1c), 30.7% (8) had medium density and 7.6% (2) had high density. While the blocks with low density were mostly located in southern portion of the buffer zone, most of the medium and high density blocks were in northern portion of the buffer zone, with only one medium density block located in the southeast of the buffer zone.

The overall pellet group density for barking deer was 7.1 pellet groups/ha and it varied significantly between different blocks (K-W One Way ANOVA $\chi^2 = 198$, d.f. = 25, P<0.001). 73% of forest blocks had low pellet group density of barking deer (Figure 1d). These blocks were located across the buffer zone, mostly in southern portion of it. Of the remaining blocks, 15% (4) had medium density. These were located in north and southeast of the buffer zone. High density of barking deer pellet groups was found in 11.5% (3) of the blocks. These were located in northeast and east of the buffer zone.

The overall dropping density for wild pig was 3.9 droppings/ha and it varied significantly between different blocks (K-W One Way ANOVA, $\chi^2 = 147$, d.f. = 25, P<0.001). Low dropping density of wild pig was found in 76.9% of the forest blocks of the buffer zone (Figure 1e). Most of the blocks in this category were located in northern and southwest portions of the buffer zone. 7.6% (2) of the forest blocks had medium and 15% (4) had high dropping density. While both the blocks with medium density of wild pig droppings were located in northern portion of the buffer zone, most of the blocks with high density of wild pig droppings were located in southeastern portion of the buffer zone.

The overall pellet group density for nilgai was 3.5 pellet groups/ha and it varied significantly between different blocks (K-W One Way ANOVA, $\chi^2 = 392$, d.f. = 25, P<0.001). In comparison to other prey species, majority of the forest blocks (65%) had no indirect evidence of nilgai (Figure 1f). These forest blocks were mostly located in northern portion of the buffer zone. 23% of the blocks, mostly located in southern portion of the buffer zone had low pellet group density of nilgai. 7.6% of the blocks with medium pellet group density were located in south of the buffer zone. The single block which had high pellet group density, was located in southwestern portion of the buffer zone.

Block-wise Abundance of Prey Species

The overall chital density estimated from forest department data was 7.5 chital km^{-2}. Chital was present in low density in 92% of the 26 forest blocks of the buffer zone. Out of the remaining 2 blocks, 1 had medium density and 1 had high density, both blocks were located in the southeast of the buffer zone. The overall sambar density estimated from forest department data was 1.7 sambar km^{-2}. While sambar were present in low density in 65% forest blocks of the buffer zone, spatially most of these blocks were in the north of the buffer zone. Sambar were present in medium density only in two of the blocks (7.6%), which were located in the southern portion of the buffer zone. Three of the blocks (11.5%) with high sambar density were located in the southeast of the buffer zone.

The overall barking deer density estimated from forest department data was 0.6 barking deer km^{-2}. While 50% of the forest blocks of the buffer zone had low density of barking deer, spatially these blocks were spread all over the buffer zone. The barking deer was found in medium density in 19% of the forest blocks, most of which were in the south of the buffer zone, with only one block in the north under this category. Barking deer were found in high density in 23% of the blocks, which were located only in the eastern portion of the buffer zone. The remaining 2 blocks (7.6%), had no presence of barking deer and were located in the north of the buffer zone. The overall wild pig density estimated from forest department data was 2.9 wild pig km^{-2}. Wild pig were present in low density in 57% of the forest blocks of the buffer zone, most of which were located in the northern portion of the buffer zone, with only 4 blocks in the southern region. Another 23% of the blocks had medium density of wild pig. Most of these forest blocks were in the southern portion of the buffer zone, with only 2 blocks, which were also comparatively very small in terms of area, in the north of the buffer zone. Of the remaining blocks, 3 (11.5%) had high density of wild pig and 2 (7.6%) had no presence of the animal. While the blocks with high density were located in the southern portion of the buffer zone, the latter were located in the northern portion of the buffer zone.

While 84% of the forest blocks, located mostly north of the buffer zone, had low prey biomass, 7.6% had medium prey biomass and an equal percentage had high availability of prey biomass. These blocks were located east of the buffer zone (Figure 2f).

The encounter rates of different prey species in different forest blocks and the density of prey species in corresponding blocks of buffer zone of CTR did not show any significant correlation. However, the encounter rate of chital was found to be significantly positively correlated with chital pellet group density (r = 0.76, d.f. =10, P<0.01). The encounter rates for other ungulate species were not found to be correlated with their corresponding pellet group densities. The pellet group densities and animal densities calculated from the forest department data showed significant correlation for barking deer (r = 0.455, d.f. = 25, P<0.05) and nilgai (r = 0.754, d.f. =25, P<0.01) only. The pellet group densities and animal densities for other species, however, did not show any significant correlation.

Habitat Analysis

Plant abundance and diversity

Table 4 provides the density and IVI values of 10 dominant tree species sampled in buffer zone of the CTR. The forest in buffer zone was dominated by *Shorea robusta* with a density of 55 individuals/ha and an IVI value of 98.2. This was followed by *Mallotus phillippinensis* Muell. with a density of 73 individuals ha^{-1} and an IVI value of 70.2. Table 5 provides the estimates of density, diversity, richness and evenness on different transects. The average tree density on transects was 280 trees ha^{-1} (range 428-152 trees ha^{-1}). The highest density was in Sal and mixed habitats in North Jashpur forest block (423 trees ha^{-1}) and it was lowest in mixed habitat and plantations in Dhela forest block (152 trees ha^{-1}). The mean tree density differed significantly between different forest blocks of the buffer zone (K-W One Way ANOVA, χ^2 = 311.12, d.f. = 25, P<0.01).

The values of mean tree richness, diversity and evenness in the buffer zone were 3.2, 0.78 and 0.70 respectively. The transects differed significantly in terms of overall tree richness (K-W One-way ANOVA: χ^2 = 67.227, d.f. = 8, P<0.001,), diversity (K-W One-way ANOVA: χ^2 = 41.297, d.f. = 8, P<0.001,) and evenness (K-W One-way ANOVA: χ^2 = 39.202, d.f. = 8, P<0.001). The estimates of tree diversity, richness and evenness did not show any significant relationship with disturbance factors (P>0.05).

The highest shrub density was recorded in plantations and mixed habitat type in Nalkatta forest block (2298 individuals/ha) whereas the lowest shrub density was also recorded in plantations and mixed habitat type in Dhela forest blocks (466 individuals ha^{-1}). Significant difference was found in shrub density across different forest blocks of the buffer zone (K-W One Way ANOVA χ^2 = 297.75, d.f. = 25, P<0.01). The mean shrub richness, diversity and evenness in the buffer zone was 2.1, 0.66 and 0.65 respectively. The mean herb density in the buffer zone was 16.5 individuals m^{-2}. The mean herb richness, diversity and evenness were 2.9, 0.83 and 0.68 respectively. The mean grass density was 21.5 individuals m^{-2} and it differed significantly between transects. The mean grass richness, diversity and evenness were 1.1, 0.6 and 0.71 respectively.

Table 4. Density (ha^{-1}) and Importance Value Indices (IVI) of dominant tree species in the buffer zone of Corbett Tiger Reserve.

Tree species (Local names)	Density	IVI values
Shorea robusta (Sal)	54.8	98.2
Mallotus philippinensis (Rohini)	72.6	70.2
Tectona grandis (Sagon)	19.8	11.8
Ehretia acuminata (Khuda)	11.1	10.8
Diospyros exsculpta (Tendu)	9.5	10.3
Holoptelea integrifolia (Kanju)	11.1	8.4
Miliusa velutina (Dum Sal)	12.5	8.2
Lagerstroemia parviflora (Dhauri)	6.9	7.5
Haplopnragma adenophyllum (Kadhsagon)	10.9	6.3
Syzygium cummini (Jamun)	4.8	5.3

Impact of Disturbance Factors on Habitat

Anthropogenic activities leave their impact on forests in terms of lopping, cutting of trees and livestock grazing resulting in weed proliferation and loss of ground cover. Impact of resource utilization on the forest of the buffer zone of CTR was assessed. The mean scores of different disturbance factors on each transect are summarized in Table 6. Among the nine transects sampled, highest degree of disturbance in terms of evidence of grazing (1.91), dung piles (0.96) and weed proliferation (2.64) were recorded on transect 2. The cutting pressure was highest on transect 1 (1.44) and lopping pressure was highest on transect 4 (1.68). While Transect-7 had no grazing pressure or presence of dung piles and also had lowest lopping pressure, Transect-10 had no tree cutting pressure. Weed proliferation was lowest on Transect-5.

Table 5. Density, diversity, richness and evenness values for trees, shrubs, grass and herb layer on transects in the buffer zone of the CTR.

Transect	Trees				Shrubs				Herbs				Grasses			
No.	Den	Div	Rich	Even	Den	Div	Rich	Even	Den	Div	Rich	Even	Den	Div	Rich	Even
1	427	0.7	2.4	0.6	906	0.5	1.2	0.7	4.9	0.6	1.9	0.6	30.6	0.4	0.6	0.5
2	151	0.7	2.5	0.6	465	0.9	2.6	0.9	75.6	0.4	1.3	0.4	39.3	0.4	1.0	0.4
3	223	0.7	3.0	0.6	1262	0.5	2.6	0.5	6.8	0.8	2.7	0.7	23.8	0.4	0.3	0.9
4	153	1.0	4.0	0.7	706	0.6	1.7	0.7	6.6	0.9	3.1	0.7	53.2	0.5	0.5	0.7
5	182	1.1	3.6	0.8	1525	0.9	3.6	0.7	4.3	0.9	2.5	0.8	10.2	0.8	1.3	0.9
6	327	0.7	2.8	0.6	866	0.3	1.2	0.4	5.6	0.9	3.2	0.8	12.7	0.8	1.9	0.8
7	372	0.5	2.9	0.4	583	0.7	2.0	0.8	14.7	1.3	5.5	0.8	9.1	0.5	0.9	0.7
8	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
9	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
10	335	0.8	4.2	0.6	2279	0.8	2.2	0.7	7.4	1.0	3.5	0.8	7.2	0.9	2.4	0.8
11	348	0.9	3.5	0.7	2297	0.8	2.4	0.7	23.1	0.7	2.6	0.6	7.9	0.7	1.4	0.7

Den = Density, Div = Diversity, Rich = Richness, Even = Evenness, Tree and Shrub density/ha, Herb and grass density/m^2,
NS = Not sampled.

Table 6. Mean disturbance scores of sampled transects in the buffer zone of Corbett Tiger Reserve.

Transect No.	Grazing	Dung piles	Cutting	Lopping	Weed abundance
1	1.7	0.1	1.4	1.3	1.7
2	1.9	0.9	0.7	0.6	2.6
3	1.3	0.5	1.1	0.9	1.7
4	1.4	0.6	1.1	1.7	2.0
5	0.1	0.1	0.6	0.4	1.2
6	0.1	0.1	0.1	0.3	1.3
7	0	0	0.3	0.2	1.3
8	NS	NS	NS	NS	NS
9	NS	NS	NS	NS	NS
10	0.6	0.5	0	1.0	1.2
11	0.6	0.5	0.3	0.9	1.4

NS = Not sampled.

The habitat types differed significantly (K-W One Way ANOVA, $P<0.01$) in terms of grazing (χ^2 = 34.35, d.f. = 8), lopping (χ^2 = 21.2, d.f. = 8) and weed abundance (χ^2 = 33.588, d.f. = 8). However no signi-ficant difference was found in terms of cutting pressure. The grazing pressure (One Way ANOVA χ^2 = 61.81, d.f. = 2, $P< 0.01$), number of dung piles (K-W One Way ANOVA χ^2 = 17.23, d.f. = 2, $P <0.01$), lopping pressure (K-W One Way ANOVA χ^2 = 6.04, d.f. = 2, $P<0.01$), cutting pressure (K-W One Way ANOVA χ^2 = 14.49, d.f. = 2, $P<0.01$) and weed abundance (K-W One Way ANOVA χ^2 = 26.46, d.f. = 2, $P<0.01$) showed significant differences viz. a. viz topography type. The tree density showed negative correlation with grazing (r_s =-0.35), livestock dung abundance (r_s = -0.61), cutting (r_s=-0.17) and weed abundance (r_s=-0.40). However these correlations were not significant ($P>0.05$, N =9). The estimates of shrub density, diversity, richness and evenness also did not show any significant relationship with grazing, livestock dung density, cutting, lopping and weed abundance ($P>0.05$). The livestock grazing was significantly negatively correlated with herb diversity (r_s =-0.80, N= 9, $P<0.01$), richness (r_s = -0.66, N= 9, $P<0.05$) and evenness (r_s = -0.71, N= 9, P<0.03). The livestock dung abundance was significantly negatively correlated with herb evenness (r_s = -0.68, N= 9, P<0.04). The weed abundance was significantly negatively correlated with herb diversity (r_s = -0.73, N= 9, P<0.02) and herb evenness (r_s = -0.81, N = 9, P<0.01). However, grass density showed significant positive correlation with grazing (r_s = 0.66, N = 9, P< 0.05), cutting (r_s = 0.81, N = 9, P<0.01) and weed abundance (r_s = 0.80, N = 9, P<0.01). The grass diversity and richness were significantly negatively correlated with cutting (r_s =-0.82 & -0.86, N = 9, P<0.05). The grass diversity was also negatively correlated with grazing (r_s = -0.71) and weed abundance (r_s = -0.81, N = 9, P<0.01). Sapling and seedling densities did not show significant correlation with any of the disturbance factors (P>0.05). Within the disturbance factors, the grazing pressure was found to be significantly positively correlated with livestock dung abundance (r_s = 0.82, N = 9, P<0.01), cutting (r_s = 0.67, N=9, P<0.05), looping (r_s = 0.71, N= 9, P<0.05), and weed abundance (r_s = 0.76, N =9, P<0.01). The weed abundance was positively correlated with livestock dung abundance (r_s = 0.79, N=9, P<0.01).

The forest blocks of the buffer zone had significant (K-W One Way ANOVA, P<0.01, df = 25) differences in terms of major disturbance factors, viz., cutting (χ^2 = 271.45), lopping (χ^2 = 262.8), dung pile density (χ^2 = 312.85), abundance of shrub weeds other than *L. camara* (χ^2 = 478.86), *L. camara* density (χ^2 = 439.44) and percentage ground weed abundance (χ^2 = 387.92) (Table 7).

Table 7. Area (ha) under different disturbance factors in the buffer zone of the Corbett Tiger Reserve.

Disturbance factors	Nil	Low	Medium	High
Tree cutting	0	25703.9	9585.9	11468.0
Tree lopping	667.3	22047.6	13578.1	10464.8
Grazing	667.3	28869.6	9698.7	7522.2
Biotic pressure	0	15838.6	18802.5	12116.7
Lantana camara	0	30946.1	9227.9	6583.8

Cutting

Twenty three percent of the blocks of the buffer zone were under high intensity of cutting pressure (Figure 2a). Most of these blocks were located in the northern portion of the buffer zone. Another 23% were under medium intensity of cutting pressure. These blocks were located in the north and eastern portion of the buffer zone. The remaining 54% of the blocks had low cutting pressure. These blocks were spread all over the buffer zone.

Lopping

Twenty three percent blocks in buffer zone had high degree of lopping pressure. Most of these blocks were in the north of the buffer zone (Figure 2b). Another 27% of the blocks were under medium lopping pressure. The rest of the blocks, except one block in the east, had low intensity lopping pressure. Most of the blocks with low intensity lopping pressure were located in the eastern portion of the buffer zone.

Grazing

Compared to cutting and lopping pressure, only 15% of the forest blocks were under high grazing pressure (Figure 2c). While one blocks was located in north, three were in the south of the buffer zone. Another 23% of the blocks were under medium grazing pressure. These blocks were located both in the north and the south of the buffer zone. Of the remaining blocks 62% blocks all, except one, were under low grazing pressure. Forest blocks with low grazing intensity were located all across the buffer zone, except in the south of the buffer zone.

Overall biotic pressure

The combined pressure from tree cutting, lopping and livestock grazing, was found to be high in 23% of the forest blocks of the buffer zone. These blocks were located both in north and south of the buffer zone. Another 23% blocks were under medium intensity of biotic pressure, most of which were in north. The rest of the blocks had low intensity of biotic pressure, most of these blocks were in the eastern portion of the buffer zone (Figure 2e).

Lantana abundance

While the majority of the forest blocks were under low density of *L. camara*, 19% of them were under medium density and another 19% under high density. Most of the blocks with high weed density were located in the southeastern portion whereas blocks with low weed density were mostly in the northern and southwestern portion of the buffer zone (Figure 2d).

Prey Abundance-Habitat Attribute Relationship

The encounter rate of chital on different transects showed no significant correlation with any habitat attribute assessed on transects. The encounter rate of sambar was negatively correlated with grazing (r_s =-0.88, P<0.01), cutting (r_s = -0.67, P<0.05) and lopping (r_s =-0.68, P<0.05) only. The encounter rate of barking deer showed positive correlation with herb diversity (r_s =0.79, P<0.01) and herb evenness (r_s = 0.71, P<0.05), grass richness (r_s = 0.78, P<0.01) and grass diversity (r_s = 0.94, P<0.01). The barking deer encounter rate was also significantly negatively correlated with grazing (r_s = -0.78, P<0.01), cutting (r_s = -0.84, P<0.1) and abundance of weed (r_s = -0.79, P<0.01). The encounter rate of wild pig did not show any significant correlation with any of the assessed habitat factors. The encounter rate of nilgai was found to be negatively correlated with tree richness (r_s = -0.70, P<0.05). It was also negatively correlated with herb richness (r_s = -0.73 P<0.05), herb diversity (r_s = -0.73, P<0.05), grass diversity (r_s = 0.73, P<0.05) and grass evenness (r_s = 0.73, P<0.05). The nilgai encounter rate was, however, positively correlated with grazing (r_s = 0.73, P<0.05)

The pellet group density of chital in different forest blocks was positively correlated with cutting and weed abundance (r_s = 0.87 & 0.71, P<0.01 & 0.05). It was negatively correlated with grass richness and grass diversity (r_s = -0.78 & -0.70, P<0.05). The pellet group densities of sambar and barking deer did not show any correlation with various habitat factors including disturbance attributes. The wild pig dropping density was positively correlated with grazing (r_s = 0.80, P<0.01), livestock dung abundance (r_s = 0.74, P<0.05), cutting (r_s = 0.71, P<0.05) and weed abundance (r_s=0.86, P<0.01) and negatively correlated with herb diversity (r_s =-0.81, P<0.01), herb evenness (r_s = -0.76, P<0.01) and grass diversity (r_s = -0.66, P<0.05). The pellet group density of nilgai was negatively correlated with herb diversity (r_s = -0.69, P<0.05) and herb evenness (r_s = -0.84, P<0.01).

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