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Vegetation types and wildlife occurrence in Baghmara Buffer zone community forest

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Abstract

Baghmara Buffer Zone Community Forest (BBZCF) is located in the central lowland of Nepal by covering 215 ha area. A year round study was conducted on 2010 in the area to find out the vegetation types and associated large wild mammals in that vegetation. To collect the primary data on vegetation 34 parallel transects traversing east to west were established. The transect pass through the all habitat types of BBZCF. Total length of transects were 68 kilometers. Nested quadrates (n = 131) were laid in each transects to collect information about vegetation type and wildlife occurrence. Vegetation types of the area were classified on the basis of Importance Value (IV) of tree species for forest area and Prominance Value (PV) of herbs and grass species in grassland area. Six vegetation types namely *Acacia catechu* forest, *Albizia julibrissin* forest, Savana, *Dalbergia sissoo* forest, *Trewia nudiflora* forest, and Grassland were reported from the study area. Wildlife signs were found only from naturally regenerated forests areas of BBZCF. On the basis of the availability of indirect signs it was found that wildlife were distributed in *Albizia julibrissin* forest, *Trewia nudiflora* forest, and grasslands of the study area. From those vegetation types, Spotted deer, Sambhar, Wild boar, Barking deer, and Rhinos were recorded. Among the studied wildlife, Spotted deer and Sambhar preferred *Trewia nudiflora* forest and rest of the wildlife preferred *Albizia julibrissin* forest as their habitats.

Keywords: Plant sociology, Importance Value, Prominence Value, Habitat.

INTRODUCTION

Resource degradation has exceeded after the nationalization of the private forest in 1957 mostly due to the unstable government and lack of proper institution for conservation. Later conservation activities were institutionalized in the form of forest law during early 60's and protected area act around early 70's [1]. The enforcement of the law and involvement of the local communities in conservation areas moved simultaneously which showed positive impact on resource conservation [2]. The lowland (subtropical) region is famous for economically valuable natural resources like *Dipterocarp* timber, One Horned Rhinoceros (*Rhinos unicornis*), Royal Bengal Tiger (*Panthera tigris*) and so on. Similarly it consists of the riverine and subtropical forests with flood plain, which are very rich in biodiversity [3].

In Chitwan, the first step to conserve bio-diversity was initiated with the establishment of rhino sanctuary in 1956 followed by wildlife protection act in 1957 [3]. A special unit called rhino patrol was created after a few years to protect rhino [4]. After community conservation initiation in 1989 in Baghmara, a healthy forest area was created and some endangered flagship species, like Asian One Horned Rhinoceros, were re-colonized. Now, this forest is a part of the Buffer Zone of Chitwan National Park (CNP). Conservation efforts have brought significant ecological and socio-economic changes. The changes need to be quantified and assessed before the concept is expanded to the other areas. The institutional engagement in the resource management and the involvement of local stakeholder in process of conservation of the community forest has totally controlled grazing and illegal collection of fuel wood, fodder and hunting. This study has attempted to analyze the current ecological situation of the area.

Study area

Baghmara Community Forest is located in Bachhauli Village Development Committee of Chitwan District, Nepal (fig 1). It is situated in Buffer Zone area of Chitwan National Park at its eastern sector. It is located in subtropical lowland region covering 215 ha area in between 27°34.78'-27°35.53' Northern Latitude and 84°28.43'-84°29.40' Eastern Longitude [19] at 170 meter of elevation.

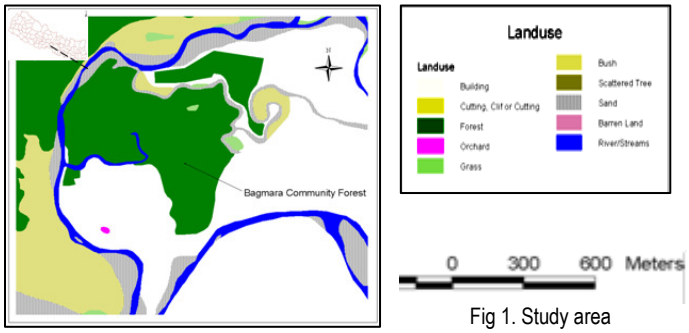

Fig 1. Study area

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The climate of the study area is sub-tropical monsoon type with high relatively humidity. Monsoon rain prevails from late June to September and amount of annual rainfall ranges from 14.04 mm to 602.2 mm [5]. Heavy flooding occurs during the monsoon. The average daily maximum temperature of the area in hot summer days is about 36.8°C. Spring starts from March and is immediately followed with summer and that ends in June [6]. The minimum temperature is about 7.8° C in cool dry winter during October to February [4].

This community forest is located on the floodplain of Rapti River with majority of the riverine forest species. Basically, the dominant species of the forest are Simal (*Bombax ceiba*), Bhellar (*Trewia nudiflora*), and Padke (*Albizia julibrissin*). The Baghmara Community Forest has provided an excellent habitat for many wildlife species. It harbors carnivores such as the Bengal Tiger (*Panthera tigris*) as frequent visitor, Common Leopard (*Panthera pardus*), Rhino (*Rhinoceros unicornis*), Spotted Deer (*Axis axis)*, Sambhar Deer (*Cervus unicolar*), Barking Deer (*Muntiacus muntjack*), Hog Deer (*Axis porcinus*), Wild Boar (*Sus scrofa*), Mugger Crocodile (*Crocodylus palustris*), and Rhesus Monkey (*Macaca mulatta*) [6].

METHOD

A year round (April 2010 to March 2011) research was conducted in BBZCF to collect information about flora and fauna. The primary data on vegetation was collected 34 parallel transects spacing 150 m traversing east to west were prepared. The transect pass through the all habitat types of BBZCF. Total length of transects were 68 kilometers.

Nested quadrates were laid along each transects systematically at each 150 m intervals. These quadrates were used to collect information about the vegetation and indirect wildlife sign. Randomization of quadrates was done by traveling 15 paces in any direction at each 150 m distance along the preset transect. The direction of travel was determined by rotating the body of researcher with lapping eyes in clockwise direction. The movement was stopped after one minute and the direction of the movement to prepare the quadrate was the direction of eyes. Preparation of quadrate always started from south-west corner. Nested quadrates of 400 m^2 (20 m x 20 m), 25 m^2 (5 m x 5 m) and 1 m^2 (1 m x 1 m) were used to collect data on tree, under-story and ground vegetation respectively. In case of grassland quadrates of 2.25 m^2 (1.5 m x 1.5 m) was used to collect information.

Tree level characteristics like scientific name, local name, DBH and height were collected from largest (400 m^2) quadrates. Shrub and understory layer information were collected by preparing two 25 m^2 nested plots at opposite corners of the 400 m^2 quadrate. First nested plot of 25 m^2 was always prepared in the starting point of large size quadrate. Information on ground vegetation was collected from other four 1 m^2 nested plots set at each corner of the 400 m^2 quadrate. For understory and ground vegetation collected characteristics included scientific name and coverage of particular species. The woody plants which has less than 5cm DBH and taller than knee height were considered sapling individuals of understory layer. Distances between quadrates were varied with the size of unit to be sampled, but were always a minimum of 50 paces apart. Sampling was conducted at least 10 m from the border of different vegetation types.

The utilization of habitat by different wildlife was recorded by observing their indirect signs. The presence of indirect signs like pellets, dung, foot mark and other body parts were recorded as indirect evidences of the animal visited in the habitat. These indirect signs were collected from 25 m^2, 1 m^2 and 2.25 m^2 quadrates prepared for vegetation survey. Total numbers of surveyed quadrates in the BCF were 961. The area covered by these quadrates were 6 ha, which is 2.8% of total area covered by BCF (215 ha) (Table 1).

Table 1. Number of quadrates surveyed in different vegetation types of BCF

Vegetation types	Number of surveyed quadrate			
	Tree	Understory	Ground vegetation	Total
Acacia catechu forest	8	16	32	56
Albizia julibrissin forest	35	70	140	245
Savana	4	8	16	16
Dalbergia sissoo forest	40	80	160	280
Trewia nudiflora forest	44	88	176	308
Grassland*			56	56
Total	131	262	580	961

* Size of the quadrates in grassland was 2.25 m^2

The percent of area covered by quadrates were highest in *Dalbergia sissoo* forest (4.8%) and lowest in grassland (0.04%) (Table 2).

Table 2 - Comparison of quadrate distribution and area covered by different vegetation types in BCF

Vegetation types	Area covered (ha.)	Quadrate distribution %	Area covered by quadrate %
Acacia catechu forest	8.0	5.8	4.5
Albizia julibrissin forest	60.5	25.5	2.6
Savana	11.7	1.7	1.6
Dalbergia sissoo forest	38.2	29.1	4.8
Trewia nudiflora forest	63.6	32.0	3.1
Grassland	33.0	5.8	0.04

Importance values of individual tree species available in the particular vegetation were calculated by adding the relative values of frequency, density and dominance [7]. Relative dominance of trees was determined by calculating the basal area. Name of each forest type was determined by ordering the Importance values of each tree species. The name of particular vegetation was provided from the name of plant with highest importance value.

Prominence values of individual species in understory or ground layers was calculated by multiplying percent cover of individual species and square root of its frequency [8]. The coverage of understory and ground flora was calculated by converting the recorded cover percentage to midpoint cover classes [9].

The abundance of wildlife in particular habitat types was calculated by making percentage ratio of number of quadrates having indirect sign with total number of plot sampled. Habitat preference by the wildlife was calculated as the relative value of the number of plot having the wildlife sign divided by total number of studied quadrate.

Sørensen's index of similarity [10] was employed to compare similarity between different vegetation types. The similarity index was the ratio of total common individual species and sum of total number of species in both compared habitats.

Maturity of the forest was calculated by using maturity index [10]. Maturity index was the ratio of sum of frequency of individual species in the habitat and total number of species in the habitat.

RESULTS

In total six types of vegetation were recorded from BBZCF. They were *Acacia catechu* forest, *Albizia julibrissin* forest, *Dalbergia sissoo* forest, *Trewia nudiflora* forest, Savana, and grassland. The highest area of BBZCF was covered by the *Trewia nudiflora* forest (29.6%) and the lowest area was covered by *Acacia catechu* forest (3.7%) (Table 3).

Table 3 - Vegetation types and area covered by the vegetation types in BCF

Vegetation types	Area covered (ha)	Percentage
Acacia catechu forest	8.0	3.7
Albizia julibrissin forest	60.5	28.1
Savana	11.7	5.4
Dalbergia sissoo forest	38.2	17.8
Trewia nudiflora forest	63.6	29.6
Grassland	33.0	15.3
Total	215.0	100.0

Located in the plantation sites of 1989 and 1990 [19], *Acacia catechu* forest occupies 8 ha (3.7%) area. This forest included the trees having average height and diameter of 14.5 m and 72 cm respectively with 116 steams per hector. Six species of tree were recorded from this forest. In this forest *Acacia catechu* was more important species with the highest important value (IV = 103.2) followed by *Dalbergia sissoo* (IV = 60.9) respectively (annex - 1). In the same way *Anthocephalus chinensis* was less important with lowest (IV = 12.8) important value. There were six species in the understory layer of this forest. Among these six species *Callicarpa macrophylla* was the most prominent species (PV = 200) followed by *Colebrookea oppositifolia* (PV = 95). The ground vegetation of this forest incorporated high diversity of species (n = 30). In the ground vegetation *Imperata cylindrica* was most prominent species (PV = 103) followed by *Cynodon dactylon* (PV = 20.5) (annex 1).

Occupying 60.5 ha area *Albizia julibrissin* forest was situated in the natural regeneration site of BBZCF. Average tree height of this forest was 16 m with an average DBH of 22.5 cm. The area was protected from barbed wire fence since 1994 [11]. This forest included 422 trees per hector with 13 species of tree. In the canopy layer *Albizia julibrissin* was the most important species (IV = 86.6) followed by *Bombax ceiba* (IV = 76.2) respectively (annex 2). Understory layer of this forest included 13 species of plants. Among them *Litsea* sp appeared as most prominent (PV = 259.1) species followed by *Callicarpa macrophylla* (PV = 95.1) respectively. Similarly, there were 46 species in the ground flora of this forest. Among them *Chrysopogon aciculatus* (PV = 35.4) was most prominent species followed by *Ageratum conyzoides* (PV = 17.5) respectively (annex 2).

In the study area some scattered trees were also found in association with ground flora which is considered as savanna. This vegetation occupied 11.7 ha area of BBZCF and was grazing land of the users' group. The average tree height of this forest was 16.5 m with 82.5 cm of average diameter. The area included quite scattered trees (57/ha) with less diverse species number (n = 3). In the canopy layer of this vegetation *Bombax ceiba* was the important (IV = 158.8) species followed by *Dalbergia sissoo* (IV = 112.7) respectively (annex 3). Only two species of plant were recorded from the understory layers of savanna. In understory layer *Callicarpa macrophylla* was most prominent (PV = 99.4) species followed by *Dalbergia sissoo* (PV = 0.3). Ground vegetation included more diverse species (n = 22) than tree and understory layers of this vegetation. In ground flora of Savanna *Cynodon dactylon* was the most prominent (PV = 87.8) species followed by *Coix* sp (PV = 31.5) respectively (annex 3).

Dalbergia sissoo forest was situated in the plantation site of BBZCF occupying 38.2 ha area. In canopy layer of this vegetation 9 species of tree were recorded. Average tree height of this forest was 15 m with 55.1 cm average DBH. There were 203 individual trees per hector. In tree canopy *Dalbergia sissoo* was the important tree species (IV = 222.1) followed by *Trewia nudiflora* (IV = 33.5) respectively (annex 4). The underground flora incorporated 8 species of plants. In understory layer *Callicarpa macrophylla* was most prominent species (PV = 75.3) followed by *Colebrookea oppositifolia* (PV = 63.4) respectively. Ground floras were quite rich in species diversity which incorporated 51 plant species. Lianas like

Parthenocissus semichordata and *Mikenia micarantha* were more prominent in this forest. In ground vegetation *Imperata cylindrica* (PV = 32) was most prominent species followed by *Mikenia micarantha* (PV = 23.2) respectively (annex 4).

Trewia nudiflora forest was situated in natural regeneration site of community forest. This area was protected from 1994 by barbed wire fence [11]. It occupied 63.6 ha area of community forest. From the canopy layer of this forest 16 species of tree were recorded. The average height of tree in this forest was 15 m with an average DBH of 24.5 cm. Number of stems per hector of forest were 363. In the tree canopy *Trewia nudiflora* was most important (IV = 97.0) species followed by *Bombax ceiba* (PV = 79.7) and *Albizia julibrissin* (PV = 43.5) respectively (annex 5). From understory layer of this forest 12 species of plants were recorded. In understory layer of this forest *Litsea* sp was the most prominent species (PV = 95.4) followed by *Ardisia macrocarpa* (PV = 77.3) and *Callicarpa macrophylla* (PV = 67.1) respectively. Similarly, *Imperata cylindrica* (PV = 90.8) and *Coix* sp (PV = 27.4) were most prominent species in ground flora. A total of 54 species were recorded in the ground flora of this forest (annex 5).

Total 33 ha area of BBZCF were managed as grassland. Inside the barbed wire fence grassland areas served as grazing ground for wildlife. In total 40 species of plants were recorded from grassland. Among the recorded species *Imperata cylindrica* was found most prominent species (PV = 178.9) followed by *Cynodon dactylon* (PV = 108.6) and *Saccharum spontaneum* (PV = 53.9) respectively (annex 6).

Similarity and maturity of vegetations

From the index of similarity (IS), the grassland was more similar to savanna (IS = 46.9) than the other vegetation of BBZCF. Similarly, *Trewia nudiflora* forest was found closer to *Albizia julibrissin* forest (IS = 74.8) in comparison to other vegetation. Among other vegetation *Dalbergia sissoo* forest was more similar to *Trewia nudiflora* forest (IS = 68.9), savanna was more similar to *Dalbergia sissoo* forest (IS = 55.0), *Albizia julibrissin* forest was more similar to *Trewia nudiflora* forest (IS = 74.8), and *Acacia catechu* forest was more similar to *Dalbergia sissoo* forest (IS = 59.3) (Table 4).

Table 4 – Similarity index of different forest types in BBZCF

Vegetation type	Grassland	*Trewia nudiflora*	*Dalbergia sissoo*	Savana	*Albizia julibrissin*
Acacia catechu forest	45.3	52.0	59.3	42.6	48.4
Albizia julibrissin forest	32.7	74.8	63.2	45.2	--
Savana	46.9	44.9	55.0	--	--
Dalbergia sissoo forest	46.8	68.9	--	--	--
Trewia nudiflora forest	44.7	--	--	--	--

On the basis of the available tree species in the canopy layer of BBZCF, maturity indices (MI) of the available vegetation types were calculated. On the basis of maturity indices (MI) Savanna vegetation was more mature (MI = 0.50) than other available vegetations of BBZCF. The other respective mature vegetations of BBZCF were *Albizia julibrissin* forest (MI = 0.37), *Acacia catechu* forest (MI = 0.31), *Dalbergia sissoo* forest (MI = 0.21), and *Trewia nudiflora* forest (MI = 0.21) respectively (Table 5)

Table 5 – Maturity index of different vegetation in BBZCF.

Vegetation type	Maturity index (MI)
Acacia catechu forest	0.31
Albizia julibrissin forest	0.37
Savana	0.50
Dalbergia sissoo forest	0.21
Trewia nudiflora forest	0.21
Gtassland	

Wildlife abundance and habitat preference

Wildlife signs were found only from naturally regenerated forests areas of BBZCF. On the basis of the occurrence of indirect signs, wildlife were only distributed in *Albizia julibrissin* forest, *Trewia nudiflora* forest, and grasslands of the study area. From *Albizia julibrissin* forest Spotted Deer, Sambar, Wild Boar, Barking Deer, and Rhinos were recorded. Among them Spotted Deer (A = 4.3%) were more abundant wildlife found in this forest followed by Barking Deer (A = 2.9). Similarly, other abundant species of this forest were Rhinos (A = 2.4%), Wild boar (A = 1.4), and Sambhar Deer (A = 1%) respectively (figure 2).

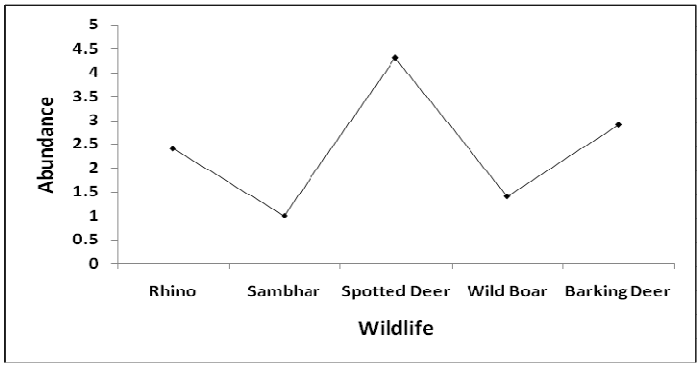

Fig 2. Wildlife abundance in *Albizia julibrissin* forest [Rhino (*Rhinoceros unicornis*), Sambhar (*Cervus unicolor*), Spotted Deer (*Axis axis*), Wild Boar (*Sus scrofa*), and Barking Deer (*Muntiacus muntjak*)]

The *Trewia nudiflora* forest was also a good habitat for different large mammals. Wildlife recorded from this forest was Sambahr, Spotted Deer, Wild Boar, Barking Deer and Rhino. In this forest Spotted Deer (A = 6.4) was most abundant wildlife species followed by Sambhar Deer (A = 4.2) respectively. Other respective abundant wildlife recorded from this forest were Rhino (A = 1.9), Barking Deer (A = 1.1), and Wild Boar (A = 0.4) (Figure 3). This area was also receiving anthropogenic activities like livestock grazing (A = 1.5) and grass cutting (A = 2.3).

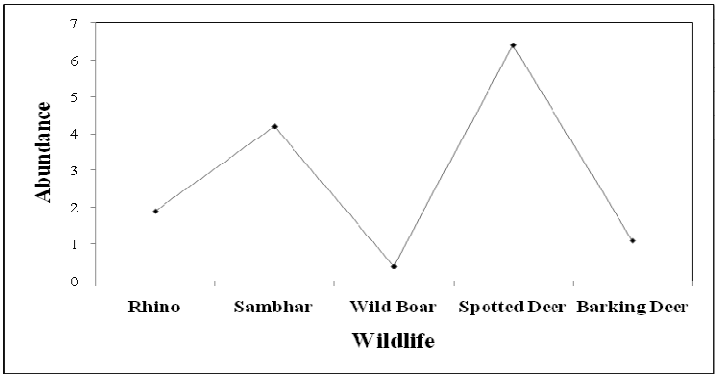

Fig 3. Wildlife abundance in *Trewia nudiflora* forest [Rhino (*Rhinoceros unicornis*), Sambhar (*Cervus unicolor*), Wild Boar (*Sus scrofa*), Spotted Deer (*Axis axis*), and Barking Deer (*Muntiacus muntjak*)]

Grassland of community forest provided the good grazing ground for wildlife. From this study Rhino was frequently (A = 1.8) visiting wildlife in grassland area. Grassland areas outside barbed wire fence were used to graze livestock from users' group. Grasslands inside the fencing were also served as daily grass collection (A = 5.4) and grazing (A = 5.4) places of users' group.

Habitat preference of Barking Deer, Spotted Deer, Rhino, Sambhar, and Wild Boar were studied in BBZCF. Indirect signs of these wildlife were distributed in *Albizia julibrissin* and *Trewia nudiflora* forests and grassland of the study area. Among the studied wildlife Spotted Deer and Sambhar preferred *Trewia nudiflora* forest and rest of the wildlife preferred *Albizia julibrissin* forest as their habitats (Figure 4).

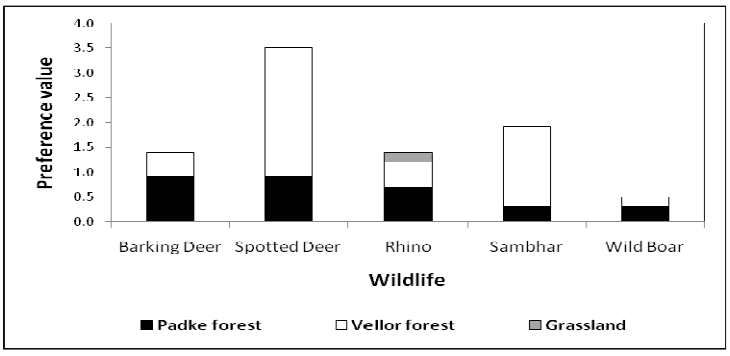

Fig 4. Habitat preference by different wildlife in BBZCF [Barking Deer (*Muntiacus muntjak*), Spotted Deer (*Axis axis*), Rhino (*Rhinoceros unicornis*), Sambar (*Cervus unicolor*), Wild Boar (*Sus scrofa*), Padke (*Albizia julibrissin*), Vellor (*Trewia nudiflora*)]

Annex 1. Importance value (IV) of the tree species and Prominence value (PV) of plant species recorded from understory and ground vegetation of BBZCF in *Acacia catechu* forest

S. No	Tree species	IV
1.	*Acacia catechu*	103.2
2.	*Dalbergia sissoo*	60.9
3.	*Bombax ceiba*	53.5
4.	*Albizia julibrissin*	38.1
5.	*Melia azaderect*	31.2
6.	*Anthocephalus chinensis*	12.8
	Species of understory vegetation	**PV**
1.	*Callicarpa macrophylla*	200.0
2.	*Colebrookea oppositifolia*	95.0
3	*Ehretia laevis*	61.5
4	*Dalbergia sissoo*	43.3
5	*Trewia nudiflora*	36.1
6	*Albizia julibrissin*	5.8
	Species of ground vegetation	
1.	*Imperata cylindrica*	103.0
2.	*Cynodon dactylon*	20.5
3.	*Ageratum conyzoides*	18.3
4.	*Dennstaedtia appendiculata*	15.4
5.	*Mikenia micarantha*	10.5
6.	*Euphorbia hirta*	9.6
7.	*Trifolium repens*	9.4
8.	*Hemarthria compressa*	9.2
9.	*Chrysopogon aciculatus*	7.8
10.	*Achyranthus aspera*	7.4
11.	*Colebrookea oppositifolia*	4.5
12.	*Diplazium esculentum*	4.5
13.	Unidentified	4.5
14.	*Eupatorium adenophorum*	3.2
15.	*Flemengia* sp	3.2
16.	*Coix* sp	3.2
17.	*Phyllanthus amarus*	3.2
18.	*Parthenocissus semichordata*	3.2
19.	*Callicarpa macrophylla*	3.2
20.	*Centella asiatica*	3.2
21.	*Adiantum venustum*	3.2
22.	*Saccharum spontaneum*	3.2
23.	*Solanum surattense*	3.2
24.	*Acacia catechu*	3.2
25.	*Cyperus rotundus*	3.2
26.	*Piper longum*	3.2
27.	*Rotala rotundifolia*	3.2
28.	*Urtica dioca*	3.2
29.	*Dalbergia sissoo*	3.2
30.	*Rungia parviflora*	3.2

DISCUSSION

Plantations in the BBZCF were conducted in three phases first in 1989 (16 ha), second in 1990 (10 ha) and third in 1997 (10 ha) in north western grazing lands of the study area [12]. Seedlings of similar species were used in all plantation sites of BBZCF but these sites now converted to two forest types, namely Khair (*Acacia catechu*) and Sissoo (*Dalbergia sissoo*). Immediately after plantation

these areas were fenced from barbed wire and restricted for open grazing. The main planted species were Sissoo, Khair, Vellor (*Trewia nudiflora*), Simal (*Bombax ceiba*) and Teak (*Tectona grandis*) [13]. Currently Padke (*Albizzia julirissin*), which was not planted species, came out as an important species in Khair (*Acacia catechue*) forest. The emergence of Padke was started from the edge of plantation sites in moist microclimate. It indicates that the succession of tree species was continued according land suitability of the area.

Since 1994, plant composition in canopy layer was also changed in the Khair (*Acacia catechu*) forest. The important value (IV) of Khair (*Acacia catechu*) was reduced from 105.9 in 1994 to 103.2 in 2011 and second important species was changed from Padke to Simal. Similarly, numbers of tree species in canopy layer were reduced from 9 to 6. The number of stem per hector of forest was reduced from 1416 stem/ha to 209 stem/ha. But, numbers of species in understory layer were increased from 4 to 6. In understory layer some species were replaced and some new species were emerged. *Urtica dioca* more prominent during early phase was reduced to very few. Previously more prominent ground vegetations were *Diplazium esculentum* (PV = 9.4) and *Clerodendrum viscosum* (PV = 6.3) respectively. In 1994, only four species of plant were recorded from the ground vegetation. The species diversity in ground vegetation was increased (n = 30) and *Imperata cylindrica* (PV = 103) and *Cynodon dactylon* (PV = 20.5) were more prominent species in ground vegetation [14].

Similarly, the community structure in Sissoo (*Dalbergia sissoo*) forest was also changed since 1994. Important value of Sissoo was reduced to 222.1 than earlier study (IV = 256) and second important species *Bombax ceiba* (IV = 15) was replaced by *Trewia nudiflora*. Tree species diversity in canopy layer was increased from 4 to 9 and average height of tree was increased from 7.5 m to 15 m. Density of the tree per hector was drastically reduced from 1759 individual/ha to 203 individual/ha. Now prominent species in understory was *Callicarpa macrophylla* and which was *Urtica dioca* in 1994. Number of plant species in understory layer was increased from 3 to 8. *Diplazium esculentum* was more prominent species in the ground vegetation in 1994 but that species was replaced by *Imperata cylindrica* (PV = 32.0). Plant species diversity was increased from 6 to 51 [14].

As earlier study (1994) natural regeneration sites of BBZCF included two types of forests. But, important value of tree was changed and form different plant community composition. Previous Simal-Padke (*Bombax ceiba-Albizia julibrissin*) forest was now changed to nearly pure stand of Padke (IV = 86.6) forest. The important value of Simal and Padke was reduced from 124.2 to 76.2 and 99.3 to 86.6 respectively. The average height of trees was increased from 9.3 m to 16 m and number of steams per hector was increased from 78 individuals/ha to 422 individuals/ha. The diversity of plant species in tree canopy was increased from 5 species to 13 species. Most prominent species (*Litsea* sp) at understory layer remained same but its Prominent value was increased from 32.5 to 259.1 and plant species diversity was increased from 4 to 13. Previous prominent species (*Dennstaedtia appendiculata*) in ground vegetation was replaced by *Chrysopogon aciculatus* (PV = 35.4). Number of plant species in ground vegetation was drastically increased from 5 to 46 [14]. As identified from previous study understory layer of this forest included good fodder plant species of deer species and Rhino [15].

Previous Padke-Bhellor (*Albizia julibrissin* and *Trewia nudiflora*) forest of natural regeneration area was now changed to pure Bhellor (*Trewia nudiflora*) forest (IV = 97.0). In this forest number of trees per hector was increased from 273 to 363 and also average height of tree was increased from 8.2 m to 15 m. Number of tree species in canopy layer was increased from 12 to 16. Prominent species at understory layer was changed from thorny *Caesalpinia decapetala* to *Litsea* sp, which is one important food plant of deer species and Rhino [15]. Understory and ground vegetation of this forest was absent in 1994 [14]. But, now the number plant species in ground vegetation was 54.

After managing by community the study area incorporated different types of forests and grassland. Plant species diversity was increased and forest areas were still in succession stage. Among identified habitats more mature was Savanna. This finding was similar to the finding of Dinnerstein in Bardia National Park [8]

Wildlife

From this study, two more species, namely Barking Deer (*Muntiacus muntjak*) and Spotted Deer (*Axis axis*), were record [11, 16] in this forest. Number of Spotted Deer was highest among the recorded species [17]. This indicated BBZCF became an attractive habitat of different wildlife, especially for the predator species.

Wildlife was more concentrated in the naturally regenerated forest sites of BBZCF. The natural regeneration sites incorporated mosaics of different habitats including small wetlands and grassland. At early stage of its management BBZCF included less species than current findings [14]. Increased diversity of floral species incorporated different plants used as fodder by different herbivores [15, 18].

Almost all studied wildlife preferred forest as their habitat. Naturally regenerated forest areas were their preferable habitat. In naturally regenerated areas wetlands and grasslands were well distributed [19]. The presence of fodder plants as well as wetlands and grassland nearby was the main cause of being naturally regenerated forest as their preference habitat. This finding was similar with the previous finding from Bardia National Park [8]. High canopy cover of the tree and less disturbance from anthropogenic activities may be another cause of their preferences of those areas.

All grassland areas of BBZCF are short types [10] which are the good habitats for wildlife like Spotted Deer, Shambhar Deer, Barking Deer and Wild Boar. In contradict with the previous findings Rhino were distributed in short grassland areas of this forest. Previous study indicated that most preferred habitat of Rhino was the Tall Floodplain Grassland. This is due to the presence of some favorable microclimates, like oxbow lakes and waterholes nearby, and preferred food in the study area [15].

CONCLUSION

Although still in the succession stage, Baghmara Community Forest incorporated mosaics of forest habitats preferred by mammals, especially by large herbivores. The area converted to a good forest, either left for natural regeneration or plantation, if it conserved from the anthropogenic pressure, especially grazing and timber collecting. This area provides preferred habitats for deer species including endangered rhinoceros.

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Abbreviation Used

BBZCF – Baghmara Buffer Zone Community Forest, BCC – Biodiversity Conservation Center, BCF – Baghmara Community Forest, CNP – Chitwan National Park, DBH – Diameter at breast height, IV – Importance Value, KMTNC – King Mahendra Trust for Nature Conservation, NCRTC - Nepal Conservation Research and Training Center, VDC – Village Development Committee.

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Annex 2 .Importance value (IV) of the tree species and Prominence value (PV) of plant species recorded from understory and ground vegetation of BBZCF in *Albizia julibrissin* forest

S. No	Tree species	IV
1.	*Albizia julibrissin*	86.6
2.	*Bombax ceiba*	76.2
3.	*Trewia nudiflora*	65.3
4.	*Litsea* sp	40.8
5.	*Dysoxylum binectariferum*	7.1
6.	*Mallotus philippensis*	5.8
7.	*Dysoxylum gobara*	5.0
8.	*Xeromphis spinosa*	3.7
9.	*Miliusa velutina*	3.1
10.	*Ehretia laevis*	2.9
11.	*Premna integrifolia*	1.5
12.	*Gmelina arborea*	1.0
13.	*Psidium guajava*	0.9
	Species of understory vegetation	**PV**
1.	*Litsea* sp	259.1
2.	*Callicarpa macrophylla*	95.1
3.	*Ardisia macrocarpa*	65.7
4.	*Trewia nudiflora*	28.4
5.	*Colebrookea oppositifolia*	6.2
6.	*Albizia julibrissin*	3.8
7.	*Xeromphis spinosa*	1.2
8.	*Mallotus philippensis*	1.2
9.	*Litsea monopetala*	0.9
10.	*Calamus tenuis*	0.4
11.	*Dysoxylum binectariferum*	0.4
12.	*Osyris wightiana*	0.4
13.	*Syzygium cumini*	0.2
	Species of ground vegetation	
1.	*Chrysopogon aciculatus*	35.4
2.	*Ageratum conyzoides*	17.5
3.	*Dennstaedtia appendiculata*	16.5
4.	*Centella asiatica*	12.7
5.	*Achyranthus aspera*	11.7
6.	*Flemengia* sp	10.9
7.	*Piper longum*	8.8
8.	*Coix* sp	8.5
9.	*Carex cruciata*	7.4
10.	*Persicaria barbata*	6.8
11.	*Cynodon dactylon*	6.4
12.	*Parthenocissus semichordata*	6.0
13.	*Adiantum venustum*	6.0
14.	Ardisia macrocarpa	5.7
15.	*Hemarthria compressa*	5.4
16.	*Albizia julibrissin*	5.2
17.	*Hydrocotyle nepalensis*	4.6
18.	*Cynoglossum zeylanicum*	4.5
19.	Unidentified	4.4
20.	*Ocimum gratissimum*	4.2
21.	*Euphorbia hirta*	4.1
22.	*Oxalis corniculata*	4.0
23.	*Ludwiga hyssopifolia*	4.0

24.	*Diplazium esculentum*	3.7
25.	*Solanum surattense*	3.6
26.	*Callicarpa macrophylla*	3.3
27.	*Cyperus rotundus*	2.9
28.	*Trewia nudiflora*	2.6
29.	*Digitaria ciliaris*	2.4
30.	*Clerodendrum viscosum*	2.4
31.	*Reinwardtia indica*	2.4
32.	*Pogostemon benghalensis*	2.3
33.	*Xeromphis spinosa*	1.9
34.	*Urtica dioca*	1.9
35.	*Trifolium repens*	1.6
36.	*Momordica dioica*	1.3
37.	*Eupatorium adenophorum*	1.3
38.	*Mallotus philippensis*	1.3
39.	*Caesalpinia decapetala*	0.9
40.	*Fumaria indica*	0.9
41.	*Dioscorea bulbifera*	0.9
42.	*Ocimum gratissimum*	0.9
43.	*Scoparia dulcis*	0.9
44.	*Colebrookea oppositifolia*	0.9
45.	*Litsea monopetala*	0.9
46.	*Imperata cylindrica*	0.9

Annex 3. Importance value (IV) of the tree species and Prominence value (PV) of plant species recorded from understory and ground vegetation of BBZCF in Savana

SN	Tree species	IV
1.	*Bombax ceiba*	158.8
2.	*Dalbergia sissoo*	112.7
3.	*Dysoxylum gobara*	28.5
	Species of understory vegetation	**PV**
1.	*Callicarpa macrophylla*	99.4
2.	*Dalbergia sissoo*	0.3
	Species of ground vegetation	
1.	*Cynodon dactylon*	87.8
2.	*Coix* sp	31.5
3.	*Bidens pilosa*	29
4.	*Hemarthria compressa*	7.3
5.	*Piper longum*	7.3
6.	*Imperata cylindrical*	6.7
7.	*Ageratum conyzoides*	5.5
8.	*Digitaria ciliaris*	4.7
9.	*Oxalis corniculata*	4.7
10.	*Callicarpa macrophylla*	4.7
11.	*Cyperus rotundus*	4.7
12.	*Justicia* sp	4.7
13.	*Sonchus* sp	3.9
14.	*Colocasia esculenta*	3.9
15.	*Gonotanthus pumilus*	2.7
16.	*Flemengia* sp	2.7
17.	*Chrysopogon aciculatus*	2.7
18.	*Scoparia dulcis*	2.7
19.	*Lippia nodiflora*	2.7
20.	*Commelina benghalensis*	2.7
21.	*Reinwardtia indica*	2.7
22.	*Trifolium repens*	2.7

Annex 4 - Importance value (IV) of the tree species and Prominence value (PV) of plant species recorded from understory and ground vegetation of BBZCF in *Dalbergia*

sissoo forest

S. No	Tree species	IV
1.	*Dalbergia sissoo*	222.1
2.	*Trewia nudiflora*	33.5
3.	*Bombax ceiba*	16.9
4.	*Acacia catechu*	9.6
5.	*Leucaena leucocephala*	7.8
6.	*Litsea monopetala*	3.4
7.	*Albizia procera*	3.0
8.	*Ehretia laevis*	2.2
9.	*Dysoxylum gobara*	1.6
	Species of understory vegetation	**PV**
1.	*Callicarpa macrophylla*	75.3
2.	*Colebrookea oppositifolia*	63.4
3.	*Litsea* sp	48.8
4.	*Ardisia macrocarpa*	41.7
5.	*Dalbergia sissoo*	36.3
6.	*Trewia nudiflora*	14.6
7.	*Ehretia laevis*	13.5
8.	*Litsea monopetala*	6.2
	Species of ground vegetation	
1.	*Imperata cylindrica*	32.0
2.	*Mikenia micarantha*	23.2
3.	*Coix* sp	18.8
4.	*Dennstaedtia appendiculata*	9.3
5.	*Parthenocissus semichordata*	8.8
6.	*Ageratum conyzoides*	8.2
7.	*Chrysopogon aciculatus*	6.8
8.	*Diplazium esculentum*	6.7
9.	*Piper longum*	6.6
10.	*Bidens pilosa*	6.5
11.	*Pogostemon benghalensis*	6.5
12.	*Urtica dioca*	6.5
13.	*Cynodon dactylon*	5.9
14.	*Commelina benghalensis*	5.9
15.	*Hemarthria compressa*	5.8
16.	Unidentified	5.0
17.	*Eupatorium adenophorum*	4.9
18.	*Digitaria ciliaris*	4.9
19.	*Clerodendrum viscosum*	4.9
20.	*Sida acuta*	4.4
21.	*Trifolium repens*	4.3
22.	*Callicarpa macrophylla*	2.6
23.	*Saccharum spontaneum*	2.6
24.	*Solanum surattense*	2.4
25.	*Colocasia esculenta*	2.4
26.	*Achyranthus aspera*	2.3
27.	Simpudina	2.3
28.	*Centella asiatica*	1.9
29.	*Lippia nodiflora*	1.9
30.	*Scoparia dulcis*	1.7
31.	*Oxalis corniculata*	1.5
32.	*Apluda mutica*	1.5
33.	*Rungia parviflora*	1.5

34.	*Circium wallichii*	1.2
35.	*Litsea monopetala*	1.2
36.	*Persicaria barbata*	1.2
37.	*Reinwardtia indica*	1.2
38.	*Dalbergia sissoo*	1.2
39.	*Fimbristalys bisumbellata*	1.2
40.	Bandhaniya	0.9
41.	*Digitaria ciliaris*	0.9
42.	*Ardisia macrocarpa*	0.9
43.	*Colebrookea oppositifolia*	0.9
44.	*Equisetum debile*	0.9
45.	*Fumaria indica*	0.9
46.	*Acacia catechu*	0.9
47.	*Ludwiga hyssopifolia*	0.9
48.	*Osyris wightiana*	0.9
49.	*Flemingia strobilifera*	0.9
50.	*Bombax ceiba*	0.9
51.	*Trewia nudiflora*	0.9

Annex 5 - Importance value (IV) of the tree species and Prominence value (PV) of plant species recorded from understory and ground vegetation of BBZCF in *Trewia nudiflora* forest.

SN	**Tree species**	**IV**
1.	*Trewia nudiflora*	97.0
2.	*Bombax ceiba*	79.7
3.	*Albizia julibrissin*	43.5
4.	*Litsea* sp	43.2
5.	*Litsea monopetala*	7.5
6.	*Ehretia laevis*	7.2
7.	*Dysoxylum gobara*	5.0
8.	*Mallotus philippensis*	4.4
9.	*Dysoxylum binectariferum*	3.6
10.	*Terminalia tomentosa*	2.0
11.	*Bischofia javanica*	1.8
12.	*Careya arborea*	1.5
13.	*Xeromphis spinosa*	1.3
14.	*Lagerstroemia parviflora*	1.0
15.	*Xeromphis uliginosa*	1.0
16.	*Miliusa velutina*	0.9
	Species of understory vegetation	**PV**
1.	*Litsea* sp	95.4
2.	*Ardisia macrocarpa*	77.3
3.	*Callicarpa macrophylla*	67.1
4.	*Calamus tenuis*	57.7
5.	*Trewia nudiflora*	30.0
6.	*Colebrookea oppositifolia*	28.0
7.	*Xeromphis spinosa*	23.7
8.	*Albizia julibrissin*	22.7
9.	*Zizyphus mauritiana*	12.9
10.	*Careya arborea*	9.1
11.	*Litsea monopetala*	6.5
12.	*Mallotus philippensis*	4.6
	Species of ground vegetation	
1.	*Imperata cylindrical*	90.8
2.	*Coix* sp	27.4

3.	*Chrysopogon aciculatus*	27.2
4.	*Centella asiatica*	14.7
5.	*Dennstaedtia appendiculata*	12.6
6.	*Ageratum conyzoides*	11.8
7.	*Saccharum spontaneum*	9.1
8.	*Ardisia macrocarpa*	8.6
9.	*Trifolium repens*	8.6
10.	*Bidens pilosa*	8.2
11.	*Hemarthria compressa*	8.1
12.	*Achyranthus aspera*	7.8
13.	*Reinwardtia indica*	7.1
14.	*Cynodon dactylon*	6.5
15.	*Equisetum debile*	6.0
16.	*Flemengia* sp	6.0
17.	Unidentified	5.9
18.	*Commelina benghalensis*	5.8
19.	*Parthenocissus semichordata*	5.1
20.	*Oxalis corniculata*	4.7
21.	*Diplazium esculentum*	4.7
22.	*Callicarpa macrophylla*	4.4
23.	*Litsea* sp	4.3
24.	*Piper longum*	4.2
25.	*Persicaria barbata*	4.2
26.	*Albizia julibrissin*	3.9
27.	Simpudina	3.9
28.	*Digitaria ciliaris*	3.7
29.	*Cyperus rotundus*	3.6
30.	*Calamus tenuis*	3.2
31.	*Marsilea crenata*	3.1
32.	*Cynoglossum zeylanicum*	3.0
33.	*Trewia nudiflora*	3.0
34.	*Crotolaria* sp	2.6
35.	*Solanum surattense*	2.4
36.	*Ludwiga hyssopifolia*	2.4
37.	*Urtica dioca*	2.4
38.	*Clerodendrum viscosum*	1.9
39.	*Sida acuta*	1.8
40.	*Scoparia dulcis*	1.8
41.	*Caesalpinia decapetala*	1.6
42.	*Eclipta prostrata*	1.6
43.	*Zizyphus mauritiana*	1.1
44.	*Colebrookea oppositifolia*	1.1
45.	*Euphorbia hirta*	1.1
46.	*Colocasia esculenta*	1.1
47.	*Flemengia* sp	0.8
48.	*Ocimum gratissimum*	0.8
49.	*Dysoxylum binectariferum*	0.8
50.	Katahar phul	0.8
51.	*Fimbristalys bisumbellata*	0.8
52.	*Helmenthostachys zeylanica*	0.8
53.	*Pogostemon benghalensis*	0.8
54.	*Mallotus philippensis*	0.8

Annex 6. Prominence value (PV) of plant species in grassland area

SN	Species	PV

1.	*Imperata cylindrica*	178.9
2.	*Cynodon dactylon*	108.6
3.	*Saccharum spontaneum*	53.9
4.	*Trifolium repens*	48.4
5.	*Bidens pilosa*	28.0
6.	*Hemarthria compressa*	19.2
7.	*Ageratum conyzoides*	18.3
8.	*Eclipta prostrata*	16.0
9.	*Cyperus rotundus*	15.4
10.	*Coix* sp	13.7
11.	*Scoparia dulcis*	12.9
12.	*Trewia nudiflora*	12.9
13.	*Sonchus* sp	11.9
14.	Unidentified	11.8
15.	*Reinwardtia indica*	9.8
16.	*Lippia nodiflora*	9.7
17.	*Crotolaria* sp	8.5
18.	*Equisetum debile*	8.5
19.	*Indigofera pulchella*	7.0
20.	*Phyllanthus amarus*	6.0
21.	*Saussurea heteromalla*	6.0
22.	*Pharagmites karka*	6.0
23.	*Albizia julibrissin*	6.0
24.	*Flemengia* sp	5.1
25.	Lichi jhar	5.1
26.	*Cassia tora*	5.1
27.	*Eleusine indica*	4.9
28.	*Acacia catechu*	4.8
29.	*Dalbergia sissoo*	4.8
30.	*Justicia procumbens*	3.9
31.	*Simpudina*	3.4
32.	*Sida acuta*	1.7
33.	*Callicarpa macrophylla*	1.7
34.	*Ficus semicordata*	1.2
35.	*Vetiveria zizanioides*	1.2
36.	*Ludwiga hyssopifolia*	1.2
37.	*Apluda mutica*	1.2
38.	*Hydrocotyle nepalensis*	1.2
39.	*Dennstaedtia appendiculata*	1.2