

HABITAT UTILIZATION BY ASIATIC WILD ELEPHANT (*ELEPHUS MAXIMUS*) IN PARSA WILDLIFE RESERVE, NEPAL

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ABSTRACT

During the habitat survey, elephants foot prints, dungs and direct observations were performed along each sampling grid. GPS points of elephant's presence were recorded. Aiming to provide quantitative analysis of habitats, circular quadrats of 10 m, 2 m and 1m radius were used to collect information about trees, shrubs and herbs. Importance values of each species of trees were analyzed by adding relative frequency, relative density and relative dominance. Name of each forest type was determined from the sequential order of the large Importance Values (IV) of tree species. Prominence values were calculated for shrubs and ground flora and were used for classification of the shrub and ground vegetation type. Higher area of the reserve was covered by the forest (85.9%) followed by agriculture and buildup land (5.1%), grassland (3%), water body (3%), riverbed (2%) and shrub land (1%), respectively. Based on the phyto-sociological combination, forests of this reserve incorporated four types namely Sal with Tarai Mixed Hardwood, Sal, Tarai Mixed Hardwood and Riverine. Ample of evidence found inside lowland part (Tarai, Bhabar and the base of Churia) of Parsa Wildlife Reserve. A suitable habitat with palatable forages (eg. *Mallotus philippinensis*, Bananas, bamboos and climbers) for wild elephants were found inside the reserve. These forests were used as prime habitat by the Asiatic wild elephant.

Key words: Parsa wildlife reserve, wild asiatic elephant, importance value, prominence value, forest types.

INTRODUCTION

Aiming to preserve the population of indigenous Asiatic wild elephant (*Elephus maximus*) with associated flora and fauna of Parsa Wildlife Reserve of Nepal was gazetted in 1984. Geographically the reserve is located within 27°15'-27°33' N latitude and 84°41'-84° 58' E longitude by occupying 499 km² core and 298.17 km² buffer zone areas (DNPWC 2006). Major

portions of the reserve occupy *Churia* and *Bhabar* zone and also it supports the conservation of spill over wildlife of the Chitwan National Park in the east. The reserve includes tropical and sub-tropical forests of Parsa, Makwanpur and Bara districts in central lowland and churia in Nepal. The reserve lies in the humid sub-tropical climatic zone and exhibits four distinct seasons summer, monsoon, winter and spring. The summer (April-June) is

intensely hot (40°C) and humid with scarcity of water. The rainy season (July-September) is dominated by monsoon clouds and rains with little decline in the temperature. Characterized by very cold evenings and mornings (7.7°C) with clear skies, winter lasts from October to December. Spring (January-March) is the enjoyable season with chilly nights and pleasing day temperatures and clearer skies (Chaudhary 1995).

Asiatic wild elephant (*Elephas maximus*), the largest megaherbivores in Asia is listed as protected species by the National Parks and Wildlife Conservation Act of Nepal (1973) (Chalise 2008). It has listed as a threatened species in CITES appendix I. This species has been also listed in the World Conservation Unions (IUCN) list of threatened species since 1986 (IUCN 2006). Loss and fragmentation of habitats, poaching, domestication, and conflicts with human decline the wild elephants significantly over the last century (Yadav and Chalise 2013a,b, Sukumar 1989, Blake and Hedges 2004). Megaherbivores are mostly compressed in the protected areas which are too small for long term population preservice (Owen-Smith 1988, Sukumar 1989). Currently 34500 to 51000 Asiatic wild elephants live in wild through out the range countries (Hedges *et al.* 2005).

There are four fragmented wild Asian elephants population in lowland harbor large and continuous, resident population of elephants (Yadav 2002, Yadav 2005a,b, Smith and Mishra 1992). Nonetheless, Malaria eradication program in 1950s resulted in heavy loss of continuous forestland for settlement purposes (Shrestha 1979), which restricted the elephants in four small partially or completely isolated fragments less than 200 animals each.

Wildlife like Elephants and other mega herbivores need more forage for foods and space than other small herbivores (Owen-Smith 1988). For such species, where population regulation through natural reduction is not common forage is

the likely limiting resource (Sinclair 1975, Owen-Smith 1988, Sukumar 1989). Preference of food and habitat varies with season (Owen-Smith 1988, Sukumar 1989, Blom *et al.* 2004). The quantity and quality of food varies with the forest types, as determined by general productivity factors. Within the same forest type, local site factors determined the distribution of food plants (Pradhan 2007). African elephants tend to concentrate around permanent water sources during the dry season (Luethold 1977, Barnes and Hamilton 1982, Owen-Smith 1988), and they annually avoid human disturbance. Increasing numbers of elephants in a small area will alter the abundance and composition of tree species (Law 1970, Croze 1974, Field 1976, Ben-Shahar 1998, Wiseman *et al.* 2004). Wild elephants mostly affect trees for feeding, and types of impact determine the intensity of damage to the forest. Trees grow slowly with secondary chemical defence in poor nutrient site (Fine *et al.* 2004, Marquis 2004). So the elephants are likely to feed more selectively in forest on nutrient poor sites than in richer forests. Jachmann and Bell (1985) inferred that the elephants improve their own habitat by knocking down trees in less preferred areas which promote secondary growth from coppicing. Elephants normally prefer secondary forest because of the ample amount of the food available in younger forest (Eltringham 1982).

The diverse representation of habitats of this reserve also provided shelters for different flora and fauna including endangered species like wild elephant (*Elephas maximus*), tiger (*Panthera tigris*) and occasional visiting rhino (*Rhinoceros unicornis*). The reserve and surrounding forests is sole area that conserve and manage the indigenous resident population of Asiatic wild elephant in Nepal. This study provided the quantitative analysis of the available habitats in the Parsa Wildlife Reserve and its utilization by the Asiatic wild elephant (DNPWC 2006).

METHODS

Grids of 2×2 km (n=181) were prepared for the whole reserve and buffer zone area. Plots were systematically distributed inside each cluster. From the designed grid, 5.5% were selected randomly to conduct inventory. One grid incorporated a cluster of 10 quadrats arranged diagonally from south-west to north-east corner of the grid. The plots are located between 150 m to each other. Circular plots were used to conduct forest inventory (Yadav 1988, 2005). Plots with 10 m radius were used to collect information on tree level characteristics. Plots with 2 m radius were used to collect information about shrubs and plots with 1 m radius were used to collect information about grass and other herbaceous plants. Characteristics like local name, scientific name, DBH and height were recorded for trees. For the shrubs information like local name, scientific name and crown cover for each species were collected. Information like local name, scientific name and coverage of each species were collected for herbaceous species and grass.

Frequency of each species was analyzed by dividing the number of quadrats in which the specific species occurred by total number of quadrats. Similarly, the percentage ratio of frequency of particular species with the sum of frequencies of all species was relative frequency. Density, the number of individuals per unit area, was calculated by dividing number of individuals of particular species by total area (ha) of the studied quadrats. Relative density was the percentage ratio of density of one species with sum of densities of all species. Dominance, amount of ground covered by the tree trunk, was the ratio of total basal area of particular species with the total area (ha) of the studied quadrats. The relative amount of ground covered by the tree trunk called as relative dominance was the percentage ratio of the dominance of particular species with the total dominance of all species. Importance values of each species of trees were analyzed by adding

relative frequency, relative density and relative dominance. Name of each forest type was determined from the sequential order of the large Importance Values (IV) of tree species (Zobel *et al.* 1987). Prominance value (PV) was calculated for shrub and ground flora (like grass and herbaceous species). Prominance values were the multiplication of mean percent covers of particular species with the square roots of its frequency. These values were used for classification of the shrub and ground vegetation type from the sequential order of large PV (Sharma *et al.* 2012).

Forest types were determined on the basis of density of the tree in canopy layer and occurrence locality of the forest (HMGN 1999). On those bases the forest types were recognized as follows:

Sal with Tarai Mixed Hardwood forest: In this forest, different tree species are present along with the Sal (*Shorea robusta*). In the forest the percentage relative basal area of Sal was 30-60%.

Sal forest: In this forest Sal was the dominant species. In this forest more than 60% relative basal area was represented by Sal (*Shorea robusta*).

Tarai Mixed Hardwood forest: This forest included different tree species. If the basal area representation of Sal is less than 30% it was also considered as Tarai mixed hardwood forest.

Riverine forest: This forest was available in the moist area mostly in the river side.

Presence of wild elephants was recorded through identifying traditional route (*Hatti dandi*) of elephants that is used as transect. Recording of foot prints, dungs and direct observations of wild elephants were carried out along to transect 50 m apart both side. Damage of trees by elephants was also recorded. Vegetation analyses were carried out in PWR with respect to elephants use. Species grazed and browsed by wild elephants were recorded during vegetation survey in PWR.

RESULTS

Total numbers of surveyed plots were 297. Among them 99 plots were used to collect tree characteristics, 99 plots were used to collect information on shrubs and 99 plots were used to collect data about herbaceous plant and grasses. The altitude of the surveyed plots varied from 121 m to 782 m.

Along the designed transects, the study team observed, and recorded ample of foot prints and dungs of wild elephants in lowland designated grids. The team did not observe or recorded sinage of elephant's foot prints and dungs in Churia hills. Sinage of elephants only recorded in Bhabar zone and lower part of Churia hills. More than 30 different forage species grazed, browsed and knocked by elephants were listed during the study. The tree species were *Ficus lacor*, *Acacia hispide*, *Musa sapientum*, *Ficus benjamina*, *Garuga pinnata*, *Dandrocalamus* spp., *Artocarpus lakoocha*, *Acacia catechu*, *Bombax cieba*, *Dalbergia sissoo*, *Dillenia pentagyna*, *Ficus benghalensis*, *Ficus racemosa*, *Ficus religiosa*, *Litsea monopetala*, *Mallotus philippinensis*, *Shorea robusta*, *Terminalia belerica*, *Terminalia chebula*, *Calamus tenuis*, *Circium wallichi*.

Grass species were *Arundodonax*, *Desmostachya bipinnata*, *Imperata cylindrica*, *Phragmites kharka*, *Saccharum bengalensis*, *Saccharum spontaneum*, *Typha elephantina*, *Vetiveria zizanioides* and the very few *Spatholobus parviflorus* and *Bauhinia vellai* (Annex 2).

On the basis of the plot location the land use types of Parsa Wildlife Reserve and its buffer zone were analyzed. Higher land area of the reserve is occupied by the forest (85.9%) followed by agriculture and buildup land (5.1%), grassland (3%), water body (3%), riverbed (2%) and shrub land (1%), respectively (Table 1).

The aquatic habitat incorporated about 5% of the study area. The East -- Rapti river is the one of the main aquatic habitat of PWR in the north of the reserve. Bhatta Khola and Sital Khola are other

aquatic habitats of this reserve. Likewise Laukidah, Dewaki Daha are also the aquatic habitat of this reserve.

Table 1. Land use type in the Parsa Wildlife Reserve and its buffer zone.

Land use category	Percentage
Forest	85.9
Agriculture and buildup land	5.1
Grassland	3.0
Water	3.0
Riverbed	2.0
Shrubland	1.0
Total	100.0

Terrestrial habitat of the reserve incorporated three vegetation types namely forest, shrubland and grassland. Based on the phyto-sociological combination, forests of this reserve are divided in four categories. They are Sal with Tarai Mixed Hardwood, Sal, Tarai Mixed Hardwood and Riverine forests.

The largest area of the reserve is occupied by Sal with Tarai Mixed Hardwood (34.8%) followed by Tarai Mixed Hardwood forest (30.3%), Sal forest (24.7%) and Riverine forest (5.6%), respectively (Table 2). Small patches of Sal-salla (*Shorea robusta-Pinus roxburghii*) forest and Salla forest (*Pinus roxburghii*) also exist in some higher altitude of the reserve.

Table 2. Vegetation types in Parsa Wildlife Reserve and its buffer zone.

Vegetation	Occupied area (%)
Sal with Tarai Mixed Hardwood forest	34.8
Tarai Mixed Hardwood forest	30.3
Sal forest	24.7
Riverine forest	5.6
Grass land	3.4
Shrub land	1.1
Total	100.0

In the canopy layer of Sal with Tarai mixed hardwood (STMH) forest, 36 species of tree were identified from this forest. In this forest importance value of Sal (*Shorea robusta*) is highest (110.8) followed by *Lagerstroemia parviflora* (37.5) and *Dillenia pentagyna* (16.2), respectively. The understory layer provided good hiding areas for the wildlife. In this study shrubs were considered as understory layer. Total number of shrub species recorded for understory was 23. Among them *Desmodium heterocarpon* was more prominent (PV = 6.23) followed by *Woodfordia fruticosa* (PV = 4.40). Ground vegetation is the important food for the wild elephant and wild herbivores. This vegetation has an important role in maintaining the food chain of the reserve for wildlife. In total 34 species of plants were recorded as ground flora of STMH forest. On the basis of prominence value, more prominent ground flora of this forest were *Imperata cylindrica* (PV = 58.2) followed by *Saccharum spontaneum* (33.9) and *Arundinella nepalensis* (10.9), respectively (Table 3).

From the canopy layer of Sal forest 21 species of tree were reported. In this forest importance value of Sal (*Shorea robusta*) is highest (189.0) followed by *Lagerstroemia parviflora* (16.0) and *Anogeissus latifolia* (11.4), respectively. In the understory layer total number of species recorded for shrub was 21. Among the recorded shrub species, *Phoenix humilis* was more prominent (PV = 16.8) followed by *Woodfordia fruticosa* (PV = 7.9) and *Desmodium heterocarpon* (PV = 3.8), respectively. Ground vegetation of this forest incorporated 23 species of plants. On the basis of prominence value, more prominent ground flora of this forest was *Cyperus compressus* (PV = 28.5) followed by *Themeda arundinacea* (PV = 21.3) and *Eulaliopsis binata* (PV = 15.6), respectively (Table 3).

The canopy tree of Tarai mixed hardwood (TMH) forest included 18 species. In this forest importance value of *Shorea robusta* is highest

(37.0) followed by *Terminalia alata* (25.4) and *Lagerstroemia parviflora* (22.3), respectively. This forest incorporated 22 species of shrubs. Among the recorded shrub species *Woodfordia fruticosa* was more prominent (PV = 6.7) species followed by *Caesalpinia decapetala* (PV=2.4) and *Colebrookea oppositifolia* (PV=1.9), respectively. In total 23 species of plants were recorded as ground flora of TMH forest. On the basis of prominence value, more prominent ground flora of this forest was *Eupatorium odoratum* (PV=63.6) followed by *Imperata cylindrica* (31.6) and *Themeda arundinacea* (24.6), respectively (Table 3).

From the canopy layer of riverine forest 13 species of tree were identified. In this forest importance value of *Adina cordifolia* was highest (60) followed by *Garuga pinnata* (41.9) and *Bombax ceiba* (36.6), respectively. Total number of species recorded for shrub was 4. In the shrub layer *Caesalpinia decapetala* was more prominent species (PV = 2.2) followed by *Pogostemon benghalensis* (PV = 0.4), *Ardisia solanacea* (PV = 0.3) and *Letsea macrophylla* (PV = 0.1), respectively. In total 10 species of plants were recorded as ground flora of riverine forest. On the basis of prominence value, more prominent ground flora of this forest was *Saccharum spontaneum* (PV = 189) followed by *Themeda arundinacea* (49.2) and *Heteropogon contortus* (31.3), respectively (Table 3).

From the grassland of Parsa Wildlife Reserve three species of shrubs were recorded. The *Colebrookea oppositifolia* was more prominent shrub (PV = 4.8) species followed by *Pogostemon benghalensis* (PV = 0.8) and *Melastoma melabathricum* (PV = 0.6). In total 10 species of plants were recorded as ground flora of grassland. On the basis of prominence value, more prominent ground flora of this vegetation was *Cynodon dactylon* (PV = 365.3) followed by *Ageratum conyzoides* (270.8) and *Digitaria ciliaris* (108.9),

respectively. From the shrubs land of PWR five of plants were recorded as ground flora of shrub species of shrub were recorded. In total 10 species land (Table 3).

Table 3. Species recorded from Parsa Wildlife Reserve with their Importance Value (IV) for tree and Prominence Value (PV) for shrub and herbaceous species.

SN	Scientific name	Local name	STMH	TMH	Sal	Grassland
1	<i>Achyranthes aspera</i>	Datiwan	6.2	1.3	0.0	0.0
2	<i>Adina cordifolia</i>	Kadam	58.2	31.6	0.0	0.0
3	<i>Ageratum conyzoides</i>	Gandehjar	1.0	13.4	270.8	0.0
4	<i>Ajuga bracteosa</i>	Ratpate	0.2	0.0	0.2	0.0
5	<i>Albizia procera</i>	Setosiris	0.8	0.8	0.0	0.0
6	<i>Anogeissus latifolius</i>	Dhauti	0.0	0.0	11.4	0.0
7	<i>Ardisia solanacea</i>	Bhanti	0.0	0.6	0.7	0.0
8	<i>Artemisia indica</i>	Titepati	4.4	6.7	0.0	38.5
9	<i>Arundinella nepalensis</i>	Kharuki, Musekhari	0.1	0.1	11.2	0.0
10	<i>Asparagus filicinua</i>	Kurilo	0.0	0.0	1.5	0.0
11	<i>Barleria cristata</i>	Bhendekuro	4.7	16.4	0.0	0.0
12	<i>Bauhinia purpurea</i>	Tanki	2.1	1.6	0.0	0.0
13	<i>Bauhinia vahlii</i>	Bhorla	0.2	0.3	0.0	0.0
14	<i>Bauhinia variegata</i>	Koiralo	0.0	0.0	3.1	0.0
15	<i>Bombax ceiba</i>	Simal	1.8	6.3	0.0	0.0
16	<i>Buchanania latifolia</i>	Piyari	0.0	0.0	4.9	0.0
17	<i>Caesalpinia decapetala</i>	Arelikanda	1.1	0.5	0.5	0.0
18	<i>Calopogonium macunoides</i>	Gahatejhar	2.1	3.1	0.0	0.0
19	<i>Carex cruciata</i>	Harkatta (Khar)	1.0	3.3	0.0	0.0
20	<i>Careya arborea</i>	Kumbhi	1.0	1.1	3.0	0.0
21	<i>Casearia elliptica</i>	Ber	0.7	0.0	0.0	0.0
22	<i>Casearia graveolens</i>	Badkaule, Piperi	0.0	0.0	5.5	0.0
23	<i>Cassia fistula</i>	Rajbriksha	0.1	0.0	0.0	0.0
24	<i>Cassia tora</i>	Chinchin	3.8	7.1	0.0	0.0
25	<i>Cautleya spicata</i>	Panisaro	10.0	1.5	0.0	0.0
26	<i>Cheilanthes dalhousiae</i>	Rani sinka	0.0	0.0	2.1	0.0
27	<i>Chlorophytum arundinaceum</i>	Dati sag	0.0	0.0	0.0	0.0
28	<i>Cissampelos pareira</i>	Batul pate	0.0	0.0	0.0	0.0
29	<i>Cissus repens</i>	Gujargano, Pureni	3.3	0.0	0.0	0.0
30	<i>Clausena pentaphylla</i>	Raunne	2.2	9.1	0.0	0.0
31	<i>Cleistocalyx operculatus</i>	Kyamuna, Phandir	3.2	0.4	2.5	0.0
32	<i>Cleome viscosa</i>	Bantori	0.0	0.0	0.5	0.0
33	<i>Colebrookea oppositifolia</i>	Dhursul	0.0	0.0	0.0	4.8
34	<i>Commelina benghalensis</i>	Kanejhar	5.5	10.5	0.2	0.0
35	<i>Corchorus capsularis</i>	Patuwa	11.9	4.9	0.0	0.0
36	<i>Cornus oblonga</i>	Latikath	0.1	0.1	2.4	0.0
37	<i>Crinum amoenum</i>	Ban pyaj	0.5	2.4	0.0	0.0
38	<i>Curculigo orchiioides</i>	Musali	0.1	1.3	1.8	0.0
39	<i>Cynodon dactylon</i>	Dubo	0.1	0.0	0.0	365.3
40	<i>Cyperus compressus</i>	Mothe	0.0	0.0	28.5	43.0
41	<i>Dalbergia latifolia</i>	Satisal	9.9	24.6	0.0	0.0
42	<i>Dennstaedtia appendiculata</i>	Uniu	0.0	0.0	12.4	0.0
43	<i>Desmodium elegans</i>	Bakhreghans	0.0	4.0	0.0	0.0
44	<i>Desmodium heterocarpon</i>	Sakhino	0.0	6.4	3.9	0.0
45	<i>Desmodium oojenense</i>	Sandan	0.0	0.0	5.3	0.0
46	<i>Desmodium sp.</i>	Desmodiumsp	0.0	1.6	0.0	0.0

47	<i>Desmostachya bipinnata</i>	Kush	0.0	0.0	1.9	43.0
48	<i>Digitaria ciliaris</i>	Chitrebanso	0.0	0.0	0.1	108.9
49	<i>Dillenia pentagyna</i>	Tantari	0.0	0.0	9.8	0.0
50	<i>Dioscorea pentaphylla</i>	Ban tarul	1.0	0.0	0.0	0.0
51	<i>Ehretia laevis</i>	Datrung	10.3	16.1	0.0	0.0
52	<i>Elaeagnus infundibularis</i>	Gunyalo	0.0	0.0	0.0	0.0
53	<i>Elatostema platyphyllum</i>	Gagleto	0.0	0.0	0.0	0.0
54	<i>Elephantopus scaber</i>	Marcha	0.1	0.1	3.7	0.0
55	<i>Elsholtzia blanda</i>	Ban silam	0.0	0.0	0.0	0.0
56	<i>Equisetum diffusum</i>	Ankhle	6.2	13.5	0.2	47.1
57	<i>Eulaliopsis binata</i>	Babio	3.5	0.0	15.6	0.0
58	<i>Eupatorium adenophorum</i>	Banmara	1.0	0.0	0.4	27.2
59	<i>Eupatorium odoratum</i>	Banmara	2.1	6.8	8.5	0.0
60	<i>Eurya acuminata</i>	Jhigane	3.1	9.6	0.0	0.0
61	<i>Ficus hispida</i>	Khasreto	0.0	0.0	0.2	0.0
62	<i>Flemingia macrophylla</i>	Bhatte	0.0	0.0	0.2	0.0
63	<i>Flemingia strobilifera</i>	Flemengiasp	0.7	0.6	0.0	0.0
64	<i>Garcinia xanthochymus</i>	Archal	1.4	0.0	0.0	0.0
65	<i>Garuga pinnata</i>	Dabdabe	9.3	16.4	0.0	0.0
66	<i>Gmelina arborea</i>	Khamari	0.0	3.3	0.0	0.0
67	<i>Gouania leptostachya</i>	Bhatmase	0.0	0.0	0.1	0.0
68	<i>Grewia subinaequalis</i>	Phorso	110.8	37.0	2.4	0.0
69	<i>Heteropogon contortus</i>	Arthunge	11.3	0.9	10.0	27.2
70	<i>Hymenodictyon excelsum</i>	Bhudkul	0.1	0.0	0.0	0.0
71	<i>Imperata cylindrica</i>	Siru	0.0	0.0	5.9	43.0
72	<i>Inula cappa</i>	Gaitihare	3.6	0.0	0.3	0.0
73	<i>Justicia adhatoda</i>	Asuro	0.7	4.9	0.2	0.0
74	<i>Lagerstroemia parviflora</i>	Botdhainyaro	0.1	0.0	16.0	0.0
75	<i>Lannea coromandelica</i>	Hallunde, Jhigat	2.7	13.4	0.0	0.0
76	<i>Leea macrophylla</i>	Galen	2.7	63.6	0.3	0.0
77	<i>Leucas</i> sp.	Leucassp	0.2	0.0	0.0	0.0
78	<i>Litsea monopetala</i>	Kutmero	0.0	0.0	0.0	0.0
79	<i>Luculia gratissima</i>	Kangiyo	2.0	0.1	0.0	0.0
80	<i>Lygodium flexuosum</i>	Janailahara	7.4	3.2	0.0	0.0
81	<i>Madhuca latifolia</i>	Latimauwa	4.1	5.0	0.0	0.0
82	<i>Maesa chisia</i>	Bilaune	0.0	0.0	0.1	0.0
83	<i>Melastoma melabathricum</i>	Kali angeri	0.1	0.0	0.1	0.6
84	<i>Melia azedarach</i>	Bakaino	2.7	1.4	0.0	0.0
85	<i>Millettia extensa</i>	Gaujo	0.0	0.0	0.6	0.0
86	<i>Mucuna nigricans</i>	Kauso	2.0	0.0	0.0	0.0
87	<i>Murraya koenigii</i>	Karipatta	0.0	0.0	1.0	0.0
88	<i>Nephrolepis auriculata</i>	Paniamala	33.9	19.0	0.0	0.0
89	<i>Nyctanthes arbor-tristis</i>	Parijat	0.0	3.6	0.0	0.0
90	<i>Parthenocissu ssemicordata</i>	Charchare	0.1	0.0	0.0	0.0
91	<i>Phoenix humilis</i>	Thakal	6.9	0.0	16.8	0.0
92	<i>Phyllanthus emblica</i>	Amala	5.4	10.9	2.3	0.0
93	<i>Phyllanthus parvifolius</i>	Khareto	0.0	0.3	0.0	0.0
94	<i>Pilea</i> sp.	Kamle	37.5	22.3	0.0	0.0
95	<i>Pinus roxburghii</i>	Khotesalla	0.0	1.5	0.0	0.0
96	<i>Pinus</i> sp	Sallo	6.2	1.6	7.9	0.0
97	<i>Pogostemon benghalensis</i>	Rudilo	9.8	25.4	0.1	0.8
98	<i>Premna barbata</i>	Gindari	0.0	0.1	0.0	0.0

99	<i>Psidium guajava</i>	Amba	2.2	8.3	0.0	0.0
100	<i>Pueraria tuberosa</i>	Biralilaharo	0.0	1.9	0.0	0.0
101	<i>Rabdosia lophanthoides</i>	Charpate	1.6	0.0	0.0	0.0
102	<i>Rubus ellipticus</i>	Ainselu	0.3	0.6	0.0	0.0
103	<i>Rubus niveus</i>	Ratoainselu	2.2	3.2	0.0	0.0
104	<i>Saccharum spontaneum</i>	Kans	0.1	0.0	3.9	86.0
105	<i>Schefflera venulosa</i>	Kursimal	0.3	0.0	0.0	0.0
106	<i>Schima wallichii</i>	Chilaune	0.0	0.0	2.3	0.0
107	<i>Schleichera oleosa</i>	Kusum	2.8	2.1	0.0	0.0
108	<i>Semecarpus anacardium</i>	Bhalayo	0.6	2.2	8.8	0.0
109	<i>Senecio cappa</i>	Marchajhar	0.0	0.0	0.0	33.3
110	<i>Shorea robusta</i>	Sal	0.0	7.8	189.0	0.0
111	<i>Smilax aspera</i>	Kukurdaino	6.4	9.3	0.0	0.0
112	<i>Sonchus asper</i>	Sonchusaspera	0.1	0.1	0.2	0.0
113	<i>Spatholobus parviflorus</i>	Debrelehara	0.2	0.1	0.0	0.0
114	<i>Sterculia villosa</i>	Odal	0.0	0.0	0.0	0.0
115	<i>Swertia angustifolia</i>	Chiraito	1.0	4.9	0.0	0.0
116	<i>Syzygium cumini</i>	Jamun	7.4	9.3	7.0	0.0
117	<i>Terminalia alata</i>	Asna	2.4	4.5	7.7	0.0
118	<i>Terminalia bellirica</i>	Barro	1.0	0.0	2.3	0.0
119	<i>Terminalia chebula</i>	Harro	0.0	0.0	2.4	0.0
120	<i>Themeda arundinacea</i>	Dhaddi	4.8	9.3	21.3	0.0
121	<i>Thespesia lampas</i>	Ban kapas	3.9	3.4	0.0	0.0
122	<i>Thysanolaena maxima</i>	Amliso	0.7	3.6	0.0	0.0
123	<i>Toona ciliatae</i>	Tooni	0.0	1.4	0.0	0.0
124	<i>Trichilia connaroides</i>	Ankhataruwa	2.1	0.0	0.0	0.0
125	Unknown	Chabo	0.6	0.2	0.0	0.0
126	Unknown	Kharkhucho	6.8	11.2	0.0	0.0
127	Unknown	---	0.0	1.4	3.9	0.0
128	<i>Vitex negundo</i>	Simali	0.0	0.0	0.0	0.0
129	<i>Wightia speciosissima</i>	Phurkeghaans	0.0	0.0	0.3	0.0
130	<i>Woodfordia fruticosa</i>	Dhairo	16.2	13.0	8.0	0.0
131	<i>Zizyphus incurve</i>	Hade bayar	0.0	0.1	0.0	0.0
132	<i>Zizyphus mauritiana</i>	Bayar	1.1	0.0	0.0	0.0
133	<i>Zizyphus rugosa</i>	Jungalibayar	2.1	0.0	0.0	0.0

Note: STMH – Sal mixed Tarai Mixed Hardwood, TMH – Tarai Mixed Hardwood

Table 4. Common species known to be eaten by elephants (grazed, browsed or eaten).

Scientific name	Nepali name	Plant Ecology	Most common vegetation type (s)
Tree species			
<i>Ficus lacor</i>	Kabhro	Tree	Mixed forest
<i>Acacia hispida</i>	Babul	Tree	Mixed forest
<i>Mussa sapientum</i>	Banana	Tree	Mixed forest (Riverine)
<i>Ficus benjamina</i>	Swami	Clump	Mixed forest (Riverine)
<i>Ficus semicordata</i>	Khnyo	Tree	Mixed forest (Riverine)
<i>Garuga pinnata</i>	Dabdabe	Tree	Mixed forest (Riverine)
<i>Dendrocalamus</i> sp	Bans	Clump	Riverine forest
<i>Artocarpus lakoocha</i>	Badahar	Tree	Mixed forest

<i>Acacia catechu</i>	Khair	Tree	Khair-Sisoo forest
<i>Bombax cieba</i>	Simal	Tree	Mixed hardwood forest, wooded grassland
<i>Dalbergia sissoo</i>	Sisoo	Tree	Khair-Sisoo forest
<i>Dillenia pentagyna</i>	Tantari	Tree	Sal (<i>Shorea robusta</i>) forest
<i>Dryothyrium boryanum</i>	Kochina (Neoro)	Tree	---
<i>Ficus affinis</i>	Gajahar	Tree	Sal (<i>Shorea robusta</i>) forest
<i>Ficus benghalensis</i>	Bara	Tree	Sal (<i>Shorea robusta</i>) forest
<i>Ficus glumerata</i>	Gular	Tree	Riverine forest
<i>Ficus religiosa</i>	Pipal	Tree	---
<i>Litsea monopetala</i>	Kutmiro	Tree	---
<i>Mallotus philippinensis</i>	Sindure	Tree	Riverine forest
<i>Shorea robusta</i>	Sal	Tree	Sal (<i>Shorea robusta</i>) forest
<i>Terminalia belerica</i>	Harro	Tree	Sal (<i>Shorea robusta</i>) forest
<i>Terminalia chebula</i>	Barro	Tree	Sal (<i>Shorea robusta</i>) forest
<i>Calamus tenuis</i>	Bent	Shrub	Riverine forest
<i>Circium wallichii</i>	GaindaKhar	Herb	---
Grass species			
<i>Arundo donax</i>	ThuloNarkat	Grass	Grassland
<i>Desmostachya bippinata</i>	Kush	Grass	Grassland
<i>Imperata cylindrica</i>	Siru	Grass	Grassland
<i>Phragmites karka</i>	Narkat	Grass	Grassland
<i>Saccharum bengalensis</i>	Baruwa	Grass	Grassland
<i>Saccharum spontaneum</i>	Senth (Kansh)	Grass	Grassland
<i>Typha elephantina</i>	Pater	Grass	Grassland
<i>Vetiveria zizannoides</i>	Kansh	Grass	Grassland
Climbers (vines)			
<i>Spatholus roxburghii</i>	Debre Lahara	Climber	Sal (<i>Shorea robusta</i>) forest
<i>Bauhunia valhlii</i>	Bhorla	Climber	Sal (<i>Shorea robusta</i>) forest

DISCUSSION

In the previous study of the core zone of PWR (DNPWC 2006) the land use incorporated forest lands (91.78%), cultivated land (0.43%), shrub land (0.45%), and river or sand (7%). This study also incorporated the buffer zone areas so the land use has been changed. The area of forest land was reduced nearly by 5% and simultaneously increased in agriculture and builtup land nearly by 4.5%. In the previous study there was no incorporation of the grassland, but current study revealed that the reserve incorporated 1% area as grassland. The cultivated land inside the reserve

(Rambhori and Bhatta) were shifted to the outside location of PWR. Two villages (Ramauli and Pratappur) of Manahari VDCs of Makwanpur have evacuated from PWR core areas in 2013. About 200 ha of cultivated land and about 10 ha of settlement land has been converted into grassland. Currently those cultivated land was converted into grassland. So, there is increase in the grassland area inside the reserve. This study also revealed that there are slight increase in shrubland area. That is due to the incorporation of buffer zone in this study.

In the previous study, Tarai mixed hardwood forest was named as mixed deciduous hardwood forest (Chaudhary 1995, BPP 1996). At the canopy layer tree composition of the TMHF resembles with the current findings. The species composition in the ground flora was differing from the previous record. The invasive species *Eupatorium odoratum* was found prominent in the ground flora. This indicated that the invasive flora are gradually arising in the study area.

The current riverine forest type was previously recognized as mixed deciduous riverine forest (Chaudhary 1995, BPP 1996). The species composition in the forest was changed from the previous record. The previously reported tree species *Acacia catechu* and *Celtis tetrandia* were not recorded from this forest.

Tree species in the canopy layer of Sal forest was similar with the previous finding of Chaudhary (1995). The shrub species of the sal forest was not recorded in previous record. The ground vegetation of Sal forest was differing from the previous findings. Previously *Curcuma leucorhiza* and *Costus speciosa* were the main species but currently *Cyperus compressus*, *Themeda arundinacea* and *Eulaliopsis binata* were common as ground flora.

Previously mentioned forests like Sal-Pine (*Shorea robusta*-*Pinus roxburghii*), Pine (*Pinus roxburghii*) as well as Khair (*Acacia catechu*) (Chaudhary 1995, BPP 1996) were not reported in this study. Instead of those forests the combine forest naming Sal with Tarai mixed hardwood forest was reported in this study.

Previously vegetations (Fodder trees, grasses and climbers) grazed, browsed and damage of trees by wild elephants was not identified. Plenty of forage for elephants have been found in Bhabar zone and lower part of the PWR during the vegetation survey.

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