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ARTICLE

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IDENTIFICATION OF SUITABLE HABITAT FOR SWAMP DEER *RUCERVUS DUVAUCELII DUVAUCELII* (MAMMALIA: ARTIODACTYLA: CERVIDAE) IN CHITWAN NATIONAL PARK, NEPAL

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Abstract: Swamp Deer is a globally threatened large-sized deer species confined within small patches of the Indian subcontinent. Historically, Swamp Deer occurred in Chitwan National Park, Nepal but was extirpated in the 1960s primarily due to widespread hunting. We assessed the habitat suitability at present for the Swamp Deer in Chitwan National Park using multi-criteria analysis in GIS and vegetation assessment using frequency, dominance, and cover. Within the 952.63km² area of the national park, the habitat suitability analysis identified 14.57km² as highly suitable, 134.87km² as suitable, and 803.19km² as moderate to least suitable area. Most of the national park's grassland is suitable for Swamp Deer. Grassland is dominated by *Saccharum* spp.; *Imperata cylindrica* is the most widely distributed grass species followed by *Saccharum* spp., *Narenga porphyrocoma*, and *Apluda mutica*. Grass species of the Poaceae family are the most preferred species by Swamp Deer, which are found within short grasslands. The study revealed that Padampur Phanta could be the most suitable site for the reintroduction of Swamp Deer due to its highest proportion of short grass and availability of preferred food species and good habitat in comparison to other blocks. Invasion of swamps of Chitwan by *Mikania micrantha* and *Eichornia crassipes* could be a limiting factor for the habitat suitability of Swamp Deer.

Keywords: AHP, grassland, habitat suitability, invasive species, Poaceae, reintroduction, vegetation assessment.

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For **Author details** and **Author contribution**, see end of this article.



INTRODUCTION

Swamp Deer *Rucervus duvaucelii* is listed as Vulnerable in the IUCN Red List and included in Appendix I of CITES. The species is distributed in isolated pockets of the Indian subcontinent with an estimated total population between 3,500 and 5,100 individuals. The altitude range of Swamp Deer is 100–300 m (Duckworth et al. 2015). Groves (1982) identified three subspecies of Swamp Deer, namely, *R. d. duvaucelii*, *R. d. branderi*, and *R. d. ranjitsinhi*. *Rucervus duvaucelii duvaucelii* is distributed in the Indo-Gangetic plain north of the Ganges, including Nepal and parts of India. *Rucervus duvaucelii branderi* is distributed between the Ganges and Godavari rivers in central India and *Rucervus duvaucelii ranjitsinhi* in the Brahmaputra floodplain in eastern India. The subspecies *R. d. duvaucelii* became extinct from Pakistan and *R. d. ranjitsinhi* from Bangladesh (Qureshi et al. 2004). Historically, the Swamp Deer was distributed in swampy grasslands throughout the Terai of Nepal (Mishra 1982; Gurung 1983). The remaining population of Swamp Deer is now limited to Bardia National Park (BNP) supporting 106 individuals and Shuklaphanta National Park (ShNP) supporting 2,300 individuals in the western Terai. The population in ShNP holds the world's largest herd of Swamp Deer (Poudel 2007; DNPWC 2015) and establishes the site as globally important for its conservation.

In contrast, the Swamp Deer populations in BNP and ShNP face continuous food shortage, disease, and other anthropogenic stresses (Poudel 2007). Small and isolated populations are much more likely to go extinct due to demographic stochasticity, environment stochasticity, and genetic drift, or simply by chance events. Therefore, identification of potential habitats and establishing new populations through translocation are necessary for the long-term survival of this species.

Swamp Deer (Image 1) is primarily a grazer species (Pokheral 1996) which strongly prefers short grasslands (Bhattarai 2015). Swampy grasslands are considered the prime habitat of this species with the exception of *R. d. branderi*. Swamp Deer mostly feed on grass species and occasionally on aquatic plants (Moe 1994). Some of the most utilized food species are *Saccharum* spp., *Imperata cylindrica*, *Cynodon dactylon*, *Narenga porphyrocoma*, *Phragmites karka*, *Oryza rufipogon*, *Hygroryza* spp., and *Hydrilla* spp. (Martin 1977; Moe 1994; Pokheral 1996; Bhatta 2008; Bhattarai 2015), with the highest preference for *I. cylindrica* followed by *C. dactylon* and *Saccharum* spp. (*S. spontaneum*, *S. bengalense*, and *S. munj*) (Bhatta 2008; Bhattarai 2015). Swamp Deer use



Image 1. Swamp Deer *Rucervus duvaucelii*

riverine forest for resting, but were never recorded there while feeding (Bhatta 2008; Bhattarai 2015). Swamp Deer usually avoid thick forested areas (Pokheral 1996); even the thickets of *Phragmites karka* were avoided by the species in all seasons in Jhilmil Jheel Conservation Reserve (JJCR), Uttarakhand, India. Similarly, Swamp Deer avoid riverine forests where there is a lack of water and preferred edible plants (Gyawali & Jnawali 2005).

Swamp Deer use water for drinking at least two times a day in winter and in monsoon but three times or more in summer (Bhatta 2008). Similarly, this species shows a high preference for grassland plots with water holes (Bhattarai 2015). On an average, Swamp Deer move 2–3 km a day (Martin 1977; Qureshi et al. 1995); therefore, water sources should be located within the daily range of the species.

The suitable habitat of a species can be assessed based on the availability of the food, water, cover, and space needed for the species. Habitat suitability index (HSI) modelling is one of the widely accepted methods used to assess habitat for the translocation/ reintroduction of species. Such assessment analyzes the relations of the species with their habitat (Guisan & Zimmermann 2000). A quantitative measurement through systematic ground surveys is a traditional and resource-intensive approach for obtaining information about the habitat. Geospatial technology can supplement such intensive survey methods (Nandy et al. 2012). Habitat suitability modelling was used in different areas throughout the world to determine potential sites for the translocation and restoration of different species. In Nepal, habitat suitability modelling was applied for the Snow Leopard *Panthera uncia* in western Nepal, One-horned Rhinoceros *Rhinoceros unicornis* in Chitwan National

Park, and Tiger *Panthera tigris* in Triyuga Forest (Jackson & Ahlborn 1984; Kafley et al. 2009; Aryal 2016), but not for the Swamp Deer. Nandy et al. (2011) used multi-criteria analysis in GIS to identify the potential habitat for *R. d. duvaucelii* in JJRC. Similarly, Singh et al. (2015) used Environmental niche modelling for habitat suitability analysis of *R. d. branderi* in Madhya Pradesh, India. In this study, we used multi-criteria analysis to identify the potentially suitable habitat for the reintroduction of *R. d. duvaucelii* in Chitwan National Park (CNP) based on vegetation composition of grassland blocks and riverine forest patches. The study is intended to provide useful information for wildlife managers, conservation officers, and government authorities.

METHODS

Study Area

CNP is the first national park of Nepal (Bhujju et al. 2007) and was established in 1973 covering an area of 952.63km², 27.282–27.703 °N & 83.839–84.773 °E) surrounded by an additional 750km² buffer zone (Fig. 1).

The vegetation of CNP consists of tropical to subtropical forests with mosaics of successional communities at different stages in alluvial floodplains, including *Bombax ceiba-Trewia nudiflora* riverine forest to climax *Shorea robusta* (Thapa 2013; CNP 2015a). Most of the national park grasslands are dominated by *Saccharum* spp. The park is home to many rare and threatened species including Tiger *Panthera tigris*, Indian Rhinoceros *Rhinoceros unicornis*, Asian Elephant *Elephas maximus*, Gaur *Bos gaurus*, Sloth Bear *Ursus ursinus*, South Asian River Dolphin *Platanista gangetica*, Bengal Florican *Houbaropsis bengalensis*, and Gharial *Gavialis gangeticus* (CNP 2015a). The park is distributed at an altitude of 150–850 m (CNP 2015b).

Habitat Survey Sample Design

The park area was divided into three strata: grassland (including swampy areas and wetlands), riverine forest, and other forest land. Floristic composition of vegetation was assessed in the preferred habitats of Swamp Deer (grassland and riverine forest). To represent the grasslands of Chitwan adequately, the three largest patches, namely, Padampur Phanta (PP), Bhawanipur-

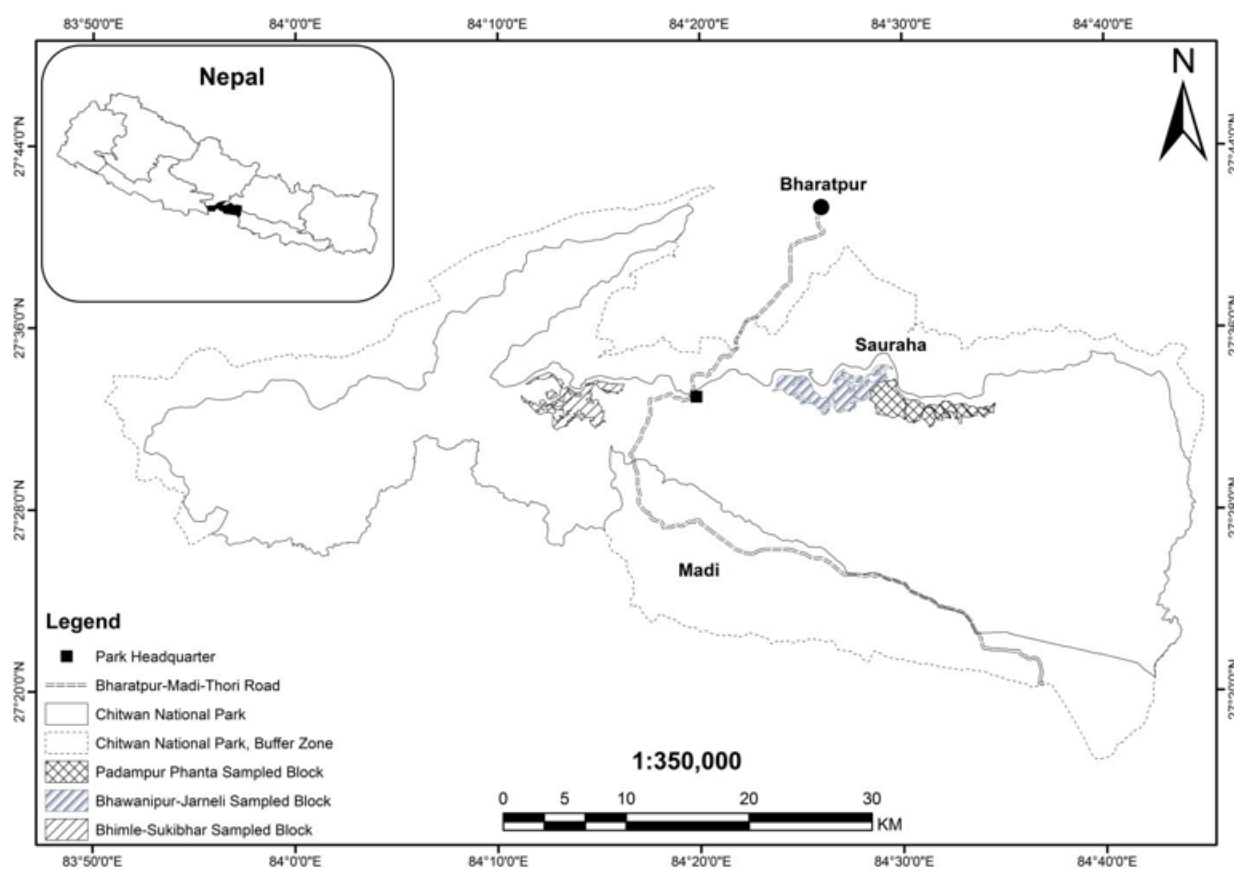


Figure 1. Sample study blocks in Chitwan National Park, Nepal.

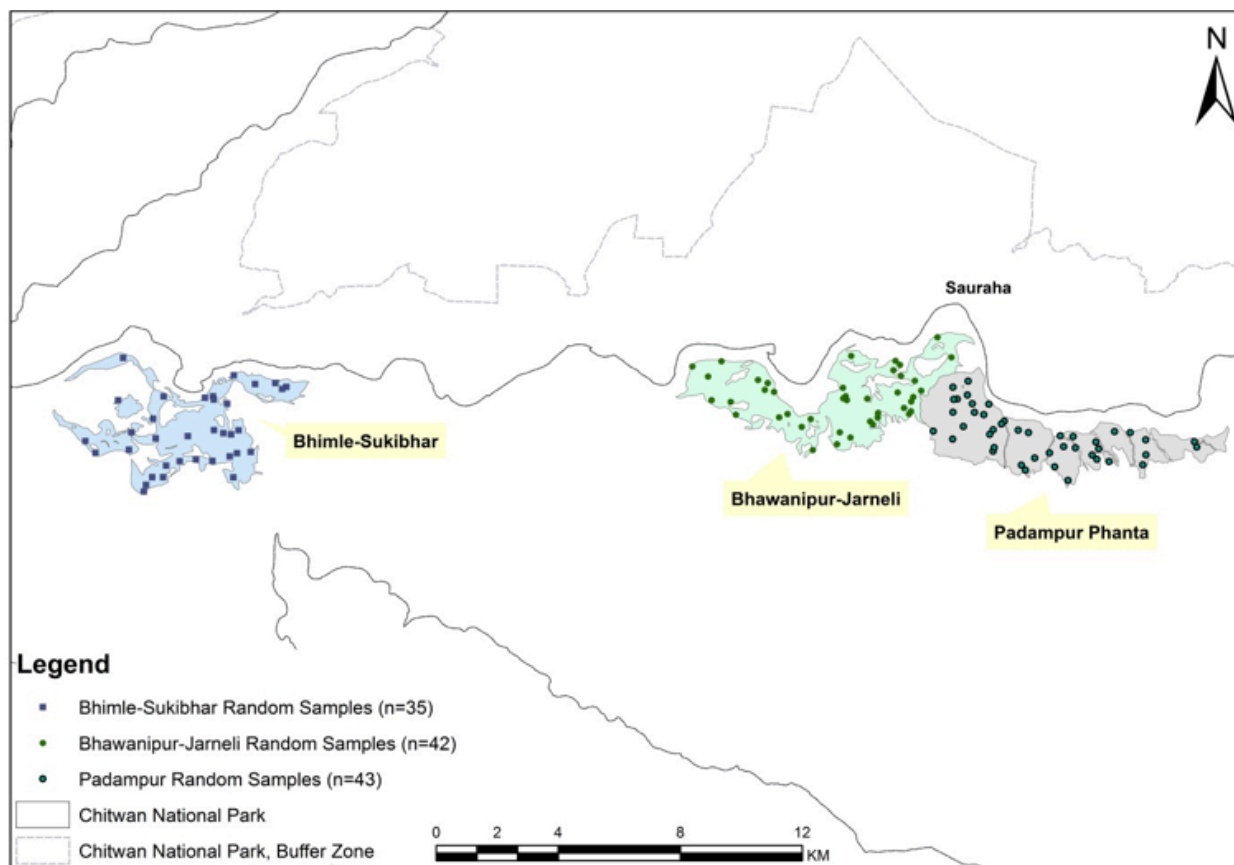


Figure 2. Random sample points in study blocks in Chitwan National Park, Nepal.

Jarneli (BJ), and Bhimle-Sukibhar (BS), were selected for field sampling. A total of 120 random sample points were set out proportionately in these grasslands (Fig. 2). Similarly, nine sample points were laid systematically (at 400m interval) in the riverine forest in the eastern sector of CNP, which starts from Sauraha.

Vegetation assessment in each sampling plot within the grassland blocks was carried out using 1m×1m quadrats (Oosting 1956). Frequency, dominance, and cover were used to assess the vegetation status. During the study, the team failed to study the density of grassland plots due to the dominance of tall grass species (>3m) in the park. Therefore, the ocular method was used to estimate the frequency, dominance, and cover in the grassland. In riverine forest patches, density, frequency, abundance, and cover were studied using nested quadrats of 20m×25m, 10m×10m, 5m×5m, and 1m×1m for poles having a diameter more than 29.99cm, trees having a diameter 10–29.99 cm, herbs having a diameter less than 10cm, and shrubs having heights less than 1m (CFD 2004).

GIS data collection/ preparation

The national park boundary layer was obtained from the department of survey (DoS), Nepal. Landsat-8 satellite images of March 2016 were used to obtain the updated land cover (or habitat type) of the park area. Supervised image classification using 253 training sample points collected from the field study was used with maximum likelihood approach. The image was classified into six land cover categories, namely, river, riverbank, riverine forest, forest, grassland, and bushes with 76.67% accuracy. The classification shows 692.47km² (72.69%) of the park area is covered by *Shorea robusta* and mixed forest, 112.80km² (11.84%) by grasslands, and 93.45km² (9.81%) by riverine forest. A small part of the park is covered by riverbank (32.10km², 3.37%), water bodies (18.86km², 1.97%), and bushes (2.95km², 0.31%). The land cover classification map is shown in Fig. 3.

Suitability Analysis

The land use classified raster image was used in suitability analysis. Water source, road, settlement, and vegetation type/land use thematic layers were rated into

Table 1. HQR for vegetation types/ land use and distance to water, road, and settlement.

	Vegetation type/ land use	HQR
1	Sal forest and other forest	4
2	Riverine forest	3
3	Waterbodies	2
4	Grassland	1
5	Bushes/ shrubs	3
6	Riverbed	2
	Distance to water (m)	HQR
1	<500	1
2	500–1000	2
3	1000–2000	3
4	>2000	4
	Distance to road (m)	HQR
1	<1000	4
2	1000–2000	3
3	2000–3000	2
4	>3000	1
	Distance to settlement (m)	HQR
1	<1000	4
2	1000–2000	3
3	2000–3000	2
4	>3000	1
1 - highly suitable, 2 - suitable, 3 - moderately suitable, 4 - least suitable.		

Table 2. Pair-wise comparison matrix.

Class [C]	Vegetation types/ land use	Water source	Road	Settlement
Vegetation types/ land use	1	3	5	7
Water source	1/3	1	3	5
Road	1/5	1/3	1	3
Settlement	1/7	1/5	1/3	1
Total	1.676	4.533	9.333	16.00

Table 3. Synthesized matrix.

Class	Vegetation types/ land use	Water source	Road	Settlement	Priority vector (W)
Vegetation types/ land use	0.597	0.662	0.536	0.438	0.558
Water source	0.199	0.221	0.321	0.313	0.263
Road	0.119	0.073	0.107	0.188	0.122
Settlement	0.085	0.044	0.036	0.063	0.057
					$\Sigma W = 1$

habitat values by assigning habitat quality rating (HQR) based on their suitability on a scale in decreasing order of suitability (1 for highly suitable and 4 for least suitable) (Nandy et al. 2012). The area close to a water source was considered to be highly suitable and the area close to district/feeder road or settlement was considered to be least suitable due to high human interference. The different thematic layers were adopted from Nandy et al. (2012) and modifications were made in HQR based on findings of Bhattarai (2015). HQR for distance to water was modified with expert judgment from less than 1000m to less than 500m for highly suitable, 500m to 1000m for suitable category, 1000m to 2000m for moderately suitable, and more than 2000m for least suitable category. Similarly, the park area having an elevation greater than 300m was considered least suitable. HQR is given in Table 1.

After rating all thematic layers into 1 to 4 suitability classes, a weighted sum was done in GIS environment. Weights were assigned to different layers by using a decision-aiding tool, analytical hierarchy process (AHP) (Saaty 1987), and weights were given using Nandy et al. (2012) and modified with site condition. Pair-wise comparison matrix of variables vegetation types/ land use, water source, road, and settlement was carried out and is shown in Table 2. Vegetation type and water source are essential habitat factors and road and settlements are disturbance factors. During the evaluation process, more weight was given to vegetation type/ land cover and then to water bodies, while less weight was given to road and settlement. Between road and settlement, more weight was assigned to road as a district road (Bharatpur-Madi-Thori) crosses the national park core region from Kasara to Bankatta and all of the settlement lies outside the natural river boundary which separates the national park core region from its buffer zone.

The pair-wise matrix was then synthesized to standardize by dividing each element of the matrix by its column value total. The priority vector was obtained by averaging row in Table 3.

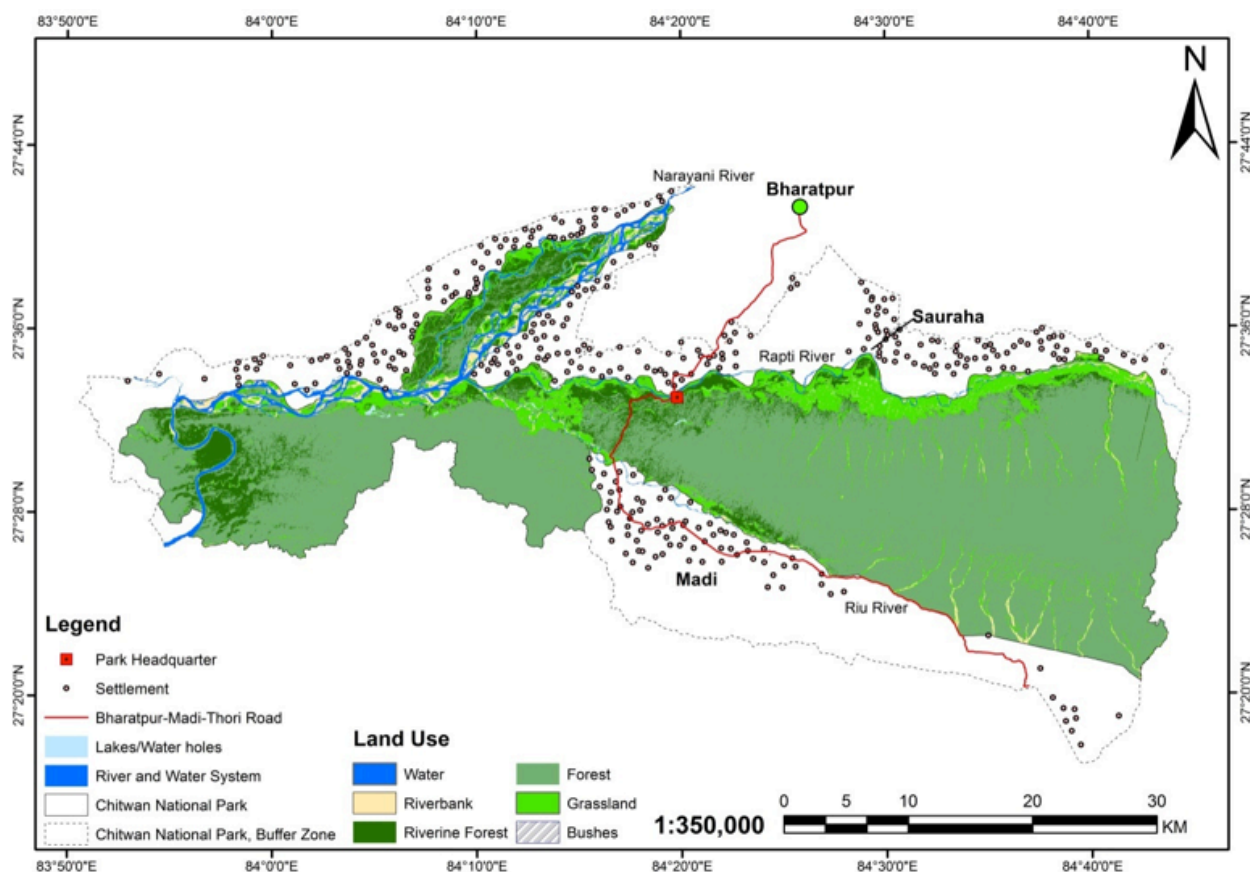


Figure 3. Land use in Chitwan National Park, Nepal.

The consistency ratio (CR) of the pair-wise comparison matrix was 0.043. The CR less than 0.1 is accepted according to Saaty's principle (Saaty 1987). To calculate consistency ratio, consistency index (CI) was calculated and random index (RI) was derived from Saaty's index.

The weights of different variables, obtained from the above analysis, were used in the weighted suitability to evaluate the suitable habitat for Swamp Deer. The HSI is calculated as

$$HSI = 0.558 \times VLI + 0.263 \times WI + 0.122 \times RI + 0.057 \times SI$$

where VLI = vegetation type/land use Index, WI = water source index, RI = road index, SI = settlement index.

RESULTS

Habitat Suitability

The habitat suitability analysis showed that about 14.57km² (1.53%) of CNP was found to be highly suitable, 134.87km² (14.16%) suitable, 203.89km² (21.40%) moderately suitable, and 599.30km² (62.91%) least suitable for Swamp Deer. Most of the grassland of

CNP falls into the suitable to highly suitable categories. The distribution of the areas with varying degrees of suitability is shown in Fig. 4.

According to the land use types, 100.14km² (67.01%) area of grassland, 25.72km² (17.21%) of riverbank, 16.64km² (11.14%) of water bodies, 4.46km² (2.99%) of forest (other than riverine), 1.86km² (1.25%) of riverine forest, and 0.62km² (0.41%) of bushes of CNP was found under suitable to highly suitable category.

Similar proportion of highly suitable to suitable area was found in all three studied blocks; however, the highest area was found in BS followed by BJ and PP grassland blocks. Some small patches were also identified as highly suitable west of BS and east of PP (Table 4).

Habitat Composition

Grassland: Among the 120 quadrats sampled, 90% (n=108) sample points were distributed in grassland, 8.33% (n=10) in forest, and 1.67% (n=2) in bushes. Of the 108 grassland quadrats, 20.37% (n=22) were found to be of short grass (<3m) and 79.63% (n=86) of tall grass (>3m). The highest proportion of tall grassland was

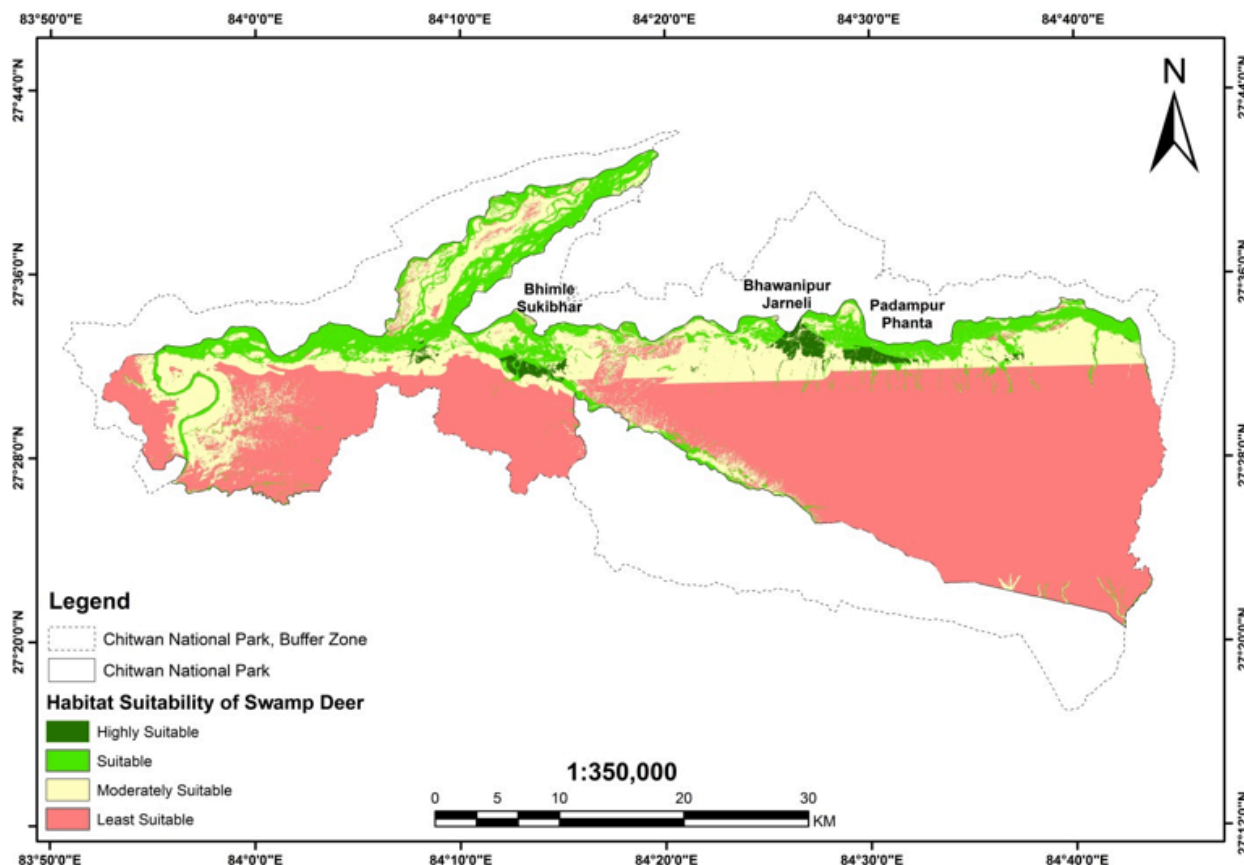


Figure 4. Potential habitats of Swamp Deer in Chitwan National Park, Nepal.

Table 4. Patch-wise habitat suitability in the study area (in km²) in Chitwan National Park, Nepal.

Block	Highly suitable	Suitable	Moderately suitable	Least suitable	Total area
Padampur Phanta	3.49	9.60	0.26	0.01	13.37
Bhawanipur-Jarneli	4.99	8.49	0.38	0.01	13.86
Bhimle-Sukibhar	2.93	11.07	0.30	0.02	14.31
Others	3.16	105.71	202.95	599.27	911.09
Total area	14.57	134.87	203.89	599.30	952.63

found in BJ (97.06%, n=33) and the lowest in PP (70.73%, n=29). Most of the short grassland quadrats observed (n=9) at BS grassland were located on the banks of the Rewa and Rapti rivers. Frequency analysis revealed *Imperata cylindrica* as the most common species with a frequency of 96.13% (n=105) followed by *Saccharum arundinaceum*, *Narenga porphyrocoma*, *Apluda mutica*, and *Cynodon dactylon*. *Saccharum arundinaceum* (54.63%) was found to be the most dominant grass species in the study area followed by *N. porphyrocoma*, *I. cylindrical*, and *Themeda* spp. All of the study quadrats had areas more than 80% covered by grass species. The swampy areas and waterholes of the park were

covered by *Mikania micrantha* and *Eichornia crassipes*. The block-wise dominant and co-dominant species are given in Table 5. During frequency and dominance calculations, species whose occurrence was less than 5% of the total number of quadrats were eliminated due to insignificant occurrence (Table 5).

Riverine Forest: The highest density (0.01, 0.42, 0.11, and 0.89), frequency (100, 100, 100, and 77.79), and abundance (2.33, 4.22, 2.78, and 1.43) in riverine forest were found on *Trewia nudiflora* in nested quadrat of 20m×25m, 10m×10m, 5m×5m, and 1m×1m area. Most of the sample plots (80%) in riverine forest were found to be an association of *T. nudiflora* and *Bombax*

Table 5. Dominance of grass species in the studied blocks in Chitwan National Park, Nepal.

Block	Dominant species	Occurrence in %	Co-dominant species	Occurrence in %
Padampur (41 quadrats)	<i>Saccharum arundinaceum</i>	46.34	<i>Narenga porphyrocoma</i>	36.59
	<i>Imperata cylindrica</i>	24.39	<i>Saccharum arundinaceum</i>	14.63
	<i>Narenga porphyrocoma</i>	21.95	<i>Apluda mutica</i>	14.63
			<i>Bothriochloa intermedia</i>	9.76
			<i>Saccharum bengalensis</i>	7.32
Bhawanipur-Jarneli (34 quadrats)	<i>Saccharum arundinaceum</i>	67.65	<i>Narenga porphyrocoma</i>	32.35
	<i>Narenga porphyrocoma</i>	20.59	<i>Saccharum bengalensis</i>	20.59
	<i>Themeda</i> spp.	5.88	<i>Apluda mutica</i>	20.59
			<i>Saccharum arundinaceum</i>	14.71
			<i>Imperata cylindrica</i>	5.88
Bhimle-Sukibhar (33 quadrats)	<i>Saccharum arundinaceum</i>	51.52	<i>Narenga porphyrocoma</i>	33.33
	<i>Imperata cylindrica</i>	21.21	<i>Imperata cylindrica</i>	15.15
	<i>Narenga porphyrocoma</i>	18.18	<i>Themeda</i> spp.	15.15
			<i>Saccharum bengalensis</i>	12.12
			<i>Saccharum spontaneum</i>	9.09
			<i>Apluda mutica</i>	6.06

ceiba. Similarly, *Ehretia laevis* and *Litsea monopetala* were also found frequently in the riverine forest. *Murrya koenigii* and *Toona ciliata* saplings were found on 30% and 10% plots, respectively. The seedlings of *T. nudiflora*, *L. monopetala*, *M. koenigii*, and *E. laevis* and invasive species *Mikania micrantha* and *Lantana camara* were also observed in the studied quadrats. An average of 75% crown coverage and 50% ground coverage was estimated in riverine forest patches.

DISCUSSION

The GIS based multi-criteria study identified 149.44km² (15.69%) as suitable of which 40.57km² (4.26%) lies in three major grasslands. This constitutes 97.67% of the total area of these three major grasslands. BS (14km²) has the largest area of suitable habitat followed by BJ (13.48km²) and PP (13.10km²). Habitat suitability was mostly influenced by the presence of water sources and vegetation types. In addition to the above-mentioned grasslands, most of the other grassland patches were also found suitable which includes the floodplain of three major river systems of the park, namely, Rapti, Rewa, and Narayani. The highly suitable area of both PP and BJ grasslands are distant from Rapti River and most of the BJ grassland is bordered by riverine forest. On the other hand, the highly suitable

area of BS falls on the river bank of Rewa and the suitable area is extended along the bank of Rapti River. All of the suitable category habitat areas have a risk of inundation and flooding during rainy season. The BS grassland, however, has a high risk of flooding. Similarly, BS is separated from the eastern grasslands (PP and BJ) by *Shorea robusta* forest and the Bharatpur-Madi-Thori District Road, which possibly restricts the movement of Swamp Deer. There is, however, the possibility of joining BS with suitable grassland patches that are uniformly distributed in the western part.

The study of vegetation composition in the quadrats showed that 20.37% area of the three grassland blocks is covered by short grasses. According to previous studies, short grasslands, rivers, and riverbeds are the most preferred habitat of Swamp Deer. In the study area, *I. cylindrica*, *C. dactylon*, *S. spontaneum*, *S. bengalensis*, *D. bipinnata*, *Phragmites karka*, *Cyperus* spp., *N. porphyrocoma*, *Themeda* spp., *Apluda mutica*, *Hemarthra compressa*, and *Arundinella nepalensis* were reported as food species of Swamp Deer by previous researchers. This study also found *I. cylindrica* as the most commonly distributed grass species followed by *S. arundinaceum* and *N. porphyrocoma* in the park. The availability of the most preferred food species *I. cylindrica* increases the suitability of the area which is dominant only in 16.67% of the quadrats. In contrast, most of the grasslands are dominated by *S. arundinaceum* (54.63%) which will be

least suitable after growth in summer (April–June).

If there is a decision to reintroduce Swamp Deer in CNP, PP has the highest proportion of short grassland and dominance of *I. cylindrica*, and therefore could be selected based on vegetation, however, this area (PP) bears challenges of inundation and flooding due to proximity to a perennial river system. Study quadrats in BJ had 97.06% tall grassland, thus, it would be favourable to Swamp Deer only from February to April when grass sprouts start to emerge. BS grassland is dominated by tall grass species (72.73%) and most of the short grasses are distributed along the Rewa and Rapti rivers. In case of heavy flooding and inundation, there is a risk of these grassland patches being modified. Hence, for this area to be appropriate for the reintroduction of Swamp Deer, habitat management interventions are required around Bhimle and Sukibhar posts.

All of the grasslands of CNP lie in close proximity to Rapti, Rewa, and Narayani rivers. Similarly, in some areas, park management developed water holes which provide water to wildlife species. All of the suitable areas of CNP lie within a 2km-distance to a water source and are, therefore, within the daily range of the Swamp Deer.

For the viability of the species, sufficient numbers of individuals need to be reintroduced. Previous studies on Swamp Deer were mainly focused on habitat preference, food and feeding behaviour, and herd size and there is no information available on the area required for this species. The study from JJCR found that 14km² is insufficient for 134 Swamp Deer (Nandy et al. 2012) and 0.009km² area per individual is insufficient in maintaining a viable population. We believe that the suitable area identified by this study can support only a small population as described by Nandy et al. (2012) based on study in JJCR. We, however, would like to recommend a more detailed study regarding population viability.

This study and previous studies by Ram (2014) and Lamichhane et al. (2014) in CNP showed that the national park is severely affected by the invasion of *Mikania micrantha*, a mile-a-minute invasive species. The intensity of *M. micrantha* invasion is greatest in and around sources of water. Most of the swampy grassland area is invaded by this species. There is no information available on the response of Swamp Deer to *M. micrantha* up to now, but this invasive species could have a strong impact by limiting food availability. In addition to invasive species, several other environment factors (such as population density, social organization, prey-predator relationship, ungulate species relationship, and

risk assessment) could affect the suitability of an area for the reintroduction of the species and these were not assessed in this study. Further research on these topics is recommended.

CONCLUSION

Habitat suitability assessment using multi-criteria analysis in a GIS environment showed 149.44km² of the park area provides suitable habitat for Swamp Deer in CNP including 100.14km² grassland, 25.72km² riverbank, 16.64km² water bodies, 4.46km² forest, 1.86km² riverine forest, and 0.62km² bushes. A total of 112.80km² of the park is grassland. Out of this, we assessed 41.54km² area in three major grasslands for the vegetation suitability. Amongst the assessed blocks of grassland, 40.57km² was found to be suitable according to the parameters of the study. Considering suitability in terms of habitat size, food, and water availability, PP is found to be more suitable for reintroduction of Swamp Deer compared to the other two sites. Alternatively, BS grassland could be another potential habitat for reintroduction of Swamp Deer with habitat management interventions. BJ has only seasonal suitability due to the high coverage of tall grass species.

REFERENCES

- Aryal, C. (2016). Evaluation of Suitability of Triyuga Forest of eastern Nepal as Potential Tiger (*Panthera tigris tigris* Linneus, 1758) Habitat. MSc Thesis. Department of Environmental Science, Tribhuvan University, Kathmandu, Nepal, 60pp.
- Bhatta, B. (2008). Daily Activities, Distribution, and Food Preference of Swamp Deer (*Cervus duvauceli duvauceli*). BSc Thesis. Department of Forestry, Tribhuvan University, Kathmandu, Nepal, 46pp.
- Bhattarai, B. (2015). Habitat Preference and Evaluation of Swamp Deer (*Cervus duvauceli duvauceli*) in Bardia National Park. BSc Thesis. Department of Forestry, Tribhuvan University, Kathmandu, Nepal, 82pp.
- CFD (2004). Guideline for Inventory of Community Forests. Ministry of Forests and Soil Conservation, Department of Forests, Community and Private Forest Division, Babarmahal, Kathmandu, Nepal. Accessed on 20 March 2018. Retrieved from <https://books.google.com.np/books?id=1wdJAAAAYAAJ>.
- CNP (2015a). Annual Report 2071/72. Chitwan National Park Office, Kasara, Chitwan, Nepal, 197pp.
- CNP (2015b). Chitwan National Park and its Buffer Zone Management Plan. Chitwan National Park, Kasara, Chitwan, Nepal, 165pp.
- DNPWC (2015). Annual Report Fiscal Year 2071/72. Department of National Parks and Wildlife Conservation, Babarmahal, Kathmandu, Nepal, 93pp.
- Duckworth, J.W., N.S. Kumar, C.P. Pokharel, S.H. Baral & R. Timmins (2015). *Rucervus duvaucelii*. In: The IUCN Red List of Threatened Species: e.T4257A22167675. Accessed on 17 March 2018. <https://doi.org/10.2305/IUCN.UK.2015-4.RLTS.T4257A22167675.en>
- Groves, C.P. (1982). Geographic variation in the Swamp Deer (*Cervus*

- duvauceli*). *The Journal of the Bombay Natural History Society* 79: 620–629. Accessed on 07 January 2018. Retrieved from <https://www.biodiversitylibrary.org/page/48745060#page/686/mode/1up>.
- Guisan, A. & N.E. Zimmermann (2000)**. Predictive habitat distribution models in ecology. *Ecological Modelling* 135(2–3): 147–186. [https://doi.org/10.1016/S0304-3800\(00\)00354-9](https://doi.org/10.1016/S0304-3800(00)00354-9)
- Gurung, K.K. (1983)**. *Heart of the Jungle: Wild Life of Chitwan, Nepal, 1st Edition*. Andre Deutsch Limited, London, 197pp.
- Gyawali, N. & S.R. Jnawali (2005)**. Population status and habitat use of Barasingha (*Cervus duvauceli duvauceli*) in Royal Suklaphanta Wildlife Reserve. *Tiger Paper: Regional Quarterly Bulletin on Wildlife and National Parks Management (FAO)* 32(1): 6–10.
- Jackson, R. & G.G. Ahlborn (1984)**. A preliminary habitat suitability model for the Snow Leopard, *Panthera uncia*, pp43–52. In: Blomqvist, L. (ed.). *Pedigree Book of Snow Leopards, Vol. 4*. Helsinki Zoo, Helsinki, Finland, 144pp.
- Kafley, H., M. Khadka & M. Sharma (2009)**. Habitat evaluation and suitability modeling of *Rhinoceros unicornis* in Chitwan National Park, Nepal: a geospatial approach, pp1–12. In: *World Forestry Congress XIII*.
- Lamichhane, B.R., N. Subedi, N.R. Chapagain, M. Dhakal, C.P. Pokheral, S.T. Murphy & R. Amin (2014)**. Status of Mikania micrantha Invasion in the Rhino Habitat of Chitwan National Park, Nepal. Proceeding of International Conference in Invasive Alien Species Management 25–27 March, 2014, Sauraha, Chitwan. National Trust for Nature Conservation, Kathmandu, Nepal, 222pp.
- Martin, C. (1977)**. Status and ecology of the Barasingha (*Cervus duvauceli branderi*) in Kanha National Park (India). *Journal of the Bombay Natural History Society* 74(1): 60–132. Retrieved from <https://eurekamag.com/research/006/475/006475102.php>.
- Mishra, H.R. (1982)**. Ecology and Behaviour of Chital (*Axis axis*) in the Royal Chitwan National Park, Nepal (with comparative studies of Hog Deer (*Axis porcinus*), Sambar (*Cervus unicolor*) and Barking Deer (*Muntiacus muntjak*)). PhD Thesis. Department of Forestry and Natural Resources, University of Edinburgh, Edinburgh, Scotland, 239pp. Retrieved from <https://hdl.handle.net/1842/15405>. Accessed on 27 February 2018.
- Moe, S.R. (1994)**. The importance of aquatic vegetation for the management of the Barasingha *Cervus duvauceli* in nepal. *Biological Conservation* 70(1): 33–37. [https://doi.org/10.1016/0006-3207\(94\)90296-8](https://doi.org/10.1016/0006-3207(94)90296-8)
- Nandy, S., S.P. Kushwaha & P. Gaur (2012)**. Identification of Swamp Deer (*Cervus duvauceli duvauceli* Cuvier) potential habitat in Jhilmil Jheel Conservation Reserve, Uttarakhand, India, using multi-criteria analysis. *Environmental Management* 49(4): 902–914. <https://doi.org/10.1007/s00267-012-9826-5>
- Oosting, H.J. (1956)**. *The Study of Plant Communities. An Introduction to Plant Ecology, 1st Edition*. W.H. Freeman & Company, San Francisco, California, USA, 440pp.
- Pokheral, C.P. (1996)**. Food Habit and Habitat Utilization of Swamp Deer (*Cervus duvauceli duvauceli*) in Royal Bardia National Park, Nepal. MSc Thesis. Department of Zoology, Tribhuvan University, Kathmandu, Nepal, 62pp.
- Poudel, B.S. (2007)**. Thirty years of managing Suklaphanta the Swamp Deer and the tiger: issues and strategies. *The Initiation* 1: 72–76. <https://doi.org/10.3126/init.v1i0.2684>
- Qureshi, Q., V.B. Sawarkar & P.K. Mathur (1995)**. Ecology and Management of Swamp Deer (*Cervus duvauceli*) in Dudhwa Tiger Reserve, U.P. (India). Wildlife Institute of India, Dehradun, India, 78pp.
- Qureshi, Q., V.B. Sawarkar, A.R. Rahmani & P.K. Mathur (2004)**. Swamp Deer or Barasingha (*Cervus duvauceli* Cuvier, 1823), ungulates of India, pp181–192. In: Sankar, K. & S.P. Goyal (eds.). *Envis Bulletin: Wildlife and Protected Areas, Vol. 7*. Wildlife Institute of India, Dehradun, India.
- Ram, A.K. (2014)**. Geospatial Modelling to assess Asian Elephant (*Elephas maximus*) Habitat Suitability, Migratory Routes and Human-Elephant Interface in eastern Nepal. MSc Thesis. Department of Forestry, Tribhuvan University, Kathmandu, Nepal, 57pp.
- Saaty, T.L. (1987)**. The analytical hierarchy process: what it is and how it is used. *Mathematical Modelling* 9(3–5): 161–176. [https://doi.org/10.1016/0270-0255\(87\)90473-8](https://doi.org/10.1016/0270-0255(87)90473-8)
- Singh, C.P., J.S. Chauhan, J.S. Parihar, R.P. Singh & R. Shukla (2015)**. Using environmental niche modeling to find suitable habitats for the hard-ground Barasingha in Madhya Pradesh, India. *Journal of Threatened Taxa* 7(11): 7761–7769. <https://doi.org/10.11609/JoTT.o3899.7761-9>
- Thapa, T.B. (2013)**. Habitat Suitability Evaluation for Leopard. PhD Thesis. Department of Ecology and Conservation Biology, Saurashtra University, Dehradun, India, 252pp.

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