

## Building the baseline: Assessment of ungulate densities in Amangarh Tiger Reserve, Uttar Pradesh, India



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RECEIVED 31 August 2024  
ACCEPTED 13 November 2024  
ONLINE EARLY 14 November 2024

### CITATION

Reza, S., Singh, V. P., Anwar, M., Khan, A. (2024). Building the Baseline: Assessment of Ungulate Densities in Amangarh Tiger Reserve. *Journal of Wildlife Science*, 1 (3), 131- 134.  
<https://doi.org/10.63033/JWLS.CBKR6481>

### FUNDING

This study was funded by WWF-India.

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### PUBLISHED BY

Wildlife Institute of India, Dehradun, 248 001  
INDIA

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### Abstract

We estimated density of ungulate species in the Amangarh Tiger Reserve using line transect distance sampling. Twelve transects were marked and monitored between February and April 2021 resulting in an effort of 108 km. A total of 210 sightings of five species of ungulates were recorded. Spotted deer (*Axis axis*) was the most frequently recorded species with 80 sightings followed by wild boar (*Sus scrofa*), sambar (*Rusa unicorn*), nilgai (*Boselaphus tragocamelus*) and barking deer (*Muntiacus muntjak*). The overall density estimate of all five ungulate species was 62.7 ( $\pm 11$  SE) km<sup>-2</sup>. Spotted deer was the most abundant ungulate (22.95  $\pm 6.5$  km<sup>-2</sup>) followed by sambar (14.26  $\pm 4.2$  km<sup>-2</sup>), wild boar (13.21  $\pm 4.8$  km<sup>-2</sup>) and nilgai (10.56  $\pm 5.06$  km<sup>-2</sup>). This study provides the first comprehensive assessment of ungulate densities in Amangarh Tiger Reserve. The findings establish baseline information for future monitoring and research studies in the area which is an important buffer to Corbett Tiger Reserve and has seen an increase in tiger numbers over the years.

**Keywords:** Carnivore prey-base, Corbett Tiger Reserve, Distance sampling, Terai Arc Landscape, *Van Gujjar*

### Introduction

The Terai Arc Landscape (TAL), at the foothills of the Himalayas in northern India, boasts approximately 14% of the global tiger population (Qureshi *et al.*, 2023). Amangarh Tiger Reserve (TR) in the western TAL provides a buffer to the dispersing tiger individuals of Corbett TR and harbours a significant breeding population of tigers (Qureshi *et al.*, 2023). Tigers rely on large home ranges, undisturbed habitats and abundant large wild ungulates to flourish (Karanth *et al.*, 1999, Sunquist *et al.*, 1981). The proposed Kandi road, connecting Kotdwar to Ramnagar towns of Uttarakhand at the inter-state border of Uttar Pradesh and Uttarakhand and running east to west along Corbett TR, cuts through the tiger connectivity between Corbett TR and Amangarh TR (DownToEarth 2024). This proposed road, may isolate the tiger population of Amangarh TR, increasing its vulnerability to local extinction caused by demographic and environmental stochasticity (Caughley 2002, Purvis *et al.*, 2000). Further, the depletion of prey base abundance may threaten the tiger population and become a significant constraint on their recovery (Karanth & Stith, 1999, Wikramanayake *et al.*, 2002, Harihar *et al.*, 2009). Understanding population parameters of prey species such as density, group size and social organisation, which are inherently linked to ecosystem effectiveness, is crucial for conservation-related decisions (Jathanna *et al.*, 2003, Witmers 2005, Skalski *et al.*, 2010). Various techniques have been used to assess such population parameters for the prey base (Dinerstein 1980, Karanth *et al.*, 1992) and distance sampling is a robust statistical method to estimate the density and abundance of the prey base. This method also accounts for missed animals during the surveys by estimating detection probability using effective strip width (Buckland *et al.*, 2015). We applied this method to generate baseline information on wild prey base for long-term conservation of tigers in Amangarh TR.

This study focuses on ungulates, a critical food source for large carnivores. They constitute a significant portion of the prey consumed by carnivore populations across numerous protected areas in India (Schaller, 1967; Johnsingh, 1983; Karanth &

Sunquist, 1995; Biswas & Sankar, 2002). It is also important to understand the ecosystem services that ungulates are providing to the habitats upon which they survive. Therefore, monitoring wild prey base becomes an essential part of the conservation and management of large carnivores.

### Study Area

Amangarh TR (95 km<sup>2</sup>) is situated in the Himalayan foothills in the Bijnor district of Uttar Pradesh and forms the southern boundary of Corbett Tiger Reserve. The forested area of the TR (80.6 km<sup>2</sup>) was sampled (Fig. 1). Before the formation of Uttarakhand state in 2000, Amangarh was buffer area of the Corbett TR. Amangarh TR has a tiger density of 9.34 (±1.96 SE) /100 km<sup>-2</sup> (Qureshi *et al.*, 2023). Tigers use Corbett and Amangarh as a continuous habitat and move towards Terai West Forest Division and eventually to Ramnagar Forest Division (Bisht *et al.*, 2019; Qureshi *et al.*, 2023). The broad forest type is deciduous with sal and teak dominated forest and a generally flat terrain (altitude varies from 240 m to 270 m above sea level). Amangarh TR consist of sal , sal-mixed, plantation, scrubland and riverine vegetation types across its 9 beats. Amangarh TR is also one of the strongholds of *Van Gujjar* (a forest-dwelling nomadic tribe) population. They live inside the forest in traditional huts (also known as Deras) alongside their livestock and rely on the forest for grazing and lopping trees to sustain their herd. Hussain *et al.* (2012) reported 73 *Van Gujjar* families (557 individuals) inhabiting the area with 1690 units of livestock.

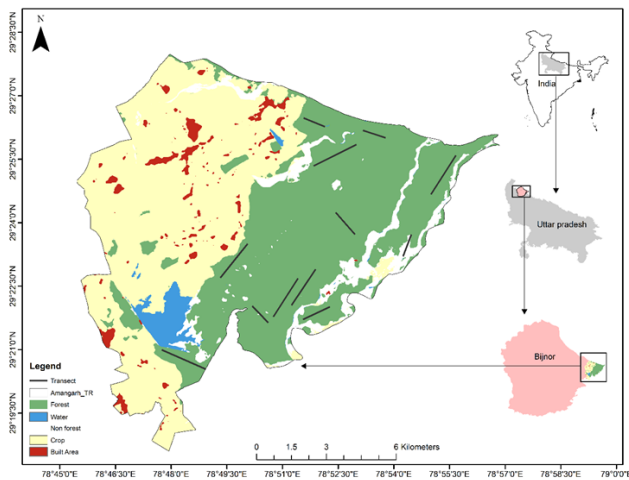


Figure 1: The location of Amangarh Tiger Reserve in Uttar Pradesh, various land use land cover classes (acquired from living atlas of ESRI) and distribution of transects.

### Methodology

Line transect based distance sampling (Eberhardt, 1978; Burnham *et al.*, 1980; Buckland *et al.*, 1993, 2001) was used to estimate the abundance of ungulates. In distance sampling, estimates are based on observed distances of animals from a line or point to model species detectability and estimate absolute density (Buckland *et al.* 1993). With a well-described theoretical framework and comprehensive software, distance sampling has become a widely used technique across a broad spectrum of species and is often used for large-scale monitoring of species that can be visually detected in reasonable numbers (Kumar 2000; Focardi *et al.* 2005). A total of 12 transects were marked in all the 9 beats of Amangarh TR. The transect length varied from 1-2 km. Transects were distributed randomly

representing different vegetation types with respect to animal distribution in the study area (Fig. 1). Each transect was walked 6 times as temporal replicates. Transects were walked twice a day- early morning (06:00-07:00 hrs) and evening (16:00-17:00 hrs), when ungulates remain most active. Data on species sighted, the number of individuals and group composition were recorded. The angular distance was recorded using a handheld compass and a range finder. The start and end points of all the transects were also recorded using Global Positioning System (GPS) eTrex 30 for marking locations of transects on a map. We used Distance 7.5 release 1 software (Thomas *et al.*, 2010) to estimate density and associated variance. Bins width was adjusted according to the collected data and best-fit model was selected based on the lowest AIC (Akaike Information Criterion) value (Fig. 2).

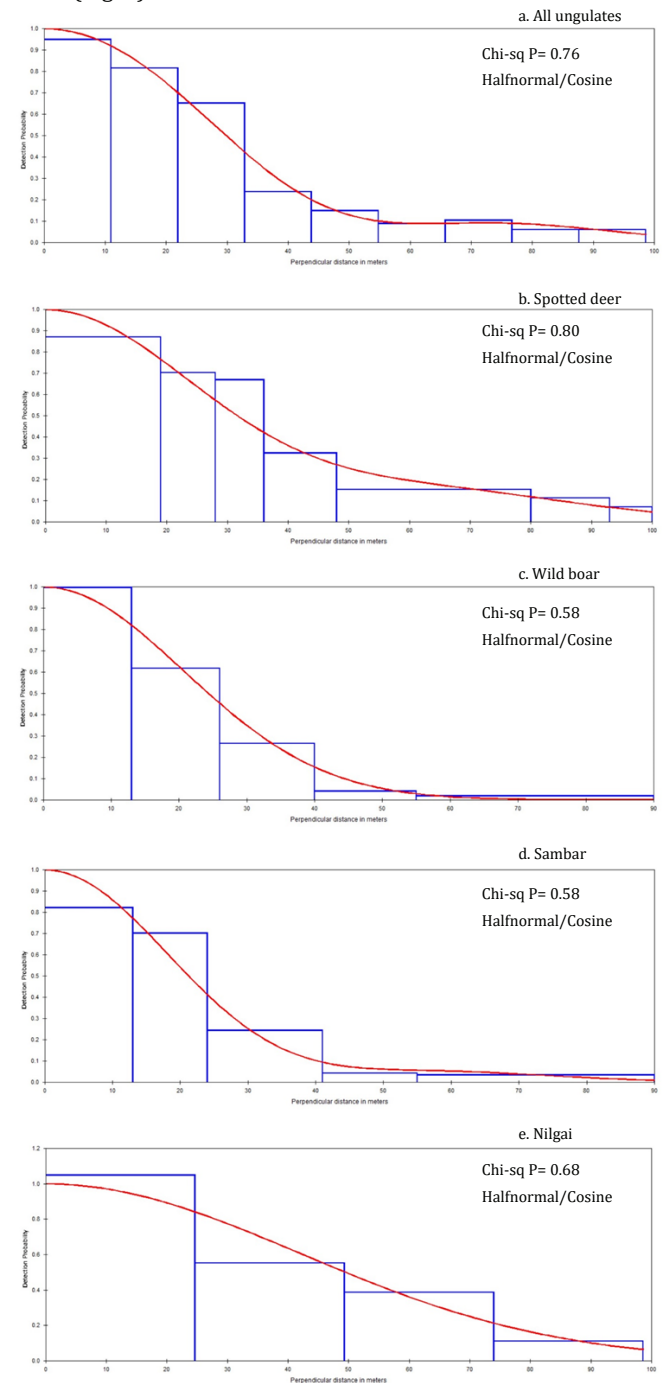


Figure 2 (a-e): Detection probability of best fit model for ungulates in Amangarh Tiger Reserve, February - April, 2021

## Results and Discussion

An effort of 108 km resulted in 210 groups (469 individuals) of 5 species of wild ungulates being detected. Spotted deer (*Axis axis*) was the most frequently recorded species with 80 groups (193 individuals) followed by wild boar (*Sus scrofa*) with 42 groups (74 individuals), sambar (*Rusa unicolor*) with 41 groups (75 individuals), nilgai (*Boselaphus tragocamelus*) with 38 groups (118 individuals) and barking deer (*Muntiacus muntjak*) with 9 groups (9 individuals) (Table 1). The encounter rate (groups/km) of all ungulates was 1.94 with 17.25 % CV. Spotted deer had the highest encounter rate (0.74, CV 22.54 %) followed by wild boar (0.38, CV 33.98 %), sambar (0.37, CV 25.94 %), nilgai (0.35, CV 44.63 %) and barking deer (0.1) (Table 1). Due to insufficient data individual density of barking deer was not estimated.

The overall density of ungulates (including barking deer) was estimated as 62.7 ( $\pm 11$  SE) individuals km<sup>-2</sup> (Table 1). The density of spotted deer was highest (22.95  $\pm 6.5$  km<sup>-2</sup>) followed by sambar (14.26  $\pm 4.2$  km<sup>-2</sup>), wild boar (13.21  $\pm 4.8$  km<sup>-2</sup>) and nilgai (10.56  $\pm 5.06$  km<sup>-2</sup>). The observed ungulate densities indicate a viable prey base for large carnivores in Amangarh TR. This density is nearly double the previously reported average density for the western TAL. The average density of wild ungulates in the western TAL region was estimated at approximately 35.16  $\pm 5.67$  individuals km<sup>-2</sup>, and it was deemed sufficient to support tiger populations and other large predators within these ecosystems (Harihar et al., 2014). It underscores the significance of Amangarh TR's prey availability in

supporting large carnivores. Such a high ungulate density could provide substantial sustenance for resident tiger populations and potentially enhance predator-prey dynamics in the region. However, TAL's protected areas are distributed as isolated patches interspersed with multiple-use forests, agricultural zones, and human settlements, creating a fragmented landscape that poses challenges to wildlife movement and survival (Ahmad et al., 2018).

Additionally, the presence of *Van Gujjar* (a forest-dwelling nomadic tribe) and encroachment may further impact ungulate densities in Amangarh TR. According to a report submitted to Uttarakhand forest department in 2013, the Amangarh TR has the highest number of *Van Gujjar* households in the region (Hussain et al., 2013). The *Van Gujjar* traditionally depend on grazing livestock for their livelihood, which can lead to increased competition with native ungulates for resources. Amangarh TR, being a relatively new tiger reserve, is likely developing its management strategies, which could potentially increase its ungulate density over time. Therefore, the findings from our study contribute crucial baseline data, serving as an important reference point for wildlife managers and conservationists aiming to formulate future management strategies. The high prey density suggests a strong ecological foundation that could facilitate predator conservation efforts in Amangarh TR. Additionally, our results advocate for a continued long-term monitoring to understand population trends, prey-predator interactions, and habitat requirements, ensuring informed decisions.

Table 2: Density estimates of all ungulates (spotted deer, sambar, barking deer, wild boar, nilgai) and spotted deer, sambar, wild boar, nilgai Amangarh Tiger Reserve during February and April 2021.

Species	No. of Group Sighted	Encounter Rate	CV	ESW (m)	SE	AIC	Average group size	SE	Detection Probability	SE	Group density /km <sup>2</sup>	SE	Individual density/ km <sup>2</sup>	SE
Spotted Deer	80	0.74	22.54	38.91	4.88	261.52	2.41	0.17	0.38	0.04	9.51	2.45	22.95	6.15
Wild Boar	42	0.38	33.98	25.92	2.94	101.45	1.76	0.14	0.28	0.02	7.49	2.68	13.21	4.85
Sambar	41	0.37	25.94	24.2	2.8	108.68	1.82	0.14	0.27	0.03	7.8	2.2	14.26	4.21
Nilgai	38	0.35	44.63	51.72	5.92	335.25	3.1	0.4	0.52	0.06	3.4	1.56	10.56	5.06
Barking Deer	9	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Overall	210	1.94	17.25	34.1	2.89	1747	2.23	0.11	-	-	-	-	62.7	11.0

\*ESW (m): Effective strip width in meters; SE: Standard error; CV: Coefficient of variance

## Acknowledgements

The authors wish to express their sincere gratitude to the Divisional Forest Officer of the Bijnor Social Forestry Division for granting permission to conduct this study. We also extend our heartfelt thanks to the Range Officer and Staff of Amangarh Tiger Reserve for their invaluable assistance and support throughout the research. Additionally, we appreciate the technical support and assistance in data collection provided by the WWF Haldwani team. Their contributions were crucial to the success of this study.

### CONFLICT OF INTEREST

The authors have no competing interests to declare that are relevant to the content of this article.

### DATA AVAILABILITY

Data available from the corresponding author on request.

### AUTHOR CONTRIBUTIONS

AK, MA and SR conceived the study. SR and VPS carried out the fieldwork and data analysis. SR wrote the first draft of the paper. All the authors revised the initial draft and approved the final draft for submission.

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